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Environmental Impact Assessment (EIA) Study for Repowering of Unit-4 of Ghorashal Power Station

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1. Introduction

1.1 Background

1. Sustainable power supply is an important precondition for the socio-economic development of Bangladesh. At present, about 60% (including off-Grid Renewable) population of Bangladesh has access to electricity and per capita electricity generation is only 348 KWh (including captive, FY 2014). The Government has therefore given top priority to the development of the power sector and has formulated the Power System Master Plan (PSMP), 2010. To this end, the government has set the goal of providing electricity to all citizens by 2021. The present electricity demand growth is 12% per annum and current installed generation capacity is around 10,817 MW including 4,437 MW from private sector, and 500 MW of electricity import. At present most of the power plants are natural gas based. Considering limited gas reserve of the country, BPDB has planned to generate electricity by converting the existing simple cycle gas plants to combined cycle plants and by re-powering the existing old steam power plants.

2. Existing Unit 4 of Ghorashal Power plant has a steam turbine with 210 MW generation capacity, but due to its age (about 25 years), the plant has become unreliable and less efficient. Currently, maximum output of this Unit is 180 MW. BPDB, therefore, has taken the decision to repower the unit to a 403.5MW combined cycle power plant (CCPP). This re-powering of the system will be done by installing one Heat Recovery Steam Generator (HRSG), one Gas Turbine (GT) of 246MW capacity and re-furbishing the existing 210MW Steam Turbine (ST) along with decommissioning of the boiler.

3. The Project after re-powering will augment about 223.5 MW of electricity to the national grid of which about 165 MW generation will be without additional, due to the utilization of exhaust heat of the gas turbine. The Project upon completion is envisaged to provide a reliable contribution in reducing the current power crisis and load shedding of the country.

4. The proposed Project falls under the 'Red' category of industrial classification made under the Environment Conservation Rules (ECR), 1997 of Bangladesh Government. The BPDB therefore, has to take into consideration the environmental rules and regulations of the country as well as the International Financial Institutions, such as the World Bank, who is the prospective donor of the project.

5. In consideration of the above, the BPDB has entered into an agreement with the Centre for Environmental and Geographic Information Services (CEGIS) for conducting the Initial Environmental Examination (IEE) for site clearance certificate and Environmental Impact Assessment (EIA) for securing approval of the Project from the Department of Environment (DoE), Government of Bangladesh (GoB) to initiate project implementation. The EIA also prepared to comply with the World Bank's operational policies and guidelines including the Environmental, Health and Safety Guidelines.

6. Based on the IEE report of March 2015, the BPDB secured exemption of site clearance certificate from the DoE as the proposed site is located on the same facility within the boundary of the existing plant. The DoE has also given its approval of the ToR for completing the EIA study. The EIA report is prepared with reference to the approved ToR, which is presented in Annex 1-1.

7. CEGIS, as per the agreement and approved ToR, developed the methodology for conducting the EIA study (which was presented in the Inception Report, February 2015) and deployed a multidisciplinary team with relevant expertise. The team made several visits to the Project site to get a better understanding of different issues and collect primary and secondary data for the study. The team also consulted various groups of stakeholders of the project site including representatives of the national agencies and local government institutions. A number of focus group discussions were conducted to generate issue specific information such as fisheries. Finally a number of public consultations were organized to solicit feedback on the provisional study outcomes, which were subsequently been used to finalize the report.

1.2 Objective of the Study

8. The objective of the study is to conduct an Environment Impact Assessment (EIA) for the Unit 4 Repowering of Ghorashal Thermal Power Plant including decommissioning of the existing boiler and associated infrastructure (additional gas pipeline for this project) to meet the compliance requirement of the Government of Bangladesh (GoB)[1] and the World Bank, and secure approval of the DoE to implement the project.

9. The specific objective is -

- To conduct Environmental Impact Assessment (EIA) with detail environmental baseline survey, alternative analysis, prediction and evaluation of possible environmental and socio-economic impacts, public consultation, and an environmental management plan (EMP) addressing decommissioning and risk/emergencies management and the institutional arrangements for environmental management and monitoring.

1.3 Need of the Project

10. At present total installed electricity generation capacity is 10,817MW but actual generation is 7,418 MW. The current electricity demand is 10,283 MW and the supply is 8,763 MW (during fiscal year 2014-2015).[2] Around 68% of the population of the country has access to electricity while electricity demand growth is 12% per annum. The Ministry of Power, Energy and Mineral Resources (MoPEMR) has forecasted that the growth in power demand in response to the desired economic growth of the country, will reach 13,000 MW in 2017 and 34,000MW by 2030. The PSMP also projected some scenarios of power demand with reference to different GDP growth rates. All these variable projects are depicted in the Figure 1-1.

[1] The GoB requires 2 stages environmental assessment as per ECA'95 and ECR'97: (i) initial environmental examination and site clearance; and (ii) environmental impact assessment and environmental clearance.

[2] Power Sector Emergency Information, System Planning Department, BPDB, February 16, 2015.

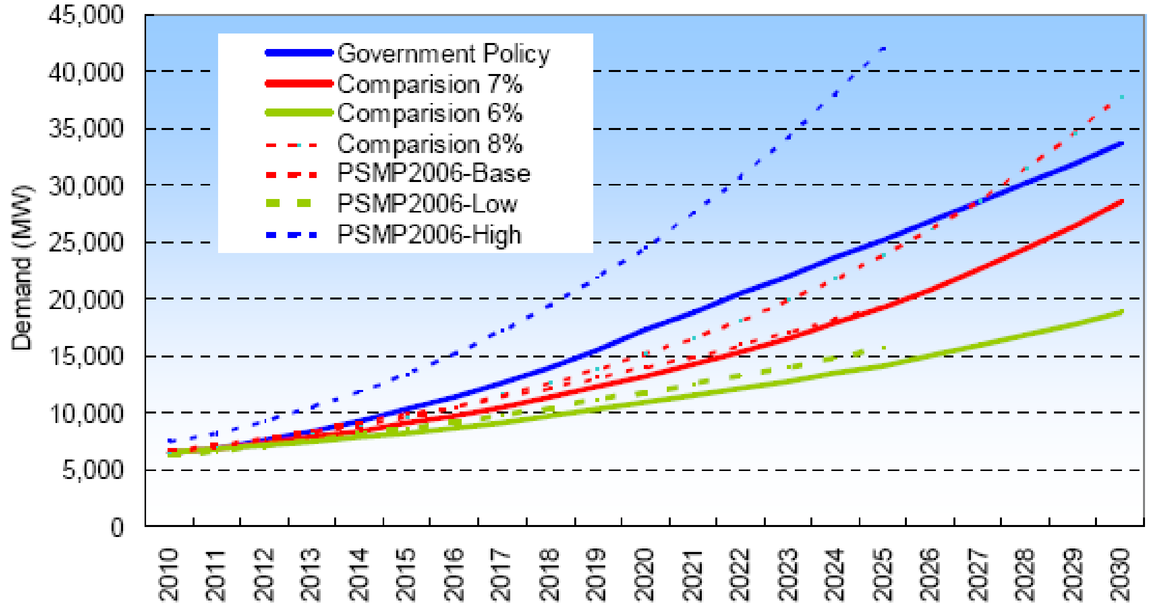

Figure 1-1: Power demand forecast for different scenarios (TEPCO 2010)[3]

11. To address the prevailing shortage of electricity supply as well as to achieve the desired economic development of the country, the BPDB has adopted a power generation enhancement plan up to 2021 in line with the PSMP, 2010 (Table 1-1). The plan includes different initiatives to generate additional electricity by diversifying fuel mixes, rehabilitating age-old power plants, and importing electricity from the neighboring countries. The proposed Ghorashal Unit-4 Repowering Project is one such steps aiming to augment 224 MW capacity and supply to the national grid for fulfilling the growing demand.

Table 1-1: Summary of the power generation increase plan

Year / Type	2015	2016	2017	2018	2019	2020	2021	Total
Public (MW)	1,218	770	2,202	846	2,070	1,000	2,400	10,506
Private (MW)	1,130	748	799	1,270	568	1,287	1,912	7,670
Import (MW)	--		--	--	--	--	--	
Total	2,348	1,518	3,001	2,116	2,634	2,247	4,312	18,176

Source: Power Sector Emergency Information, System Planning Department, BPDB, February 16, 2015

1.4 Scope of the EIA Study

12. The scope of the study is to carry out environmental impact assessment of the proposed Project to address all the applicable environmental requirements, including the

[3] TEPCO (2010); Power System Master Plan, Power Division, Ministry of Power, Energy and Mineral Resources, Government of the Peoples Republic of Bangladesh, http://www.powerdivision.gov.bd/user/brec/112/58

laws, bylaws and rules of Bangladesh Government and the World Bank Group's operational policies, guidelines including environment, health and safety guidelines.

13. In compliance to the GoB rules and the WB's policies the EIA study presents its analyses under the following headings.

a) Description of the proposed Project
b) Description of the Environment (baseline conditions)
    i. Physical environment
    ii. Biological environment
    iii. Socio-cultural environment
c) Legislative and regulatory considerations
d) Determination of the potential impacts of the proposed Project
e) Analysis of alternatives to the proposed Project
f) Cumulative impact assessment
g) Development of an Environmental Management and Monitoring Plan (EMMP) covering decommissioning and emergency/risks, Institutional Arrangements and Capacity Building, and Estimation of budgets.
h) Consultation, Disclosure and Grievance Redress.

1.5 Study Limitations

14. As per the world standard and more importantly, instruction of the DoE, the EIA study should be carried out considering all seasonal aspects including a complete hydrological cycle. But because of the limited time allocated for this study, hydrological aspects for all seasons could not be covered in the present study. However, DoE regulations also kept provision that in case of priority projects and emergency of work, IEE and EIA could be carried out over six months covering parts of both dry and wet seasons.

1.6 Process Followed

15. This environmental impact assessment followed a number of steps and process presented in Figure 1-2. The main steps are:

- Review of previous studies
- Harmonization of Environmental Safeguard Requirements of the Government and the World Bank.
- Scoping, baseline environmental quality monitoring and ecological and fisheries surveys and finalization of the ToR for the EIA Study
- Screening of impacts and prioritization
- Expert consultations with scientific and professional community
- Conduct focus group discussions in project area
- Public consultation with affected population, local government bodies, public representatives, NGOs and business communities to introduce the project components and anticipated impacts.
- Prediction of impacts/risks and prepare mitigation/enhancement measures by field investigation, data analysis, and mathematical modelling.
- Integration of environment with engineer's design.
- Preparation of Draft EIA Report, Environmental Management and Monitoring Plan, Boiler Decommissioning Plan, and emergency response and disaster management plan.

- Present Draft EIA Report in Public Consultation Meetings and disclosure in the BPDB, World Bank, and DOE websites for Public review and comments.
- Revise the Draft and update EIA Report, EMP, Boiler Decommissioning Plan, and emergency response and disaster management plan based on comments by the BPDB Advisor, DOE, the World Bank and the public at large.
- After incorporation of all comments, submit the Final EIA Report, EMMP, Boiler Decommissioning Plan, and emergency response and disaster management plan to DOE and the World Bank for Approval
- Implement Boiler Decommissioning Plan during preconstruction, EMMP (including emergency response and disaster management plan) during construction and operation and maintenance (O/M) stages
- Environmental auditing by assessing EIA process and feedback to future EIA Study
- Implement measures beyond compliance.

16. Initial step of an EIA is the collection of primary and secondary data in addition to the data collected at the IEE stage. Reviews of available literature from various sources, interviews of experts and representatives of agencies and institutions, and consultation with local stakeholders and site visits are conducted to collect baseline information for the Project site as well as for the study area. Important Environmental and Social Components (IESCs)/Valued Environmental Components (VECs) are identified through scoping session based on the physical investigation, expert consultations and dialogues with local stakeholders. Setting up of boundaries is an important step, as this takes into account elements such as geographical boundary, time horizon for alternative actions and the affected groups, etc. The bounding is done with reference to IECA/VEC which are covered under the scoping.

17. A number of methods have been used to conduct impact assessment for the EIA study. In this project, matrix methods by determining magnitude and sensitivity have been used to identify significance of impacts of the proposed Project. Mitigation measures of the identified significant impacts have been suggested and a comprehensive Environmental Management Plan (EMP) has been proposed for the EIA study. The unresolved critical issues and resolution of issues have been discussed in the EMP.

18. The EIA report of the proposed Project has been prepared to fulfil the requirements of Environmental Conservation Rules (ECR) 1997, its subsequent amendment 2005 and Noise Pollution (Control) Rules, 2006. The report was developed based on field observations and consultation with various stakeholders. This study was initiated with collection of environmental and socio-economic data from secondary sources. The primary data and public opinions have been collected from the project site and the study area. However, most of the data, which were used for outlining baseline condition, are from secondary sources, especially repowering of Unit 3 EIA report. Remotely sensed satellite images were procured, processed, verified with field condition (i.e., ground truthing) and interpreted for enrichment of this EIA study. The various environmental standards considered in this report were based on the standards set out in the ECR, 1997, its subsequent amendment 2005 and Noise Pollution (Control) Rules, 2006.

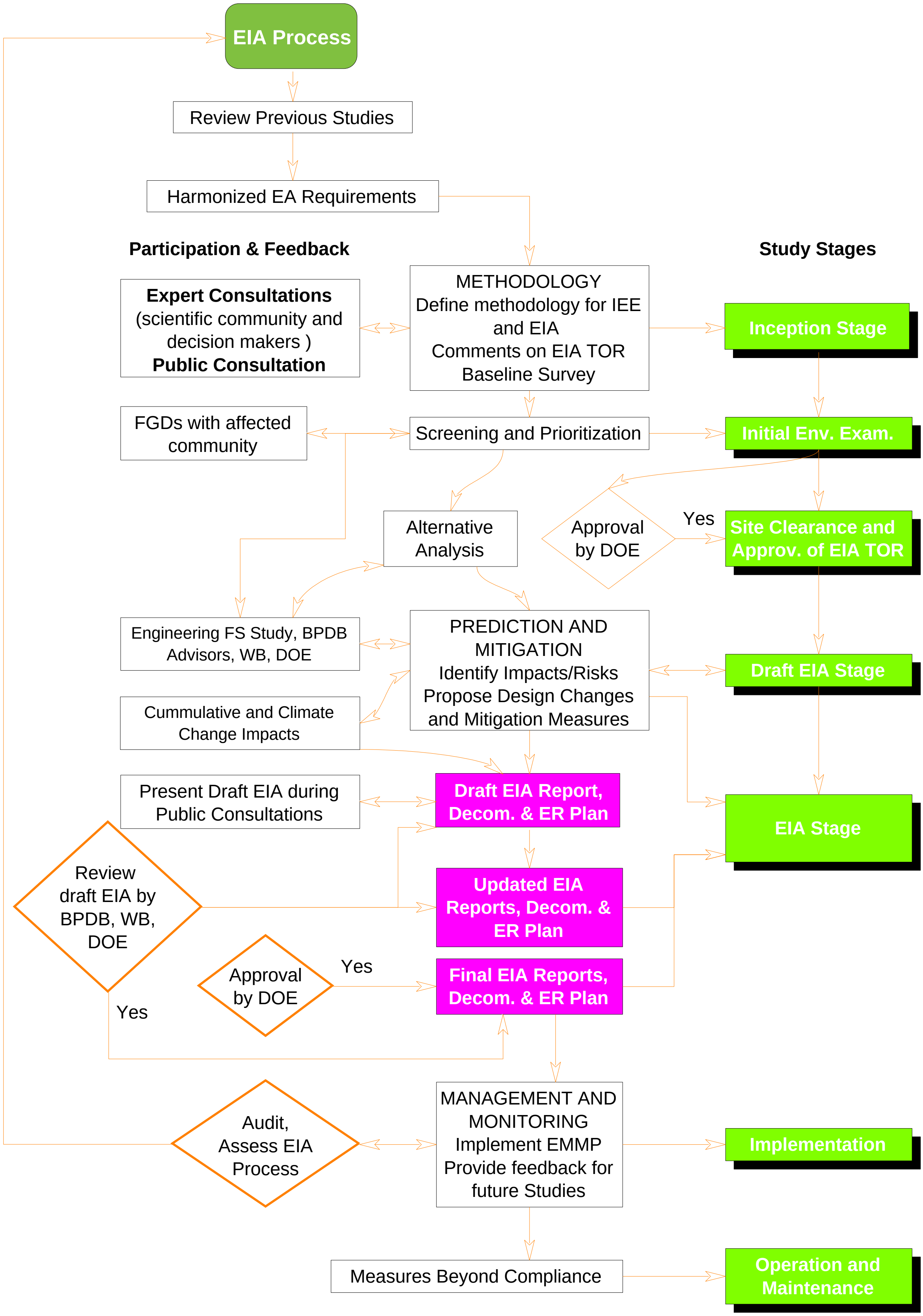

Figure 1-2: Process followed in the EIA study

19. The baseline has covered a detail description of the ***physical environment, water resources, land resources, agriculture, fisheries, eco-systems*** and ***socio-economic*** conditions including identification of problems in respect of resources management.

20. Field visits were carried out for data collection as well as conducting public consultation and disclosures as suggested in the EIA guidelines of the DoE. Baseline situation of soil and climatic conditions (temperature, rainfall etc.) were established through use of long term data that were at the disposal of different organizations like: Soil Resource Development Institute (SRDI), Bangladesh Water Development Board (BWDB), Bangladesh Small and Cottage Industries Corporation (BSCIC), Department of Fisheries (DoF), Department of Public Health and Engineering (DPHE), Bangladesh Meteorological Department (BMD), Department of Environment (DoE) and Upazila Offices of different agencies. Furthermore, as part of baseline primary data on air quality, water quality, micro-climatic parameters, fisheries, and ecological information were collected from the field. Most of the social and economic data have been generated from the census reports of the Bangladesh Bureau of Statistics (BBS). CEGIS's own database for different resource sectors, were also used in preparing the EIA report.

21. Data from secondary as well as primary sources on physical environment, water resources, land resources, agriculture, fisheries, eco-systems and socio-economic conditions have been collected for assessing environmental and social impact of the proposed project and developing the environmental management plan.

22. In the impact assessment, various modeling software/tools were used for predicting parameters of different aspects of the physical environment. For the prediction of air quality, United States Environment Protection Agency (US-EPA) regulatory model AERMOD[4] has been used for air quality assessment. For noise modeling, CUSTIC model, CORMIX for Thermal Plume modeling; ALOHA for chemical exposure modeling and SWAT tool for hydrological and hydrodynamic analyses have also been used.

1.7 EIA Study Team

23. A multidisciplinary as per the ToR and the Technical Proposal carried out this study. The study team and their responsibilities are presented in Table 1-2.

Table 1-2: Team composition for the EIA Study

Sl. No.	Name of Professional	Position Assigned
International Professional		
1	Dr. Masud Karim (masud@eng-consult.com)	Team Leader/ Environment Impact Assessment Specialist
2	Dr. Mohan Shankar Deshpande	Power System Engineer
3	Mr. Navin Bindra	Air Quality Modeler
National Professional		
3	Mr. Md. Sarfaraz Wahed	Environmental Management Planning Specialist
4	Mr. Md. Golam Mostafa	Air Quality Specialist

[4] A steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

Sl. No.	Name of Professional	Position Assigned
5	Dr. Maminul Haque Sarker	Water Resources Specialist
6	Mr. Kazi Kamrull Hassan	Water Quality Specialist
7	Mr. Md. Shibly Sadik	Hazardous Waste Management Specialist
8	Dr. Anjan Kumar Datta	Institutional Specialist
9	Mr. Mohammed Mukteruzzaman	Ecologist
10	Mr. Mohammad Shafiqul Islam	Occupational Health & Safety Specialist
11	Mr. Pronab Kumar Halder	Technical Persons (air quality, water quality and other subjects as necessary)

24. In addition to the above mentioned professionals some additional professionals listed below also provided valuable inputs into the study.

25.

Sl. No.	Name of Professional	Position Assigned
1	Mr. Jalal Ahmed Choudhury	Co-Team Leader (Internal) and Power Plant Expert
2	Mr. Md. Azizul Haque	Water Resources and Power Management Adviser
3	Mr. Mollah Md. Awlad Hossain	Water Balance Specialist
4	Mr. M. Habibur Rahman	GIS Specialist
5	Mr. Mohammad Saidur Rahman	RS Analyst
6	Mr. Arup Kumar Biswas	Junior Geotechnical Survey Specialist
7	Mr. Ashraful Alam	Junior Water Resources Engineer
8	Mr. Zahid Hasan Dhali	Agricultural Specialist
9	Mr. Muhammad Shifuddin Mahmud	Socio-economic Specialist
10	Mr. Mohammad Kamruzzaman	Ecology and Biodiversity Specialist
11	Mr. Redwan Hossain Jeshan	Junior Health and Environment Specialist
12	Mr. Tanvir Ahmed	Water Resources Modeller

1.8 Report Structure

26. The report has been prepared in accordance with the ToR, and it contains 16 chapters. These are as follows:

Chapter 1 describes the introduction containing background, purposes, and methodologies, limitations of EIA study, need and importance of the project and concludes by introducing the study team.

Chapter 2 is on legislative and regulatory aspect describing the relevant policy and legal frameworks for the EIA process of the power plant Project.

Chapter 3 covers project data sheet of the proposed power plant comprising of Project proponent, Project location and area, Project Impact Area, nature and size of the Project, Project concept, Project components, Project activities, Project schedule, resources required and their quality, and utilities demand etc.

Chapter 4 covers Project description depicting Project layout, fuel requirement and performance, water requirement and hydrology of the Shitalakhya river, Description of the Existing Boiler, Technology Selection and Process description, Description of Major Sub-

Systems, Stack and Emission, Solid Waste Disposal, Emission Monitoring etc. of the proposed power plant

Chapter 5 presents an analysis of various alternatives options for project component siting, fuel type, technology selection, cooling water system, and water treatment system.

Chapter 6 describes the environmental and social baseline condition with detail on land use and cover, physical environment, water resources, land resources, agricultural resources, fisheries, ecological resources and socio-economic conditions.

Chapter 7 presents the potential impacts of Project during decommissioning of boiler, pre-construction; construction and post-construction phases. This chapter also includes cumulative impacts of identified VECs.

Chapter 8 identifies mitigation measures for various identified impacts, enhancements, and compensation to restore including transport routes, disposal routes or locations of hazardous waste, pollution control systems, waste treatment, engineering measures etc.

Chapter 9 describes the Environmental Management Plan (EMP) with mitigation measures for minimizing the effect of the negative impacts and enhancement measures for increasing the benefits of the positive impacts during decommissioning, pre-construction, construction, and operation stages. Institution strengthening and capacity building, institutional arrangements for the implementation of the EMP are also covered in this chapter.

Chapter 10 outlines all possible hazards and risks associated with the decommissioning and proposed combined cycle thermal power plant, and management of the hazard and risks.

Chapter 11 describes the Environmental Monitoring Plan, Implementation of Monitoring Plan, performance indicators, and reporting and feedback mechanisms.

Chapter 12 deals with measures beyond compliance including CDM intent, corporate social responsibility, irrigation preference with cooling water discharge, and greenbelt development.

Chapter 13 outlines institutional arrangements and capacity building.

Chapter 14 presents the results of Public Consultation and Information Disclosure including consultation with experts' representatives of institutions and selected focus group discussions.

Chapter 15 presents the conclusions and recommendations based on the study outcome.

27. Literature used in preparation of the report is listed under references at the end of the report.

2. Legal and Legislative Frameworks, Regulations and Policy Considerations

28. This Chapter presents a review of the national policy, legal, and regulatory framework relevant to the environmental and social aspects of the Project. Also reviewed in the Chapter are the World Bank Group (WBG) environmental and social safeguard policies and health and safety guidelines.

2.1 The Context

29. The Bangladesh government is committed to accelerate inclusive economic growth and reduce poverty. The government has articulated its development target in “The Vision 2021” document and these have been further elaborated in the Perspective Plan 2010-2021. The Perspective Plan, according to the government, “is a lighthouse to point to the broad directions of the development perspective envisioned. It draws on development planners' viewpoints and the government’s development vision representing the hopes and aspirations of the people of Bangladesh” (GoB: 2010:1). Review of the plan/policy documents of the Bangladesh government, attest to the fact that the government wants to transform socio-economic environment of Bangladesh and lift the country from a low income economy to the middle income economy. The emphasis of government is not only to raise per capita income, but also to give its citizens the opportunity to pursue livelihood activities and a lifestyle of their choice, with higher standard of living, access to quality education, energy availability to ensure per capita energy consumption of about 600 kWh (ibid. 2010:2)

30. The key policies, acts, plans and strategies of the government recognize that economic growth, environmental protection and sustainability and poverty reduction are inextricably linked and reinforce each other. According to available reports Bangladesh though succeeded in reducing poverty from 40% to 27%, studies have also noted that due to environmental degradation the country is paying a very high premium e.g., loss of nearly 4% of GDP and 22% higher incidence of diseases are due to environmental degradation of which water quality is a predominant factor (GoB 2015. Planning Commission. Environment, Forestry and Biodiversity Conservation. Background Paper for the 7th Five Year Plan. http://www.plancomm.gov.bd/7th-five-year-plan/).

31. In a densely populated country like Bangladesh where there is an intense pressure on its natural resources, the manifestation of above noted conflicting processes are not a total surprise, and also did not escape the government’s policy attention. Therefore to redress some of the problems that came to the surface and also to prevent repetition of the same in future, the government over the years enacted and/or adopted various Acts, Legislations, Policies, Plans, Strategies and Guidelines to ensure environmental sustainability of all development interventions. This Chapter aims to review and analyze the key acts, legislations, policies etc that have direct relevance for designing and implementing projects and programs in the ‘power sector’. Keeping in view the core objective of this report (i.e., Environmental and Social Impact Assessment), and to set the context, this chapter starts with a brief overview of Bangladesh Perspective Plan 2010-2021, followed by review and analysis of environmental acts, legislations, rules and regulations and thereafter with other relevant sectoral policies and legislations of Bangladesh, concluded with a short summary. Next in the light of this analysis the mandate of the key institutions are discussed.

Finally, the chapter analyses relevant policies and guidelines of the development partners. In the context of this project they are the WBG.

32. It is however, important to note that the World Bank's Operational Policy with reference to environmental assessment (WB OP 4.01; 1999 revised April 2013) recognizes that environmental impact assessment must take into consideration the national legislations, action plans and policy frameworks as well as country's obligations and commitments to relevant international environmental treaties and agreements pertaining to project activities (WB 2013:1).[5]

2.2 The Perspective Plan 2010 - 2021

33. The Perspective Plan 2010-2021 elucidates the country's aspiration, and this is clearly reflected in the preamble, which notes that the Plan "is a lighthouse to point to the broad directions of the development perspective envisioned" (GoB 2010:1) The Plan envisages Bangladesh as a nation with "food and energy security, with low level of unemployment and poverty" and emphasizes on human development through greater access to education and health for them to take advance of science and technologies among others the information and communication technologies for establishment of a Digital Bangladesh.

34. The chapter 9 of the Perspective Plan elaborated government vision with respect to "power sector" under the title 'Ensuring Adequate Supply of Electricity and Fuel'. In the Plan electricity has been considered as "an essential ingredient for development in both economic and social arena" (GoB 2010:89) and to ensure dependable electricity supply to its citizens at a reasonable price outlined its power generation strategy based on diversified sources of fuel such as gas, coal, liquid fuels as well as through renewable sources, for example, solar, wind and micro hydro (ibid. 90). This vision was further elaborated in the Power System Master Plan (February 2011). The "Master Plan aims to acquire a 25% share of domestic coal and a 20 percent share of domestic natural gas, and a 5% share of national hydropower and renewable energy, thus ensuring the self-sufficiency of the primary energy resource to be over 50 percent by Year 2030" (GoB 2011: 2-4).

2.3 National Energy Policy 1996 and 2004

35. The first National Energy Policy (NEP) of the county was formulated in 1996 "to ensure proper exploration, production, distribution and rational use of energy sources to meet the growing energy demand of different zones, consuming sectors and consumers groups on a sustainable basis" (GoB 2004:2). However, in recognition of the importance of energy in socio-economic development, the government decided to update the NEP as an integral part of the overall development of the energy sector, and this was accomplished in May 2004. The NEP 2004 covers issues pertaining to "survey, exploration, exploitation and distribution of indigenous natural gas; establishment of petroleum refining facility and distribution systems; and establishment of power generation plants and networks for transmission and distribution of electricity" (GoB 2004:1).

36. The NEP 2004 recognized that "policy formulation is a continuing process for decision making at different levels by different institutions and individuals" and hence for

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[5] http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTPOLICIES/EXTOPMANUAL/0,,contentMDK:20064724~menuPK:4564185~pagePK:64709096~piPK:64709108~theSitePK:502184,00.html. web accessed on 7 April 2015.

operationalizing the NEP there is a need to ensure that these "decisions are taken in a synchronized manner at macro level, sectoral level as well as sub-sector (utility) level" to achieve the stated objectives (GoB 2004:17). The NEP also stated that implementation of the NEP "will necessitate introduction of new Acts and modifications of the relevant Acts and Ordinances in this regard and Environmental issues to be considered under National Energy Policy are to be mandated under National Environment Policy and Environment Act" (ibid. 22, emphasis added).

37. The NEP 2004 devoted a section on Environment Policy, which deserves closer attention with reference to this project and hence we give an extensive quote as under. As regards to environment, the NEP 2004 (ibid 27-28) outlined 10 policy measures and they include the following;

a. Carrying out environmental impact assessment (including a consideration of social impact) should be made mandatory and should constitute an integral part of any new energy development project.
b. Use of economically viable environmental friendly technology is to be promoted.
c. Use of fuel wood is to be discouraged and replacement fuels are to be made available at an affordable price.
d. Popular awareness to be promoted regarding environmental conservation.
e. In case of coal based power plants, disposal of ash and reduction of environmental emission are to be considered in technology selection.
f. Use of lead free petrol is mandatory.
g. Use of low sulfur content Diesel will be encouraged.
h. Production of liquid fuels like Petrol, Kerosene, and Diesel Oil from Natural Gas (NG) will be encouraged.
i. Other technical options such as use of Catalytic Converter and Diesel Particulate Filter will be encouraged to reduce vehicular emissions.
j. For improving the environment condition in the country, producing energy from wastes will be encouraged.

2.4 Key Policies, Acts and Strategies

2.4.1 The National Environment Policy - 1992

38. The National Environment Policy 1992 sets out the basic framework for environmental action together with a set of broad sector guidelines. The Environment Policy provides the broader framework of sustainable development in the country. The core objective of the policy is to ensure the protection and improvement of the environment. It outlined actions that need to be pursued while planning development interventions by any sectors to facilitate long term sustainable use of all natural resources.

39. It embraces 15 broad sectors including energy to deal with overall environmental issues. Under the energy sector in section 3.4 of the policy it articulated the following objectives:[6]

[6] Unofficial translation from Bengali text.

- Reduce and discourage use of fuels that adversely impact the environment, and promote environment-friendly fuel use
- Reduce use of wood and agricultural residues as fuel and encourage alternative sources
- Adopt adequate precaution measures to safeguard environment while using nuclear energy
- Promote innovation of fuel saving technologies and ensure dissemination of such technologies and knowledge for public uses
- Ensure proper preservation of country's all energy resources
- Conduct comprehensive environmental impact assessment study before undertaking any intervention for exploitation of energy and other minerals in support of energy production.

40. The policy also gave the direction of amending the existing laws, formulating the new laws and implementing the same. To this effect, the policy assigned the Ministry of Environment and Forests to coordinate the implementation of the policy and to constitute a high level National Environmental Committee with the head of the government as the chairperson to give the direction, and ensure supervision and overseeing the implementation of the policy.

2.4.2 Environmental Conservation Act - 1995 (and the Revisions)

41. The Bangladesh Environment Conservation Act 1995 (ECA 1995) is currently the main Act governing environmental protection in Bangladesh. The ECA 1995 replaced the earlier environment pollution control ordinance of 1992 and provides the legal basis for Environmental Conservation Rules, 1997 (ECR 1997). The main objectives of ECA 1995 are: conservation of the natural environment and improvement of environmental standards, and control and mitigation of environmental pollution. The main strategies of the Act can be summarized as:

- Declaration of ecologically critical areas, and restriction on the operation and process, which can be continued or cannot be initiated in the ecologically critical areas.
- Regulation in respect of vehicles emitting smoke harmful for the environment.
- Environmental clearance.
- Remedial measures for injury to ecosystem
- Regulation of the projects and other development activities - discharge permit.
- 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 and declaration of environmental guidelines.

42. The Act is implemented by Department of Environment (DoE), under the Ministry of Environment and Forest. Under the Act, for any new development project, the project proponent must take Environmental Clearance from the DoE. The procedures to take such clearance are in place. Failure to comply with any part of ECA 1995 may result in punishment by a maximum of 10 years imprisonment or a maximum fine of Tk. 100,000 or both.

43. Bangladesh Environmental Conservation Act (Amendment 2000) focuses on: (1) ascertaining responsibility for compensation in cases of damage to ecosystems, (2) increased provision of punitive measures both for fines and imprisonment and (3) fixing authority on cognizance of offences. This Act was amended in 2002 (Bangladesh Environmental Conservation Act - Amendment 2002) and added the following under the purview of the Act: (1) restriction on polluting automobiles, (2) restriction on the sale and production of environmentally harmful items like polythene bags, (3) assistance from law enforcement agencies for environmental actions, (4) break up of punitive measures and (5) authority to try environmental cases. In 2010 the Act was further amended and the Bangladesh Environmental Conservation Act (Amendment 2010) elaborates on (1) demarcation of wetlands and water bodies, (2) Hazardous waste import, transportation, storage etc., (3) Cutting of hills, mountains (4) Ecologically Critical Areas.

2.4.3 Environmental Conservation Rules - 1997 (as amended in 2005)

44. Environmental Conservation Rules 1997 (ECR 1997) and amended in 2005 consists of a set of rules to implement the ECA 1995, which elaborated the following:

- Categorized list of the projects as green, orange and red,
- Procedure to take environmental clearance,
- Ambient standards in relation to water pollution, air pollution (as amended in 2005) and noise, as well as permitted discharge/emission levels of water and air pollutants and noise by the project’s Environmental Categories.

45. ECR 1997 classifies projects by potential environmental impact and assigns different assessment and management requirements as follows:

Green projects are those with positive environmental impacts or negligible negative impacts such as plantation and nursery. Clearance for these is obtained on the basis of project description, initial screening and No Objection Certificate (NOC) by the local authority.

Orange projects fall into two categories i.e., Orange A and Orange B. Orange A projects are those with minor and mostly temporary environmental impacts for which there are standard mitigation measures, such as the installation of tube wells, pond sand filter, tank/reservoir, sanitary latrines etc. Application for DoE’s environmental clearance requires general information, a feasibility report, a process flow diagram and schematic diagrams of facilities, environmental screening form, NOC from local authority. Orange B projects are those with moderately significant environmental impacts for which mitigation measures are easily identified, such as construction/re-construction of earthen roads, culverts, community centers, office buildings for general services, re-excavation of canals, repairing embankments, and school fields, etc. Such interventions require environmental clearance certificate from DoE, based on an Initial Environmental Examination report and an Environmental Management Plan, among others.

Red projects are those which may cause 'significant adverse' environmental impacts such as the construction of bridge, industrial factories, flood shelter, embankment, water control structures, etc. Projects under this category require IEE report to obtain the Site Clearance Certificate, and subsequently a full EIA report for environmental clearance certificate, along with the information required for other Categories. A number of sectoral EIA guidelines have been prepared to assist the EIA process.

46. Environmental standards also promulgated under the Environment Conservation Rules 1997 are prescribed for varying water sources, ambient air, noise, odors, industrial effluents and emission discharges, vehicular emission, etc. with the aim of limiting the volume and concentrations of pollution discharged into the environment. A number of surrogate pollution parameters like Biochemical Oxygen Demand, or Chemical Oxygen Demand; Total Suspended Solids, etc. are specified in terms of concentration and/or total allowable quality discharged in case of waste water and solid wastes. Additionally specific parameters are specified such as phenol, cyanide, copper, zinc, chromium, and various types of particulate, sulfur dioxide, nitrogen oxides, volatile organic compounds and other substances.

2.4.4 National Environment Quality Standards

47. Under the Environment Conservation Rules of 1997 the government has promulgated environmental standards and they are in operation. The standards have been defined for varying water sources, ambient air, noise, odor, industrial effluent and emission discharges, vehicular emissions, etc. Under the rule, the government imposes restrictions on the volume and concentrations of wastewater, solid waste and gaseous emissions discharged into the environment. In addition, a number of surrogate pollution parameters like biochemical oxygen demand, or chemical oxygen demand; total suspended solids, etc. are specified in terms of concentration and/or total allowable quality discharged in case of wastewater and solid waste. Additionally, specific parameters depending on the manufacturing process are specified such as phenol, cyanide, copper, zinc, chromium, etc. Air emission quality standards refer mostly to concentration of mass emission of various types of particulate, sulfur dioxide, oxides of nitrogen and in some cases volatile organic compounds and other substances. For defining the air quality standards, the 2005 Amendment to the ECR, 1997 has been considered and incorporated in this report.

48. The Bangladesh standards in general are less stringent compared to that of the developed countries. This is to promote and encourage industrialization in the country. The Bangladesh standards are not for any specific period of time and there is no provision for partial compliance either.

49. The Environmental Quality Standards are legally binding. There is a separate schedule on industry specific standards, other than the general industrial emission and effluent standards. This schedule covers a wide range of industries – fertilizer, tannery, integrated textile, food, cement, etc.

2.4.5 The Environment Court Act - 2000

50. The Environment Court Act - 2000 has been enacted in order to establish environmental courts in each administrative division of Bangladesh. Under this Act, the court has concurrent jurisdiction i.e. to try both civil and criminal cases. The basis for instituting a case is a violation of the "environmental law", meaning the Bangladesh Environment

Conservation Act - 1995 and Rules made there under. In particular the environment court is empowered to:

- Impose penalties for violating court orders;
- Confiscate any article, equipment and transport used for the commission of the offence;
- Pass any order or decree for compensation;
- Issue directions to the offender or any person (a) not to repeat or continue the offence; (b) to take preventive or remedial measures with relation to any injury, specifying the time limit and reporting to the DoE regarding the implementation of the directions.

51. Under this Act the Director General of the DoE has the power to impose penalties to polluters who, for example, are dumping untreated wastewater into the environment or not operating their legally mandated effluent treatments plants.

52. The Environment Court Act - 2000 allowed the government to form court only at divisional headquarters. According to this law, a person might be jailed for maximum three years or fined Taka 300,000 for polluting environment. But the new legislation increased the jail term up to five years and the fine up to Taka 500,000. Both the special magistrate's court and the environment court will enjoy authority to realize fines from the offenders. Besides, the courts may order to meet expenses for conducting cases and give the money in compensation to the affected individuals or organizations.

53. The Parliament also passed bills in 2010 for increasing the number of environment courts and their authority to take stern actions against polluters, making provision for establishing a trust to tackle adverse impacts of climate change. A new bill was also placed in parliament seeking to enact a law to punish illegal sand extraction and to lease sand quarries in an environmentally friendly way. The new legislation, which was passed repealing the existing Environment Court Act - 2000, aims to expedite trial of environment related offences and offers setting up environment court at every district headquarters with expanded jurisdiction to take stern actions against all sorts of polluters.

2.5 Strategies and Plans

2.5.1 National Conservation Strategy - 1992

54. Bangladesh National Conservation Strategy was drafted in late 1991 and submitted to the Government in early 1992. This was approved in principle; however the Cabinet is yet to give its final approval of the document. For sustainable development in the energy sector, the strategy document offered various recommendations but none was there concerning the present specific project execution program or related matter. Major relevant recommendations are:

- To use minimum possible area of land in exploration sites;
- Rehabilitate site when abandoned;
- To take precautionary measures against Environmental Pollution from liquid effluent, condensate recovery and dehydration plants; and
- Technology assessment for selection of appropriate technologies.

2.5.2 National Biodiversity Strategy and Action Plan for Bangladesh - 2004

55. “The National Biodiversity Strategy and Action Plan of Bangladesh (NBSAP) provides a framework for conservation, sustainable use and sharing the benefits of biodiversity of the country” (GoB 2004: v). The core focus of NBSAP has been ensuring cross-sectoral linkages and provides a framework for securing the necessary environmental settings to reduce poverty and ensure sustainable development. Sixteen strategies have been developed to shape and direct the actions towards achieving the goals and objectives of the NBSAP. The NBSAP emphasizes on integration of biodiversity conservation into the national development planning and processes.

56. From this perspective, the proposed project needs to recognize the value and importance of biodiversity and adopt measures to ensure that the integrity of the ecosystems is not adversely impacted by project activities in any stages of project implementation and operations. This is also reflected in the National Energy Policy of 1995 which committed “to ensure environmentally sound sustainable energy development programs causing minimum damage to environment".

2.6 Other Sectoral Policies

2.6.1 National Industrial Policy - 2010

57. The National Industrial Policy – 2010 outlined with the vision to accelerate “economic development that will, by 2021, witness the creation of a strong industrial sector in which the percentage of GDP with industrial ancestry will grow from the present 28% to 40%, and where the proportion of the labor force employed will rise from the present 16% to 25%” (GoB 2010:5-6).

58. The policy, presents an integrated strategy for rapid industrialization taking into consideration the government’s determination to achieve the Millennium Development Goals (MDGs) by 2015, and halve the number of the unemployed and hunger- and poverty-stricken people by 2017. To realize this vision the policy emphasized on taking environmentally-friendly and technologically-modern initiatives to facilitate growth of all important industrial sectors such as energy and fuel, agriculture and forestry, acquiring and processing of minerals, tourism and hospitality, construction, information and communications technology by mobilizing capital and manpower.

59. The policy aims to ensure a high rate of investment by the public and private sectors, a strong productive sector, direct foreign investments, development of labor intensive industries, and introduction of new appropriate technologies, women's participation, development of small and cottage industries, entrepreneurship development, high growth of export, infrastructure development, and environmentally sound industrial development.

2.6.2 National Water Policy - 1999

60. The National Water Policy of 1999 was adopted by the government “to manage the water resources of the country in a comprehensive, integrated and equitable manner…..to ensure continued progress towards fulfilling the national goals of economic development, poverty alleviation, food security, public health and safety, decent standard of living for the people and protection of the natural environment” (GoB 1999:2). Hon. Prime Minister in the Foreword of the policy noted that “the declaration of the National Water Policy is a bold step towards good governance in Bangladesh ……… by bringing order and discipline in the exploration, management and use of water resources in Bangladesh…….and unequivocally declares the intention of the government that all necessary means and measures will be

taken to manage the water resources of the country in a comprehensive, integrated and equitable manner".

61. The policy "aims to provide directions" to all agencies and institutions working in the water sector and/or are related to water in one form or another, to ensure efficient and equitable management of water resources, proper harnessing and development of surface and ground water, availability of water to all concerned, and institutional capacity building for water resource management. It has also addressed issues like river basin management, water rights and allocation, public and private investment, water supply and sanitation and water needs for agriculture, industry, fisheries, wildlife, navigation, recreation, environment, preservation of wetlands, etc.

62. It provides the framework for the management of water resources of the country in a comprehensive, integrated and equitable manner. The policy recognizes that water is essential for human survival, socio-economic development of the country, and preservation of its natural environment. It is vital that the continued development and management of the nation's water resources should include the protection, restoration, and preservation of the environment and its bio-diversity. The policy emphasized on development of knowledge and capability to design future water resources management plans addressing economic efficiency, gender equity, social justice and environmental needs through broad public participation.

63. With reference to "water and industry" the policy noted concern about the excessive salinity of water, especially in the southwest region of the country, and identified this as a major deterrent to industrial development. The discharge of untreated effluents from various industrial centers has been identified as an important source of pollution affecting the ground and surface water resources system, and defined as a core water management issue. With respect to industry, the policy outlined four actions namely (a) zoning regulations for establishment of new industries in consideration of fresh and safe water availability and effluent discharge possibilities; (b) monitoring of effluent disposal by relevant Government agencies to prevent water pollution; (c) setting standards of effluent disposal into common watercourses by WARPO in consultation with DoE, and (d) polluting industries under the lay will be required to pay for the cleanup of water- body polluted by them (GoB 199:12).

2.7 Agencies and Institutions Mandated to Address and Ensure Environmental Sustainability

64. In Bangladesh, the Ministry of Environment and Forest (MoEF) is the apex body with the mandate for matters relating to national environmental policy and regulatory issues and to guide and monitor all activities pertaining to the state of the environment in the country. Realizing the ever-increasing importance of environmental issues, the MoEF was established in 1989 and a permanent member of the Executive Committee of the National Economic Council, which is the decision-making body for economic policy and is also responsible for approving public investment projects. Under the MoEF, there are several agencies which undertake specific tasks within the framework of the MoEF's mandate. They are:

- Department of Environment (DoE)
- Department of Forest (DoF)
- Forest Industries Development Corporation
- Bangladesh Forest Research Institute and Institute of Forestry

- Forestry Division of the Bangladesh Agricultural Research Council and
- National Herbarium

65. Of the above agencies, in view of the present project objectives, descriptions of the DoE and DoF are presented below.

2.7.1 Department of Environment

66. The Department of Environment (DoE), established in 1989 under the jurisdiction of the MoEF, is the executing agency for planning and implementing environmental issues including, but not limited to, the following activities.

- Reviewing environmental impact assessments and issuing environmental clearance where appropriate;
- Implementing environmental monitoring programs and enforcement measures;
- Developing and maintaining environmental data bases, and
- Coordinating international events with the MoEF (e.g., representing Bangladesh in the meetings of various multi-lateral environmental agreements, international seminars, workshops, etc.).

67. The DoE is headed by a Director General (DG) who is supported by a team of Directors, Deputy Directors, Assistant Directors, Engineers, and other technical staff (e.g., chemists and laboratory technicians). The DoE has regional offices in Sylhet, Rajshahi, Khulna, and Barisal monitoring stations and several laboratories.

2.7.2 Forest Department

68. The Forest Department (FD), under the Ministry of Environment and Forest, is responsible for protection and management of the Reserve Forests, National Parks, and Sanctuaries in the country. The department manpower extends down to Union levels in areas where reserve forests exist. Officers of the FD are responsible for protection of wildlife in these forest areas.

69. In addition to the MoEF there are several other ministries and departments which are also relevant to the project activities, and they are:

2.7.3 Ministry of Land

70. The Ministry of Land (MoL) manages revenue generation for Government-owned land (called khas), excluding agency-owned lands controlled by the Bangladesh Water Development Board (BWDB), Roads & Highways, etc. The MoL controls open water bodies (rivers, beels, and haors) above a specified size, except for those that were transferred to the Ministry of Fisheries and Livestock under the public water bodies (Jalmohal) Management Policy, 2009. The MoL must approve the process where the Government acquires private land on behalf of a private development program.

2.7.4 Ministry of Water Resources

71. The Ministry of Water Resources (MoWR) is responsible for the water management program of the country. This includes preparation and implementation of water master plans, flood control measures, surface and ground water hydrology data-collection, modeling, monitoring and planning irrigation and drainage projects. Bangladesh Water Development Board is the executing agency of the MoWR.

2.7.5 Ministry of Fisheries and Livestock

72. The Ministry of Fisheries and Livestock is responsible for all policy matters in the field of fisheries resources management. The Directorate of Fisheries advises the Ministry on policy matters and is also responsible for managing the fish seed farms which are spread all over the country and managing 152 open water bodies which includes open rivers, depressed basins (haors), oxbow lakes (baors) and other large inland permanent water bodies (beels).

2.7.6 Ministry of Power, Energy and Mineral Resources

73. The Ministry of Power, Energy and Mineral Resources is the apex body with responsibility for exploration, production and marketing of all forms of primary energy sources. These primary energy sources encompass natural gas, petroleum, coal and peat. This Ministry also deals with all issues related to the generation, transmission, distribution and sales of electricity.

2.7.7 Bangladesh Power Development Board

74. The Bangladesh Power Development Board (BPDB), an autonomous body under the jurisdiction of the Ministry of Power, Energy and Mineral Resources, is responsible for generation, transmission and distribution of electricity in the country. The BPDB is the proponent of the current project.

2.8 International Treaties Signed by GoB

75. Bangladesh has signed most international treaties, conventions and protocols on environment, pollution control, bio-diversity conservation and climate change, including the Ramsar Convention, the Bonn Convention on migratory birds, the Rio de Janeiro Convention on biodiversity conservation and the Kyoto protocol on climate change. An overview of the relevant international treaties signed by GoB is presented in Table 2-1.

Table 2-1: Treaty or Convention and Responsible Agency

Treaty	Year	Brief Description	Relevant Department
Protection of birds (Paris)	1950	Protection of birds in wild state	DoE/DoF
Ramsar Convention	1971	Protection of wetlands	DoE/DoF
Protocol Waterfowl Habitat	1982	Amendment of Ramsar Convention to protect specific habitats for waterfowl	DoE/DoF
World Cultural and Natural Heritage (Paris)	1972	Protection of major cultural and natural monuments	DoArch
CITES convention	1973	Ban and restrictions on international trade in endangered species of wild fauna and flora	DoE/DoF
Bonn Convention	1979	Conservation of migratory species of wild animals	DoE/DoF
C139 - Occupational Cancer Convention, 1974	1974	Convention concerning Prevention and Control of Occupational Hazards	MoH

Treaty	Year	Brief Description	Relevant Department
		caused by Carcinogenic Substances and Agents	
C148 - Working Environment (Air Pollution, Noise and Vibration) Convention, 1977	1977	Convention concerning the Protection of Workers against Occupational Hazards in the Working Environment Due to Air Pollution, Noise and Vibration	MoH
C155 - Occupational Safety and Health Convention, 1981	1981	Convention concerning Occupational Safety and Health and the Working Environment	MoH
C161 - Occupational Health Services Convention, 1985	1985	Convention concerning Occupational Health Services	MoH
Convention on oil pollution damage (Brussels)	1969	Civil liability on oil pollution damage from ships	DoE/MoS
Civil liability on transport of dangerous goods (Geneva)	1989	Safe methods for transport of dangerous goods by road, railway and inland vessels	MoC
C170 - Chemicals Convention, 1990	1990	Convention concerning Safety in the use of Chemicals at Work	DoE
Convention on oil pollution	1990	Legal framework and preparedness for control of oil pollution	DoE/MoS
Vienna convention	1985	Protection of ozone layer	DoE
London Protocol	1990	Control of global emissions that deplete ozone layer	DoE
UN framework convention on climate change (Rio de Janeiro)	1992	Regulation of greenhouse gases emissions	DoE
Convention on Biological Diversity (Rio de Janeiro)	1992	Conservation of bio-diversity, sustainable use of its components and access to genetic resources	DoE
International Convention on Climate Changes (Kyoto Protocol)	1997	International treaty on climate change and emission of greenhouse gases	DoE
Protocol on biological safety (Cartagena protocol)	2000	Biological safety in transport and use of genetically modified organisms	DoE
Convention on persistent Organic Pollutants, Stockholm.	2004	Eliminate dangerous POPs, support the transition to safer alternatives, target additional POPs for action, cleanup old stockpiles and equipment containing POPs, and work together for a POPs-free future	DoE

2.9 Implication of GoB Polices, Acts and Rules on the GPS Unit 4 Repowering Project

76. The legislations relevant for environmental assessment for Unit 4 Repowering are the Environmental Conservation Act 1995 (ECA 1995) and the Environmental Conservation Rules 1997 (ECR 1997). Department of Environment (DoE), under the Ministry of Environment and Forest (MoEF), is the regulatory body responsible for enforcing the ECA 1995 and ECR 1997. According to the Rule 7 (1) of the Environmental Conservation Rules 1997; for the purpose of issuance of Environmental Clearance Certificate (ECC), every industrial units or projects, in consideration of their site and impact on the environment, will be classified into four categories and they are: Category I (green), Category II (Orange-A), Category III (Orange B) and Category IV (Red). The Project which is a gas based combined cycle thermal power plant fall under the 'red' category according to the Bangladesh Environment Conservation Rules 1997 (Amendment, 2005). For project under this category, it is mandatory to carry out EIA including Environmental Management Plan and where necessary develop a resettlement plan for getting environmental clearance from the Department of Environment. The responsibility to review EIAs for the purpose of issuing Environmental Clearance Certificate rests on DoE. The procedures for "Red" Category include submission of:

- An Initial Environmental Examination (IEE)
- An Environmental Impact Assessment (EIA)
- An Environmental Management Plan (EMP)

77. Environment clearance has to be obtained by the respective implementing agency or project proponent from Department of Environment. The environmental clearance procedure for Red Category projects can be summarized as follows:

78. Application to DoE → Obtaining Site Clearance →Applying for Environmental Clearance → Obtaining Environmental Clearance → Clearance Subject to annual renewal. Steps to be followed for obtaining Environmental Clearance Certificate (ECC) (under Red Category) from DoE are outlined in Figure 2-1.

79. Public participation or consultation is not a condition in the ECR 1997 and or EIA Guidelines, however, DoE prefers the proponent to engage in public participation and put conditions while providing site clearance or during the approval of the EIA ToR.

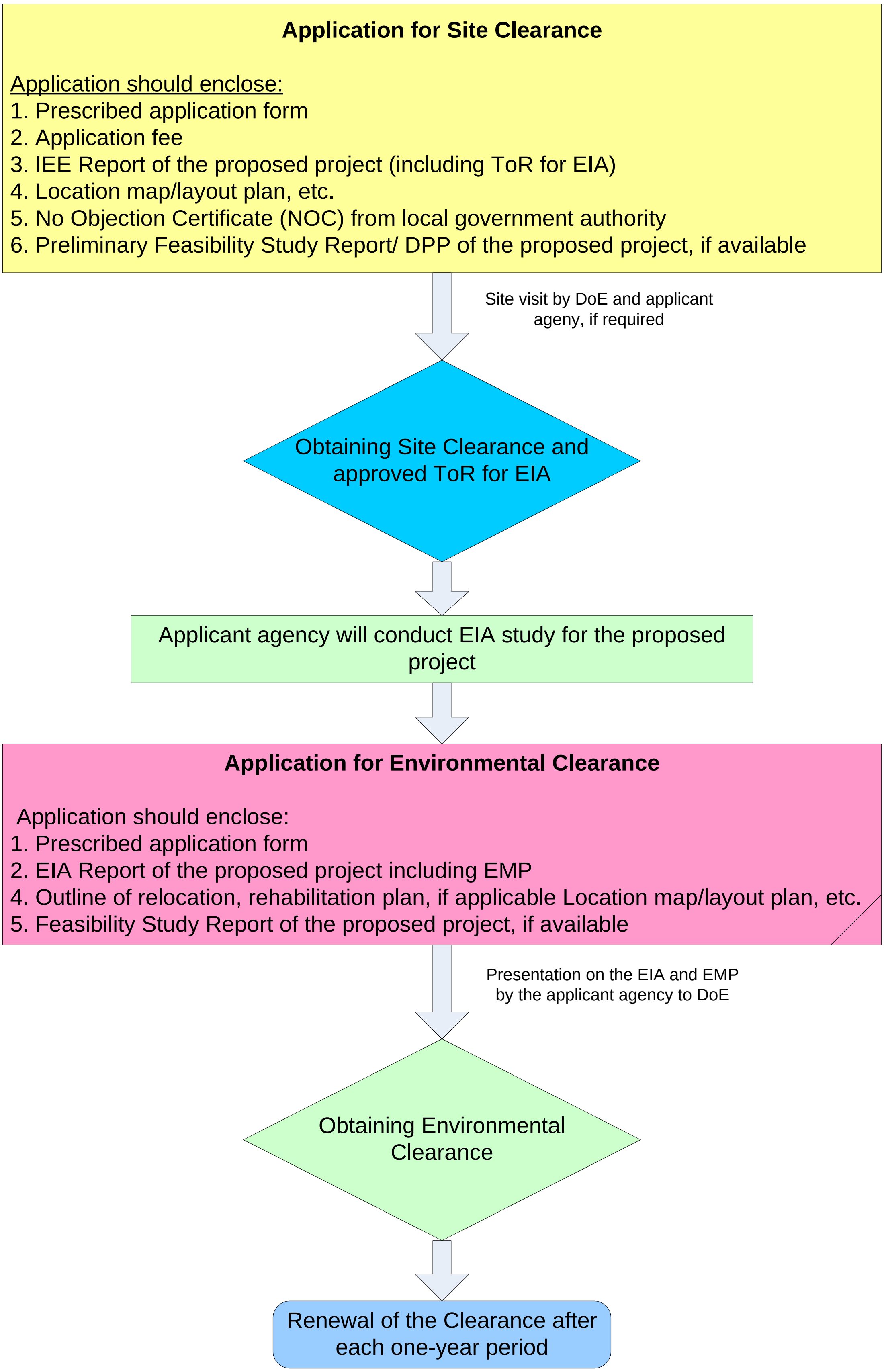

Figure 2-1: Process of obtaining Clearance certificate from DoE

2.10 World Bank's Environmental Safeguard Policies

80. The World Bank has developed a number of Safeguard Policies to ensure that all possible impacts are considered and mitigation measures are spelled out prior to the implementation of any proposed project. These policies ensure uniformity of the quality of operations is across different settings worldwide. If the decision is taken that a Safeguard Policy should be applied, mitigation measures and plans must be developed and be in place before the implementation of a proposed project.

81. The Bank requires environmental screening and classification for all investment projects (including ones financed by Trust Funds, Project Preparation Facilities and Guarantees) proposed for Bank financing, to help ensure that they are environmentally and socially sound and sustainable. Screening and classification take into account the natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples); cultural property; and trans-boundary and global environmental aspects.

82. The objectives of environmental screening and classification are: to evaluate the environmental risks associated with a proposed operation; to determine the depth and breadth of Environmental Assessment (EA); and to recommend an appropriate choice of EA instrument(s) suitable for a given project. The Bank recognizes that environmental screening and classification is not absolute and involves professional judgment on a case by case basis. When screening, careful consideration needs to be given to potential environmental impacts and risks associated with the proposed project. Judgment is exercised with reference to the policy expectations and guidance; real impacts on the ground; and established regional and Bank-wide precedence and good practice.

2.10.1 Environmental Assessment (OP 4.01)

83. **EA requirement**. The World Bank requires environmental assessment (EA) of projects proposed for the Bank support to ensure that they are environmentally sound and sustainable, and thus to improve decision making. The Bank Policy OP 4.01 considers that EA is a process whose breadth, depth, and type of analysis depend on the nature, scale, and potential environmental impact of the proposed project. EA evaluates a project's potential environmental risks and impacts in its area of influence; examines project alternatives; identifies ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts; and includes the process of mitigating and managing adverse environmental impacts throughout the project implementation period. EA takes into account the natural environment (air, water and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples and physical cultural resources); and trans-boundary and global environmental aspects. The Bank Policy also envisages that the borrower Government is responsible for carrying out the EA and the Bank advises the borrower on the Bank's EA requirements.

84. The present EIA has been prepared in compliance with this OP.

85. **EA classification**. The World Bank classifies the proposed project into one of the four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts. These categories are defined below.

Category A: A proposed project is classified as Category A if it is likely to have significant adverse environmental impacts that are sensitive, diverse, or unprecedented. These impacts may affect an area broader than the sites or facilities subject to physical works.

Category B: A proposed project is classified as Category B if its potential adverse environmental impacts on human populations or environmentally important areas--including wetlands, forests, grasslands, and other natural habitats--are less adverse than those of Category A projects.

Category C: A proposed project is classified as Category C if it is likely to have minimal or no adverse environmental impacts. Beyond screening, no further EA action is required for a Category C project.

Category FI: A proposed project is classified as Category FI if it involves investment of Bank funds through a financial intermediary (FI), in subprojects that may result in adverse environmental impacts.

86. The proposed project has been classified as Category A, since some of the potential impacts are likely to be significant and diverse.

2.10.2 Natural Habitats (OP 4.04)

87. The Policy describes the conservation of natural habitats, like other measures that protect and enhance the environment, to be essential for long-term sustainable development. The Bank therefore supports the protection, maintenance, and rehabilitation of natural habitats and their functions in its economic and sector work, project financing, and policy dialogue. The Bank also supports, and expects borrowers to apply a precautionary approach to natural resource management to ensure opportunities for environmentally sustainable development. The Bank- promotes and supports natural habitat conservation and improved land use by financing projects designed to integrate into national and regional development, the conservation of natural habitats and the maintenance of ecological functions. Furthermore, the Bank promotes the rehabilitation of degraded natural habitats. The Bank does not support projects that involve the significant conversion or degradation of critical natural habitats.

88. The activities under the proposed project will not alter the natural habitat hence this policy is not triggered.

2.10.3 Pest Management (OP 4.09)

89. Through this OP, the WB supports a strategy that promotes use of biological or environmental control methods and reduces reliance on synthetic chemical pesticides. Rural development and health sector projects have to avoid using harmful pesticides. Other pesticides can be used, but only as an element of an Integrated Pest Management Plan (IPMP) that emphasizes environmental and biological controls.

90. The project will not promote the use of chemical pesticides and fertilizers. Hence, this policy is not triggered.

2.10.4 Indigenous Peoples (OP 4.10)

91. For purposes of this Policy, the term 'Indigenous Peoples' is used in a generic sense to refer to a distinct, vulnerable, social and cultural group possessing the following characteristics in varying degrees:[7]

- self-identification as members of a distinct indigenous cultural group and recognition of this identity by others;
- collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories;
- customary cultural, economic, social, or political institutions that are separate from those of the dominant society and culture; and
- an indigenous language, often different from the official language of the country or region.

92. The OP defines the process to be followed if the project affects the indigenous people.

93. There are no indigenous communities residing in the project area and therefore, no impacts on them are expected under the project. Therefore, this OP is not triggered.

2.10.5 Physical Cultural Resources (OP 4.11)

94. The World Bank's general policy regarding cultural properties is to assist in their preservation, and to seek to avoid their elimination. The specific aspects of the Policy are given below. [8]

- The Bank normally declines to finance projects that will significantly damage non-replicable cultural property, and will assist only those projects that are sited or designed so as to prevent such damage.
- The Bank will assist in the protection and enhancement of cultural properties encountered in Bank-financed projects, rather than leaving that protection to chance. In some cases, the project is best relocated in order that sites and structures can be preserved, studied, and restored intact in situ. In other cases, structures can be relocated, preserved, studied, and restored on alternate sites. Often, scientific study, selective salvage, and museum preservation before destruction is all that is necessary. Most such projects should include the training and strengthening of institutions entrusted with safeguarding a nation's cultural patrimony. Such activities should be directly included in the scope of the project, rather than being postponed for some possible future action, and the costs are to be internalized in computing overall project costs.
- Deviations from this policy may be justified only where expected project benefits are great, and the loss of or damage to cultural property is judged by competent authorities to be unavoidable, minor, or otherwise acceptable. Specific details of the justification should be discussed in project documents.

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[7] Excerpts from the OP 4.10.WB Operational Manual, July 2005.

[8] Excerpts from the OPN 11.03.WB Operational Manual. September 1986.

- This policy pertains to any project in which the Bank is involved, irrespective of whether the Bank is itself financing the part of the project that may affect cultural property.

95. As part of the environmental assessment study for the project, a full baseline assessment has been carried out, including consultations, to identify any physical cultural resources (PCR) in the project area. Since, this project is a repowering project within the existing property line, no impact on PCR is expected. However, the 'chance find' procedures are included in the EMP.

2.10.6 Involuntary Resettlement (OP 4.12)

96. The WB's experience indicates that involuntary resettlement under development projects, if unmitigated, often gives rise to severe economic, social, and environmental risks: production systems are dismantled; people face impoverishment when their productive assets or income sources are lost; people are relocated to environments where their productive skills may be less applicable and the competition for resources greater; community institutions and social networks are weakened; kin groups are dispersed; and cultural identity, traditional authority, and the potential for mutual help are diminished or lost. This policy includes safeguards to address and mitigate these impoverishment risks.[9]

97. The overall objectives of the Policy are given below.

- Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs.
- Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs.
- Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.

98. Since the proposed Project will be located within the property line of the GPS facility. No requirements of land acquisition is expected and hence this OP is not triggered.

2.10.7 Forests (OP 4.36)

99. This Policy recognizes the need to reduce deforestation and promote sustainable forest conservation and management in reducing poverty. The Bank believes that forests are very much essential for poverty reduction and sustainable development irrespective of their location in the world. The Bank assists borrowers with forest restoration activities that maintain or enhance biodiversity and ecosystem functionality. The Bank also assists borrowers with the establishment and sustainable management of environmentally appropriate, socially beneficial, and economically viable forest plantations to help meet growing demands for forest goods and services. The Bank does not finance projects that, in its opinion, would involve significant conversion or degradation of critical forest areas or

[9] Excerpts from WB OP 4.12.WB Operational Manual. December 2001.

related critical natural habitats. Furthermore, the Bank does not finance projects that contravene applicable international environmental agreements.

100. Though the proposed project will support some compensatory tree plantation, this OP is not triggered since the project is not located in any forested area and will therefore not have any direct or indirect impact on forests. The tree plantation will nonetheless be carried out fully in compliance with the relevant paragraph of OP 4.36 on plantations (paragraph 7), which states: "The Bank does not finance plantations that involve any conversion or degradation of critical natural habitats, including in Project footprint or in Project influence area with critical natural habitats. When the Bank finances plantations, it gives preference to siting such projects on unforested sites or lands already converted (excluding any lands that have been converted in anticipation of the project). In view of the potential for plantation projects to introduce invasive species and threaten biodiversity, such projects must be designed to prevent and mitigate these potential threats to natural habitats."

2.10.8 International Waterways (OP 7.50)

101. Projects on International Waterways may affect the relations between the World Bank and its borrowers, and between riparian states. Therefore, the Bank attaches great importance to the riparian making appropriate agreements or arrangements for the entire waterway, or parts thereof, and stands ready to assist in this regard. A borrower must notify other riparian countries of planned projects that could affect water quality or quantity, sufficiently far in advance to allow them to review the plans and raise any concerns or objections. The project is located on the Shitalakhya River, which is a distributary of Old Brahmaputra River, a tributary of Dhaleshwari River, both these rivers are located within Bangladesh. In addition, there is no international traffic in Shitalakhya River. Therefore OP 7.50 is not applicable.

2.10.9 Access to Information

102. This BP deals with the World Bank policy on disclosure of information. It is a mandatory procedure to be followed by the borrower and Bank and supports public access to information on environmental and social aspects of projects.

103. Once finalized, the EIA including EMP and Bengali translation of its executive summary will be disclosed to the public and will also be available on the official website of the BPDB. EIA and EMP will also be sent to the WB InfoShop.

2.10.10 Applicable World Bank Policies

104. The project is classified as a Category A project, due to the complexity of environmental issues associated with project activities involving major civil works by repowering and decommissioning of existing boilers. Since the area is densely populated and of ecological sensitivity, certain negative environmental impacts may occur during the implementation and operational phase of the project. There may be localized impacts on the natural habitats especially on the fish spawning areas close to the outfalls and jetty renovation works.

105. The environment assessment (OP/BP 4.01) has been triggered for the proposed operation. The status of the environmental and social safeguard policies of the World Bank is summarized below in Table 2-2.

Table 2-2: Triggering the World Bank Policies

Directive	Policy	Triggered	Comments
Environmental Assessment	OP/BP 4.01	Yes	As the Project falls into Category A, the present full EIA has been carried out.
Natural Habitats	OP/BP 4.04	No	Not triggered. Closed cycle cooling system and NOx control measures are proposed in repowering and hence no major impact expected in the natural habitats.
Pest Management	OP 4.09	No	Not triggered. Because, no agro-chemicals will be used in any of the project activities or promoted
Indigenous Peoples	OP 4.10	No	Not triggered since no Indigenous People or ethnic minorities are living in the area.
Physical Cultural Resources (PCR)	OP 4.11	No	Not triggered. The Project will not affect any PCR, as the proposed repowering will be limited to the existing property line. However, 'chance find' procedures have been included in the environmental management plan (EMP).
Involuntary Resettlement	OP/BP 4.12	No	Not triggered. No land acquisition is expected.
Forests	OP/BP 4.36	No	Not triggered since the project activities will not impact any forests or associated resources. However, a total of 25 trees will need to be cut in the proposed gas turbine location. Compensatory tree plantation will be carried out to mitigate this impact. This tree plantation will be carried out in accordance with the provisions of this OP (para 7).
Projects in International Waterways	OP/BP/GP 7.50	No	The Project is located on Shitalakhya River, which is a distributary of Old Brahmaputra River, a tributary of Dhaleshwari River, both these rivers are located within Bangladesh. In addition, there is no international traffic in Shitalakhya River
Access to Information		Yes	World Bank has developed a new approach to the disclosure of information, transparency and sharing of knowledge. The public will have access to a broad range of information about the project in preparation and implementation. The EIA report will be disclosed on BPDB website and also sent to WB InfoShop. Consultations have been held while conducting EIA. The first public consultation was held in Palash Upazila Convention Hall on 11 April 2015; 2nd Public consultation and disclosures will be carried out with the affected community after the submission of the draft EIA Report. The EIA Executive Summary will be translated in Bangla and will be placed on BPDB website and also in relevant offices in the project influence area, and will be sent to WB InfoShop.

2.11 Bangladesh Standards and International Guidelines

2.11.1 ECR 1997 (as amended in 2005)

106. Under the Environment Conservation Rules of 1997 (as amended in 2005) the government has promulgated environmental standards and they are in operation. The standards have been defined for varying water sources, ambient air, noise, odor, industrial effluent and emission discharges, vehicular emissions, etc. Under the rule, the government imposes restrictions on the volume and concentrations of wastewater, solid waste and gaseous emissions discharged into the environment. In addition, a number of surrogate pollution parameters like biochemical oxygen demand, or chemical oxygen demand; total suspended solids, etc. are specified in terms of concentration and/or total allowable quality discharged in case of wastewater and solid waste. The standards, commonly known as Environmental Quality Standards (EQS), are legally binding. The following standards will be applicable to the project:

- Schedule 2, Clause 12 (as amended in 2005): Air Quality Standards
- Schedule 3, Rule 12: Water Quality Standards (A. Inland Surface Water Quality Standards (e) industrial use water including cooling and other processes, B. Potable water quality)
- Schedule 4, Rule 12: Noise Quality Standards

2.1.1 WHO Guidelines

107. The World Health Organization (WHO) is the directing and coordinating authority for health within the United Nations system. It is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms, standards, and guideline values articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends.

108. WHO Guidelines relevant to the Project include:

- Guideline values for drinking water
- Air Quality Guidelines, 2005
- Air Quality Guidelines for Europe, 2000 for risk estimates of asbestos

109. WHO also develops global guidelines such as the WHO Guideline on HIV/AIDS which are also relevant to the Project.

2.11.2 WBG's General Environment, Health and Safety Guidelines, 2007

110. The General Environment, Health, and Safety (EHS) Guidelines[10] contain the performance levels and measures that are generally considered to be achievable in new facilities or project by existing technology at reasonable costs.

111. The variables and the thresholds that are suggested in the EHS guidelines under the four themes 'environment, occupational health and safety; community health and safety and construction and decommissioning' have distinct merits and on several counts will

[10] EHS Guidelines available at:
http://www.gcgf.org/wps/wcm/connect/554e8d80488658e4b76af76a6515bb18/Final%2B-%2BGeneral%2BEHS%2BGuidelines.pdf?MOD=AJPERES

complement and enhance the efficacy of the Bangladesh national environmental quality standards as discussed above. However, there are some areas, for example, communication and training, biological and radiological hazards with respect to occupational, health, and safety; for which it will be an obligation on the part of the BPDB to take a cohesive management approach. These Guidelines will be applicable to the Project.

2.11.3 WBG's Environmental, Health, and Safety Guidelines for Thermal Power Plants, 2008

112. These guidelines include information relevant to combustion processes fueled 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.[11] It applies to boilers, reciprocating engines, and combustion turbines in new and existing facilities. Annex A of this guidelines contains a detailed description of industry activities for this sector, and Annex B contains guidance for Environmental Assessment (EA) of thermal power projects. Emissions and effluent 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. Emissions and Effluent Guidelines from this Guidelines will be applicable to this Project.

2.11.4 WBG's Good Practice Note: Asbestos, 2009

113. The purpose of this Good Practice Note is to increase the awareness of the health risks related to occupational asbestos exposure, provide a list of resources on international good practices available to minimize these risks, and present an overview of some of the available product alternatives on the market. Good practice is to minimize the health risks associated with ACM by avoiding their use in new construction and renovation, and, if installed asbestos-containing materials are encountered, by using internationally recognized standards and best practices to mitigate their impact.

2.12 Public consultation and disclosure requirements by World Bank Group

114. The WBG reaffirms its recognition and endorsement of the fundamental importance of transparency and accountability to the development process. Accordingly, it is Bank's policy to be open about its activities and to welcome and seek out opportunities to explain its work to the widest possible audience. According to 'OP 4.01: Environmental Assessment' of World Bank, the following conditions applies to the GPS Unit 4 Repowering Project.

115. **Consultations**. For all Category A (e.g., GPS Unit 4 repowering) and B projects the borrower should consult the project-affected groups and local nongovernmental organizations (NGOs) about the project's environmental aspects and takes their views into account. The borrower should initiate such consultations as early as possible. For Category A projects, the borrower should consult these groups at least twice: (a) shortly after environmental screening and before the terms of reference for the EIA are finalized; and (b) once a draft EIA report is prepared. In addition, the borrower should consult with such groups throughout project implementation as necessary to address EIA-related issues that affect them. In line with these requirements, extensive consultations have been carried out in the project area; details are presented in Chapter 14 of this document.

[11] Total capacity applicable to a facility with multiple units.`

116. **Disclosure**. For a Category A project, the borrower should provide relevant information on project interventions in a timely manner prior to consultation and in a form and language that are understandable and accessible to the groups being consulted. The borrower should provide a summary of the proposed project's objectives, description, and potential impacts for the initial consultation. For consultation after the draft EIA report is prepared, the borrower should provide a summary of the EIA's conclusions. In addition, for a Category A project, the borrower makes the draft EIA report available at a public place accessible to project-affected groups and local NGOs. The borrower also ensures that EIA reports for Category A project are made available in a public place accessible to affected groups and local NGOs. The document needs to be translated into Bengali. Public availability of the EIA report for Category A project in the borrowing country and official receipt by the Bank are prerequisites to Bank appraisal of these projects.

2.13 Harmonized Environmental Safeguard Requirements of the GoB and the WBG

117. In view of the possibilities of support from the World Bank, the environmental assessment of the Project will need to satisfy the requirements of the Government as well as those of WBG. It is appropriate therefore to develop a harmonized environmental safeguard framework for conducting the EIA study for the GPS Unit 4 Repowering project. Accordingly, a harmonized environmental safeguard framework is developed and presented in Annex 2-1.

3. Project Data Sheet

3.1 Project Proponent

118. The Proponent of the Project is the Bangladesh Power Development Board (BPDB), established in 1972 as an autonomous body and one of the major power generation wings of the Ministry of the Power, Energy and Mineral Resources (MoPEMR) of the Government of Bangladesh.

3.2 Project Location and Area

119. Ghorashal Power Station (GPS) is located in Palash Mauza of the Ghorashal Municipality under Palash Upazila of Narsingdi district (Figure 3-1). The site is located at 4.2 km northeast of the Ghorashal Municipality Office, 4 km northeast of the Railway Bridge and 3.7 km northeast of the Palash Upazila Headquarters. The site is aerially 36 km northeast of Dhaka Zero Point (Table 3-1 **and** Figure 3-2). The major point sources of pollution around the Project site is shown in Table 3-2. Details of the emissions of pollutants are given in Section 7.10 for the considered sources for air quality modelling activities.

120. The site is located at around 23°58′52.9″ N latitude and 90°38′13.5″ E longitude within the boundary of the GPS on the left bank of the river Shitalakhya and on the northwest side of the Palash-Issakhali Road.

Table 3-1: Aerial distances of different facilities from the proposed project location

Sl. No.	Facility Name	Distance (km)	Sl. No.	Facility Name	Distance (km)
1	Ghorashal Municipality	4.2	11	Gazaria Union HQ	7.2
2	Palash Upazila HQ	3.7	12	Panchdona Union HQ	7.8
3	Jinardi Union HQ	6.6	13	Panchdona Road Morr	10.0
4	Bahadursadi Union HQ	2.7	14	Railway line	4.6
5	Jamalpur Union HQ	2.5	15	Zero point at Dhaka	36.0
6	Moktarpur Union HQ	3.1	16	Shahjalal International Airport	28.0
7	Char Sindur Union HQ	4.2	17	Aggreko Rental Power	0.404
8	Tongi Power Station	24.7	18	Max Power Station	0.373
9	Regent Power	1.175	19	Ghorashal Fertilizer	0.895
10	Palash Fertilizer	0.936			

Source: Imagery and NWRD using GIS tool

Table 3-2: Major point sources of pollution around the Project site

Sl. No.	Name/Type of Industry/Pollution Source	Within Aerial Distance from the Plant Location
1	Ghorashal Fertilizer Factory	1 km
2	Palash Urea Fertilizer Factory	1 km
3	Ghorashal 108 MW Rental (Regent) Power plant	1 km
4	Max Power Plant	1 km
5	Aggreko Power Plant	1 km
6	Janata Jute Mill	5 km
7	Pran Agro Food Processing Industry	5 km

Sl. No.	Name/Type of Industry/Pollution Source	Within Aerial Distance from the Plant Location
8	Siam Bangla agro Industry	5 km
9	Deshbandhu sugar mill	5 km
10	Gazi Textile	5 km
11	Brick Field (7 nos.)	5 km
12	Brick Field (31 nos.)	10 km
13	N I N Embroidery	10 km
14	Master Cement Paper Mills ltd	10 km
15	Bandhob Textile	10 km
16	GHB Glassware	10 km
17	Mom Tex Ltd. (Pakiza)	10 km
18	Ishaque Textile Ltd.	10 km
19	Hamid Fabrics ltd. Unit-2	10 km
20	Hamid Weaving Mills Ltd.	10 km
21	Tazrian Weaving Mills Ltd.	10 km
22	Abdullah Dyeing	10 km
23	R K Dyeing	10 km
24	Chondrima Textile	10 km
25	Akhondo Textile	10 km
26	Talukder Textile	10 km
27	Sakibul Textile	10 km
28	Samiul Textile	10 km
29	Pran RFL	10 km
30	Pubali Jute Mill	10 km
31	Seven Rings cement	10 km
32	Mahim ceramics	10 km

Source: Development of GIS based industrial database of the DoE, 2015 (Ongoing)

121. The current boiler (Boiler no. 4: Russian made TGME-206-COB) of Unit 4 will be de-commissioned. For storing the decommissioned boiler components, space will be required close to the boiler. The warehouse beside Unit-4 will be dismantled. The present steam turbine (ST) will be overhauled and retrofitted. The proposed Gas Turbine (GT) and the Heat Recovery Steam Generator (HRSG) will be installed at the northern side of the Unit 4 boiler. The new equipments will be sited in the 8 acres of land designated for the repowering work, which is now covered by grasses and bushes and occupied by some old warehouse structures. The land belongs to BPDB and is within the boundary of the GPS, hence, no new land acquisition is required. There are a number of other major point sources in the airshed and the details are provided in Section 7.22.1 and their distance from GPS is presented in Table 3-2.

122. Installation of major components of the proposed repowering of Unit 4, will require a land space with 55 m width (27.5 m on either sides of the stack) and 223 m length from the northeast side of the existing stack (Figure 3-3).

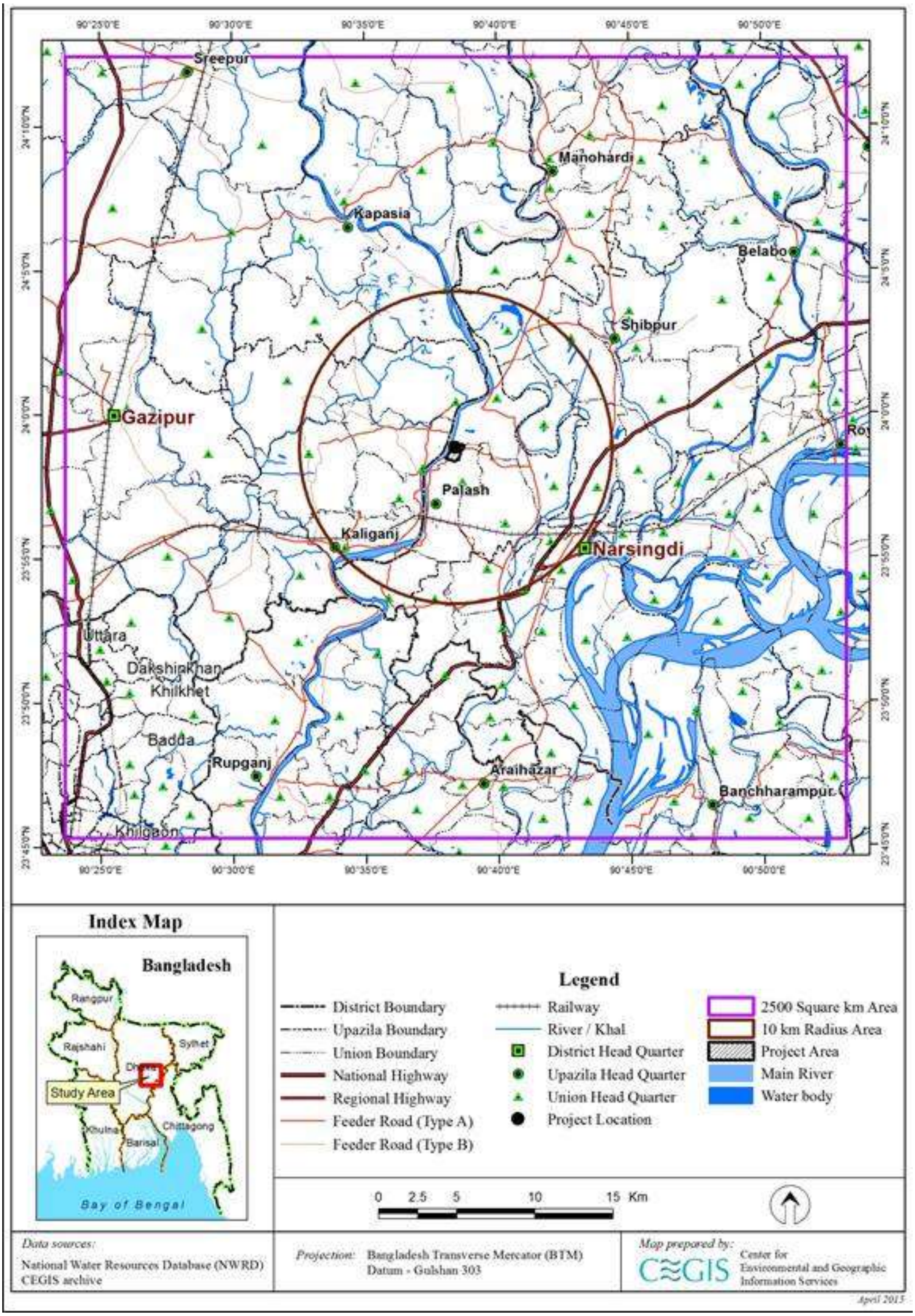


Figure 3-1: Base map of the study area showing the proposed Project site

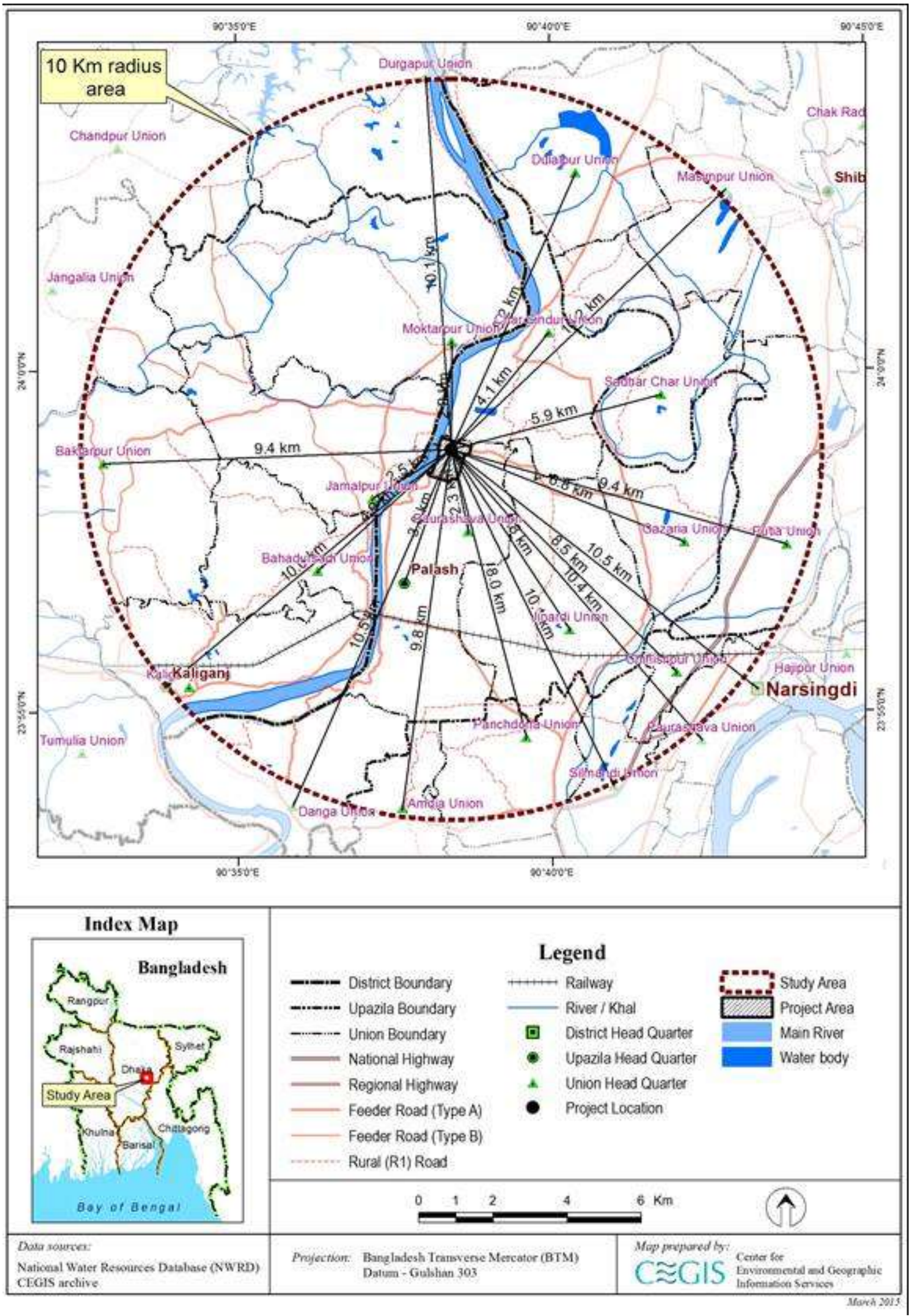


Figure 3-2: Distances of administrative units from the proposed site

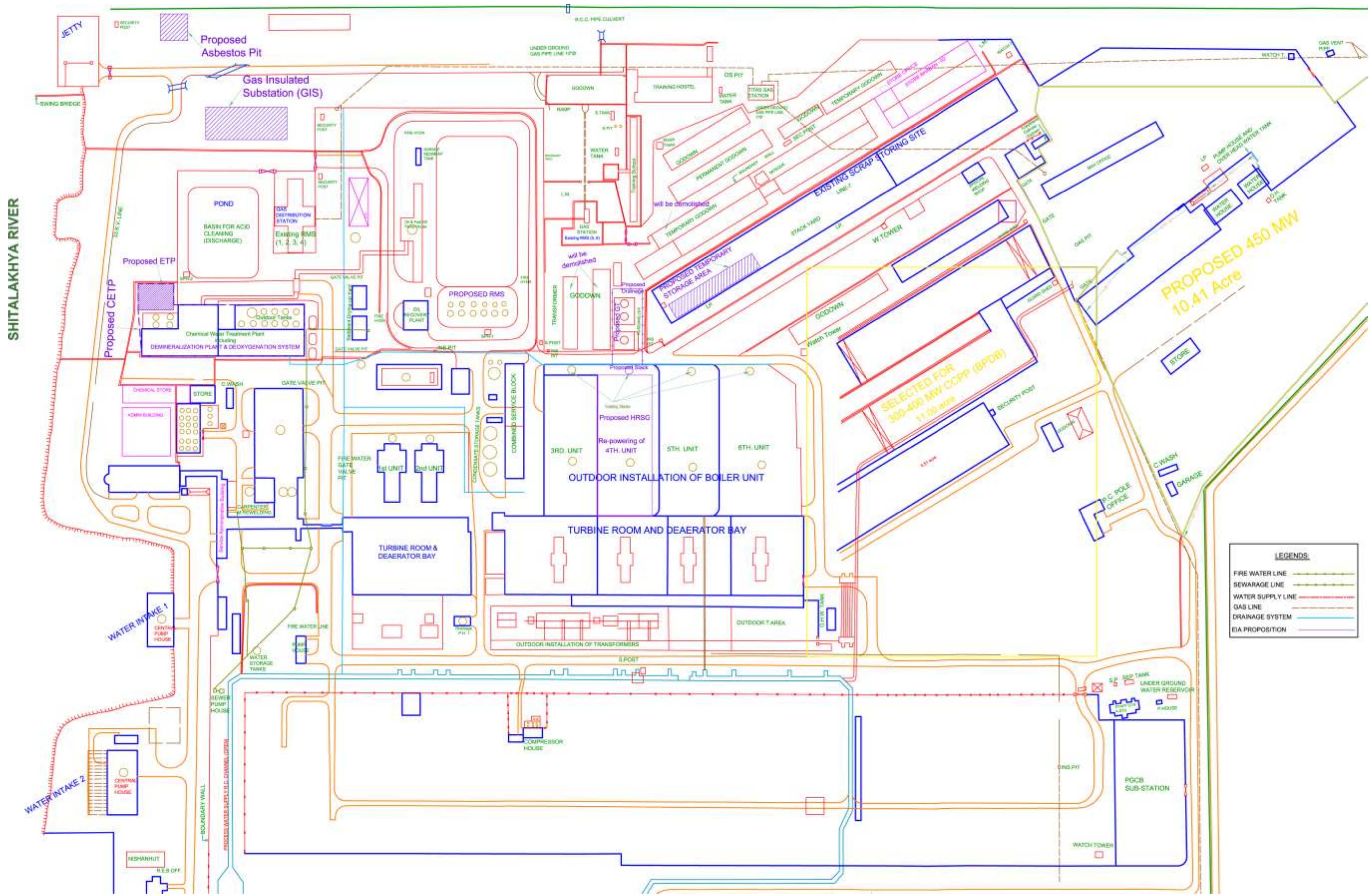


Figure 3-3: Major components of Unit 4 repowering

3.3 Project Impact Area

123. Siting of project components will require 55m x 223 m land within the GPS property boundary. The Department of Environment (DoE) requires a 10 km radius area as minimum centering the stack location of the proposed repowering plant. This 10km radius is used for environmental quality baseline and ecology and fisheries impact assessment. In the cumulative impact assessment, an airshed of 50 km x 50 km is considered centering the stack of Unit 4 for air quality impact, water quality impact in the Shitalakhya, and water demand assessment.

3.4 Nature and Size of the Project

124. The project involves decommissioning of the existing Unit 4 boiler (Russian made TGME-206-COB) The nature of the proposed Project is a retrofitted/ refurbished combined cycle power plant with an HRSG having supplementary firing facility and a 246 MW Gas turbine with dry-low NOx burners- a fuel NOx control technology. The power generation capacity of the proposed Project after refurbishment will be 403.5 MW.

3.5 Project Concept

125. The proposed Project is a repowering of 210MW gas-fired steam power unit to a 403.50MW combined cycle power unit by installing one heat recovery steam generator (HRSG) with supplementary firing, one heavy duty gas turbine (GT) for indoor installation (GE 9FB version 2003 Frame F) and retrofitting/refurbishing the existing steam turbine (ST). The hot exhaust gas of GT will generate steam in HRSG which will be directed to the retrofitted/refurbished steam turbine making combined cycle plant output to 403.50MW. About 67.3 MMSCFD natural gas for the proposed gas turbine and supplementary firing will be supplied by Titas gas transmission and Distribution Company through the existing gas network and the proposed Regulating Metering Station (RMS).

126. The surface water from the Shitalakhya River will be used for closed-cycle cooling (cooling water of 0.38194 m^3/s), auxiliary cooling (0.06528 m^3/s), other plant use (0.00742 m^3/s, HRSG (0.01083 m^3/s) etc.

127. Generated Power of gas turbine will be evacuated through the proposed 230kV Gas Insulated System (GIS) switchyard and that of steam turbine will be evacuated through Bay No. 6 of the existing 230 kV Air Insulated System (AIS) switchyard.

3.6 Project Components

3.6.1 Decommissioning of Existing Boiler

128. The existing steam boiler of TGME-206C0b type, made at Taganrog Manufacturing plant is of drum type with two-stage evaporating system. The boiler is mainly fired with natural gas and equipped with two rotating air heaters and flue gas recirculation. The high pressure water-steam loop encompasses an economizer, a HP drum, HP evaporator, a low temperature ceiling super heater (SH), a radiant wall SH, a platen SH and a convective final SH. Between each SH stage injection coolers control the steam temperature. After the HP steam passed through HP turbine, the steam (cold re-heat steam) is returned to the intermediate pressure (IP) boiler. Steam is reheated in two steps: (a) an injection cooler controls the steam temperature between step one and two and (b) reheated (hot- heat steam) returns and passes through IP and LP turbine. LP steam is condensed in the condenser and returned back to economizer of the boiler through condensate and feed

water cycle. The boiler has a left and right part which are clearly separated, without any cross-linking. The boiler has 2 layers with 6 back side gas burners installed. The air pre-heater is situated after the rotating type economizer (end of boiler). After air pre heaters flue gas passes to atmosphere through a 60 meter high stack. A boiler decommissioning plan is prepared and presented in Vol. 3. The hazardous waste generated from the boiler decommissioning will be treated as per the WBG General EHS Guidelines, 2007 and WBG's Good Practice Note: Asbestos: 2009.

3.6.2 Power Generation

129. The power plant mainly consists of one heavy duty 246 MW gas turbine (GE Frame F) for indoor installation, one heat recovery steam generator (HRSG) with supplementary firing for outdoor installation and one condensing type 165 MW retrofitted/refurbished steam turbine for indoor installation (1:1:1 configuration). Other significant components are surface water intake and outfall, effluent treatment plant, generator switch gear, gas insulated system (GIS) and air insulated system (AIS) sub-stations, air supply system, emergency diesel generating set, etc. Electricity is expected to be produced at the rate of 2448.5 GWh/year at 70% plant factor. The main plant consists of three interconnected structures namely one gas turbine building, HRSG structure, and steam turbine building. Emission factors for gas turbine for CO and NO_x are taken from USEPA AP 42, 5^{th} Edition and for PM_{10} and $PM_{2.5}$ are taken from National Energy Technology Laboratory, United States Department of Energy. Emission factors for CO and NO_x are considered as 14.3 lb/MMSCF and 94.1 lb/MMBTU, respectively. On the other hand, emission factors for PM_{10} and $PM_{2.5}$ are considered as 0.00259 lb/MMBTU and 0.00017 lb/MMBTU, respectively. More detailed information is presented in Section 7.10. Specifications of the Gas Turbine are as follows:

- Baseload Efficiency (%): 38.3 simple cycle, 59.3 combined cycle (109FB)
- Emissions: 50 mg/Nm^3 NOx (at 15% O_2), 30 mg/Nm^3 NOx (at 15% O_2) option
- Emission compliant turndown (% CC baseload): 45%
- Start time (minutes for CC hot start): 35 minutes
- Combustion Interval (hours/starts): 12k/450
- HGP Interval (hours/starts): 24k/900
- Major Interval (hours/starts): 48k/1800
- Rotor Maintenance (hours/starts): 144k/5000.

3.6.3 Heat Recovery Steam Generator (HRSG)

130. An HRSG consist of four major components: the economizer, evaporator, super-heater and water pre-heater. It has a steam drum and an evaporator where water is converted into steam. In horizontal type HRSG, the exhaust hot gas of GT flows horizontally over vertical tubes and through main stack to the atmosphere and generates high pressure (HP) superheated steam. This steam is then directed to the steam turbine to spin it and generate electricity.

3.6.4 Deaerator

131. A deaerator is a device used for removing oxygen and other dissolved gases from the feed water of a steam-generating device. The current Hydrazine based treatment of feedwater will be replaced by more environment friendly chemicals, as explained in earlier Section. The horizontal tray-type deaerator has a vertical domed deaeration section

mounted above a horizontal feed water storage vessel. Feed water enters the vertical deaeration section above the perforated trays and flows downward through the perforations. Low-pressure deaeration steam enters below the perforated trays and flows upward through the perforations. The steam causes the dissolved gases to release and exit via the vent at the top of the domed section. It may be mentioned that in the existing plants (other than Unit 4), the replacement of hydrazine will not be immediately possible because of the existing stock and disposal of them may be a critical issue. All the Units in GPS are expected to be progressively repowered and hydrazine will be phased out.

3.6.5 Turbine and Auxiliaries

132. A turbine is a rotating machine that extracts energy from a fluid flow and converts it into useful work. Moving fluid acts on its blades and impart rotational energy to the rotor. The rotor drives the mechanically coupled electrical generator and thus, generates electrical power.

a) Steam Turbine

133. The steam generated in a boiler or HRSG is delivered to the steam turbine that extracts thermal energy from pressurized steam and causes rotation of its shaft that drives the mechanically coupled electrical generator and thus, generates electrical power. Exhaust steam living the steam turbine is condensed in the condenser. The condensate is then pumped from the condenser hot well by condensate extraction pumps to the deaerator inlet of the boiler or HRSG and thus completing the feed water-steam cycle.

b) Gas Turbine

134. A gas turbine is a type of internal combustion engine that has an upstream rotating compressor coupled with a downstream turbine and a combustion chamber in-between. In the combustor gas is mixed with compressed air and is ignited. The hot gas thus produced is directed to the turbine blades where it expands and loses energy. This loss of energy is ultimately converted to electrical power through the rotation of the turbo generator.

3.6.6 Exhaust system and stack

135. Gas turbine unit shall be equipped with an exhaust duct and a suitable bypass stack with hydraulic diverter damper for prolonged continuous simple cycle operation. The exhaust system shall have a silencer to reduce the sound level of 65 dB when measured at a distance of 100 meter from the plant operating at full load. The duct shall be supplied complete with all necessary expansion joints thermal and acoustic insulation, manholes, drains, supports, bolting and jointing. It shall be arranged in such a way that normal maintenance can be carried out on any component without dismantling the duct. A 50 m stack height with 3 m inner diameter is considered in the design. The exhaust flow at the stack is considered as 176.75 m^3/s and flue gas temperature is 90.8^0 C.

3.6.7 Cooling System

136. Condenser cooling system of a thermal power plant is either of closed cycle or of open cycle system. Existing cooling system is open cycle (once through cooling) for which a large quantity of water is required. On the other hand, the closed cycle cooling system (with cooling towers) requires lesser quantity of water but it has associated cost involved. Temperature increase by thermal discharge from cooling system of Unit 4 is currently violating WBG Guidelines in the thermal plume zone of influence. Based on water balance analysis and water quality information in Shitalakhya River, quantity and quality of water will

not pose any immediate threat to the repowering Project. However, closed cycle cooling system is considered to bring the Unit under compliance with WBG Effluent Guidelines.

137. It has been found from our study that there will not be any shortage of water in the Shitalakhya River during the plant life of the project. Though environmental flow for the river during dry season may get shortfall by only about 10% after withdrawing of required water for whole GPS (details of e-flow is given in Section: 7.22.3). On the other hand, the water quality cannot be ensured suitable for Plant intake, because Shitalakhya River flows through an industrial area. There are many industries on both banks of Shitalakhya and many more will come. So, a realistic regulation of industrial waste disposal in the river cannot be ensured.

3.7 Resources and Utility Demand

138. Resources required to develop the project include soil, construction material, manpower etc. The site is a part of the existing power plant and of the same level, therefore will need only minor earth dressing. Local construction material will be used for the proposed project and the project will provide employment opportunity for unskilled, semi-skilled and skilled categories. Employment opportunities will be available with the start of construction activities and continue through the operation phase, mainly in service sector.

139. Electricity demand during construction phase will be met by the existing sub-station and distribution facility. During the construction period, water can be fetched from the nearby Shitalakhya River and drinking water can be drawn from underground sources such as Deep Tube well. Natural gas as fuel will be available under the existing allocation of the Petro Bangla from nearby Regulating and Metering Station (RMS) for Units 3 and 4. Waste will be disposed of in the approved designated site preferably apart from the Plant site.

140. For reducing the outage time of the existing power station during construction period of the new gas turbine, the Gas Turbine Generator and HRSG shall be installed first at the north side of Unit 4 for full repowering. The old existing control system of the target unit shall be completely replaced by new state-of-the-art control system during shutdown of the concerned unit for interfacing between existing and new system.

141. A temporary sanitation facility for the workers during pre-construction and construction phases will be developed with septic tank with adequate capacity. The sewerage system will be connected to the existing facility.

142. A temporary road and drainage system will be developed in addition to the existing system until a final road and drainage system is designed and developed.

3.8 Source of Natural Gas and Quality

143. At present the gas is supplied to the Ghorashal Power Station by the Titas Gas Transmission and Distribution Co. Ltd (TGTDCL) of Petro Bangla through a 16˝ diameter pipeline and a Regulating and Metering Station (Titas RMS) situated at the Northeast corner of the GPS complex. The fuel gas is supplied under a contract for 190 MMSCFD. The contract needs to be reviewed and enhanced to meet the future demand of gas.

144. In the existing distribution system, Gas from Titas RMS flows to the gas distribution Plant (GDP 1-5) via gas metering and regulating sections through a 1.8 Km long 10˝ dia pipe. The gas through GDP-2 goes to Boiler 3 and 4.

145. The proposed Gas Turbine needs a stable gas pressure of 30 bar and hence installation of gas booster has been proposed. Due to the space restriction in the existing

Titas RMS a new gas station will be required to be installed in the space available at the Northeast of the unused fuel oil tanks, i.e., at the Northwest of the proposed HRSG site. A 16˝ diameter gas pipeline from inlet header of the Titas RMS up to the bus of the proposed gas station mentioned above is to be constructed. From this bus, a number of gas pipelines will be branched out and will lead through individual gas compressor and associated facilities to the individual unit to be repowered. Existing and proposed gas supply arrangement are presented in Figure 3-5 and Figure 3-6 and the composition of gas used in the plant is presented in Table 3-3.

Table 3-3: Gas analysis report

Gas Composition	% Mole
Nitrogen	0.788
CO_2	0.008
Methane	97.644
Ethane	1.544
Propane	0.006
Normal Butane	0.002
Hexane Plus	0.008

Source: Bangladesh Gas Fields Company Ltd. Ref. Letter No: 105.0000.020/2011/03

3.9 Pipelines for Natural Gas and new Gas Regulating and Metering System

146. At present the gas is supplied to Ghorashal Power Station from Titas Gas Transmission and Distribution Company Ltd. (TGTDCL). A Gas transmission line constituting 46.31 km distance from Titas field through one DN16 diameter pipeline with 1,000 psi pressure come to Narsingdi. From Narsingdi VS#12, 2 nos. DN 14 of 23.31 km transmission line with the same pressure of 1,000 psi connect to a Regulating & Metering Station (RMS) situated at the north east corner of the Ghorashal Power Station (Figure 3-4). Gas inlet pressure of Titas RMS varies from 420 psi to 600 psi. This pressure is likely to decrease in future. The proposed GT needs a stable gas pressure of 460 psi and hence installation of a gas booster has been proposed. Due to the space restriction in the existing Titas RMS, a new gas station is needed and will be installed in the space available at the Northeast of the unused fuel oil tanks, i.e., in the Northwest of the proposed HRSG site. A 16˝ diameter gas pipeline from inlet header of the Titas RMS up to the bus of the proposed gas station will be constructed. From this bus, a number of gas pipelines will branch out and will lead through individual gas compressors and associated facilities to the individual unit to be repowered. Compressor fouling is a common event and dependent on the quality of the ambient air, the quality of the inlet filters, and the washing regime. The gas booster will be installed within the property line of GPS and no new land acquisition is required. The new RMS is included in the bidding document for Unit 4. This will be constructed by the EPC contractor with supervision of the Gas supplier TGTDCL. This RMS will be within the Ghorashal boundary and adjacent to the existing RMS.

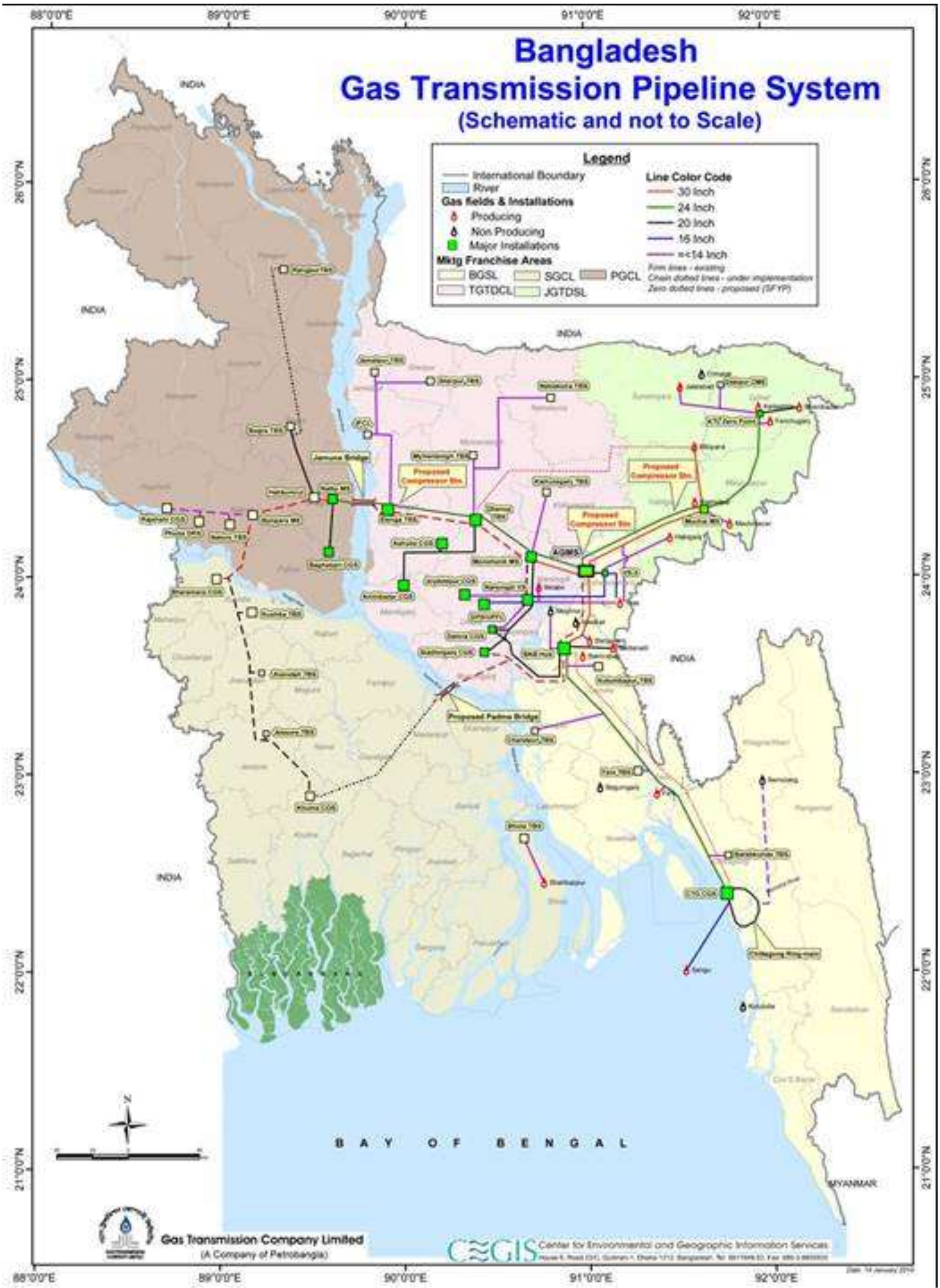


Figure 3-4: Gas transmission network

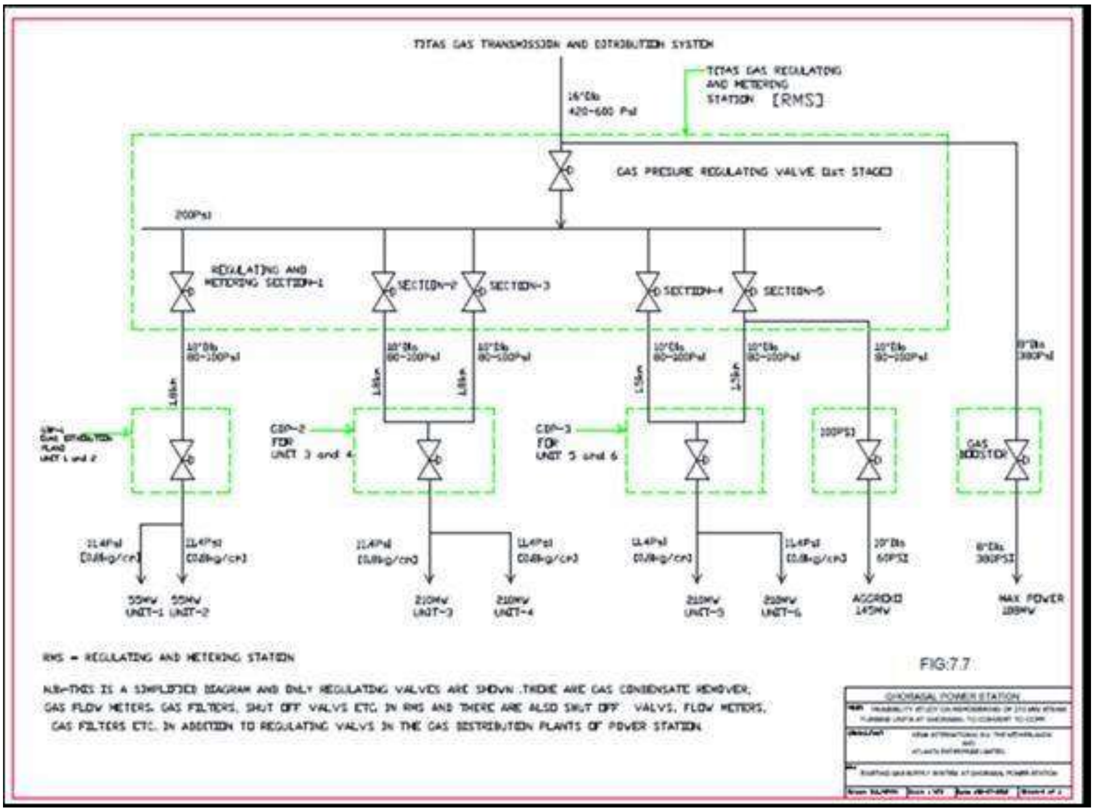


Figure 3-5: Existing Ghorashal gas connection system

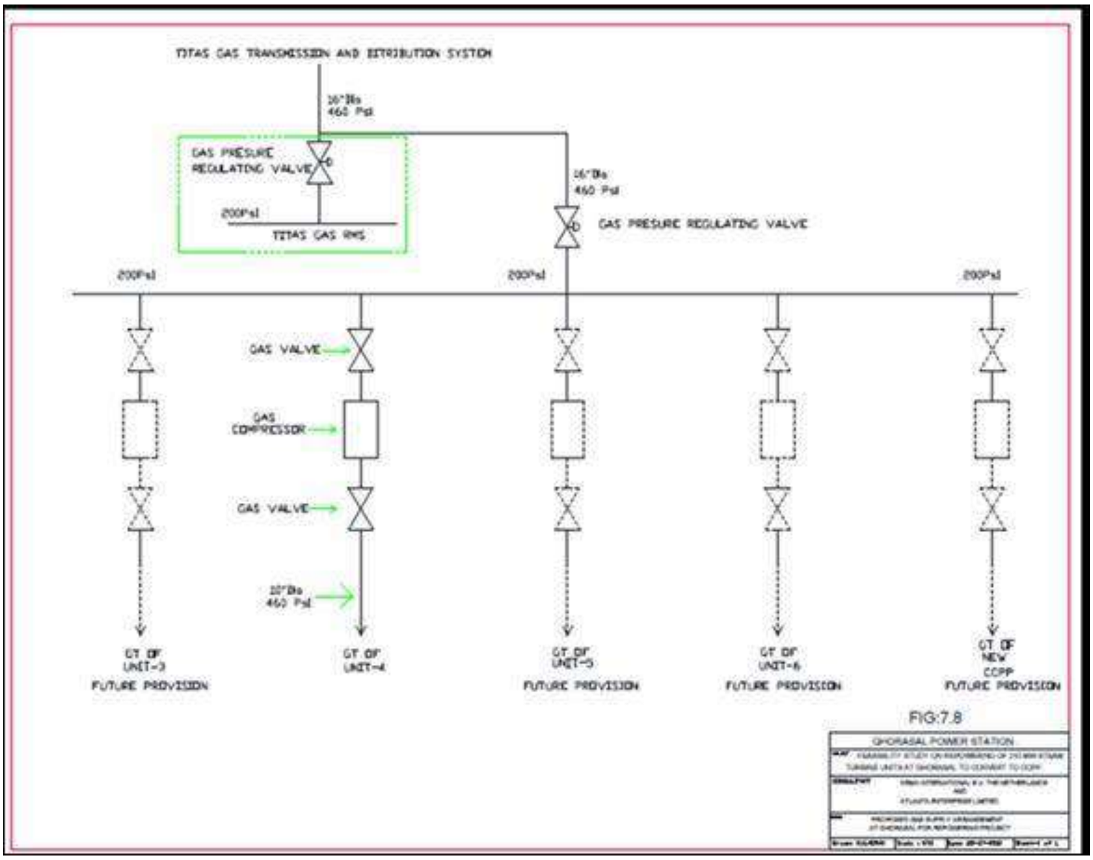


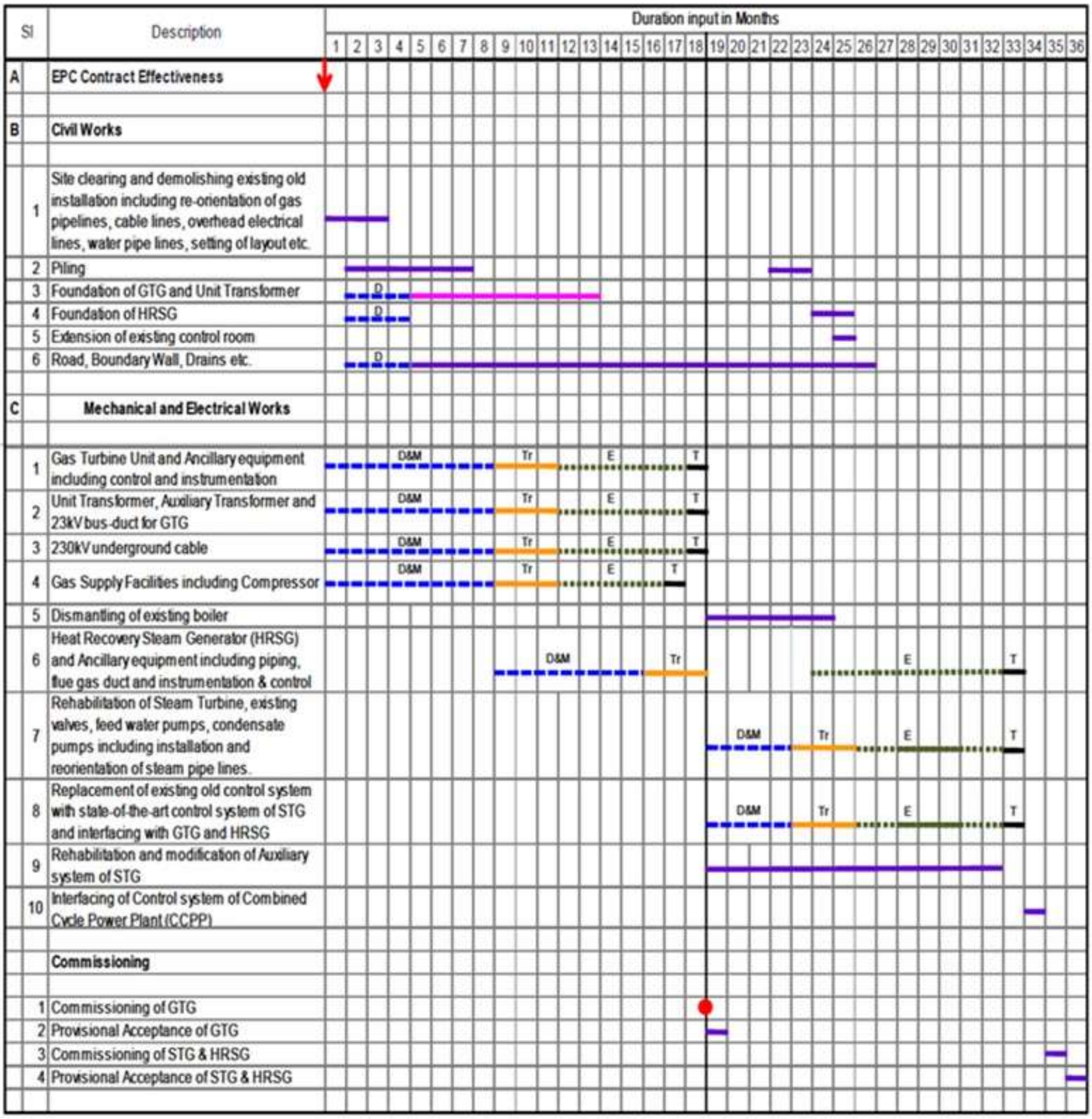
Figure 3-6: Proposed new gas supply connection system

3.10 Project activities and schedule

147. There are two main project activities, (a) Decommissioning of existing Boiler and (b) Full Repowering of Unit #4. The main activities of decommission of boilers are dismantling of the following: Heavy boiler drum, Economizer, Water tubes, Steam pipes, FD, ID & recirculating Fans, Chimney, Air ducts, etc., Insulation sheets and material, and demolishing of the foundations. Detailed activities for the decommissioning of boiler is presented in Table 3-4. On the other hand, main activities related to full repowering are: commissioning of Gas Turbine, construction of HRSG, rehabilitation of Steam Turbine, replacement work of existing old control system of STG and interfacing of control system, interfacing of control system of the combined cycle power plant, and commissioning of HRSG & STG. Detailed activities and time Schedule for completion of repowering is presented in Figure 3-7.

Table 3-4: Activities for Demolishing Boiler #4

Sl	Description
1	Remove the insulation from all around the boiler, segregate asbestos containing material, pack and store them at the designated place and final disposal to on-site asbestos pit
2	Disassemble the air ducts, bring down and store them at the designated place
3	Disassemble the Gas recirculation ducts/ gas ducts, bring down and store them at the designated place
4	Disassemble the RAH, bring down and store them at the designated place and remove the foundation
5	Disassemble and remove the chimney and remove the foundation
6	Remove the FD fans, ID fan & Gas recirculation Fans and store them at the designated place and remove the foundation
7	Disconnect all pipes to and from the boiler drum
8	Disconnect the down corner pipes from boiler drum and from water wall headers down and bring them down and store them at the designated place
9	Bring down the boiler drum and store them at the designated place
10	Disconnect the feed water pipe from the economizer with proper support
11	Dismantle, bring down the economizer and store them at the designated place
12	Disconnect the miscellaneous pipes
13	Disconnect interconnection between headers of different super heater coils and reheater coils
14	Disconnect the Main Steam pipes line, reheater inlet and outlet pipe lines providing proper supports
15	Remove the ceiling super heater and store them at the designated place
16	Remove the other super heater coil (SH & RH) and store them at the designated place
17	Remove the Boiler condenser (Right & Left) and store them at designated place
18	Remove the Steam super heater (Right and Left) and store at the designated place
19	Remove the water walls and store them at the designated place
20	Remove the scaffoldings, stairs etc. and store them at the designated place
21	Remove the supporting structures, if necessary and store them at the designated place
22	Remove the foundations of Boiler, if necessary.



Notes: D: Design, M: Manufacture, Tr: Transportation, E: Erection, and T: Testing

Figure 3-7: Detailed activities and schedule of boiler decommissioning and repowering

4. Project Description

4.1 Overview of Existing Facility

148. The Ghorashal Power Station (GPS) is a major power generation center of Bangladesh Power Development Board (BPDB) located on the eastern bank of river Shitalakhya in the Palash Upazilla of Narsingdi District. Currently, it has six generating units with a nominal generating capacity of 950MW (2x55 MW and 4x210 MW) based on gas fired conventional steam turbine technology. The average efficiency of the units at is around 31% which is quite poor compared to the efficiency of around 55% for the modern combined cycle power plants.The purpose of the current project is to repower Unit 4 (nominal capacity of 210 MW) of Ghorashal power station. The project involves the repowering of the current steam plant with a more efficient combined cycle plant. As part of the new plant, a gas turbine will be installed and the present boiler will be replaced by a HRSG (Heat Recovery Steam Generator).

Boiler

Turbine Hall

Effluent Canal **Stack**

Irrigation Canal **Waste disposal site**

Figure 4-1: Major equipments in Unit 4

4.1.1 Description of Existing Unit 4 Boiler

149. The existing boiler of Unit 4 is a conventional drum boiler and is fired with natural gas. The boiler was designed and built by Taganrog (a Russian Manufacturing Company) and is a type TGME-206 COB. The boiler has two rotating air heaters and flue gas recirculation. The high pressure water-steam loop encompasses an economizer, a HP drum, HP evaporator, a low temperature ceiling super heater (SH), a radiant wall SH, a platen SH and a convective final SH. Between each SH, stage injection coolers control the steam temperature. After the HP steam passes the HP turbine, the steam returns to the boiler as intermediate pressure (IP) steam and is reheated in two steps. An injection cooler controls the steam temperature between step one and two. Boiler materials and design conditions are presented in Table 4-1.

Table 4-1: Boiler materials and design conditions

Component	Dimensions (mm)	Material	P op (bar)	T design Medium (°C)
HP BOILER				
Inlet header economizer	219×26	CS		
Economizer tube size	28×4	CS	157.8927	344
Outlet header economizer	219×36	CS		
Steam Drum		High Strength Steel	154.95	
Inside diameter	1,600			
Thickness	112			
Length of drum	225,000			
Down comer			157.89	345
Vertical Tube	465×40	CS		
Lower Header tube	159×15	CS		
Water wall tube	60×60	CS	156.912	405
Transfer line eco outlet header to Steam Drum	108×12	CS		
Radiant SUPERHEATER(SH)			154.95	525
Vertical Header	159×18	Alloy steel		
U- shaped tube size	42×5	Alloy steel		
Platen SUPERHEATER(SH)			149.06	561
Headers	159×18	Alloy steel		
U-shaped vertical tube size	32×5	Alloy steel		
Celling SUPERHEATER(SH)		Steel-20		
Inlet Header	219×36			
Tube size(front block)	32×5		156.912	
Tube size(rear block)	32×5			
Saturates Steam				
Header	159×15	CS		
Tube size	60×6	CS		

150. The boiler drum is made of high strength alloy steel with an operating capacity of 640 ton/h, inner diameter 1.6 meter, wall thickness of 0.112 meter, and length 24.31 meter. The water Wall is made of Steel 20 and Boiler Condenser is made of carbon steel. Chemical compositions of the boiler drum, water wall and boiler condenser are presented in Table 4-2. The boiler has numerous pipes, Table 4-3 presents component-wise number of piping.

Table 4-2: Chemical compositions of boiler drum, water wall, and boiler condenser

Element	Chemical Composition in %		
	Boiler Drum	Water Wall	Boiler Condenser
	Alloy Steel	Steel 20	Carbon Steel
C	0.17	0.2	0.2
Mn	0.92	0.43	0.47
Si	0.2	0.21	0.26
P	0.005	0.008	0.008
S	0.019	0.018	0.012
Cu	0.14	0.1	0.15
Ni	1.06	0.12	0.19
Cr	0.2	0.18	0.09
Mo	0.47		
Fe	3.184		

Table 4-3: Number of piping of the boiler

Water wall 640 tubes			
	Back wall 224 tubes		Each platen has 2 header
	Front wall 224 tubes		16 u-shaped vertical coils
	Side (left) wall 96 tubes	Ceiling Superheater	
	Side (Right) wall 96 tubes		8 front blocks
Radiant Superheater			8 rear blocks
	Six blocks		Front block consist of inlet header 219*366mm
	2 blocks each on front wall and rear wall		32*5mm tubes
	1 blocks each on side wall	Economizer	
	Each block contains of 2 vertical header		2 parts
	19 u-shaped coil		Each parts is made of 8 blocks
Platen Superheater			Upper header transfer the load to 32 suspension tubes
	24 platen arrange in one row		

151. The boiler consists of various insulation materials such as mineral wool, glass fiber, asbestos, aluminum powder, glass, and steel. A partial list of insulation materials were retrieved from the erection reports available in the GPS library and are presented in Table 4-4. However, even after extensive search and consultation with GPS staffs, the full-list of the boiler materials was not available. The feasibility study report also did not account the insulation materials. Hence, it is recommended that the boiler decommissioning contractor make an estimate of the full-list with quantities.

152. The standards of asbestos for the ambient air[12] are: (i) at outdoor: an average of $3x10^{-5}$ fibers per cubic centimeters (f/cc) for fibers >5 microns; (ii) at indoor: concentrations of fibers > 5 microns generally average about $5x10^{-5}$ to $2x10^{-4}$ (f/cc), with an overall average of about $1x10^{-4}$ f/cc (U.S EPA, 2013); for occupational health[13] 0.1 f/cc of air at eight (8)-hour -weighted average and (ii) 1.0 f/cc at 30 minutes weighted-average (29 CFR, 1910.1001, n.d.); for drinking water[14] the maximum contaminant level (MCL) for asbestos is 7 million fiber per liter (MFL) for fibers >10 microns (ATSDR, 2014).

Table 4-4: List of insulation materials (partial)

Materials used	Possible use	Unit	Quantity
Mineral Wool	Insulation	m^3	2729.06
Glass-Fabric	Insulation	m^3	1459.3
Asbestos[15]	Insulation	tons	17.67

[12] U.S EPA (2013). *Summary of Published Measurements of Asbestos Levels in Ambient Air.* Retrieved from http://www2.epa.gov/sites/production/files/2013-08/documents/libbyasbestos_ambientairlitsearch5-20-2013.pdf

[13] OSHA (n.d.). *29 CFR, 1910.1001(c)(1) and 1910.1001(c)(2): Asebstos.* Retrieved from https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9995

[14] ATSDR (2012). *Asbestos Toxicity*. Retrieved from http://www.atsdr.cdc.gov/csem/asbestos_2014/docs/asbestos.pdf

[15]TOR states that the total quantity of asbestos is about 50 tons. However, the Consultant was not able to get any reference of this quantity.

Materials used	Possible use	Unit	Quantity
Zinc-Coated Sheet Steel	Insulation/cladding/making and installing diaphragms	tons	276.45
Carbon Steel	Supporting structures/making and installing small structures	tons	9.43
Alloyed Steel	Supporting structures/making and installing small structures	tons	9.83
Aluminium Powder	Cladding	kg	197.5
Sovelite Slab	Insulation	m^3	11.52
Steel Braided Net (Zinc Coated)	Making frame	m^2	13825
Glass Twisted Complex		kg	287.6
Glass Canvas		m^3	61.34
Glass Fibric (Length)		m	13192
Steel		tons	3.6447
Others		kg	86.4

Source: TPP Ghorashal, 2nd Phase, Unit4, Working Project of Heat Insulation Code: 087-04-11-TN; Book-I- Explanatory Note.

153. The existing boiler has now become old and is not repairable for the proposed repowering project. It is therefore redundant and has to be demolished and removed. The boiler plant and associated parts will be removed one by one and stored at temporary sites before being transported to the final disposal site and/or collected by recycling companies. There is sufficient space available in the northwestern side of the existing boiler, the area is mostly covered with grass and bushes and is marked as laydown area in Figure 4-3. Further northeast some temporary old warehouse structures may be demolished and used as a designated site for temporary storage of decommissioned materials. However, the decommissioning contractor is responsible for dismantling the boiler in consultation with the GPS authority. The GPS authority will make the final decisions on the location of the temporary storage areas. The last item in the decommissioning work is the demolishing of the boiler foundations. It is estimated that it will take about 6 months to demolish and remove the existing boiler and this is critical to the implementation of inter-connection of the 210MW Steam Turbine with the heat recovery boiler. Proper precautions need to be taken by workers who will dismantle and remove heavy parts during the decommissioning phase. There are always risks involved in decommissioning projects, but they can be minimized and mitigated through proper training and by taking all necessary precautions.

154. Proper sequence of dismantling is considered very important. For example, air ducts are to be dismantled first, so that parts that are higher up can be brought down. The stack should be demolished before other sections to make space for the crane to enter in to strategic points to reach the super structures. Precautionary measures must be adopted by the EPC contractor at the time of implementation of the project; and bidders will be required to submit their proposal taking into consideration adequate safety measures and the time frame. During dismantling the boiler dust from breaking of insulation, flume from cutting different pipes and other pollutants maybe emitted. The release of toxic substances such as asbestos will have to be carefully monitored and controlled.

4.1.2 Existing Steam Turbine

155. The existing steam turbine Type K210-130-3 of Unit-4 is designed and built by LMZ (Russian Manufacturer). It consists of an HP cylinder, an IP cylinder and a double LP cylinder. The HP and IP cylinder are in opposite positions to balance the axial force from the pressure differences. There are two condensers placed at the bottom of the LP Cylinder.

The turbine is provided with an electro hydraulic governing system. The blades are mainly of the impulse type. The principal characteristics of the steam turbine are presented in Table 4-5.

Table 4-5: Characteristics of existing steam turbine

Steam consumption at 210 MW (t/h)	636 (~177 kg/s)
Steam consumption in condenser at 210 MW (t/h) (with normal steam extraction for e.g. Pre-heaters)	423 (~118 kg/s)
Pressure of HP steam (bar)	130
Temperature of HP steam (°C)	540
Pressure of IP steam (bar)	25.8
Temperature of IP steam (boiler outlet) (°C)	540

156. The HP turbine is equipped with 12 stages, including the control stage and four control valves in a common steam chest. The IP turbine consists of 11 stages including the control stage and four control valves in a common steam chest. The LP turbine consists of two sections with four stages. The total shaft train (including generator) has seven radial journal bearings and one thrust bearing, located between the HP and IP turbine. Coupling between HP and IP turbine is a bolted, rigid, and flange type coupling. The connection between IP and LP turbine consists of a flexible type coupling connected with keys on the journals. The coupling between LP turbine and generator is a fixed bushing connected with keys on the journal ends. The bushing is separable at the bolted flanges and contains the turning gear wheel.

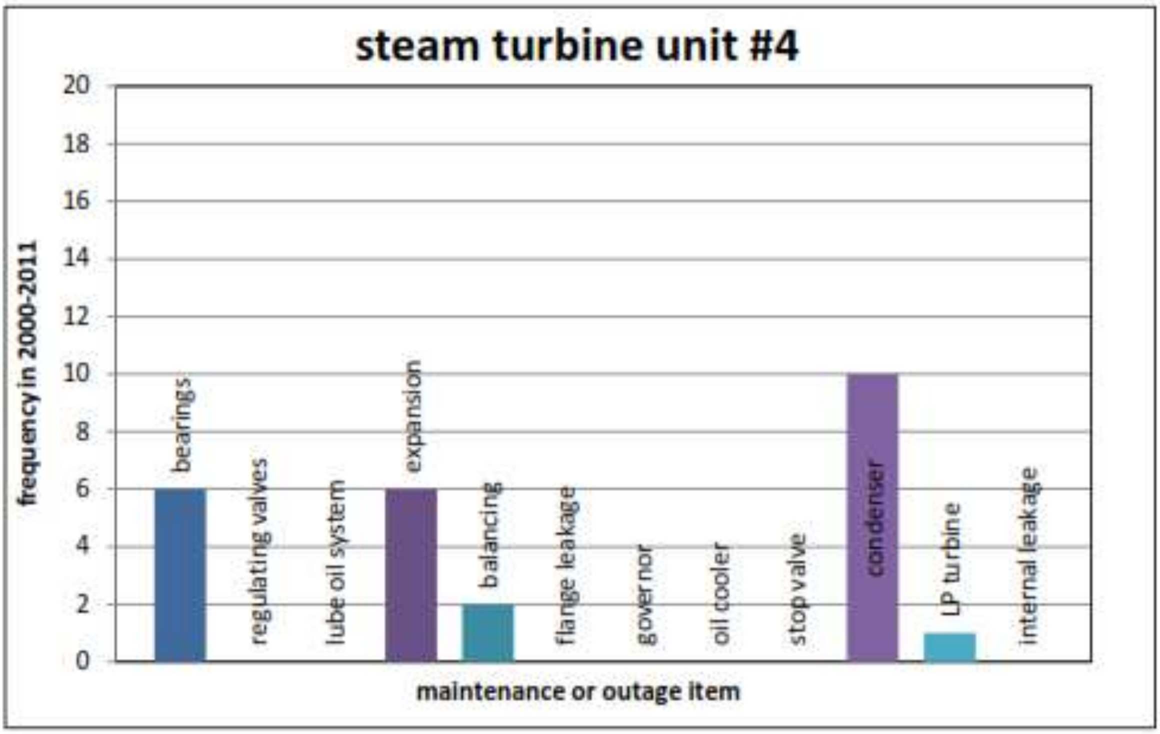


Figure 4-2: An inventory of maintenance and outage items

157. A graph of the inventory of maintenance and outage items for the period 2000- 2011 is shown in Figure 4-2. The graph shows that the “bearings” and “expansion” are the frequently responsible for Unit 4 outage. It has been noted that Unit 4 has also substantial condenser problems, as can be seen by the replacement with (new tubes in the turbine hall). In Unit 4 approximately 30% of turbine condenser tubes had already been blocked due to

leakage. Frequent Turbine condenser leakage of this unit has resulted in high hardness of condensate water. Boiler dismantling should be synchronized to clear the site and steam pipes to and from turbine should be cut and isolated at the entrance point of turbine hall to be welded with the new pipes of HRSG.

158. A technical issue of repowering is that in an existing power plant, the amount of steam in the steam turbine is decreasing from the high pressure part to the low pressure part because of the extraction of steam. In a modern combined cycle steam turbine, the amount of steam is increasing from high to low pressure due to the two/three pressure operation in the HRSG. For Unit 4, this means that after repowering the electrical output of the steam cycle will decrease by approximately 10%. In this perspective, the Feasibility Study conducted some back calculations taking into considerations the design parameters from the manual. The results are presented in Table 4-6 (data sourced from the manual is underlined).

Table 4-6: Indicative process values back calculated from the manual on existing steam turbine

Steam flow		**Situation**	**Power max MW**	**Flow steam**		**P- chamber ~bar**
%	**(%)**			**kg/s**	**(t/h)**	
100	(105.3)	Max	<u>215</u>	186	<u>(670)</u>	<u>98</u>
95	(100)	Nominal	210	177	(636)	88
92.5	(97.5)	HP bleeds closed	<u>200</u>	172	(620)	<u>84</u>
88.7	(93.4)	LP bleeds closed	<u>184</u>	165	(594)	<u>77</u>
80.7	(85.0)	HP/LP bleeds closed	<u>175</u>	150	(541)	<u>64</u>

159. The calculations show that the LP steam turbine can consume about 150 kg/s steam as the amount of HP steam is about the same as the input amount of the LP turbine while the bleeds are closed. In normal (nominal) situation with the bleeds open the end of the LP turbine will consume about 122 kg/s steam.

160. The capacity of 150 kg/s steam should result in a power of about 175 MW. The repowering option ~125 kg/s steam is chosen as a base for the feed of the steam turbine in case the bleeds are all closed and only some bleed steam for de-aerating is used.

4.1.3 Existing Cooling System

161. The present condenser cooling system is a once through open cycle cooling system. About 27,500 m^3/h of surface water from the Shitalakhya River is withdrawn using two out of three circulating water pumps (CW Pump). The hot water (after it goes through the condenser) flows through a long open channel for natural cooling. A portion of this water is channeled to the nearby agriculture fields for irrigation purpose and the rest is returned back to the river at temperature close to the ambient temperature (outside the mixing zone). During winter when Shitalakhya water is relatively low or during any break down of CW pumps, cooling tower is used to support the existing cooling. Out of the 27,500 m^3/h water, about 300 m^3/h of water after due treatment is applied for other cooling, boiler makeup and etc. The plant’s effluent after being neutralized in the neutralizing pond is returned back to the Shitalakhya River. The effluent pH at the neutralizing tank is maintained slightly more than 7 °C to keep the property of effluent basic. Usually, the acidic effluents and the basic effluents are mixed in the neutralizing

basin where they react to form salts and get neutralized. In special cases during acid cleaning, caustic soda and calcium oxide are added for neutralization of the effluents coming from different sources in the neutralizing pond. The sludge gradually settles at the bottom of the tank and after a couple of years the sludge is collected and disposed in a location to the west-side of a pond within the GPS boundary.

162. Condensate water from the condenser hot well is delivered through condensate extraction pumps to the de-aerator. The existing cooling tower is not operating properly due to poor maintenance for a long period of time. Most of the blower fans and motors including the induced fan at the top of the tower are not working and require replacement.

4.1.4 Stack

163. The existing stack (main stack) for Unit 4 is a steel structure of about 50 meters height and inner diameter of 3 meters. The exit velocity of the stack is 22-25 m/s and gas temperature is 125-130 ^{0}C.

4.1.5 Other Equipment and process require refurbishments or upgrading

164. There is no specified list of items for refurbishment in the Feasibility Report of Unit 4. However, the following items have been listed from the Tender Document of Unit 3 which is similar to the Unit 4.

165. Existing steam turbine generator and its auxiliaries need to be renovated/ modified/ retrofitted to maximum capacity for using as a steam turbine for combined cycle operation. In general:

- all system/components belonging to turbine (HP,IP, LP) parts, turning gear assembly,
- main oil pump, AC Aux lube oil pumps, AC control oil pump, DC emergency lube oil pump, oil coolers, vapor exhauster, oil filters, valves and etc.,
- gland steam system with gland steam condenser and valves,
- feed water system: Corrosion is a major problem in steam systems with high consumption of make-up water. Fresh water contains dissolved oxygen. Oxygen together with the high temperature is highly corrosive for the carbon steel piping used in steam systems. To avoid corrosion, the oxygen in the make-up water for saturated steam production needs to be removed. Currently hydrazine is used in GPS as a scavenger chemical to remove oxygen. Hydrazine is a toxic chemical (a carcinogen) which requires proper treatment prior to disposal in the river, which also supports food processing systems in up and downstream. There are a number of environmentally friendly alternatives to hydrazine, (a) Erythorbic acid and its sodium salt can replace scavenger chemicals like Hydrazine as oxygen scavengers. Sodium Erythorbate is a non-toxic oxygen scavenger that can be used also in food processing systems and (b) HELAMIN is formulations consisting of poly-carboxylates and surface-active fatty alkyl polyamines in combination with other amines of varying volatility. The use of HELAMIN in the preparation of boiler make-up water has a synergetic effect. The poly-carboxylate (as sodium salt) causes alkalization at every temperature because of hydrolysis. As a polyelectrolyte it has greater affinity to bivalent cations (e.g. Fe^{++} or Ca^{++}), like a weak acidic ion exchanger. Hence, quite stable calcium or iron salts are formed which can be removed by blow down. At the stoichiometric

limits any residual hardness is kept in solution. The EPC contractor in their proposal states a possible environmentally friendly alternative to replace hydrazine as the scavenger chemical. Owner's engineer will review the proposal and in consultation with GPS a final decision will be made.

- control valves required for open cycle, close cycle, and combined cycle operation,
- condensate water system, circulating water (CW) system and their auxiliaries(vacuum pump, drainage pump, delivery valve, etc.),
- fire-fighting system,
- cooling system including blower fans, ad motors and the induced fan, and
- generator rotor, stator, generator other auxiliaries (gas cooling pump, stator cooling pump, sealing oil pump) and etc.

166. The existing instrumentation and control are old and obsolete in view of the latest control systems currently available. It is very difficult, time consuming and costly to interface the outdated control system with the state-of-the-art control system of the modern Gas Turbine. A visit to the control room of Unit 4 indicates that insulations in two doors have been damaged and noise level in the control room is a little higher than expected. These doors require replacements.

4.2 Proposed Project Design

4.2.1 Project Layout and Site Drainage

167. The detailed layout plan showing all structures, road network, drainage network, different pollution abatement measures, waste water and effluent treatment facilities shall be developed by the EPC contractor before construction. The EPC contractor shall be appointed after receiving approval of the EIA report from DoE. BPDB shall submit the final layout plan to DoE for their review and comments considering availability of land, landscape, ground features, elevation, environmental aspects and social concerns recommended by the EIA study. However, a preliminary layout plan of the proposed repowering project prepared by the feasibility study Consultant is presented in Figure 4-3. A layout plan showing proposed components of the EIA findings in addition to the components mentioned in the feasibility study of the Unit-4 is given above in Figure 3-3. The EPC contractor will need to show waste storage and sorting areas as well as a secured disposal location on the layout plan. Given the sensitivity of the decommissioning activity, it is recommended that the EPC Contractor is certified on OHSAH 18000. The Environmental Management Plan (EMP) and the Emergency Preparedness Plan in this report provides more details.

168. There is an existing drainage network in GPS for storm water runoff. Runoff is collected through open drains and stored in a common basin for sedimentation and the overflow is then connected with another drain to finally discharge to the condenser cooling water discharge channel for ultimate disposal to the Shitalakhya River.

169. The runoff drainage network of GPS requires improvement with the repowering as new equipment will be installed and existing structures will be demolished. Segregation of stormwater runoff and cooling water discharge may be required to avoid possible contamination at the disposal site close to the jetty area. Moreover, it is recommended to avoid decommissioning work during the monsoon season.

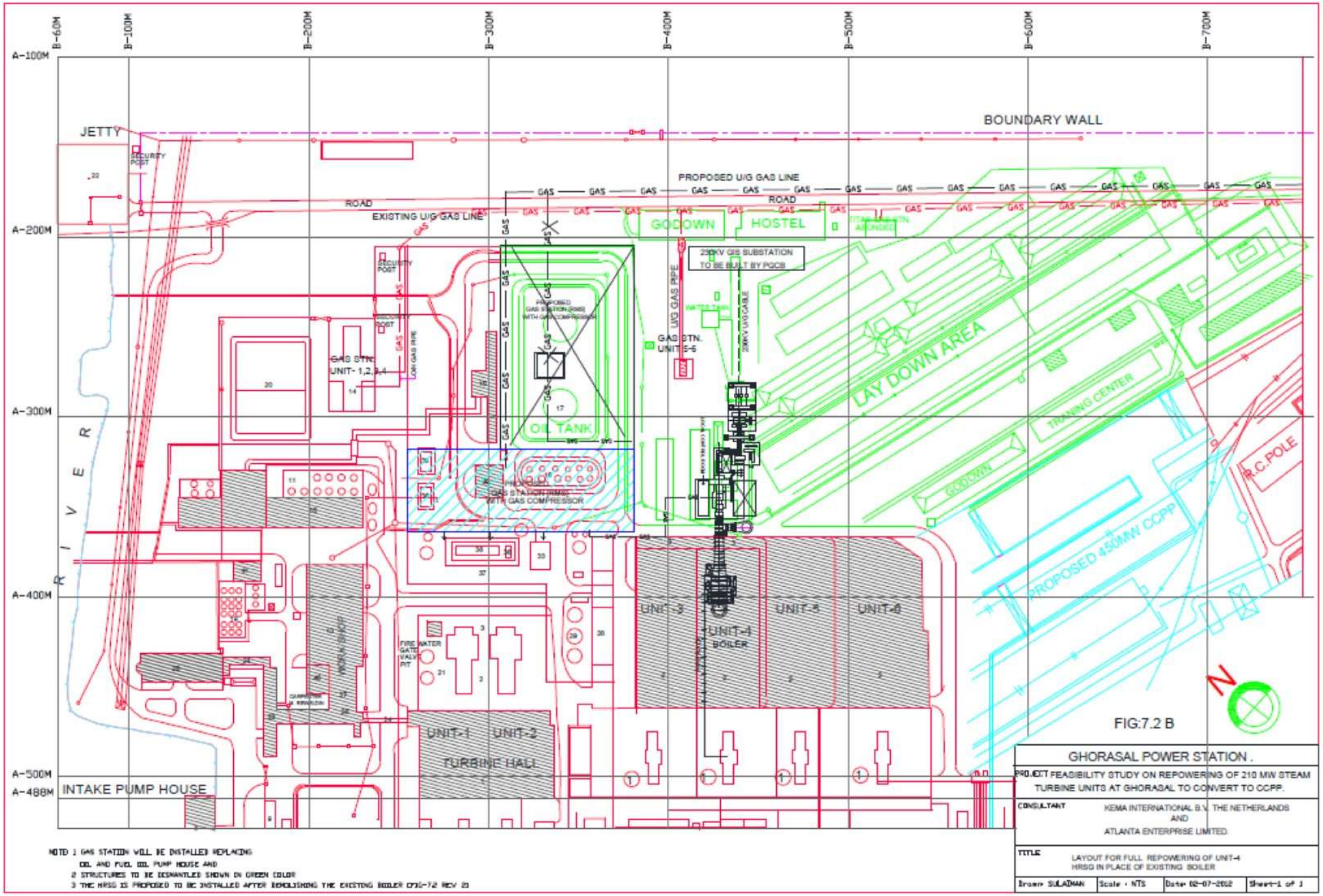


Figure 4-3: Full Repowering 1:1:1 configuration layout plan for Unit 4

4.2.2 Plant components of the layout plan

170. The major components of the proposed Plant layout are listed in Table 4-7.

Table 4-7: Major components of the layout plan

Sl. No.	Components	Sl. No.	Components
1	Proposed underground gas line	6	Jetty
2	230 KV sub-station	7	Existing gas station for unit 1-6
3	Go down/warehouse	8	Oil Tanks
4	Intake pump house	9	Boundary Wall
5	Unit 2 and4 Turbine hall	10	Asbestos disposal facility

Source: Feasibility report, BPDB

171. Drainage of storm water and effluent generated from the condenser cooling will follow the existing drainage system of the GPS. The new drainage network to be built for the proposed Plant will be connected with the existing drainage network.

4.2.3 Land Requirement

172. The area of the proposed project site is about 8 acres including the required land area for the construction of the new RMS. The site is partially fallow land on the northern side of the existing Unit 4 and near to the oil tanks having bushes, trees and tin shed warehouses exist. Adequate land is available within the property line of GPS and no land acquisition will be required for the proposed expansion.

4.2.4 Fuel requirement and performance

173. The Full Repowering option for Unit 4 requires a gas supply of 67.28 MMSCFD (20.86 Nm^3/s) for the gas turbine including supplementary firing of the HRSG. The current natural gas required for Unit 4 amounts to 49.17 MMSCFD based on 180 MW gross power output. When Unit 4 will be fully repowered, the increase in gas consumption will be 18.11 MMSCFD (5.62 Nm^3/s), which is 37% more gas consumption compared to the current consumption of Unit 4. Unit 4 has a design efficiency of 37.79%, however the current efficiency of the unit is 33.63%. After repowering, the net efficiency will be 54.6%.

4.2.5 Water requirement

174. At present, approximately 8.9629 m^3/s of surface water from the Shitalakhya River is used for condenser cooling, other cooling systems like ST generator stator cooler, ST generator sealing oil cooler, cooling water pumps, generator gas cooler and etc. The design condition for the exhaust of the LP-turbine of the existing steam turbine is 125 kg/s exhausted steam. In the Full Repowering option, the amount of exhaust steam is expected to be 122.7 kg/s. This is slightly less (98.2% of 125 kg/s) than the design value. In repowering, close cycle cooling system is recommended to replace the existing once through cooling system. A water balance diagram is presented in Figure 4-4 for the full repowering option. Water consumption will be significantly reduced from 8.9629 m^3/s to 0.46583 m^3/s, due to close cycle cooling system. There are a number of small-medium industries along the upstream of Shitalakhya River. In the 10km project impact area, industries that abstract water from the river are Desh-Bandu Sugar Mills, Ghazi Textile, and Ghorashal and Polash Urea fertilizer factories. The locations of these industries are presented in Figure 4-5. The project impact area also includes brick fields, which require minimal water consumption.

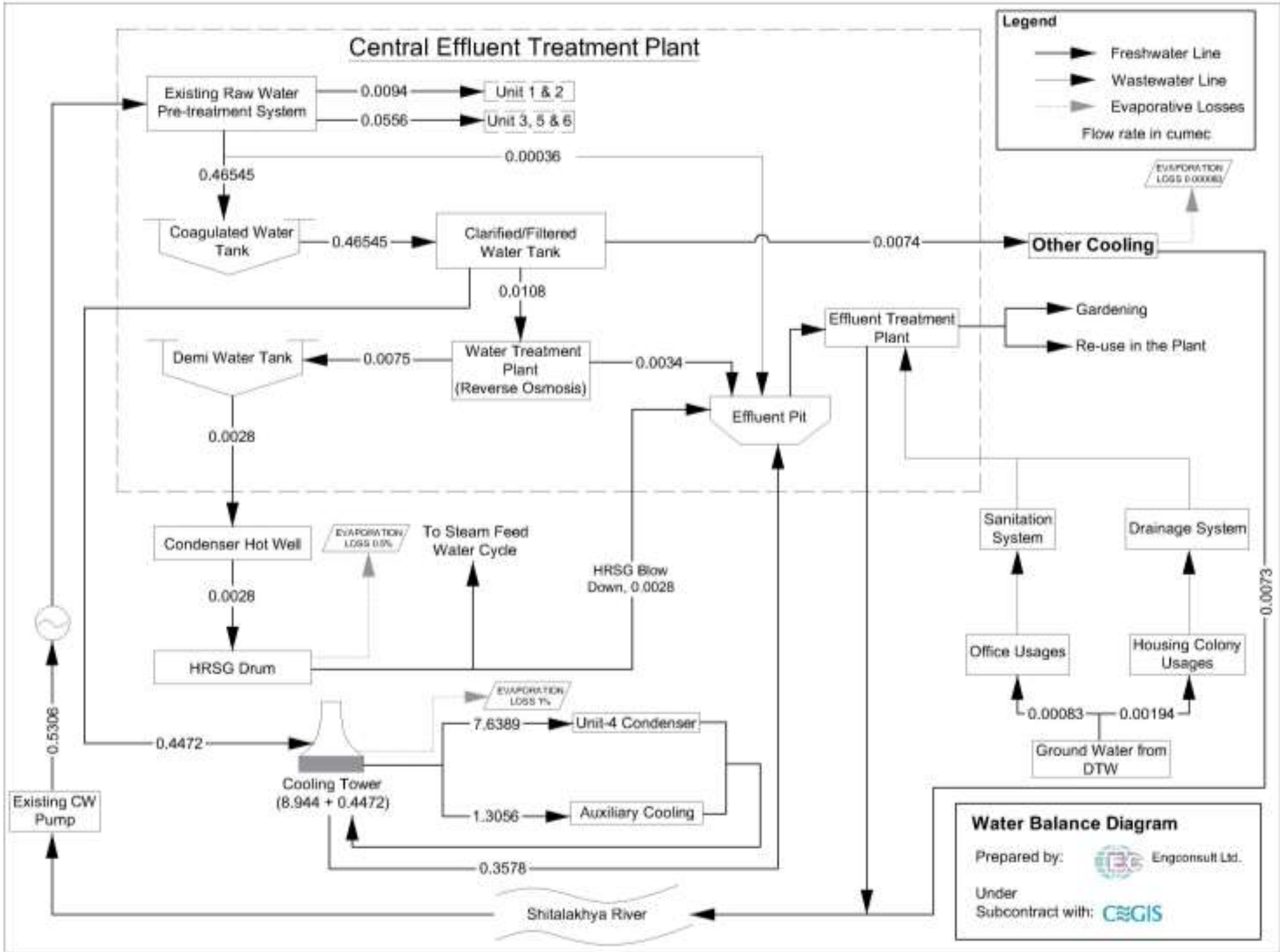


Figure 4-4: Water balance diagram for Unit 4

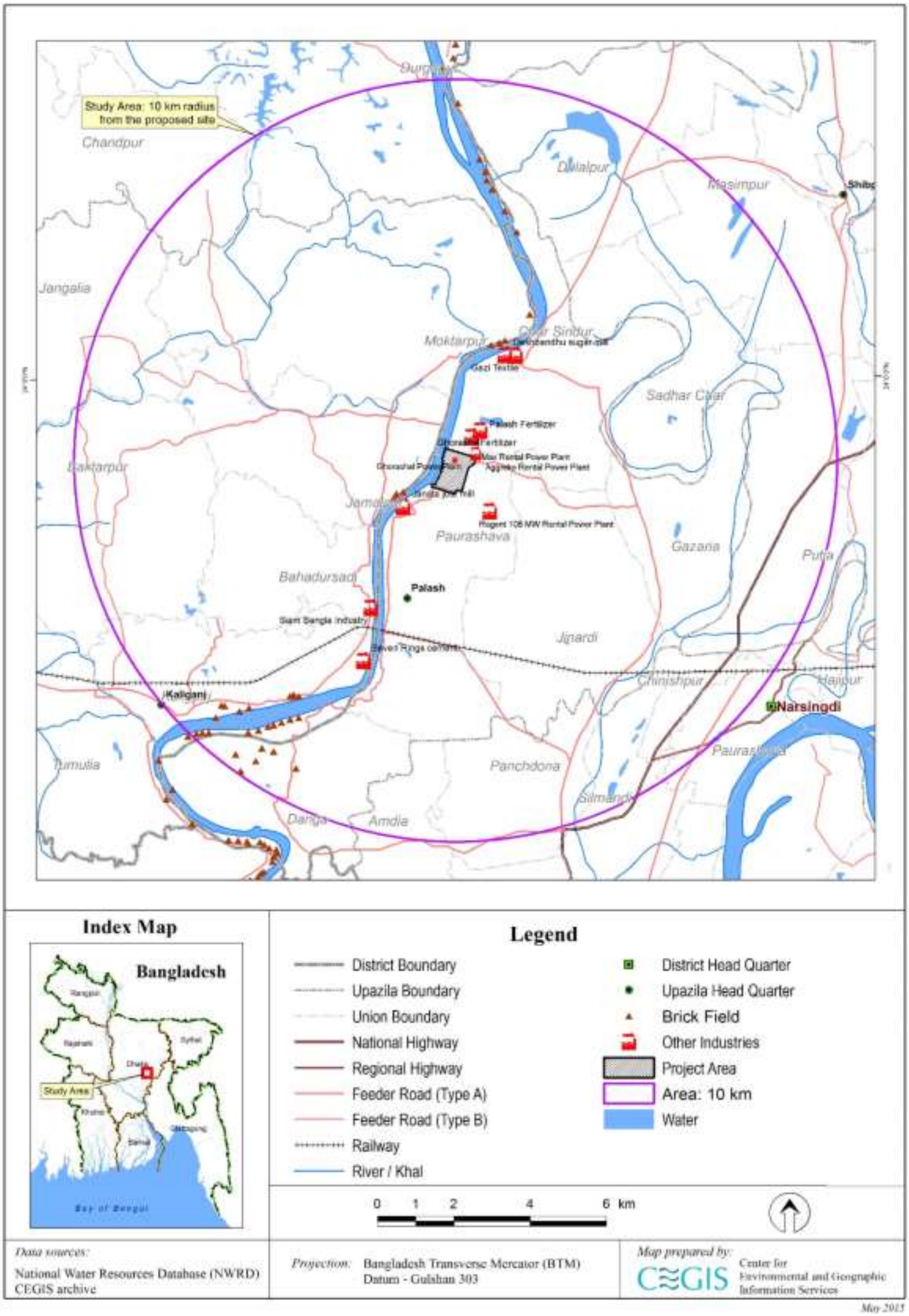


Figure 4-5: Major industries in Project Impact Area

4.2.6 Technology Selection and Process Description

175. In the full repowering case, the existing gas fired boiler will be replaced with one gas turbine and heat recovery steam generators (HRSG). The exhaust gases of the gas turbine are fed into the HRSG. The steam generated in the HRSG is supplied to the existing steam turbine and convert the plant into a combined cycle power plant. It is considered that noise generated from the gas turbine is 90 dBA.

176. The waste heat of a simple cycle gas turbine plant is used to generate steam in a heat recovery steam generator (HRSG) to drive a steam turbine and generate additional electrical power. The advantages are 1) higher efficiency and consequently less fuel consumption, 2) augmentation of power generation at steam turbine end with less fuel, and 3) less emission of flue gas

177. A typical flow diagram of a gas based CCPP with HRSG is shown in Figure 4-6.

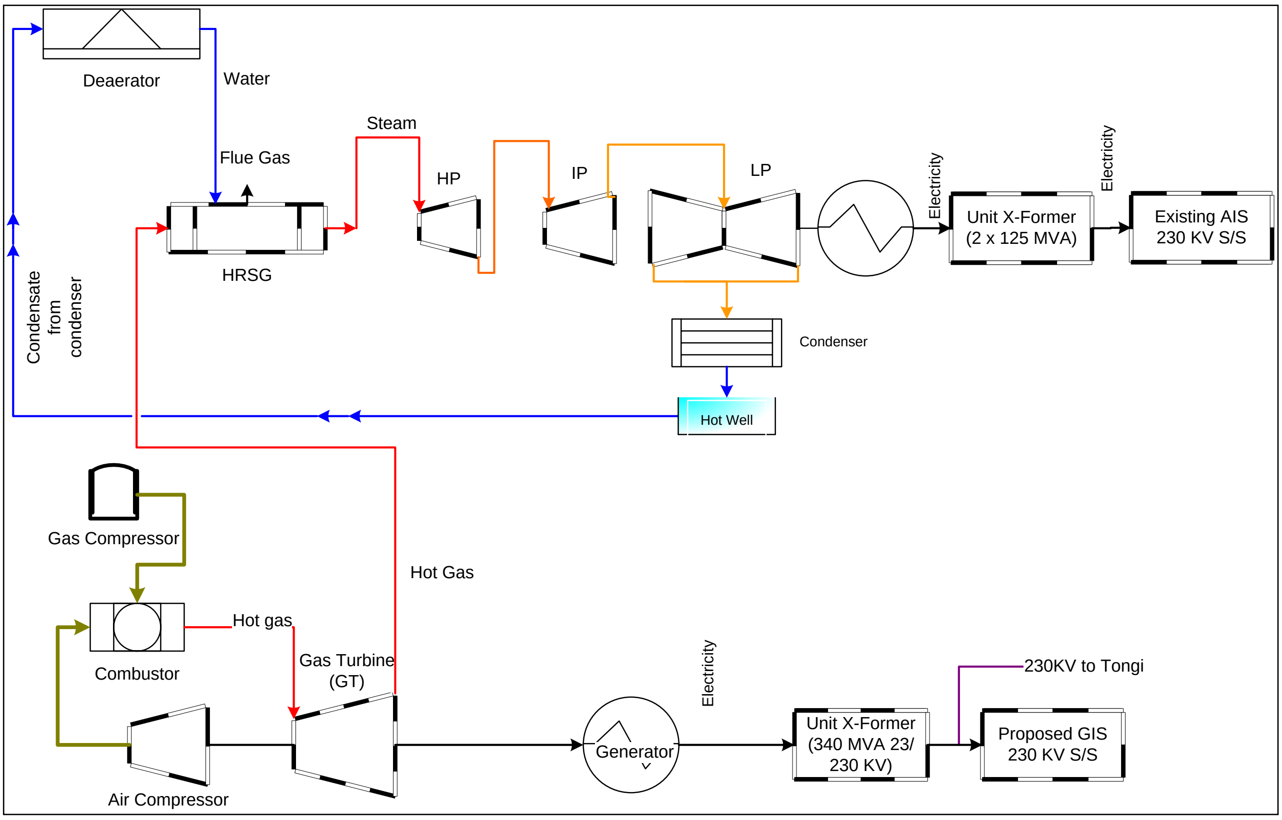


Figure 4-6: Process Flow Diagram of proposed CCPP

178. The rated capacity of Unit 4 is 210 MW but the present maximum power generation capacity is 180 MW. After repowering the total gross output will be 411.7MW and net Unit output will be 403.5 MW (Ambient condition) and average net capacity over life time will be 391.4 MW (auxiliary power use of 8.2 MW and impact of ageing and fouling of 12.1 MW).

179. The compressed natural gas is mixed with compressed air in the combustor to perform firing. The hot gas is directed to the gas turbine where the hot gas expands and loses its pressure and temperature and finally generates 246 MW electrical power in the generator. The exhaust hot gas of the GT will pass through the HRSG. The HRSG in turn will generate HP steam that will be directed to the steam turbine; this will in turn generate 165.7 MW of power making plant output to 403.5 MW (combined cycle). The condensed steam in the condenser will be pumped by condensate extraction pumps to the HRSG deaerator. The deaerated water will be pumped to the HRSG drums by feed water pumps

and thus a steam feed water cycle will be completed. All existing feed cycle equipments and piping will be retained and used in proposed repowering of Unit 4.

180. In combined cycle power plants the heat rejected by the higher temperature cycle is recovered and used by the lower temperature cycle to produce additional power and gives high efficiency. Some of the common advantages of combined cycle over conventional reheat cycle (steam turbine) are presented below:

- The efficiency of the combined cycle plant is better or higher than the turbine cycle or steam cycle plant.
- The capital cost of combined cycle power plant with supplementary firing is slightly higher than the simple gas turbine plant and much below those of the classical steam turbine power plant of the same capacity.
- The combined cycle power plant is more suitable for rapid start and shutdown than the steam power plant. Therefore these plants accepts load variations quickly and helps in maintaining the stability in the electrical grid.
- The cooling water requirement of the combined cycle plant is much lower than the normal steam turbine power plant having same capacity output. In these type of plants almost 2/3rd of the power is generated by the gas turbine plant which requires very little or no cooling water. Conventional cooling water system (once through) or recycle system is adopted. In case of lack of sufficient water at the site, dry cooling system can also be provided for cooling. Less water requirement for combine cycle plants is also major advantage while selecting the site of the plant.
- The combined system offers self-sustained feature. For example if the plant is shut down due to any fault or maintenance, no start up power supply can be required to start the unit. Gas turbine offers to start the plant and supply power to plant auxiliary loads. Therefore combined cycle plants has advantage of self sustaining feature.
- Maintenance duration (down time) for combined cycle power plant is significantly low. This improves the plant availability feature
- The superior efficiency of the combine cycle power plants over conventional reheat cycle plants not only conserves the fossil fuels but also drastically reduces the emissions and waste per unit of electricity generated.

4.2.7 Improvement of Existing Steam Turbine

181. Due to the fact that the repowering option must operate for at least 20-25 years, it is advisable to keep the process conditions below the design conditions. As a starting point the steam from the HRSG will have a temperature of 530 ºC. The pressure of steam produced by the existing boiler will not exceed 120 bars (the pressure which will arise depends on steam turbine load and function of the steam control valve). The original design for the steam turbine is 540 ºC and 130 bars.

182. The stack temperature of the HRSG can be quite low due to the condensate temperature of 40-45 ºC from the condenser. The total heat to be delivered by the HRSG with or without additional burning has to be according to: (a) heating up condensate to saturated water and a pressure of about 125 bar (drum pressure) including evaporation heat and superheating of the steam takes about 3,245 kJ/kg energy and (b) reheating a thermal input in the water/steam system for a flow of ~125 kg/s, which is about 460 MJ/s.

183. These considerations have led to the following assumptions for the steam turbine:

- Approximately 125 kg/s of steam;

- Steam temperature of 530 ºC;
- HRSG exhaust gas inlet temperature minimal of 570 ºC to produce the needed steam temperature.

184. The most obvious approach for the existing steam turbine would be to rehabilitate without major efficiency modifications. It is therefore recommended to slightly de-rate the original steam parameters of the turbine. A slight de-rating will be necessary as it will be difficult to find a gas turbine of proven design with an exhaust gas temperature over 560 - 570 °C, unless duct firing is added to the HRSG. Duct firing however has a consequence of more complex HRSG. Another, beneficial effect of de-rating is that the remaining life of the high temperature turbine parts increases. With this in mind, de-rating with 10 °C in steam temperature and ~10 bar in pressure for the HP-steam and 10 °C and ~5 bar for the IP steam are recommended.

4.2.8 Description of Major Sub-systems

a) Power station facilities

185. The gas turbine and HRSG will be designed in a way that the generated steam amount and conditions match with the requirements of the existing steam turbine producing the highest feasible output. The original steam turbine, condenser and its auxiliary equipment can be used. The new gas turbine and HRSG can fit in place of the existing boiler. The new gas turbine transformer will be connected to the external grid. The existing station transformers can stay in place. Modifications for this option will be as follows:

- Installment of new gas turbine + generator + HRSG,
- Adjustment in balance of plant (BOP) in case of higher condensate flow,
- Large expansion switch yard and grid due to augmented power output,
- Possibly a gas compressor needed to augment natural gas pressure for gas turbine(s),
- Control system has to be renewed. The same system is not available anymore, and control system has to be modified because of incorporation of Gas Turbine,
- Bypass stack(s) for flexibility, shorter start-up time, gas turbine(s) can run in open cycle mode,
- Demolition of existing boiler and parts of BOP, and
- Overhaul steam turbine, bringing back close to original efficiency.

b) Plant control system

186. In full repowering,a digital PLC based distributed control system compatible with the HART communicator and with analogue to digital converter and vice versa is proposed. An interface will be developed to integrate the old and new digital control system as a mitigation measure.

187. The plant control system will be integrated with the control, instrumentation and alarm equipment of the plant, to maximize automation of the plant. The design of the control and monitoring system as well as its constructive feature will be guided by the following principles:

- Standardization and interchangeability,
- Modular concept of control system,

- On line testing of critical parameters, and
- Fail safe operation.

188. The plant system consists of redundant controllers. The control system will be designed in distributed process control system based on the microprocessor technology and will be operated by auto/manual operations on the monitor located in UCR.

189. The Distributed Control and Information System (DCIS) will be provided for control & monitoring of the combined cycle power plant. The manufacturer's standard packaged control system will be provided for GTG's, HRSG etc., for respective control and monitoring facilities. However, a standard control system will be required to be procured for the steam turbine and generator. The standard packaged control system includes instrumentation and alarm system and is integrated with the DCIS for centralized control, monitoring, and supervision. The DCIS will provide for the safe, efficient and reliable operation of the plant. It is integrated with subsystem control of steam turbine, generator, gas turbine and HRSG with their packaged auxiliaries systems control and supervision will be performed by this integrated plant control system. The DCIS will provide modulating and digital control monitoring, alarm, indication and data acquisition for overall CCPP and its auxiliaries.

190. The DCIS operator stations, ST operator stations, and GT operator stations will be placed in the UCR. The local control stations for GT will be placed in GT local electrical and control enclosure close to the GTG. The DCIS provides for supervisory control to the GT, ST and other essential packages. The HRSG will be controlled directly from the DCIS.

191. During normal operation of the plant the operator carries out his tasks from the UCR. The essential plant operation and management functions of start-up, shut down, and normal load operation will be done with the operator of the DCIS.

192. The auxiliary package control system will have redundant control systems to avoid plant outage in case a single controller fault causes trouble for continuous operation of plant.

c) Functional Description of Control and Information System

General

193. Centralized supervision and automatic operation of plant startup, shutdown, and normal load change will be performed by the use of operator stations through the Distributed Control and Information System (DCIS). The DCIS functions will include control, monitoring and data blogging.

194. The control system for load output is only adjusted by the power output from GT controller. The steam turbine valves are normally full-open and the power output is adjusted according to the amount of heat supplied from the GT system. The steam cycle is operated with sliding pressure and the steam turbine inlet valves are fully opened for high efficiency and low wetness at the steam turbine exhaust during normal partial load operation.

195. The DCIS integrates the total plant system. The DCIS will provide automatic operation and supervision ranging from unit start-up, load operation and unit shutdown.

196. The functions of plant control are as follows:

- Automatic Plant Start-up/Shutdown Control (APS)
- Automatic Power Regulation Control (APR)
- Modulating Control
- Binary Control

Automatic Plant Startup/ Shutdown Control (APS)

197. Automatic plant startup/shutdown control function (APS) is provided in order to control the startup and shutdown of the gas turbine, HRSG, and steam turbine. The APS produces the command signals for each control system, including gas turbine control system, HRSG control system, steam turbine control system and auxiliary control system after completion of manual preparation steps.

Automatic Power Regulation Control (APR)

198. The APR will modulate the generating unit equipment as a whole including the gas turbine generator and steam turbine generator. The APR is designed to accept unit load demand signal (MW) from central load dispatch system, or unit load demand setting by the operator. Commands to increase or decrease power generation are usually received as a series of pulses representing an increment of generation (e.g., MW/pulse). APR produces demand signals for gas turbine from unit load demand. The maximum load demand signal is limited to unit load, which is achievable with the equipment currently in service.

199. The APR includes provisions for automatic control or for manual control of any element of the process equipment by the operator at the unit control console. The operator interface will permit the operator to adjust the following factor:

- Maximum and minimum unit load limits
- Maximum load rate or change
- Manual load set points
- Central load dispatch system (enable/disable)

Unit Protection System

200. Unit protection scheme is applied to assure safe operation of the overall plant. This system will consist of Steam Turbine trip interlock and HRSG trip interlock system. The critical plant safety system of GT, HRSG, and ST will be configured in triplet channel with 2-out-of-3 redundant sensors. Once the emergency shutdown has been set, then the plant is blocked from restarting again until the fault is rectified and acknowledged by the operator.

Conversion of manually operated valves into electrically driven valves

201. Most of the valves of the turbine house including all drain valves are manual operated. For a fully automated system all these valves are to be converted to electrically driven valves. However, this matter is to be taken up during designing of the repowering unit.

d) Cooling water system

202. The existing cooling system is a once through cooling system using about 8.9629 m^3/s of water from the Shitalakhya River. River water is first siphoned to the pump suction pit and then pumped to the intake channel by two pumps of 16,200 m^3/h capacity each. Unit 3 and 4 are cooled by cooling water towers or direct cooling depending on the amount of river water available. The cooling system is a common system so each unit can take cooling water out of the common cooling system. The cooling towers comprise of five open air coolers (one is spare), each with 6 fans. The drain of the cooling system and the evaporation losses are supplied by water from the river. The cooling water after extracting heat from condenser flows through the open channel and divides into two parts. One part is sent to the nearby agriculture field and the other part finally discharges to the downstream of the River. The typical temperature of cooling water discharge is about 38^0C. The locations of outfalls

and irrigation discharge is presented in Figure 4-3. In case of non-availability of any pump, the shortage of cooling water is compensated by using the standby cooling tower.

203. The existing cooling tower will be refurbished by maintenance work and replacement of blower fans and motors including the induced fan. Existing cooling systems will be augmented by the construction of new towers to meet the required capacity of close-cycle cooling of Unit 4 repowering.

e) Central Water treatment system

204. A central water and effluent treatment plant (CETP) is recommended for Unit 4 repowering. The CETP will be an integral part of the Environmental Infrastructure of the Unit 4. This centralized facility will meet all statutory norms laid by the DoE. It will be a state-of-the-art technology based on Sequential Batch Reactor (SBR) System. It will be an environmentally sustainable and cost viable system for the collection, treatment and ultimate discharge of effluents from the Unit 4. The CETP will consists of the following systems:

205. **Water supply and treatment system**: There are two sources of water supply; (i) Shitalakhya River for once through condenser cooling and other cooling system like ST generator auxiliaries, GT generator auxiliaries, gas boosters and etc., and (ii) existing plant's coagulated water (based on the experience of Ghorashal Unit 3, this may be finalized during Contractor's bidding) with due treatment in water treatment plant (WTP) shall be used for production of demineralized water for HRSG make up and cooling system makeup. Coagulated water will also be used as make up water of cooling tower, service water and potable water. The effluent from the water treatment plant and other places like clarifier is collected in the neutralizing tank where the sludge gradually settles at the bottom of the tank and after couple of years the sludge is collected and buried in the southwest side of the existing pond within the GPS property line.

206. The typical water balance for the GPS (including proposed Unit 4 repowering) is presented in Figure 4-4. The generated waste water from various sources including runoff, sewerage, and cooling system can be reused as cooling tower makeup or discharged to the Shitalakhya River after proper treatment and meeting the DoE's standard for effluent discharge in Inland Water.

207. **Raw and waste water treatment system:** Waste water treatment system comprises of clarifiers, filters, chlorination plant, de-mineralization plant, liquid waste effluent treatment plant and etc. No waste water shall be discharged to the river without appropriate treatment and satisfying effluent standard as defined in ECR 1997.

208. **Clarifiers** remove large quantities of suspended and organic matter from the raw water. The type of clarifier to be used is dependent on the level of suspended solids and type of suspended materials in the water.

209. **Filters** (after clarification) are required for removing a large percentage of suspended particulate from the water by straining it through various media. The type of filters to be used will be based on flow rate, the quality and properties of water.

210. **De-mineralization (DM) Plant:** The configuration of De-mineralization plant is as follows:

a. Pre-treatment have two number clarifiers.
b. Mechanical filters- 3 nos.
c. Cation first Stage- 3 nos.
d. Cation second stage- 3 nos.

e. Anion first stage- 3 nos.

f. Anion second stage- 3 nos.

g. Mixed Bed- 3 nos.

211. Demineralization is the process of removing mineral salts from water by using the ion exchange process. Demineralized water is completely free (or almost) of dissolved minerals and is used as feed water makeup for HRSGs. It includes degasification and polishing. During normal operation stream, two clarifiers remain in service and one as stand by. Capacity of present plant is 250 m^3/h. This should meet the make-up water requirement of all four units. When all four units were operating at rated load, it was difficult to meet the requirement of makeup water (this was observed in past when all four units were operating at 210 MW).

f) Augmentation of DM water capacity for full repowering

212. As mentioned above, it is difficult to meet makeup water requirement of all four units with the present DM plant. DM water requirement will be increased after full repowering of Units 3 and 4 and addition of new 365 MW combined cycle unit. The following parameters should be considered to design a new DM Plant:

- The auxiliary cooling water for present gas turbine accessories requires treated DM water. The amount of water requirement shall be worked out during detailed engineering stage.
- Due to this additional DM water requirement, new plant shall be installed at appropriate location. DM Plant capacity shall be decided whether all four units are likely to be converted by full repowering.
- It is proposed that a Reverse Osmosis (RO) plant is established for combine use of the entire plant to replace current resin based demineralization. The plant capacity can be finalized based on the detailed design. Economic analyses has demonstrated that when the total dissolved solids content of feed water is above 200 mg/l, RO is the most cost-effective demineralization technology.[16] Based on the water quality analysis TDS content observed is between 210-239 mg/l.

213. **Effluent Treatment Plant/system** to be provided to maintain the standards of Industrial Waste as mentioned in the Environment Conservation Rules, 1997 and amendment, 2005. A central monitoring basin (CMB) of RCC construction shall be provided to collect all plant effluents. Quality of the effluents shall be measured, monitored and treated. Through a set of waste effluent disposal pumps and piping, the effluents shall be disposed of from CMB up to final disposal point at a safe distance.

g) Septic tank and sewage handling

214. The sludge to be generated from the proposed repowering will be treated and discharged into the underground pit with concrete revetment or encircled with durable polythene sheet. For monitoring the effluent quality, a monitoring system has also been considered in the design. As long the effluent shall be discharged satisfying ECR, 1997

[16] The Dow Chemical Company (2009-2013), http://www.dowwaterandprocess.com/en/Industries%20and%20Applications/Industrial_Water/Boiler_Feed_and_Process_Water/Demineralization/Reverse_Osmosis, Page visited on May 16, 2015

defined standard, there will be no danger to existing water systems in the project area. The following measures are included in the project design:

- EPC Contractor will provide septic tank for a building or cluster of buildings or connect to existing septic tank depending upon the layout to be decided during detailed engineering for the new buildings. The maximum size of septic tank is foreseen to be 4.6m × 1.15m.
- The sludge removal from the septic tanks is expected to be done once a year or as per the requirement of local laws and regulations by the Project Proponent.

h) Sludge from water and effluent treatment plants

215. Sludge may be generated from a number of sources of the proposed power plant. These are: raw water pre-treatment plant or clarifier, water treatment plant, effluent treatment plant, cooling tower blowdown, and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from power plant operations. It needs to be evaluated on a case-by-case basis to establish whether it constitutes a hazardous or a non-hazardous waste.

216. About 0.0036 m^3/s of wastewater is generated in the pre-treatment system which will be transferred to the effluent pit. About 0.0034 m^3/s of wastewater will be transferred to effluent pit from reverse osmosis system. The sludge generated in the effluent pit will be transferred to effluent treatment plant prior to dispose to the environment after ensuring ECR 1997 standards.

217. Possible components of sludge may include; asbestos, oil and grease, chlorine, copper, zinc, lead, arsenic, mercury, lead, suspended solid particles, sewage, demineralizers, and other chemicals used to manage the quality of water in feed water and cooling systems. Sludge characterization (analysis) will be done to determine various contents, both hazardous and non-hazardous. Some of the analysis may include BOD, COD, presence of coliform, metals (iron, copper, lead, mercury, arsenic etc.) etc. to determine the hazard potential of the sludge. It may affect the groundwater quality and receiving water bodies if comes into contact to the sludge. Appropriate treatment measures will be taken based on the sludge characteristics, to treat them prior to final disposal to the natural environment.

218. The chemical and oil contaminated water will be collected separately and treated in specialized plants within the CETP. All oil contaminated drains from process area (HRSG, turbines, steam turbine hall, storage tanks, etc.) will be collected in retention basins of sufficient size and will then be treated by oil separators.

219. All waste containing particles shall be collected and treated in the collection and sedimentation tank or basin of the sludge treatment plant before discharge. The collection and sedimentation tank or basin shall feature sludge scrappers at the bottom. The Contractor may enhance the process by dosing coagulant or flocculent into the tank or basin, primarily to collect metals and suspended solids. The clear water effluents are then transferred to the central effluent monitoring sump, where these are further monitored and treated for bacterial contents before being discharged into the river.

i) Natural gas pipeline relocation including RMS

220. At present the gas is supplied to Ghorashal power station by Titas Gas Transmission and Distribution Co. Ltd. (TGTDCL) of Petro Bangla through a 16˝ diameter pipeline and Regulating and Metering Station (Titas RMS) situated in the Northeast corner of the Ghorashal Power Station.

221. In the existing distribution system, gas from the Titas RMS flows to the Gas Distribution Plant (GDP 1-5) via gas metering and regulating sections through a 1.8 km long 10″dia pipe. Gas through GDP-2 goes to Units 3 and 4.

222. The proposed GT needs a stable gas pressure of 30 bar and hence installation of a gas booster has been proposed. Due to the space restriction in the existing Titas RMS, a new gas station is needed and will be installed in the space available at the Northeast of the unused fuel oil tanks, i.e., in the Northwest of the proposed HRSG site. A 16″ diameter gas pipeline from inlet header of the Titas RMS up to the bus of the proposed gas station will be constructed. A Layout map of the proposed repowering is presented in Figure 4-3 and shows the existing and new RMS. From this bus, a number of gas pipelines will be branched out and will lead through individual gas compressor and associated facilities to the individual unit to be repowered. It is considered that noise generated from the RMS is 100 dBA and from associated gas pipes are 90 dBA. The proposed gas supply arrangements are shown in Figure 4-7.

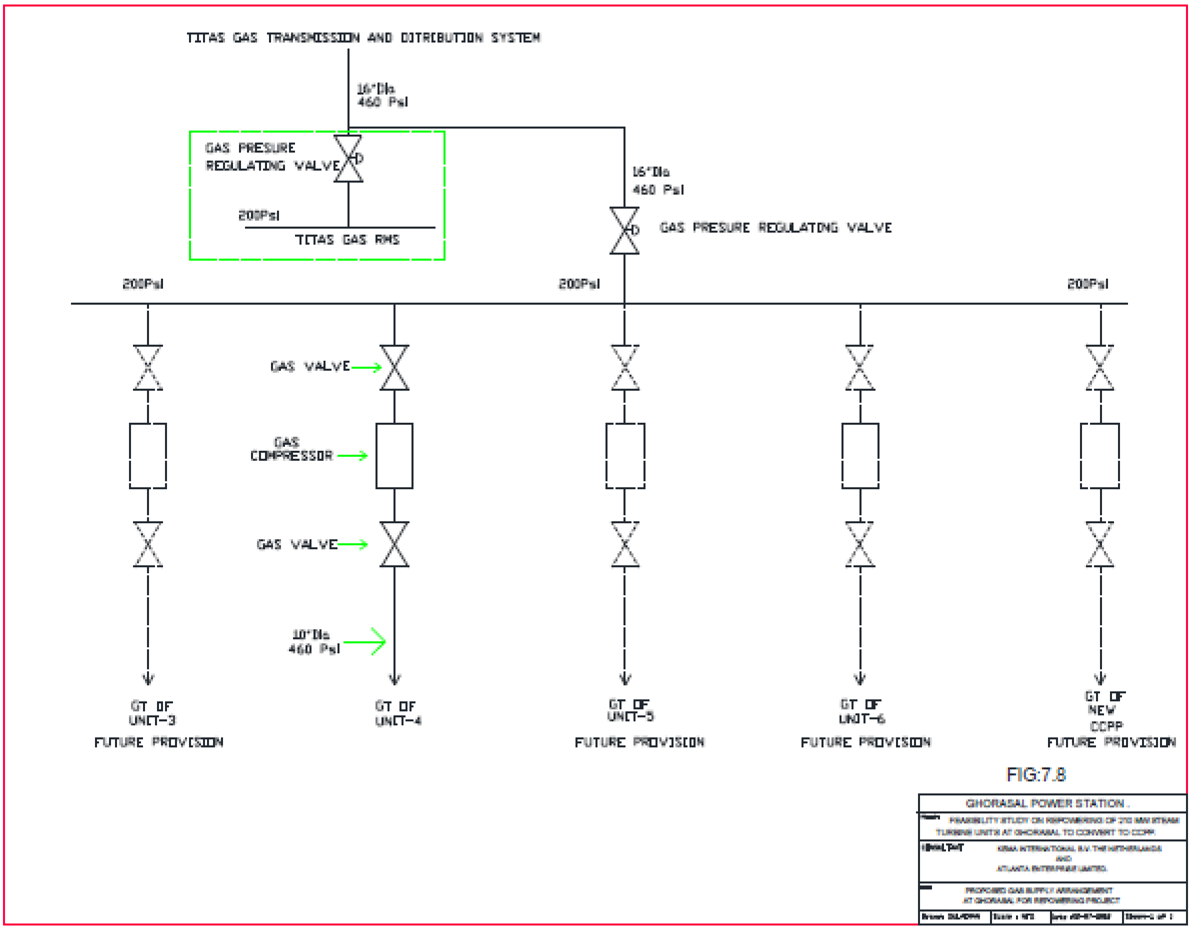


Figure 4-7: Proposed gas supply arrangements

j) Transportation of large equipment

223. Both Chittagong and Mongla sea ports are well connected to Ghorashal Power Station through rail, road, and waterways. For transportation of heavy equipment for the proposed repowering of 128 MW and 298 MW gas turbines, both Chittagong and Mongla ports can be used and subsequently river transportation to GPS is the best transportation route.

224. There is a heavy capacity jetty at the river side very close to GPS site with a 125 ton capacity crane on the jetty. But the condition of the crane is poor and cannot be used without

major overhauling. The capacity of the crane even after overhauling will be very much limited and may not be suitable for handling major equipment. Moreover, the Jetty will also need strengthening. The heaviest piece of cargo of the proposed repowering plant would be around 300 tons. The site of the proposed power plant is about 750 m from the jetty. The heavy cargoes may be unloaded on the jetty by a crane of appropriate handling capacity which will be brought with the barge or rented from other sources at home or abroad.

225. The River Meghna is navigable throughout the year for transporting large cargoes. The River Shitalakhya is also navigable during the monsoon period for 500 to 1000 ton barges up to GPS site. So, it will be advisable to schedule the transportation of heavy cargoes during the monsoon season. There exists free space at the jetty site for unloading cargoes by crane and transport them to the plant site by a low buoy truck. Only some civil concrete pillars need to be dismantled on the way to GPS.

k) Firefighting and emergency management

226. Fire hazards are generally reduced through proper handling and storage of flammable materials. For fire prevention and reduction of fire risk, it is required that all fuel and ignition sources be removed from the site or reduced as much as practically possible.Smoking is only allowed in designated areas as identified in the Emergency Response Plan (ERP). For emergency firefighting, a diesel engine for running at off grid system was setup during plant erection of Units 1 and 2. The pump is now out of order from 2002 and there is no DC firefighting pump available.

227. Appropriate firefighting and protection systems must be designed and constructed for the proposed repowering. Standard local (e.g., Bangladesh National Building Code) and international codes will be followed for this purpose. Regular checking and monitoring of the firefighting equipment will be carried out during the operation phase of the project. Also, fire drills are planned in the ERP and will be carried out at regular intervals.

4.2.9 Material storage and handling

a) Hazardous Waste

228. Hazardous waste disposed at GPS includes asbestos sheets, and soot removed from the cleaning of the boilers operating on fuel oil. There is no facility available for storage of hazardous waste at the plant. Currently hazardous waste is buried underground in a location close to the jetty (Figure 4-8). A secured onsite asbestos disposal Facility will be constructed close to the existing disposal site to store the hazardous waste including asbestos, mineral wool, glass wool and etc. It is estimated that 50 tons of asbestos will be removed from the existing Unit 4 boiler insulation materials[17]. A partial list of insulation materials with quantity is presented in Table 4-4. The capacity of asbestos disposal facility should be designed to consider the hazardous waste generated from Unit 3 and future decommissioning of older boilers. The decommissioning Contractor of Unit 4 should coordinate with Unit 3 contractors to resolve any scheduling conflicts that may arise during these works. PCB containing equipment such as transformers and condensers are usually found in old power stations. However, GPS does not use PCB as coolants for transformers and there is no historical disposal or storage of PCB within GPS compound. Condensate is generated at gas regulating and metering stations, which requires proper handling and storage.

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[17] TOR of the EIA for GPS Unit 4 repowering.

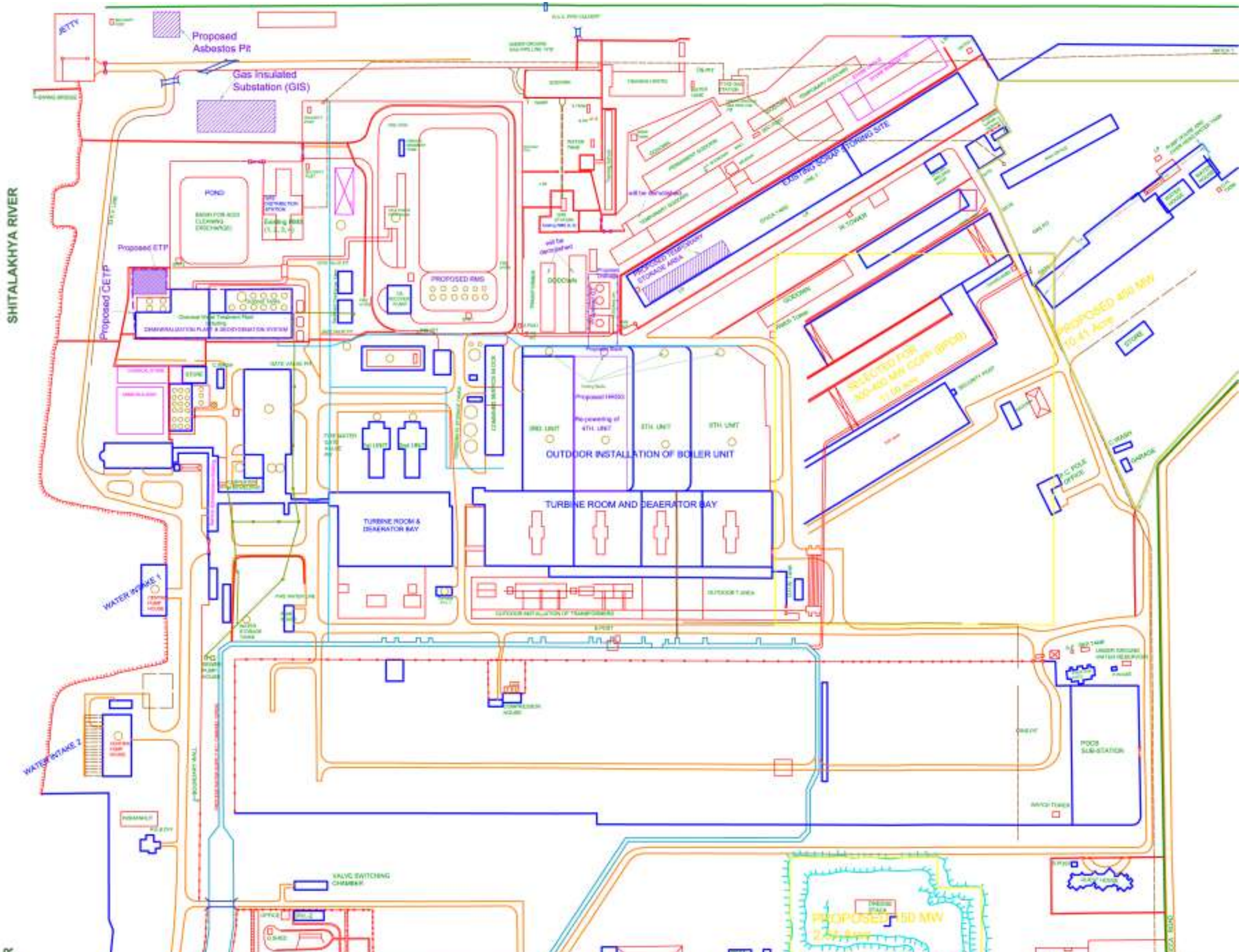

SHITALAKHYA RIVER
JETTY
Proposed
Asbestos Pit
Gas Insulated
Substation (GIS)
POND
Proposed ETP
Proposed CETP
PROPOSED RMS
GODOWN
OUTDOOR INSTALLATION OF BOILER UNIT
TURBINE ROOM AND DEAERATOR BAY
TURBINE ROOM &
DEAERATOR BAY
WATER INTAKE 1
WATER INTAKE 2
VALVE SWITCHING
CHAMBER
PROPOSED 450 MW
10.41 Acre
PGCB
SUB-STATION

Figure 4-8: Plant layout with important component

b) Non-Hazardous

229. Other non-hazardous solid waste generated at the plant includes mainly metallic wastes and other materials removed during plant maintenance and are currently stored in an open area located at the northeastern side of Unit 4. Approximately 1.55 ton/d of solid waste is produced from the GPS staff colony and 0.18 ton/d from the administrative building and other offices. Municipal wastes generated in the housing colony are stored in designated garbage disposal areas (made of concrete) for collection by the Ghorashal Municipality waste collection system.

4.2.10 Solid and liquid waste and air emission

a) Solid Hazardous Waste

230. About 50 tons of asbestos material will be removed from the boiler insulation material from Unit 4 boiler. This material will be temporarily stored in the laydown area and finally disposed at the proposed hazardous material disposal site close to the jetty area.

b) Solid Non-Hazardous Waste

231. Wastes generated during the construction phase (including decommissioning) of the project include boiler materials (containing large metal pipes, tubes, alloyed steel, carbon steel, zinc coated sheet), construction debris and wastes (e.g., scrap iron, wooden frames, glass canvas, etc.),and some other solid wastes (e.g., from construction camps). Non-hazardous solid waste will be disposed of at designated sites. Scrap material will be sold to recycling companies and the remaining waste will be collected by the Ghorashal municipality for final disposal to designated landfill sites.

c) *Sanitary Sewage*

232. Sanitary sewage will be generated from people working at the project site (e.g., from construction camps), and some liquid waste from construction activities. In addition, sanitary sewage will also be generated from the administrative buildings and staff colonies during the operation stage. The appropriately designed wastewater disposal facilities (septic tank system) of the proposed repowering will take care of the human wastes to be generated within the plant. It should be noted that human waste generated within the complex (e.g., from residential buildings, schools, power plant offices and other facilities within the complex) is disposed through a septic tank system. While the sullage is disposed of directly into the Shitalakhya river. Solid wastes, e.g., those from offices of the power plant, to be generated during the operation of the power plant will not be significant and should be handled locally.

d) Air Emissions

233. Air emissions will include those from the operation of construction equipment and machineries, vehicles transporting construction materials to the site and construction debris out of the site. If construction equipment such as stone (aggregate) crushers is used at the site, this may result in emission of particulate matter during its operation. Since construction of the proposed repowering would involve significant earthworks, an increase in particulates in the air from wind-blown dust will also be a concern, especially considering the close proximity of the high school and the staff colony (and also the residential area) to the project

site. During the operation phase, air emissions will also be generated due to the operations of the existing, repowered and new GPS units.

4.2.11 Water Balance

234. The plant liquid waste that will be generated during plant operation may include, but is not limited to (1) cooling water blow down, (2) demineralizer waste, (3) oily water and chemical area drains, (4) sanitary waste, (5) HRSG blow down and etc. An estimate of the amount of liquid waste to be generated may include cooling tower purge, water treatment plant rejection, HRSG purge and oily water. All plant process wastewater and industrial wastewater effluents shall be collected and treated by chemical neutralization, physical, chemical and biological treatment methods to comply with the effluent discharge limit criteria set forth in ECR 1997.

235. The existing water balance for the GPS and Unit 4 is summarized in Table 4-8. Current total uses of water for the entire GPS including the office use and staff colony are (40.30 m^3/s and 8.971 m^3/s for Unit 4 and the operation of the coagulator/clarifier where coagulated silt is removed and returned back to the river as coagulator blow down (0.002 m^3/s for GPS and 0.0004 m^3/s for Unit 4). Other uses include the boilers, offices, and the housing colony. The water balance presented in Table 4-8 is for the peak requirement in the month of July for existing GPS and Unit 4, and repowering of Unit 4. It is expected that due to repowering with close cycle cooling system there will be a significant reduction in water requirements of cooling water systems. In existing once through cooling system, water requirement for cooling water system is 7.6389 m^3/s while it is 0.38194 m^3/s in the proposed close cycle cooling system. Similarly, for auxiliary cooling, water requirement for existing unit-4 is 1.3056 m^3/s while it is 0.06528 m^3/s for the proposed system.

Table 4-8: Plant water balance

Items	**m^3/s**		
	Total GPS	**Existing Unit 4**	**Repowering Unit 4**
Supply	40.30	8.971	0.4686
Distribution			
Cooling Water System	34.29	7.6389	0.38194
Coagulator Flushing	0.002	0.0004	0.00036
Boilers (for existing) & HRSG (for proposed)	0.049	0.0108	0.01083
Other Plant Uses	0.033	0.0074	0.00742
Auxiliary Cooling	5.875	1.3056	0.06528
Offices	0.00633	0.0011	0.00083
Housing Colony	0.042	0.0070	0.00194
Total Distribution (A)	**40.30**	**8.971**	**0.46861**
Waste Generated			
Coagulator Blow Down	0.002	0.0004	0.00036
Other Plant Wastewater	0.0003	0.0001	0.00007
Auxiliary Cooling	5.8163	1.2925	0.06463
Other Water			
Condenser Cooling Water	27.22	6.04	0.000
Total Returned to the River (B)	***33.04***	***7.330***	***0.065***

Items	m³/s		
	Total GPS	Existing Unit 4	Repowering Unit 4
Boiler Blow Down and Demi Plant Waste	0.015	0.003	0.003
Office Septic Tanks	0.00146	0.000243	0.0002
Total to Evaporation Pond (C)	***0.017***	***0.004***	***0.004***
Wastewater Drained Outside from Office (D)	0.00487	0.00081	0.00064
Wastewater Drained Outside from Housing Colony (E)	0.042	0.007	0.00194
Total Wastewater (F=B+C+D+E)	**33.10**	**7.34**	**0.07**
Losses, Evaporation and Uses			
Condenser Cooling Water Evaporation	0.69	0.153	0.3056
Cooling Tower Blowdown	0.00	0.000	0.0764
Other Losses and Uses (Irrigation)	6.38	1.449	0
Other Plant uses	0.03	0.0073	0.0073
Auxiliary Cooling Evaporation	0.059	0.0131	0.00065
Boiler (for existing) and HRSG (for proposed) use	0.03	0.007	0.007
Total (G)	***7.20***	***1.63***	***0.40***
Total Waste, Losses and Uses (F+G)	**40.30**	**8.9711**	**0.4686**

4.3 Human resources required during construction and operation

236. The estimated number of workers required during (i) Construction and (ii) Operation phase are as follows:

- During construction, EPC contractor is expected to have manpower around 700 at peak, including unskilled, skilled, supervisors, engineers, management staffs, etc. BPDB employees will be around 35.
- During O&M phase, EPC Contractor will employ 3 persons for the period of warranty (i.e., 2 years from plant take over) and BPDB employees are expected to be around 219 (139 present + 80 additional).

4.3.1 Construction Labor Camp

237. Ghorashal is an industrial area located in Ghorashal Municipality. Many workers skilled or unskilled from different parts of Bangladesh come to Ghorashal for work. They live in rented houses on monthly basis locally available and work in the industries. Renting houses has become a lucrative additional source of monthly income of the local people. During site visit and discussion with the local BPDB authority it is learnt that the EPC contractor can easily rent houses and accommodate all workers with water, electricity and sanitation facilities just outside the boundary of Ghorashal power station.

4.4 Operation and Maintenance

238. The actual operating times of the power station will be largely dependent on supply and demand conditions in the electricity market. Peak use typically occur during morning and afternoon periods during the summer and winter months. However, the power station is required to be available to operate at any time should it be required to respond to system

emergency or security situations. Economically, the power station is very unlikely to increase its operation to intermediate or base load operation due to the high operating costs of the facility and due to the low efficiency.

4.4.1 Emission Control system (Units and Devices especially for NO_X reduction)

239. Natural gas of Bangladesh is known as sweet gas. Its sulfur content is negligible and hence the emission of Sulphur dioxide (SO_2) is negligible and emission of particulates (PM) is fairly low. Modern Gas turbines are provided with dry low NO_X burners to keep the NO_X level below 25 ppmv. During repowering, dry low NOx burners will be installed to reduce NOx emissions.

4.4.2 Emission Monitoring System

240. Online continuous emission monitoring system (CEMS) will be installed consisting of electronic emission analyzers like CO, CO_2, NOx, PM, SO_2 and etc. that will take flue gas samples from the stack. A periodic (once every shift) flue gas analysis will be carried out in the chemical laboratory to cross check the values obtained by the CEMS.

4.4.3 Environmental Quality Monitoring System

241. Two ambient air quality monitoring stations (to monitor CO, NOx, $PM_{2.5}$, PM_{10} and SO_2) and one weather station to monitor meteorological parameters (wind speed, direction, temperature, rainfall, humidity and etc.) are recommended in the project impact area. The locations of the stations will be based on the dispersion modeling output of maximum ground level concentrations in downwind directions. Noise level will be monitored at the same locations where environmental quality baseline monitoring were conducted. In addition, two monitoring wells are recommended, one close to the newly proposed hazardous waste disposal site and one close to the neutralization pond to monitor groundwater quality.

4.4.4 Power Evacuation

242. Power generated from the gas turbine will be evacuated through the proposed 230KV gas insulated sub-station (GIS) switchyard and 230 KV high voltage Tongi transmission line via 340 MVA unit transformer. While power generated from the steam turbine will be evacuated through the existing bay of the 230 KV Air insulated sub-station (AIS) switchyard via the existing 2x125 MVA unit transformers. Location of GIS and distribution line have been shown in

243. Figure 4-8. No land acquisition is expected for GIS.

4.4.5 Life Cycle Overview (including Decommissioning)

244. Project development for Ghorashal Unit 4 repowering has proceeded to preparation phase. There are a number of important points for the plant life cycle that must be carefully considered. These include (i) the current planning phase, (ii) decommissioning of boiler and old installations including re-orientation of gas pipelines, cable lines, overhead electrical lines, water pipelines, (iii) rehabilitation of steam turbine, (iii) replacement of existing old control system with state-of-the-art control system of STG and interfacing with GTG and HRSG, (iv) foundation of GTG, unit transformer, and HRSG, (v) erection of GTG, transformer, and HRSG, and (vi) decommissioning of the plant either completely or partially at the end of current economic life (25 years). In addition, energy consumption due to natural

gas feedstock including drilling/extraction, processing, and pipeline transport are also considered in the life cycle analysis.

245. A total overview of the full repowering option including the total plant output and efficiency under ambient conditions in repowering and averaged over the life time is shown in Table 4-9.

Table 4-9: Life cycle plant output and efficiency for repowering

Items	Unit	Impact	Outcome
Heat input gas turbine	MJ/s		668.5
Supplementary Firing	MJ/s		70.0
Total Thermal input	MJ/s		738.5
Natural gas consumption (LHV 950 BTU/scf) in the plant	MSCFD		67.3
Net output gas turbine, ambient conditions	MW		246.0
Gross output steam turbine, ambient conditions	MW		165.7
Auxiliary power (steam system, gas compressor)	MW		-8.2
Total net plant output, ambient conditions, repowering	**MW**		403.5
Impact of ageing and fouling	MW	3%	-12.1
Average net capacity over life time	**MW**		391.4
Net efficiency ambient conditions, repowering	**%**		**54.6**
Impact ageing and fouling	%	1.5%	-0.8
Average net efficiency over life time	**%**		53.8

System boundaries

246. An assessment is made to track the material and energy flows between the process blocks within the system and is presented in Figure 4-9. The solid lines in Figure 4-9 represent actual material and energy flows, while the dotted lines indicate logical connections between process blocks. The steps associated with obtaining the natural gas feedstock are drilling/extraction, processing, and pipeline transport.

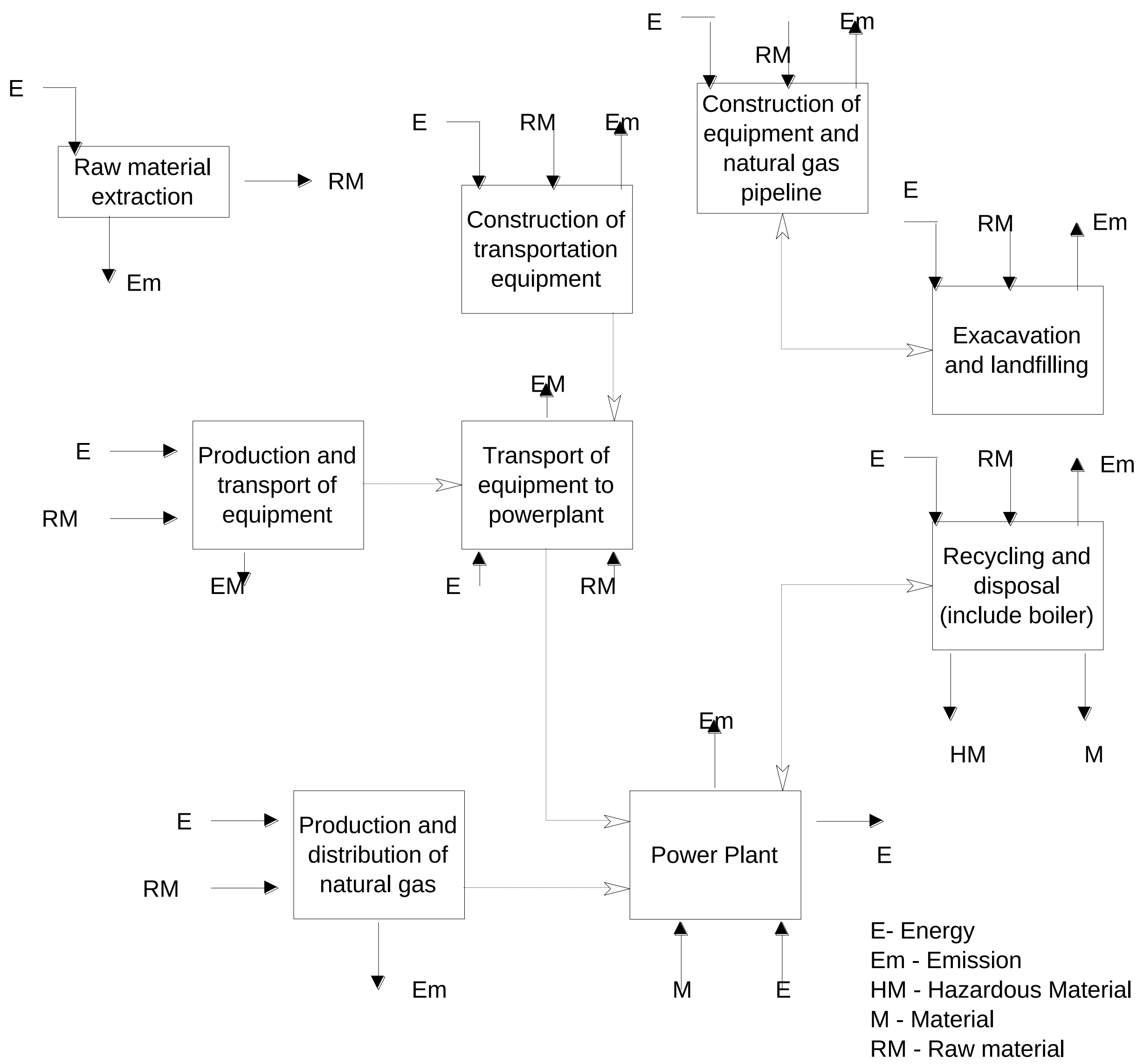


Figure 4-9: System boundaries for electricity production using natural gas combined-cycle process (including decommissioning)

Life cycle energy consumption and system energy balance

247. Table 4-10 shows the energy balance for the repowering system (LHV basis). The majority, 79.5%, of the total energy consumed is that contained in the natural gas feedstock. The upstream fossil energy, which accounts for 20.5% of the total energy consumption, includes the energy of the natural gas that is lost to the atmosphere.[18] Although not listed separately in Table 4-10, this energy loss is equal to 2.2 MJ/kWh or 1.4% of the total energy consumed by the system.

[18]Spath, P. and Mann, M. (2000); Life Cycle Assessment of Natural Gass Combined Cycle Power Generation System, NREL, Colorado, USA.

Table 4-10: Average Energy Requirements per kWh of net electricity produced (LHV basis)

	System total (MJ/kWh)	% of total	% of total from construction & decommissioning (a)	% of total from natural gas production, distribution and use
Energy in the natural gas to power plant	8.53	79.50 %	N/A	100.00%
Non-feedstock energy consumed by system (b)	2.20	20.50 %	1.40%	97.90%
Total energy consumed by system	10.73	N/A	N/A	N/A

248. The energy use within the system was tracked so the net energy production could be assessed. Several types of efficiencies can be defined to study the energy budget. As stated earlier, the power plant efficiency for this repowering system is 54.6% (LHV basis). This is defined as the energy to the grid divided by the energy in the natural gas feedstock to the power plant. Four other types of efficiencies/energy ratios can be defined as shown in Table 4-11.

Table 4-11: Energy Efficiency and Energy Ratio Definitions

Life cycle efficiency (%) (a)	External energy efficiency (%) (b)	Net energy ratio (c)	External energy ratio (d)
$= \frac{E_g - E_u - E_n}{E_n}$	$= \frac{E_g - E_u}{E_n}$	$= \frac{E_g}{E_{ff}}$	$= \frac{E_g}{E_{ff} - E_n}$

where: -

E_g = electric energy delivered to the utility grid

E_u = energy consumed by all upstream processes required to operate power plant

E_n = energy contained in the natural gas fed to the power plant

E_{ff} = fossil fuel energy consumed within the system (e)

Notes:
(a) Includes the energy consumed by all of the processes.
(b) Excludes the heating value of the natural gas feedstock from the life cycle efficiency formula.
(c) Illustrates how much energy is produced for each unit of fossil fuel energy consumed.
(d) Excludes the energy of the natural gas to the power plant.
(e) Includes the natural gas fed to the power plant since this resource is consumed within the boundaries of the system.

249. The net energy ratio is a more accurate and rigorous measure of the net energy yield from the system than the external energy ratio because it accounts for all of the fossil energy inputs. However, the external definitions give a better understanding of upstream energy consumption. It is important to have these four definitions because the fossil fuel fed to the

power plant overshadows the energy consumption from other process steps. Table 4-12 contains the resulting efficiencies and energy ratios for the system, given on an LHV basis.

Table 4-12: Efficiencies and Energy Ratio Results (LHV basis)

System	Life cycle efficiency (%)	External energy efficiency (%)	Net energy ratio	External energy ratio
Re-powering	-51.66	48.34	0.39	1.92

250. Since the natural gas is not a renewable resource, the life cycle efficiency (which gives the total energy balance for the system) is negative, indicating that more energy is consumed by the system than is produced in the form of electricity. Excluding the consumption of the natural gas feedstock, the low values of the external energy efficiency and the external energy ratio indicate that upstream processes are large consumers of energy. Although not derived from the information in Table 4-12, disregarding the energy in the natural gas feedstock, 97.9% of the total energy consumption comes from natural gas production and distribution (Table 4-10). This process block can be further broken up into natural gas extraction, processing, transmission, storage, and distribution. Of these, the largest consumers of energy are the natural gas extraction and pipeline transport steps. Diesel oil is combusted to meet the energy requirements of the drilling equipment, while pipeline transport uses a combination of grid electricity and natural gas to move the natural gas from its point of origin to its destination. Additionally, the net energy ratio in the Table 4-12 shows that for every 1 MJ of fossil energy consumed 0.39 MJ of electricity is produced.

5. Analysis of Alternatives

5.1 Introduction

251. This chapter presents alternative analysis of the Project components in terms of infrastructure sitting, selection of repowering options, technology options, selection of cooling water system , various water and effluent treatment system, and a comparison with 'no' Project scenario. Alternatives are compared in terms of potential social and environmental impacts, costs, technical requirements, constructability, operation and maintenance requirements. The alternative analysis has been carried out in reasonable detail to enable the Power Development Board, World Bank and other stakeholders, if any, to appreciate the recommended options and confident on the preferred options. Further details about the selected options are included in other chapters of this report.

5.2 Framework for Assessment of Alternatives

252. Consideration and evaluation of project alternatives are important parts of the environmental and social impact assessment process. An alternative analysis has been conducted in terms of project options including: location, repowering options, technology selection, cooling water system, water and effluent treatment system, and operation and maintenance procedures. A comparison of the proposed project alternatives is made with the without-project alternative to provide a fuller picture of the pros and cons of implementing the proposed re-powering project. Alternatives are compared in terms of technical requirements, e.g., constructability, operation and maintenance, economic and financial viability, and potential environmental and social impacts (Table 5-1). The overall feasibility of the project alternatives is considered based on the combination of the criteria upon which the alternative components are evaluated.

253. This chapter provides an overview of considered alternatives, with particular attention to environmental and social impacts accounted for in the evaluation and selection process and potentially needing mitigation during project implementation.

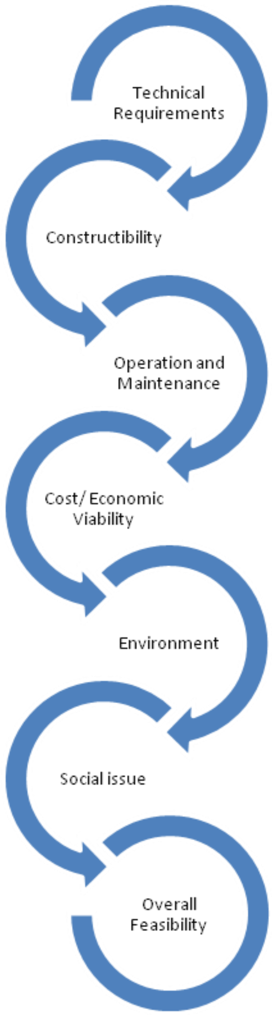


Table 5-1: Criteria and sub-criteria used in evaluating project alternatives

Criteria	Sub-Criteria
Technical Requirements	Life time extension
	Capacity/output
	Efficiency improvement
	Fuel Consumption / energy requirements
Constructability	Suitability of construction/erection
	Materials/ Machineries required as per the considered options are available.
	Disposal of non/hazardous waste
Operation and Maintenance	Availability of fuel
	Automated Control System
	Operation and maintenance ease.
Cost / Economic Viability	Construction Cost
	Operation Cost (including Maintenance and Energy Cost)
	Economic rate of return
Environment	Air pollution and noise
	GHG emission benefits
	Benefits in thermal pollution
	Solid waste
	Centralized water/effluent treatment system
Social	Improved Power Supply Security
	Employment Potential

5.3 Without Project Alternative

254. No project alternative in simple term means without implementing the proposed project of re-powering and converting the plant to a combined cycle plant.

255. This without project scenario is not recommendable because at present Bangladesh is suffering from acute shortage of electrical power which is seriously hindering the economic growth of the country as well as achieving the Government's millennium development program. This project is a part of total effort of BPDB to achieve the targeted generation of 34,000 MW by 2030 in a most economic and efficient way and fulfillment of Government's commitment to provide electricity to all by 2021.

256. Implementation of the project will increase the present power plant generation from 180 MW to 404 MW (gross). If the project is not implemented the plant will remain in its present low efficiency level with 180 MW derated capacity and augmented generation of about 224 MW due to combined cycle technology with relatively less fuel requirements will be lost.

5.3.1 Environmental and Social Impacts of Without Project Alternative

257. The without project alternative has some positive impacts (benefit) that it will avoid the negative impacts of the project implementation during decommissioning of boiler, construction and operation phase such as generation of hazardous waste, fugitive particulate matter, gaseous pollutants, release of solid waste, toxic chemicals etc. However, these are limited to decommissioning and construction period only and are mitigable with proper mitigation and compensation measures. The most significant negative impact of the

without project alternative is the continued thermal pollution of Shitalakhya River water through warm effluent discharge generated from the condenser cooling. Potential of hydrazine based deoxygenated water and resin based demineralization effluent discharge to the river.

258. The most important negative social impacts of no project alternative are the loss of new job opportunity of un-skilled, semi-skilled and skilled people and the loss of additional economic activity in the communities and national development from the augmented power generation.

5.4 Repowering Options

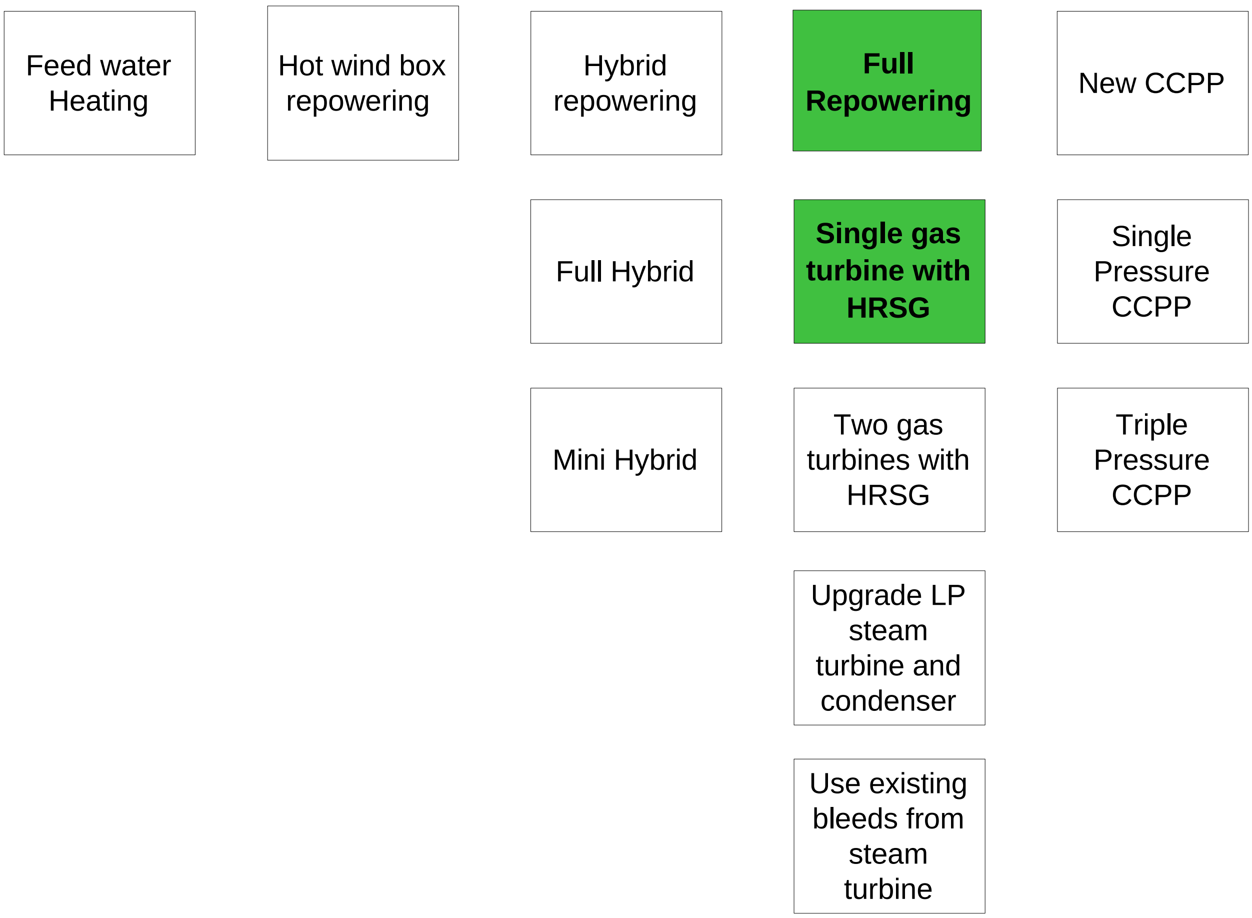


Figure 5-1: Different repowering options

259. Different repowering options are presented in Figure 5-1. The green shaded box was finally chosen as the best option. The following sections provides the process configuration of each of the options. The advantages,disadvantages and investment costs are discussed for each option and the preferred alternative was chosen that was taken for investigation for repowering of GPS.

5.4.1 Feed water heating

260. For feed water heating repowering a new gas turbine is required, in which the heat in the exhaust gas is used to heat the feed water. Therefore, the quantity of steam extraction from the steam turbine bleeds to the feed water heaters is reduced or eliminated. This steam can expand to the condenser and produce additional power in the steam turbine. The

increased power output of the plant comprises of the power generated by the gas turbine and the additional power of the steam turbine. Feed water heating will increase the efficiency with 2 to 4 percent.

261. Advantages of this option will be:

- Small efficiency increase 2 to 4% points because of usage of a gas turbine cycle which has a higher efficiency than a conventional cycle
- Investment would be relatively low compared to other options.

262. Disadvantages of this option will be:

- Small increase of power output
- Small efficiency increase
- The gas turbine would be very small because it is only used for feed water preheating.
- The power output of the steam turbine would become lower if no modifications are applied. This is because the turbine bleeds will be closed. Because these bleeds are closed, less steam can be fed to the high pressure and intermediate pressure cylinders.

263. Because of many limitations and disadvantages of feed water preheating, this option was not studied further.

5.4.2 Hot Wind Box Repowering

264. Repowering installation of a new gas turbine is required. The exhaust gas is used as hot combustion air for the existing boiler. The exhaust gas could be pre-cooled before entering the existing boiler. The original fuel is still burned in the boiler. The efficiency will increase with 4 to 5 percent with hot windbox repowering.

265. Advantages of Hot Windbox Repowering are:

- Total efficiency of the power plant will increase with 4 to 5%.
- Old boiler can be re-used but have to be modified
- O_2 content in the flue gases of the gas turbine can be used for burning of the fuel in the boiler
- The regenerative air pre-heaters are not used anymore because the exhaust gases from the gas turbine have a temperature of 400 ºC to 550 ºC, depending on the gas turbine chosen
- Because of the lower oxygen content of the exhaust gases less fuel can be combusted, resulting in a lower average boiler temperature and strong decrease of the NOx emissions.

266. Disadvantages of Hot Windbox Repowering are:

- Hot windbox repowering of the units shows a relatively large reconstruction and extension works of the existing boiler
- A gas turbine has to be selected with approximately the same exhaust gas quantity as the design combustion air quantity of the boiler. This will give a relatively small size of the gas turbine compare to the total size of the plant

- The total power output will only be slightly higher compare to the original power output because the steam turbine will produce less power
- This efficiency gain is mainly due to shifting of fuel supply from the steam process to the gas turbine process. Moreover, hot exhaust gases from the gas turbine considerably reduce the fuel supply to the boiler. However, it is essential that the entire quantity of heat of the gas turbine exhaust gases is effectively used by the boiler steam turbine cycle. In practice this means that the exhaust heat of the gas turbine must be absorbed by the condensate and feed water through LP and HP economizers
- Down time for modification will be approximately 6 to 9 months
- After repowering, if the gas turbine is out of service, the unit can still operate but the efficiency will be lower due to lack of air pre-heaters.

267. Because of the above mentioned disadvantages of hot windbox repowering, this option was not be studied further.

268. By eliminating feed water heating and hot wind box repowering for detailed study. Three other options were studied further and a comparison of the options are presented in Table 5-2.

Table 5-2: Comparison of various repowering options studied

Criteria	**Selected Option**	**Alternative 1**	**Alternative 2**	**Alternative 3**
Description of Alternatives	**Full re-powering**	**Full Hybrid**	**Mini hybrid**	**New CCPP**
Technical Requirements				
Life time extension	25 years is considered	25 years is considered	25 years is considered	25 years is considered
Power output and efficiency	Expected higher output (404MW) and efficiency (54.6%)	Expected output of 265.7MW, efficiency 43.2%	Expected output of 291.5MW, efficiency 41%	Total plant output of single pressure is 374.4 MW and efficiency 57%, and the triple pressure is 393.4MW and efficiency is 59.9%.
Fuel Consumption	20.86 m^3/s or (0.05 $m^3/s/MW$), additional 2.27 m^3/s	17.38 m^3/s (0.06 $m^3/s/MW$) additional 5.17 m^3/s	20.10 m^3/s (0.07 $m^3/s/MW$) additional 5.98 m^3/s	18.85 m^3/s (0.05 $m^3/s/MW$ single pressure), (0.047 $m^3/s/MW$ triple pressure) with and HRSG, respectively.
Constructability				
Local Suitability	Suitable	Suitable	Suitable	Suitable

Criteria	Selected Option	Alternative 1	Alternative 2	Alternative 3
Available Materials	Construction Materials Available. Machineries need to be imported	Construction Materials Available. Machineries need to be imported	Construction Materials Available. Machineries need to be imported	Construction Materials Available. Machineries need to be imported
Operation and maintenance				
Availability of fuel	Fuel available for the life of the project. New agreement with Titas required.	Fuel available for the life of the project. New agreement with Titas required.	Fuel available for the life of the project. New agreement with Titas required.	Fuel available for the life of the project. New agreement with Titas required.
Distributed Control System	New DCS will be required to replace obsolete control system	Since ST and boiler are old, some of the control system may be still in use.	Since ST and boiler are old, some of the control system may be still in use.	Completely new DCS
Operation and maintenance ease	Only steam turbine is refurbished. Other components GT and HRSG are new.So there will be more maintenance than option 4	Steam turbine with existing boiler will stay. GT and HRSG will be new. Boiler is a very old one and its overall condition is very bad. So here maintenance will be same as Mini hybrid option.	Steam turbine with existing boiler will stay. GT and HRSG will be new. Boiler is old and its overall condition is very bad. So higher maintenance compared to repowering and new plant option.	The plant is completely new. So maintenance will be very low.
Cost				
Capital cost	USD 264 million (augmented Cost USD1,183/kW)	USD 145 million (augmented Cost USD1,690/kW)	USD 141 million (augmented Cost USD1,263/kW)	USD 311 million for Single pressure and 407 million for Triple Pressure HRSG
Annual O&M Cost	Variable Cost US $ 6.0 million. Fixed cost US$ 0.9 million	Variable cost US$ 4.0 million, Fixed cost US$ 0.6 million	Variable cost US $ 4.3 million. Fixed cost US$ 0.7 million.	Variable cost US$ 5.6 million Fixed cost US $ 0.9 million.
Environmental Issues				
Emission	Air and GHG emission (488 g CO_2/kWh) will be less as the fuel consumption is less	Higher GHG emission (618 g CO_2/kWh) due to no-control system for air emissions	Higher GHG emission (651 g CO_2/kWh) due to no-control system for air emissions	Equal or less GHG emission (423 g CO_2/kWh for single pressure and 402 g CO_2/kWh for triple pressure) of repowering
Thermal pollution	Less pollution with a closed-cycle cooling system	Less pollution due to less water use and less generation	Less pollution due to less water use and less generation	Less pollution with a closed-cycle cooling system

Criteria	Selected Option	Alternative 1	Alternative 2	Alternative 3
Non/Hazardous waste	*Management of boiler material including hazardous waste will require special attention*	Existing boiler will be used	Existing boiler will be used	-
Social				
Improved power supply security	224MW additional power in the grid	98MW additional power in the grid	124MW additional power in the grid	-
Employment potential	Fewer number of people required	More people required since boiler will remain with the plant	More people required since boiler will remain with the plant	Similar as repowering

5.4.3 Hybrid Repowering

Full Hybrid

269. For Full Hybrid Repowering it is considered to install a 128 MW E-class gas turbine with HRSG alongside the running of the existing boiler. The heating up of the full condensate /feed water flow is done in the HRSG. Both the HRSG and existing boiler will produce superheated steam. By this way heat requirement in the boiler will be less and the efficiency of total plant afterward will increase to 43.2%. Total plant net output after Hybrid Repowering will be 265.7 MW (ambient conditions, new state).

Mini Hybrid

270. In the case of Mini Hybrid Repowering, a variant of Full Hybrid Repowering, the condensate flow will be preheated additionally by bleed steam from the steam turbine. This will give a maximum output of the steam turbine of 192 MW and total plant net output after Mini Hybrid Repowering will be approximately 291.5 MW (ambient conditions, new state). However the efficiency will be slightly lower (41%) compared to Hybrid Repowering.

271. Advantages of hybrid repowering are:

- Higher power output due to additional combined cycle
- Efficiency improvement due to addition of a combined cycle
- Very flexible, different kinds of operation modes possible
- Outage time will be relatively short if first combined cycle is build and then coupling with existing system is done
- HRSG can be tuned optimally to existing system
- Existing station transformers and connections to the external grid can be kept. Only the new gas turbine transformer requires an additional connection.

272. Disadvantage of hybrid repowering is:

- If no bleed steam is needed for pre-heaters, the steam turbine will have to be modified or will otherwise be restricted.

5.4.4 Full Repowering

273. For Full Repowering the feasibility explored 2-gas turbine option and 1-gas-turbine (GT) option. Full Repowering with the 1-gas turbine option is the most suitable because of higher exhaust gas temperature of the GT and less expenditure due to single GT and HRSG. But to achieve required flow and temperature of superheated steam, for both cases supplementary firing is required. Expected efficiency of 1-GT option is 54.6% and an output of approximately 403.5 MW.

274. Advantages of Full Repowering are:

- Efficiency improvement is much higher than any of the other options.
- Considerable higher power output and total output would be more than two times of existing output
- State-of-the-art plant, everything almost new (except the steam turbine)
- With bypass stack very short start-up time and high flexibility. If the steam turbine is out of order, power output is still possible
- Because of re-usage of existing steam turbine and condenser, lower investment costs than a complete new combined cycle plant.

275. Disadvantages of Full Repowering option are:

- Relatively long down time of the unit. Existing boiler will be demolished, new combined cycle(s) have to be installed
- Restrictions to design because of usage of existing steam turbine. Because of this also not the highest obtainable efficiency (which would be around 60% with a completely new combined cycle).

5.4.5 New Combined Cycle Power Plant

276. A probably alternative for repowering was to study a new combined cycle of 450 MW capacity. Four options have been elaborated two with single pressure (option A and B) and two with triple pressure steam operation (option C and D) and on the foundation of a current unit or at the north east side of the complex. The total plant output of the single pressure option under ambient conditions is approximately 375 MW and the triple pressure 390 MW under new state. The efficiencies of the single and triple pressure steam cycle are 57% and 59%, respectively.

5.5 Plant Layout Alternatives

277. Layout of the different repowering options are presented below:

- Layout for Hybrid/mini Hybrid Repowering;
- Layout for Full Repowering
- New Combined Cycle Power Plant on foundation of Unit 4.
- New Combined Cycle Power Plant on east side of the Complex.

278. For layout planning of the above options, the following assumptions were taken into consideration:

a) The various installations, store buildings, some temporary sheds and low voltage overhead lines on the north side of the complex shall be demolished to accommodate new gas regulating station, along with gas compressor, GIS substation, gas pipe lines, HV cable lines and lay down area during construction. The existing gas regulating station for Units 1 to 4 and 5 & 6 will be retained.

b) New gas regulating station with Gas Compressor is to be installed south of the existing fuel oil tanks, so that the gas pressure is maintained at a minimum of 460 psi.

c) There are no obstacles along the proposed routes of the gas pipe lines and HV cable lines. However, at one point HV cable going out from gas turbine generator for each such unit to GIS sub-station will cross the Gas line where appropriate protection will be required.

d) The large equipment shall be transported via the River Shitalakhya up to the existing Jetty. The heavy cargoes shall be unloaded on the Jetty by crane of appropriate capacity which may be brought with the barge or rented from other sources for unloading the cargoes. There shall be no obstacles for transportation from the existing Jetty up to the proposed site of the equipment to be installed.

e) For reducing the outage time of the existing power station during construction period of the new gas turbine, the Gas Turbine Generator and HRSG shall be installed first at the north side of the target Unit 4 for Hybrid/Mini Hybrid and Full Repowering options.

f) The old existing control system of the target unit shall be completely replaced by new state-of-the-art control system during shutdown of the concerned unit for interfacing between existing and new system.

5.5.1 Layout of Hybrid / Mini Hybrid Repowering

279. For layout of Hybrid/Mini Hybrid Repowering, the assumptions considered for layout planning indicated in Section 5.5 are applicable. For Hybrid repowering, new gas turbine, gas turbine generator, and HRSG will be installed parallel to the existing boiler and the present boiler and steam cycle can be used. The steam supply of the de-rated original boiler and new HRSG can be connected with each other and feed the existing turbine. The ground plan size of gas turbine, gas turbine generator and HRSG including BOP are estimated to be 35 m x 85 m.

280. The following equipment has been considered for layout planning:

- Installation of new gas turbine generator (GE9E) at the north of the Unit 4
- Installation of new HRSG (Equivalent Capacity) at the north of the Unit 4
- Adjustment of Balance of Plant
- New GIS Substation for the gas turbine generator
- Installation of a new gas regulating station along with Gas Compressor to maintain gas pressure at minimum 460 psi at the location probably south of the existing Fuel Oil Tanks(these fuel tanks will be maintained)
- Installation of a bypass stack.

281. The footprint of Hybrid and Mini Hybrid Repowering will be the same.

5.5.2 Layout of Full Repowering

282. In Full Repowering the existing boiler is replaced with one or more gas turbines and heat recovery steam generators (HRSG). The exhaust gases of the gas turbine are fed into the HRSG. The steam generated in the HRSG is supplied to the existing steam turbine. For layout of Full Repowering, the assumptions considered for the layout planning indicated in Section 5.5 are applicable.

283. The following equipment has been taken into consideration for layout planning of Full Repowering:

- Installation of new gas turbine generator
- Installation of HRSG (Equivalent Capacity)
- Adjustment of Balance of Plant
- New GIS substation for the gas turbine generator
- Installation of a new gas regulating station along with of Gas Compressor to maintain gas pressure at minimum 460 psi to be installed south of the existing Fuel Oil Tanks (will be maintained)
- Installation of a bypass stack.

284. The footprint of the new equipment require for repowering, such as gas turbine generator and HRSG including BOP are estimated to be 45 m x 110 m. Two layout options are considered, one for 1:1:1 configuration, i.e., 1 Gas Turbine, 1 HRSG and 1 Steam Turbine and one for 2:2:1 configuration, i.e., 2 Gas Turbines, 2 HRSG and 1 Steam Turbine.

5.5.3 Layout of New CCPP at North East side of Unit 6

285. The possible layout of a new Combined Cycle Power Plant unit near Unit 6 on the North East side of the premises has been investigated. For this new combined cycle unit, a complete new cooling water system will be required. Also the connections of the steam turbine and gas turbine generators require new installation. The same gas turbine generator, steam turbine generator and HRSG of the above option in Section 5.5 for new CCPP on the foundation of the existing units have been considered for this option as well. For New Combined Cycle Power Plant on foundation of Unit 4, the assumptions considered in Section 5.5 are applicable except Item f. It may be mentioned that, BPDB has already decided to install a new 365MW combined cycle power plant at the same location for which tender has already been invited.

5.6 Alternatives for Cooling Water System

286. Present cooling system of Unit 4 is once through open cooling system supported by cooling tower during winter or during maintenance of cooling water (CW) pumps.The design cooling water quantity is 27,500 m^3/h for the 210MW generation plant. Present generation is 180 MW. But due to maintenance problems some plant components like HP heaters are not in service and hence all HP extractions are closed resulting an increased steam flow to condenser. During winter or during any breakdown of CW pumps an additional support from the existing cooling tower is required. Due to lack of maintenance some cooling tower components like blower motors, induced draft fan etc. are not working properly, resulting in a more extensive thermal plume (about 9^0C warmer than the ambient water temperature). For this the additional cooling tower support is needed. The present status is that due to the tidal flow of the river the intake water temperature is escalating from the ambient water temperature due to the thermal plume discharge at the downstream (higher thermal plume), resulting a warmer water intake. BPDB is currently considering closed-cycle cooling system for all new power generation projects including proposed 365MW CCPP in GPS and Siddirganj 335MW CCPP.

287. The feasibility study has recommended to study water balance in Shitalakhya River for the life of the project and make a decision. Based on the water balance modeling results,

it is predicted that Shitalakhya will have sufficient water available for condenser cooling, and based on existing study[19] water quality will not pose any immediate threat to the repowering Project in Ghorashal. However, temperature increase by thermal discharge from cooling system of Unit 4 is currently violating WBG Guidelines in the thermal plume zone of influence. Hence, the Consultant would like to recommend that a closed-cycle cooling system is considered in the repowering of Unit 4 to bring the Unit under compliance with WBG Effluent Guidelines. By introducing close-cycle cooling water requirements will be significantly reduced from 6.04 m^3/s to 0.0191 m^3/s. A comparison of new cooling tower, refurbishment of existing cooling tower, and open cycle cooling is presented in Table 5-3.

Table 5-3: Condenser cooling water alternatives

Condenser Cooling water	Refurbishment of existing cooling system	New cooling tower (closed cycle)	Open Cycle Cooling System
Technical requirement			
Temperature increase by thermal discharge from cooling system (3^0C)	Yes, but capacity may be a concern to serve repowering unit, eventually unable to maintain WBG guideline of effluent discharge quality	Yes. New cooling tower with adequate capacity (existing tower can also be used if found suitable) can serve repowering	No. Can't maintain the WBG guideline of effluent discharge quality
Efficiency	Less efficiency due to old system	Higher efficiency due to new construction	-
Energy consumption	Less energy consumption due to low capacity	Higher energy consumption due to large capacity, however, reduction in pumping of Rawwater will offset the overall energy consumption	Energy consumption in pumping only
Life time	Less life time due to old system	Full life time due to new system	Not applicable
Constructability			
Available Materials	Refurbishment Materials Available. Blower motors and induced draft fan may require import	Construction Materials mostly Available. Some of the components may require import	The system is already working. No new construction required, except increasing the raw water quantity
	Disposal or recycling of old materials	Dismantling of existing towers will generate solid waste for disposal	No solid waste generation

[19] Alam, M. A., Badruzzaman, A. B. M, and Ali, M. A (2012); Spatiotemporal Assessment of Water Quality of the Sitalakhya River, Bangladesh, Intl. Journal of Engineering and Technology Volume 2 No. 6, pp. 953-962

Condenser Cooling water	Refurbishment of existing cooling system	New cooling tower (closed cycle)	Open Cycle Cooling System
Operation and Maintenance			
Maintenance	Regular maintenance with chlorine required to clear bacteria	Regular maintenance with chlorine required to clear bacteria	Maintenance of CW pumps required
Operation	Water circulates in a closed cycle and is subjected to alternate cooling and heating. Heat is dissipated in the atmosphere through	Water circulates in a closed cycle and is subjected to alternate cooling and heating.	Simple operation
Cost			
Investment cost	Refurbishment cost is estimated as US $12 million	Construction cost of new cooling system is estimated as US $16 million	Construction of a retention pond may be required
Yearly O&M Cost	Proposed one will be completely new. So O&M cost of existing one will be more than the proposed one.	Much less than the proposed one.	O&M costs involve CW pumping and operation
Environmental			
Thermal pollution	May be difficult to fulfil thermal plume requirements, as the capacity of the existing system may not be sufficient to fulfil the requirements of all repowering units	May or may not fulfil thermal plume requirements, as the capacity will be design to cater the requirements of all cooling water needs of the plant	Can't fulfil thermal plume requirements, unless further investment in retention pond or dilution effluents with additional water before the discharge
Water requirements	7.6389 m^3/s of water required for cooling water system	0.38194 m^3/s of water required for cooling water system	7.6389 m^3/s of water required for condenser cooling
Generation of solid waste	Disposal of refurbished parts and components	Disposal of existing cooling tower materials	No solid waste is generated
Noise Level	Generation of noise	Generation of noise	No noise generation
Social			
Irrigation water	Not possible to continue irrigation water supply to agriculture field.	Not possible to continue irrigation water supply to agriculture field.	Positive impact by irrigating 4,000 acre of croplands

5.7 Alternatives for Water/Effluent Treatment

288. Currently, existing water/effluent treatment systems consists of, (a) effluent treatment is currently done by neutralizing effluents using acid and alkali, (b) a demineralization plant with capacity about 94 ton/h with two cells, (c) a rawwater treatment plant with capacity 300 ton/h having clarifier, coagulator, filter etc., and uses aluminum sulfate to treat Rawwater, and (d) There is no sludge treatment plant in GPS. Currently hydrazine is used in GPS as scavenger chemicals to remove oxygen in the boiler feed water system. Hydrazine is a toxic chemical (a carcinogen) which require proper treatment prior to disposal at the river, which also supports food processing systems in up and downstream.

289. A new separate effluent treatment plant (ETP) along with the water treatment plant (WTP) is recommended with state-of-art equipment to treat raw and effluent water and sludge produced in Unit-4. The new plant will have (a) an effluent treatment plan with a capacity of 450 tons/h. A central monitoring basin (CMB) of RCC construction shall be provided to collect all plant effluents. Quality of the effluents shall be measured, monitored and treated. Through a set of waste effluent disposal pumps and piping, the same shall be disposed of from CMB up to final disposal point at a safe distance, (b) a reverse osmosis (RO) system to treat demineralization water with capacity of about 225 ton/h (3 cells @ 75ton/h), two cells in service and one standby. The proposed RO plant is designed for the combine use of the entire plant to replace current resin based demineralization. Economic analyses have demonstrated that when the total dissolved solids content of feed water is above 200 mg/l, RO is the most cost-effective demineralization technology. Based on the water quality analysis TDS content observed in between 210-239 mg/l, (c) rawwater treatment plant with capacity 450 ton/h, and (d) sludge treatment plant with capacity 100 ton/h.

290. There are a number of environmentally friendly alternatives to hydrazine, (a) Erythorbic acid and its sodium salt can replace scavenger chemicals like Hydrazine as oxygen scavengers. Sodium Erythorbate is a non-toxic oxygen scavenger that can be used also in food processing systems and (b) HELAMIN is formulations consisting of poly-carboxylates and surface-active fatty alkyl polyamines in combination with other amines of varying volatility. EPC contractor in their proposals states a possible environmental friendly alternatives to replace hydrazine as scavenger chemicals in the feed water of new HRSG. Owner's engineer will review the proposal and in consultation with GPS a final decision will be made.Various alternatives for water/effluent treatment is presented in Table 5-4.

Table 5-4: Water/effluent treatment alternatives

Criteria/Sub criteria	Existing Plant	Proposed CWT Plant
Technical Requirements		
Life time/extension		
Capacity	(a) No effluent treatment plant exist, only a neutralization pond. (b) Demin plant capacity is about 94 ton/h with two cells. (c) Rawwater treatment plant capacity is 300 ton/h having clarifier, coagulator, filter etc. and uses of aluminum sulfate. (d) Hydrazine is used as	(a) A new CWTP with capacity to treat 450 tons/h of water (Effluent). (b) A reverse osmosis for demin plant with capacity about 225 (3x75) ton/h, two cells in service and one standby. (c) Rawwater treatment plant with capacity 450 ton/h.

Criteria/Sub criteria	Existing Plant	Proposed CWT Plant
	scavenger chemicals to remove oxygen in the boiler feed water system. (e) No sludge treatment plant	(d) More environment friendly alternatives (Sodium Erythorbate or Helamin) of hydrazine are proposed to treat feed water. € Sludge treatment plant capacity 100 ton/h.
Life time extension	With maintenance the plant may run for few more years	25 years or more.
Efficiency improvement	Very old plant. May have present efficiency 35-40%	90%
Fuel consumption/energy requirement	Will need more energy as the plant is old with outdated technology	Will need less energy as the plant is new with latest technology
Constructability		
Suitability of construction /erection	Existing	Suitable for construction
Materials/Machineries required as per the considered options are available	Not applicable	Construction Materials available. Machineries need to be imported
Disposal of non/hazardous waste	Municipal people collects non-hazardous waste periodically and liquid non-hazardous waste flows to river.	Municipal people collects non-hazardous waste periodically and liquid non-hazardous waste flows to river.
Operation and Maintenance		
Automated Control System	Semi-automatic	Full automatic
Operation and Maintenance ease	Old and less efficient, needs more man power, more expenditures	Easy to operate, easy to maintain, less man power, less expenditure
Cost		
Construction Cost	--------	US $ 8 Million
Operation Cost (including Maintenance and Energy cost)	US $1.25Million	About US $1Million
Environment		
Water pollution	Toxic chemicals from hydrazine and resin based demineralization posed greater threat	State-of-art non-toxic chemicals are proposed for various system. Reverse Osmosis is proposed to make demi water
Effluent quality	Poor boiler water quality, inefficient effluent treatment	Will produce high quality boiler, better neutralization of effluent
Social		
Employment Potential	Will use the same number of staffs	Some people may lose job but some job opportunity will be created for highly skilled people.

5.8 Selected and Recommended Options

291. Selected and preferred option of various components of the project are finalized based on the Engineering Design and EIA study. The Figure 5-2 shows the overall layout of the project components selected for inclusion in the project design. Table 5-5 provides a summary of the selected alternatives for each component included in the project.

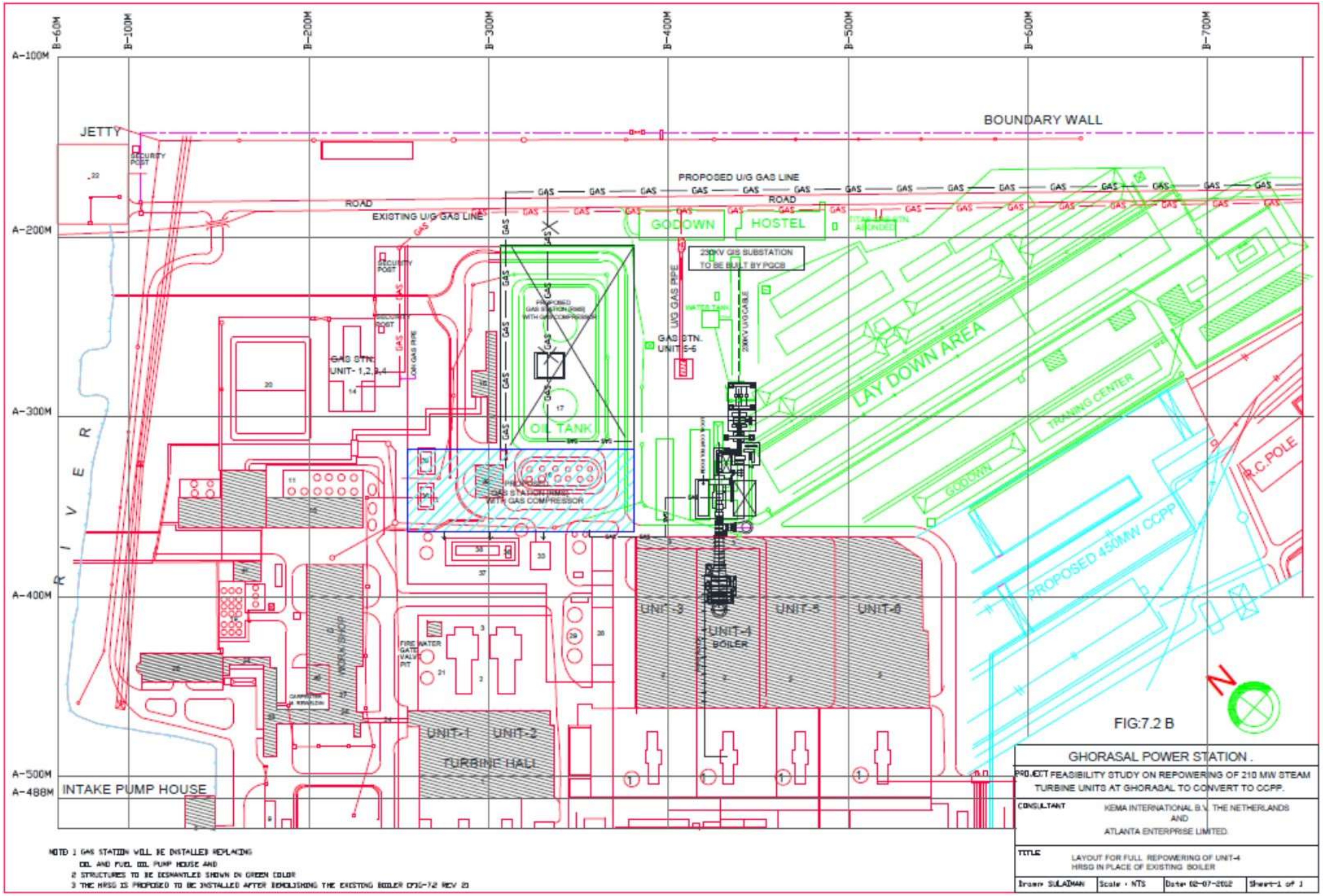


Figure 5-2: Selected plant layout of full repowering

Table 5-5: Recommended and selected options of Unit 4 Repowering

Component	Design Features Included in Engineering Design Report
Repowering Options	Full Repowering is technically the most attractive option for repowering of Unit 4 Ghorashal PowerStation because the expected output and efficiency is much higher compared to the hybrid repowering solutions.
Plant Layout Alternatives	For full repowering 1 Gas Turbine, 1 HRSG and 1 Steam Turbine configuration has been chosen over other options. First gas turbine generator will be placed and commissioned, then existing boiler will be shut down and dismantled and the new HRSG will be installed at the footprint of the existing boiler. Limitation of space is one of the major reason for rejecting 2:2:1 configuration.
Cooling water system	Closed-cycle cooling system with new cooling tower construction is considered in the repowering of Unit 4 to comply with the WBG guideline of effluent discharge quality (3^0C difference between effluent water at mixing zone and ambient water temperature)
Water/effluent treatment plant	New central water treatment plant is recommended with state-of-art equipment to treat raw and effluent water and sludge produced in the GPS including the requirements of repowering and new 365 MW combined cycle power unit. The new plant will have (a) an effluent treatment plan with a capacity of 450 tons/h, (b) a reverse osmosis (RO) system to treat demineralization water with capacity of about 225 ton/h (3 cells @ 75ton/h), two cells in service and one standby, (c) rawwater treatment plant with capacity 450 ton/h, and (d) sludge treatment plant with capacity 100 ton/h.

6. Description of the Environment

6.1 Introduction

292. This chapter on environmental and social baseline has been prepared using both primary and secondary data collected for the proposed Project site and defined study area. The baseline condition has been defined in respect of physical environment (e.g., including meteorological, hydrological, geological components and processes), biological environment (e.g., including flora, fauna, and ecosystems), land use pattern, agriculture practices, cultural activities, economic status, and hazards of the study area.

6.2 Topography

293. The study area mostly lies in flat topography. Presently, the area is dominated by agricultural practices followed by settlements, fishing during wet season. The ground elevation gently lowers from east to west. The Project site is situated at the elevation ranges between 7-12 m PWD (Figure 6-1). The entire area is vulnerable to occasional riverine flood. Topographic survey has been conducted to collect the spot level and to prepare the elevation contour of the area. Figure 6-2 envisages contour lines of the site.

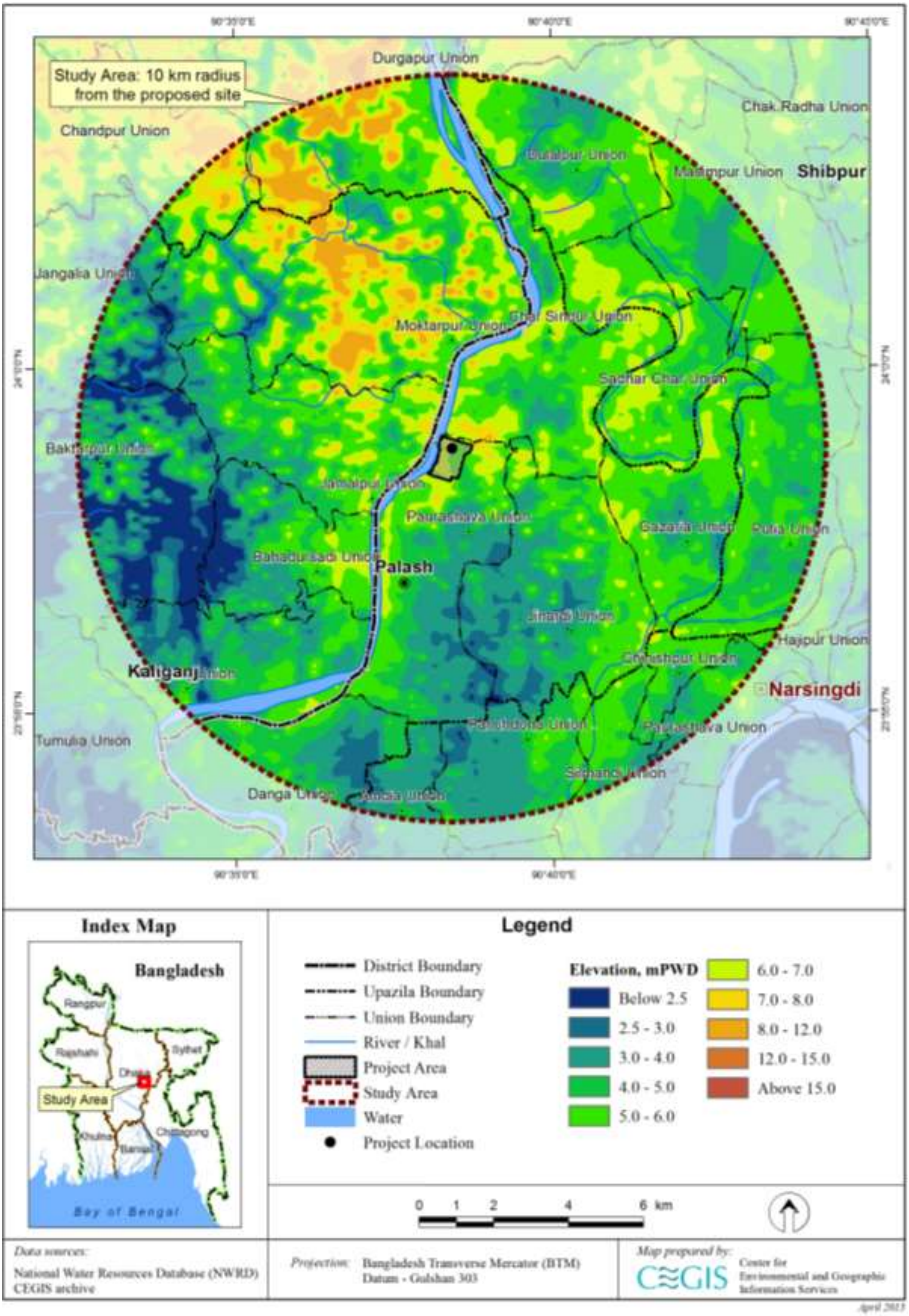


Figure 6-1: Digital Elevation Map of the study area

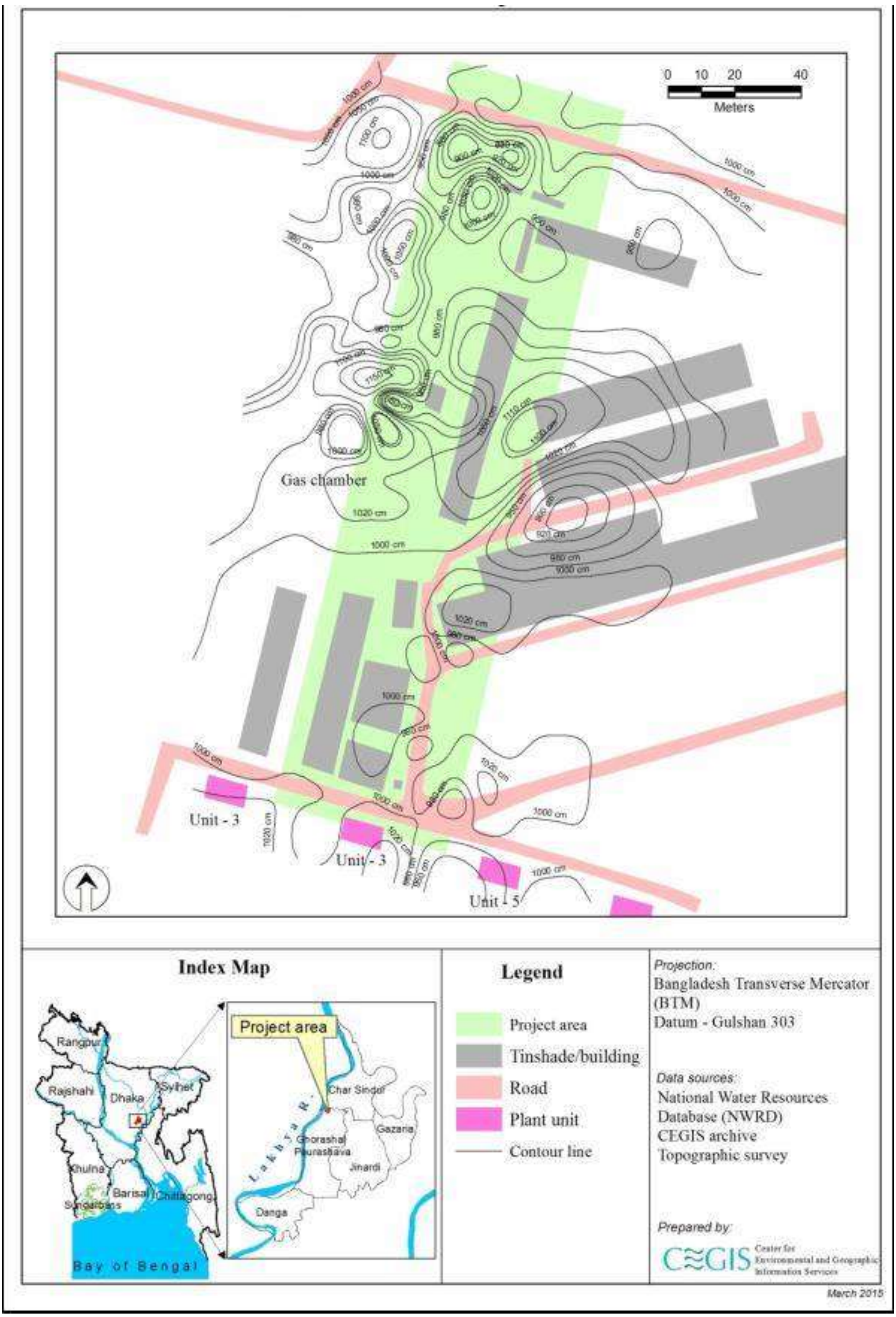


Figure 6-2: Contour line map of the Project site

6.3 Land Use and Land Cover

294. An overview of the land use and land cover pattern has been prepared based on the satellite images and presented using Geographical Information System (GIS). The total land of the study area is 31,415 hectares. The land cover of the study area is derived from multi-spectral color Rapid Eye satellite images of 15th February, 2013 and 29th March, 2014. The major classes extracted from the images are as follows: agricultural land, char land/sandbars, forest, industrial area and other land uses (i.e., road, rural settlement with homestead vegetation, built-up area and water bodies). Figure 6-3 shows the detailed general land use map of the study area.

295. The area is mostly surrounded by *agriculture land* (15,457 ha, which is 49.2% of the total area) followed by *rural settlement with homestead vegetation* of 38.5%, *water bodies* 5.74%, built-up area amounting to 1.7%, *forest land* cover of 1.5%, *industrial area* (including Ghorashal Power Plant) of 1.3%, *road coverage* 1.01%, *other land uses* of 0.78% and char land/sandbar occupying a very insignificant area of 0.04%. The detail area coverage of each class and sub class is given in the Table 6-1.

Table 6-1: Land covers classification

Major Class	Sub-Class	Area (ha)	(%)
Agricultural Land	Aman-Fallow-Fallow	141.7	0.45
	Aman-Boro-Fallow	6208.3	19.76
	Aman-Boro-Other Crops	2753.6	8.76
	Fallow-Boro-Fallow	5240.1	16.68
	Permanent Fallow	15.0	0.05
	Fallow-Fallow-Robi Crops	1098.3	3.50
Built-up Area	Built-up Area	554.5	1.77
Char Land/Sand	Char Land/Sand	13.1	0.04
Forest	Plantation	21.2	0.07
	Vegetation	448.7	1.43
Industrial Area	Industrial Area	433.9	1.38
Other Land Uses	Area Under Development	63.1	0.20
	Brick-field	182.4	0.58
	Chatal	0.2	0.00
Road	Access Road	17.2	0.05
	National Road	21.1	0.07
	Railway	24.6	0.08
	Regional Road	36.1	0.11
	Rural Road	126.6	0.40
	Zila Road	92.2	0.29
Rural Settlement with Homestead Vegetation	Rural Settlement with Homestead Vegetation	12121.6	38.58
Water Bodies	Beel	197.7	0.63
	Canal	14.2	0.05
	Ditch	348.6	1.11
	Pond	472.4	1.50
	River	750.3	2.39
	Seasonal Waterbody	18.6	0.06
Total		31415.5	100

Source: Satellite image analysis

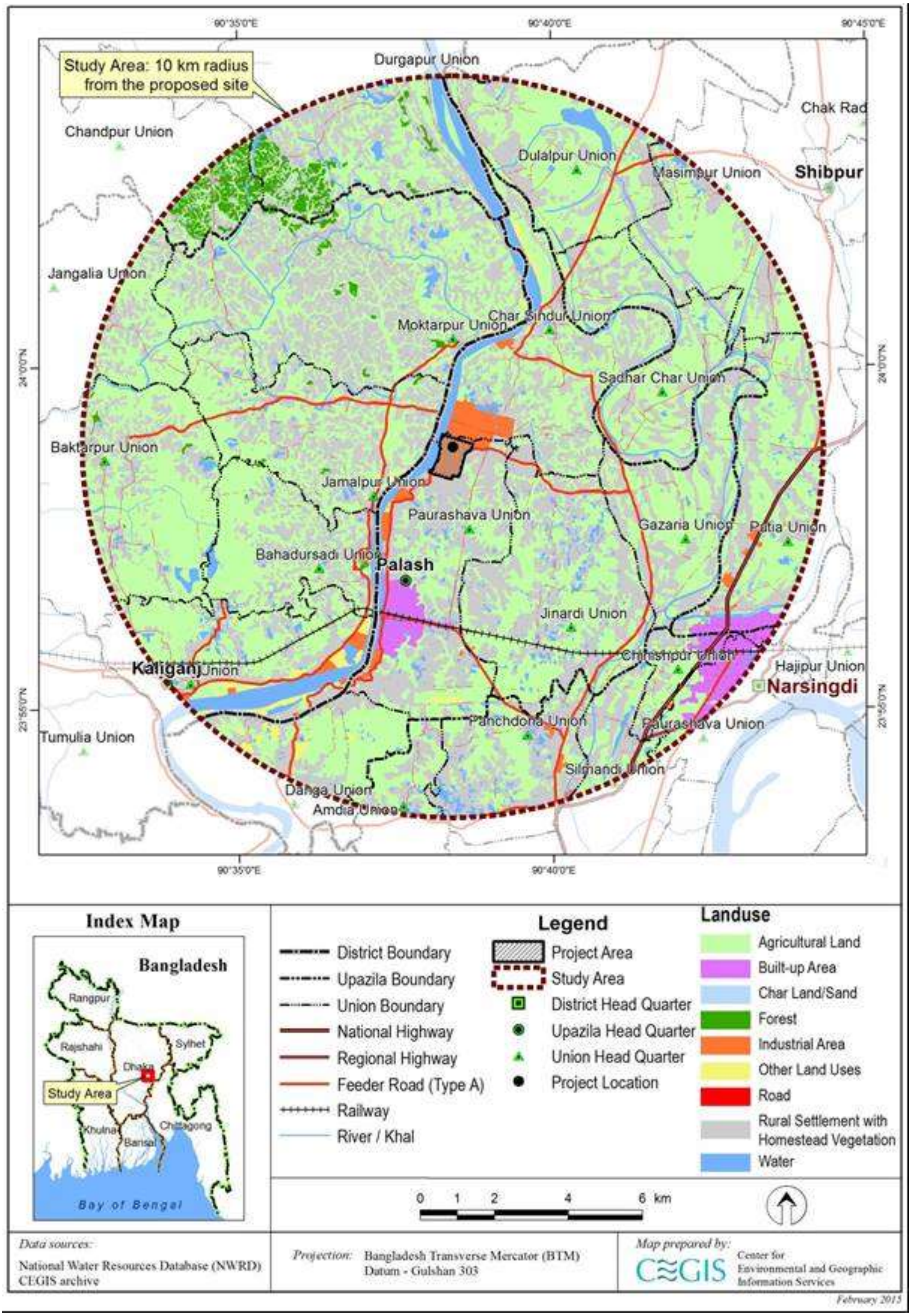


Figure 6-3: General land use map

6.4 Geology

296. Physiographically, the area falls partly in the Young Brahmaputra – Jamuna floodplain and Madhupur tract which are marked respectively as code 3 and 16b on the physiographic map of Bangladesh. The area is located in the central part of the Bengal basin– an extensive alluvial plain of the quaternary sediments laid down by the Ganges-Brahmaputra-Meghna river system.

297. The surface of the area is covered by paludal deposit. The thickness of this section ranges from 7 to 9 meters. It is composed of Holocene river alluvium, meander, inter-stream, swamp deposit, marsh clay and peat. Immediate below this section underlies 16,000 m thick sequence of quaternary sediments. Lithology shows that the area comprises of alternation of sand/silt and clay sequences.

298. As per tectonic classification, the area falls under Madhupur Tripura threshold of eastern platform flank of the Bengal basin. Tectonically this area is inactive and no apparent major structure like fault or fold exists in the region that might be geologically significant (Figure 6-4).

6.5 Seismicity

299. Ghorashal was under Zone II with design Peak Ground Acceleration (PGA) value of 0.15g (Z=0.15) according to the seismic zoning map of Bangladesh provided in BNBC (Bangladesh National Building Code 1993). This level of acceleration may be considered as more or less equivalent to a seismic intensity of VII. Historical information reveals that earthquakes of magnitude around 6 stroke in the past in the vicinity of Ghorashal. Thus, the nearby areas were considered as the Medium Risk Zone for earthquakes.

300. However, the BNBC adopted new code in 2010 after Bangladesh experienced several shock wave of higher intensity. This proposed seismic zoning map based on PGA values for a return period of 2475 years. The country is divided into four seismic zones with zone coefficient Z equal to 0.12 (Zone 1), 0.2 (Zone 2), 0.28 (Zone 3) and 0.36 (Zone 4).

301. In the newer adopted code of BNBC 2010[20] (Figure 6-5), it is observed that the Project area is on the border line of the Seismic Zone II (seismic coefficient 0.20 g) and Seismic Zone III (seismic coefficient 0.28 g). This zone has the mediocre vulnerability for earthquake in Bangladesh with a risk of possible earthquake of magnitude 6 (on Richter scale).

[20] Sarraz A., Ali M. K., Das D. C., 2015; Seismic Vulnerability Assessment of Existing Buildings Stocks at Chandgaon in Chittagong city, Bangladesh, American Journal of Civil Engineering 2015; 3(1): 1-8, retrieved from http://www.sciencepublishinggroup.com/j/ajce

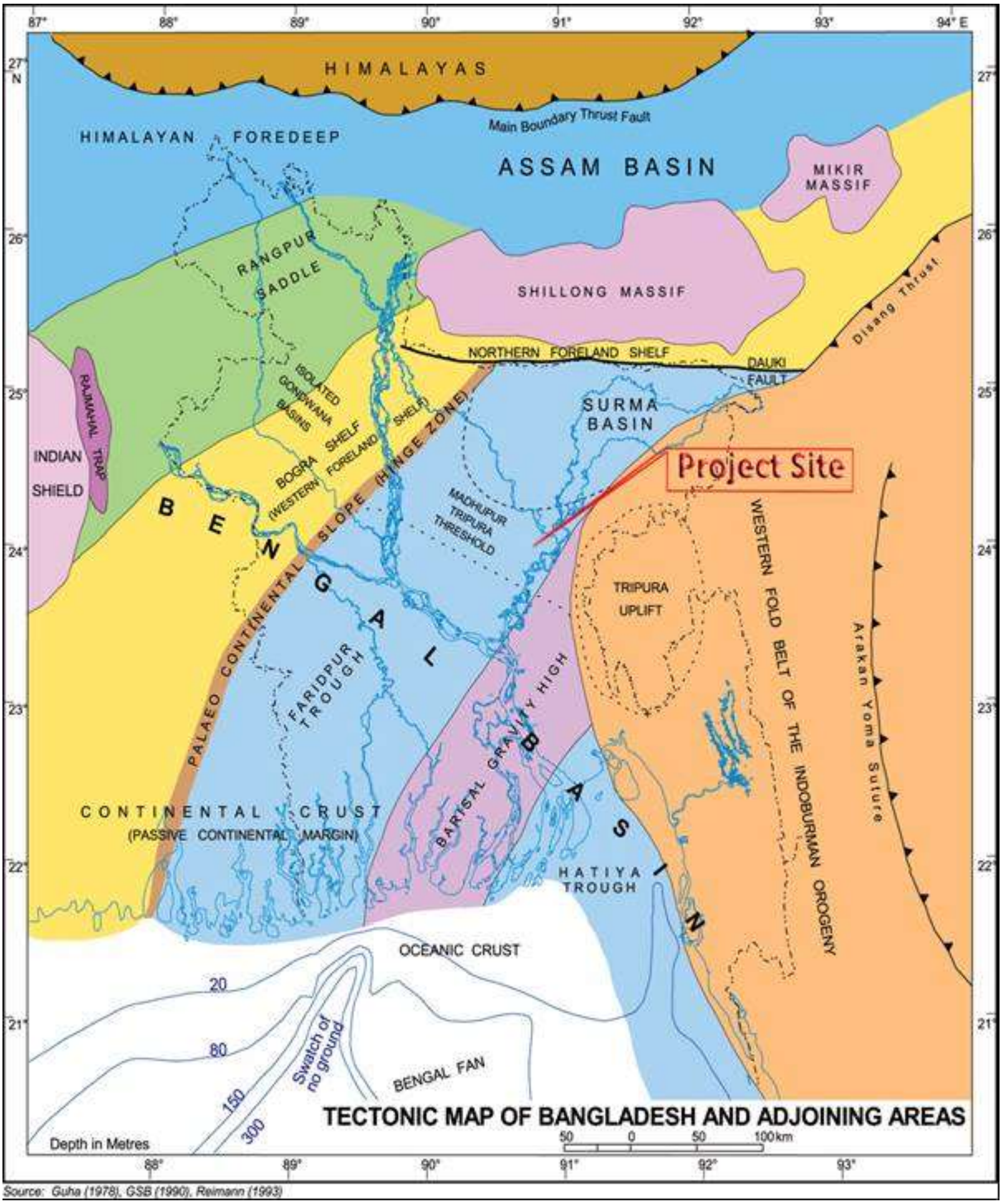


Figure 6-4: Project site shown on the Generalized tectonic map

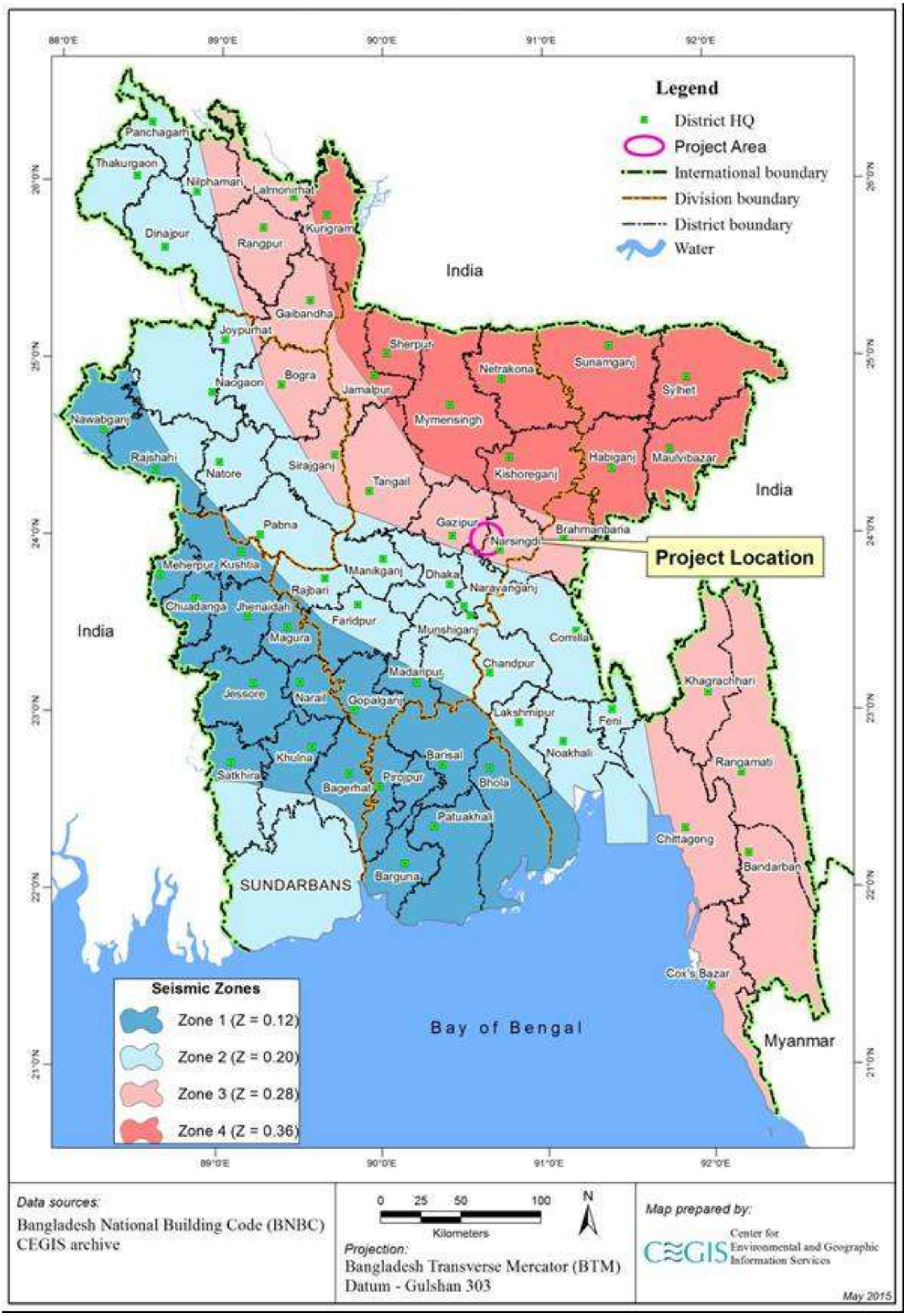


Figure 6-5: Project site shown on seismic zone map

6.6 Surface Water Resources

302. The Shitalakhya River is main water system that flows in close proximity of the proposed site of the project, is a distributary of the Old Brahmaputra River (Figure 6-6). It receives fresh water flow from the Old Brahmaputra and the Lower Banar River. The off-take of the Shitalakhya River is Old Brahmaputra River at Monohordi Upazila under Narsingdi district and drains into the Dhaleswari River in Narayanganj district. Due to the desertion of the original link to the Old Brahmaputra River, the Shitalakhya River receives most of its freshwater flow presently through the Lower Banar River as shown in Figure 6-6. The relatively inert geo-morphological characteristics of the Shitalakhya River guarantee fairly suitable water depths for navigation, throughout the year.

6.6.1 Surface water system

303. Shitalakhya is a tidal river and the maximum average variation of water level is 20 cm between high tide and low tide. The river is perennial in nature and the average lowest discharge is during dry season (January) with a flow of 83 m^3/s and the average lowest water level during low tide is 0.94 mPWD close to the study area. The average highest flow observed during rainy season (Jul- Sept) and varies from 1,181 m^3/s to 1,066 m^3/s and the average maximum water level during the high tide is 6.62 mPWD. There is no other significant surface water system found around the project area.

304. The river inundates nearby agricultural lands during monsoon and remains navigable round the year. The tendency of the river erosion is very low. Based on water availability and navigation facilities, a large number of industries have been established along its banks both up and downstream. Bangladesh Inland Water Transport Authority (BIWTA) declared this river as a class III route of Bangladesh. The relatively inert geo-morphological characteristics of the Shitalakhya River guarantee fairly suitable water depths for navigation, throughout the year.

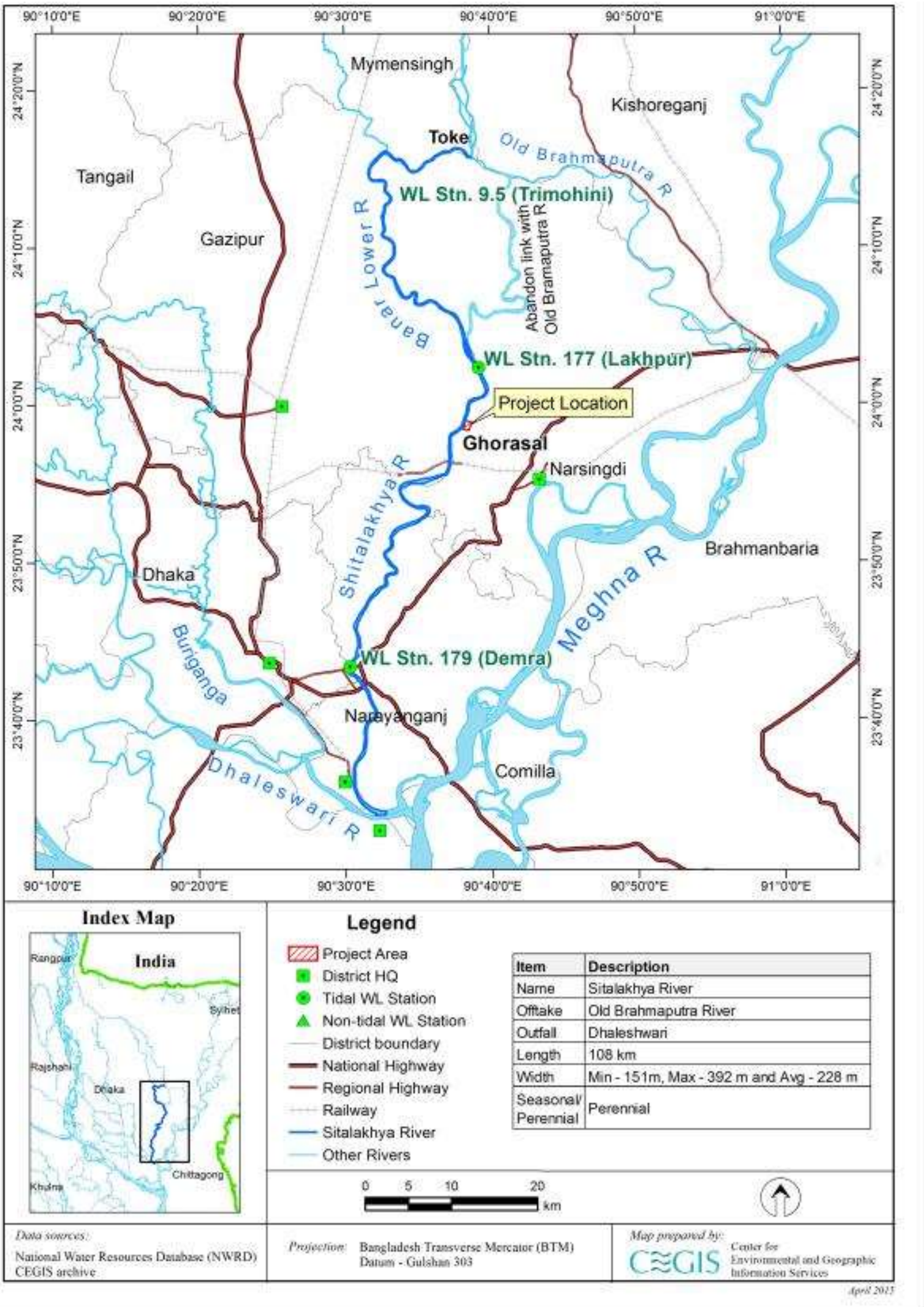


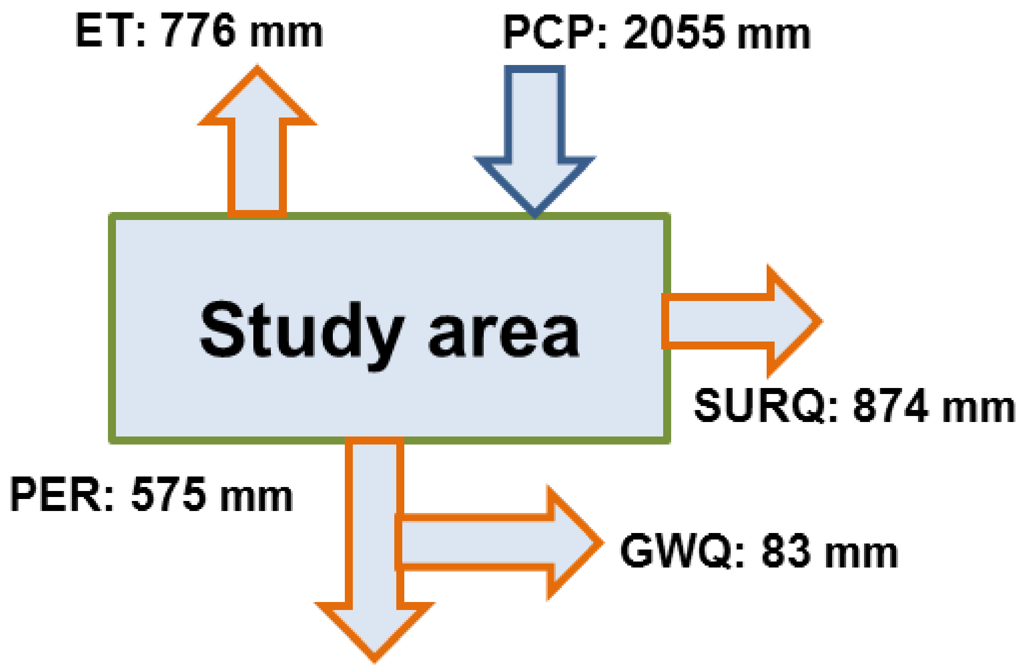
Figure 6-6: Water resources system map of the study area

6.6.2 Shitalakhya water availability assessment

305. The Shitalakhya River was one of the main distributaries of the Brahmaputra River in the eighteenth century. The Banar River was also contributing flow to the Shitalakhya River. During the middle of the twentieth century, the avulsion process of the Brahmaputra was completed and, like the Shitalakhya River, the Old Brahmaputra received a small amount of flow from the Jamuna River. During this period the main link channel from the Old Brahmaputra to the Shitalakhya River became abandoned.

6.6.3 Water Balance during Base Condition (1981-2012)

306. Water balance is the assessment of water resources and its use in the system. The main principle of water balance is that the difference between total incoming water and total losses should equal to the storage change in the system. The calibrated and validated model has been simulated for the period of 1981 to 2012 to estimate the availability of water for the study area. The simulation results of the annual and monthly water balance for the study area are shown in Figure 6-7.



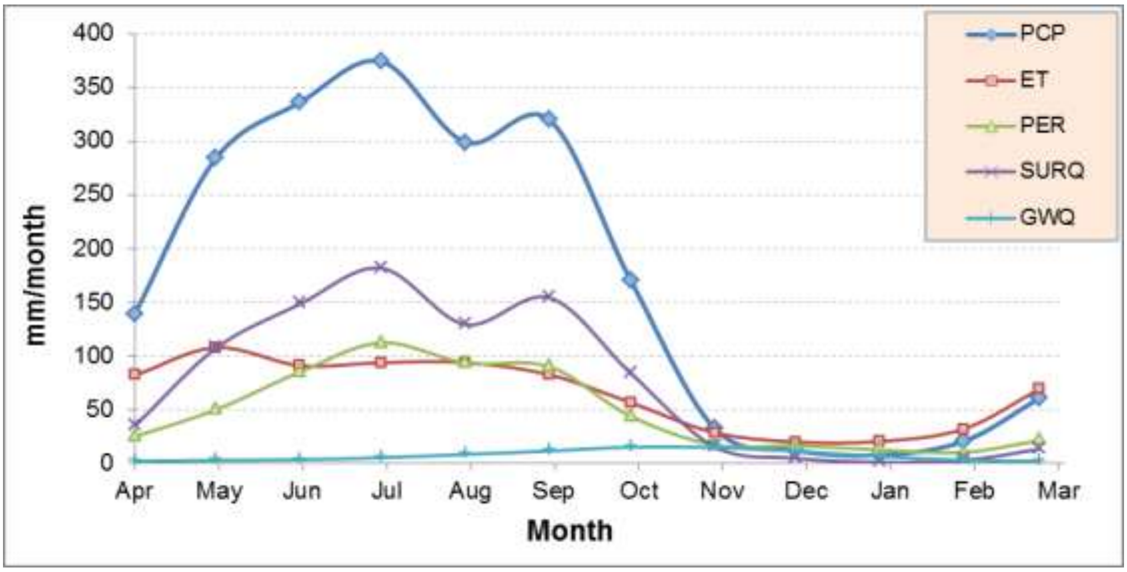


Figure 6-7: Water balance of the study area (a) annual and (b) monthly for the period 1981-2012

307. The average annual rainfall is 2,055 mm. The monsoon starts from April and reaches its peak in July. There is a decreasing trend of rainfall during the month of August, a slight increase in September and then rapidly decrease again. The maximum monthly precipitation is about 375 mm.

308. Rainfall in watersheds/catchments is main inflow whereas the evapo-transpiration and percolation and other abstraction are losses. The balance contributed into the river as surface runoff and subsurface flow. The annual actual evapo-transpiration of the area is 776 mm which is 37% of the annual rainfall. The evapo-transpiration is maximum during April and May and which is about 107 mm per month. The evapo-transpiration rate is minimum during November to February. The percolation rate for the study area is 575 mm per year which is 28% of the annual rainfall. The percolation rate follows similar trend like rainfall and the maximum rate is 112 mm per month. After the losses of water through evapo-transpiration and percolation, the remaining water contributes to stream flow as overland flow and lateral (subsurface) flow. Around 43% (874 mm) of rainfall contributes to stream flow through surface runoff while the lateral flow is negligible only 83 mm.

6.6.4 Water level analysis

309. Shitalakhya is a tidal river where dry season tidal range is about 20 cm which reduces to a few centimeters during the monsoon. The average maximum and minimum water level varies seasonally from 5.86 mPWD to 1.24 mPWD respectively at the project site during the base condition. Generally, the river reaches its highest water level in the months between July and September and the lowest in the months between January and March. The historical highest and lowest water level was found at the project site for base condition is about 8.00 and 0.70 mPWD, respectively, as shown in Figure 6-8.

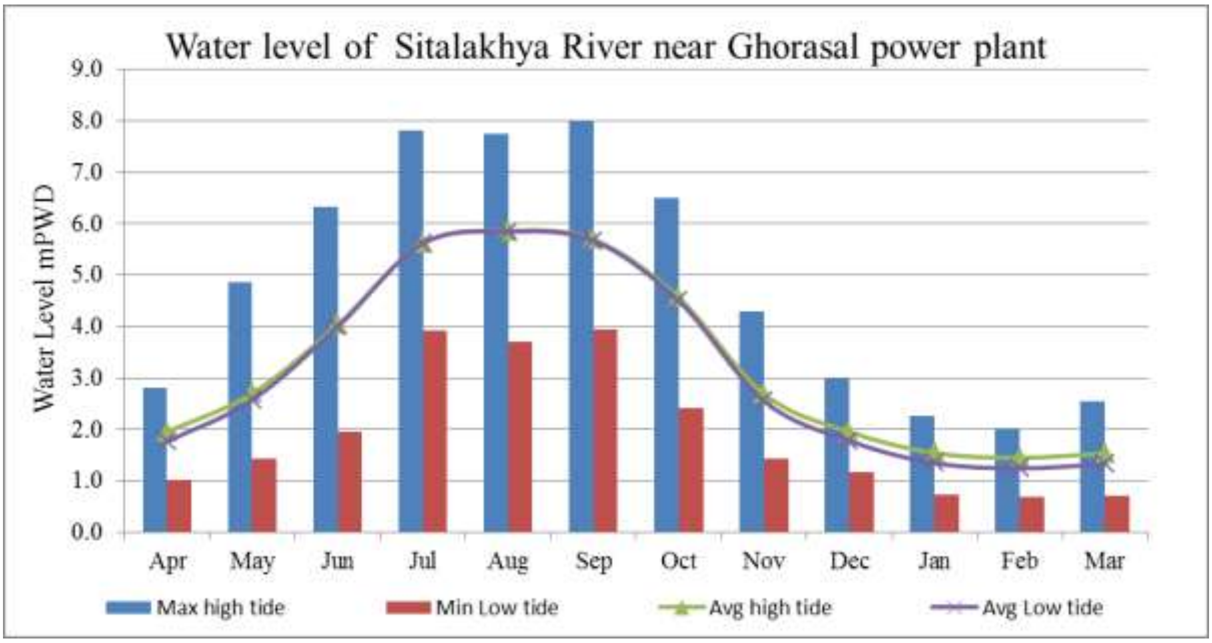


Figure 6-8: Water level of Shitalakhya River near GPS (Base condition)

6.6.5 Discharge analysis

a) Average Seasonal Flow (1981-2012)

310. The annual discharge distributed seasonally in Shitalakhya is about 7% (980 Mm^3) in dry (December-March), 6% (842 Mm^3) in pre monsoon (April-May), 72% (10,545 Mm^3) in monsoon (June-September), and 16% (2,300 Mm^3) in post-monsoon (October-November) seasons. The flows are mainly concentrated during the monsoon period (highest) and pre monsoon (lowest), as shown in Figure 6-9.

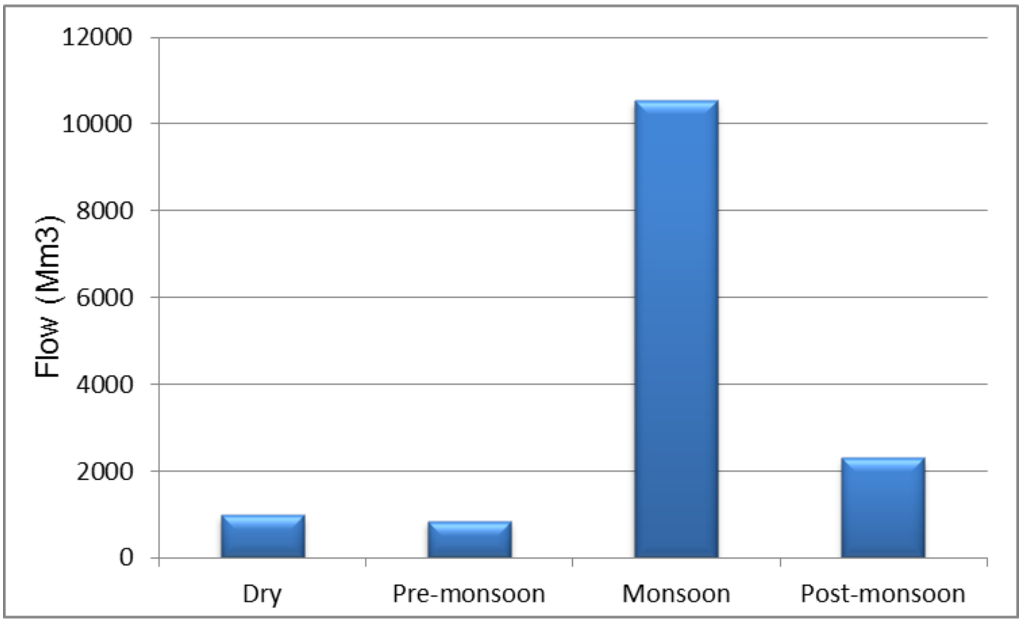


Figure 6-9: Average seasonal outflow from the basin during 1981-2008

b) Historical Annual Flow (1981-2012)

311. The historical annual flow from the study area is presented in Figure 6-10. The outflow of the basin has been reduced gradually after 2000. Before 2000, the annual flow was 16,000 – 22,000 Mm^3 while it has been reduced to 9,000 – 14,000 Mm^3 in the recent years.

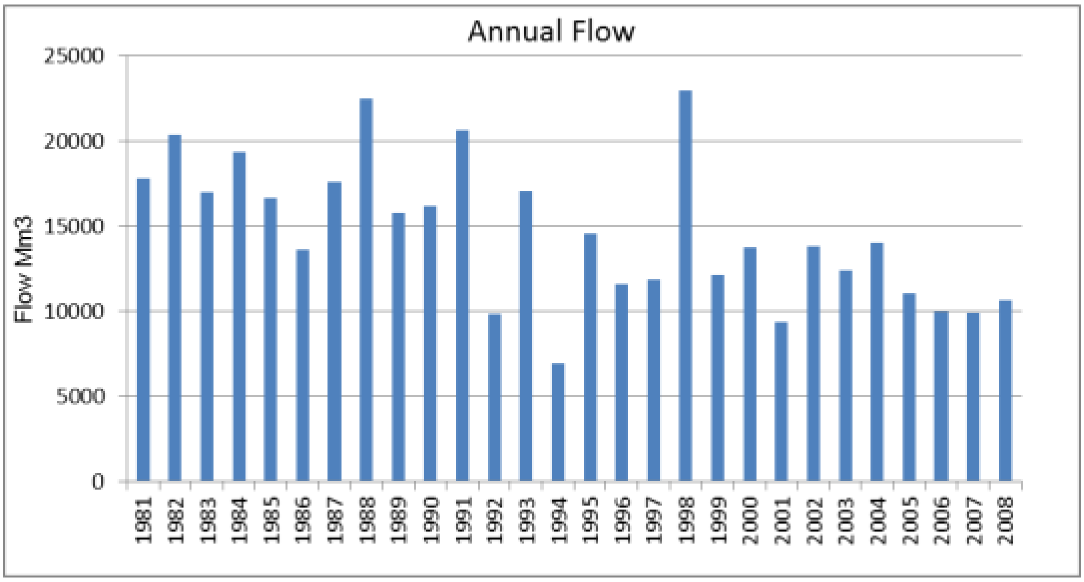


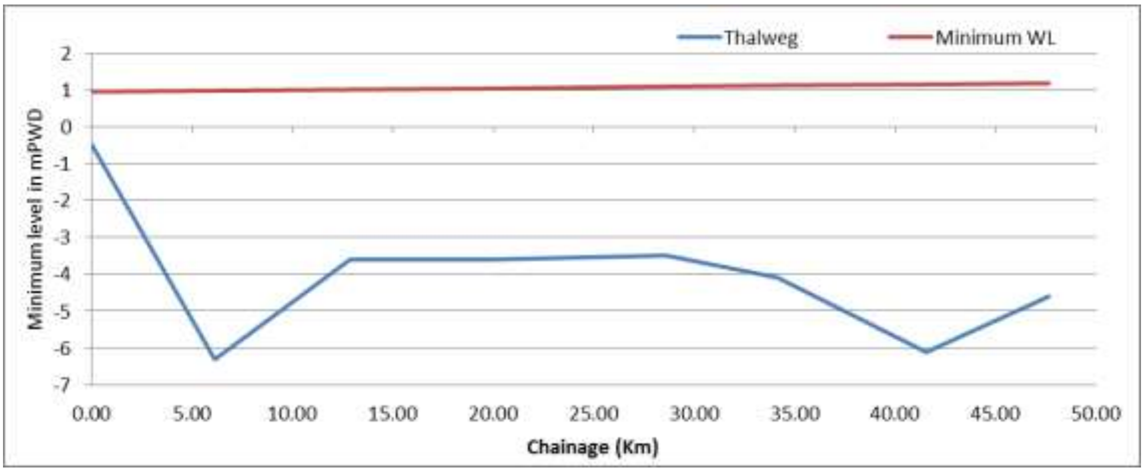
Figure 6-10: Historical annual outflow from the basin

c) Environmental Flow and GPS withdrawal

312. It is estimated that environmental flow of Shitalakhya River is about 92.2 m^3/s, current GPS water requirement is 40.30 m^3/s , which is about 43.7% and Unit 4 repowering will require 0.46583 m^3/s, which is only 0.5% of the environmental flow of Shitalakhya River.

d) Depth of River Water around the Project Site for Navigation

313. After analyzing the average minimum water level of 1981-2012 and longitudinal profile of the river, it is found that throughout the year the Shitalakhya maintains a minimum of more than 4 m depth in the whole reach of the river as depicted in Figure 6-11. The relatively inert geo-morphological characteristics of the river made fairly suitable water depths for navigation. Moreover, due to its lesser fluvial activity, riverbank erosion is negligible and shifting of the thalweg or navigation channel from one bank to the other is not dynamic in nature. These characteristics of the river have facilitated the growth of industries, commercial centers and power plants on either side of its banks.



Ch 0.00 km at Lakhpur; Ch 8.40 km at near Ghorashal power plant and Ch 47.65 km at Demra

Figure 6-11: Long profile of the Shitalakhya River from Lakhpur to Demra

6.6.6 Ground water system

314. In the GPS, potable water is generally used from the ground water source while river water is used for condenser cooling and other plant purposes. It is reported from the DPHE that the average depth of the shallow tube well in the project area is 61 m (200 ft). According to Bangladesh Water Development Board, the ground water level of Palash Upazila is about 6.5 m. There is a good availability of ground water abstracted using tubewells for drinking and domestic purposes. Most of the industries are using water from deep tube wells in their premises to meet the water requirements. The scattered homesteads are using hand tube well (HTW) to meet their domestic demand having no specific complaint about non-availability of ground water.

6.7 Natural hazards

315. Bangladesh is susceptible to several natural hazards, such as, flood, drought, river bank erosion, cyclone etc. This is due to its combination of geographic, physiographic, morphological and other natural features which have led to the direct loss of life and properties, and sometimes on a massive scale. Among these various natural hazards flood is the most recurring one, hence analyzed within the framework of this study.

316. **Flood**: Bangladesh is receptor of flows from three major rivers namely the Ganges, the Brahmaputra and the Meghna. The origin of these rivers are located outside its national boundary. It was observed that extreme flood events occurred due to excessive rainfall in the catchments mostly upper basins. When a water level in the major river systems rises simultaneously and crosses the danger levels, the flood usually occurs all over the country. This was observed during the three major floods of 1987, 1988, and 1998. Water levels crossing the danger levels start occurring from mid-July and continue till mid-September. Inundated area during 1987, 1988 and 1998 were 66%, 68% and 70%, respectively. Duration of the extreme flood events usually extends from 15 days to 45 days occurred during 1998. Sometimes, Individual River may also experiences extreme flood events due to excessive rainfall in the respective river catchments independently.

317. According to the topographical survey, land alleviation of the proposed Project site has a formation level of 10 m.PWD. The nearest water level station is situated at Lakhpur in the Shitalakhya River which is at about 8 km upstream of the proposed project site. Analyses

of the historical water level data of this station show that the maximum water level reached at about 8 m.PWD since 1980 (Figure 6-12). The highest water level was recorded 7.84 m.PWD in 1988 which was an extreme flood event in Bangladesh. These observation indicates that the proposed project site is not vulnerable to flooding unless any extreme natural hazards occur in future.

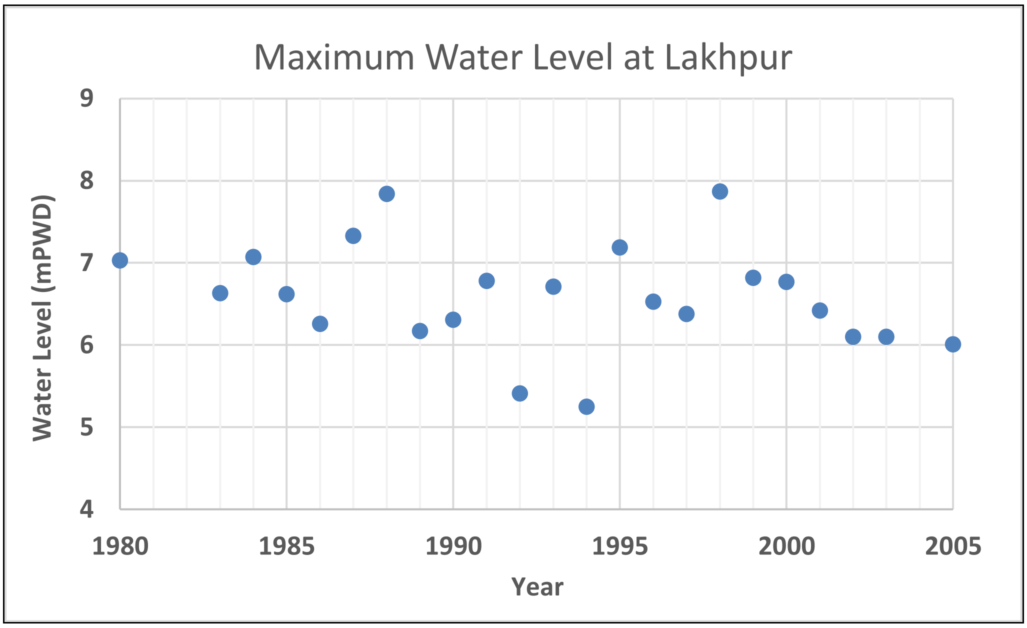


Figure 6-12: Maximum water level of different years at Lakhpur

6.8 Physical Environment

6.8.1 Climate and Meteorology

318. The project site is located in Dhaka Division. According to Köppen climate classification, it falls under *Aw* category which is characterized by tropical wet and dry climate. Hence, it experiences hot and humid summer and dry winter. According to the climatic characteristics, Bangladesh is divided into 7 different climatic sub-regions. The study area of the project falls under category "*G*", which is the south-central climatic zone of the country (Figure 6-13).

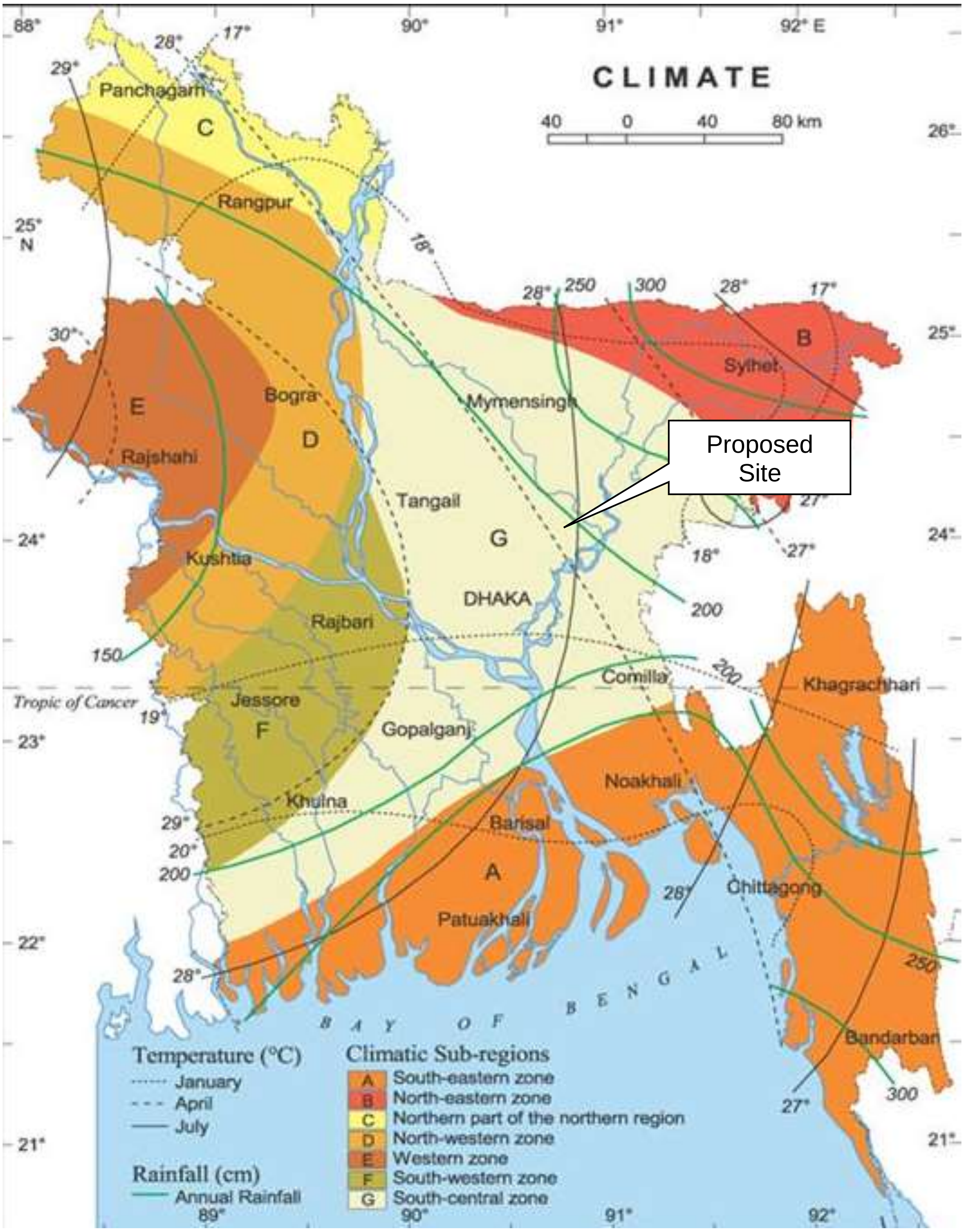
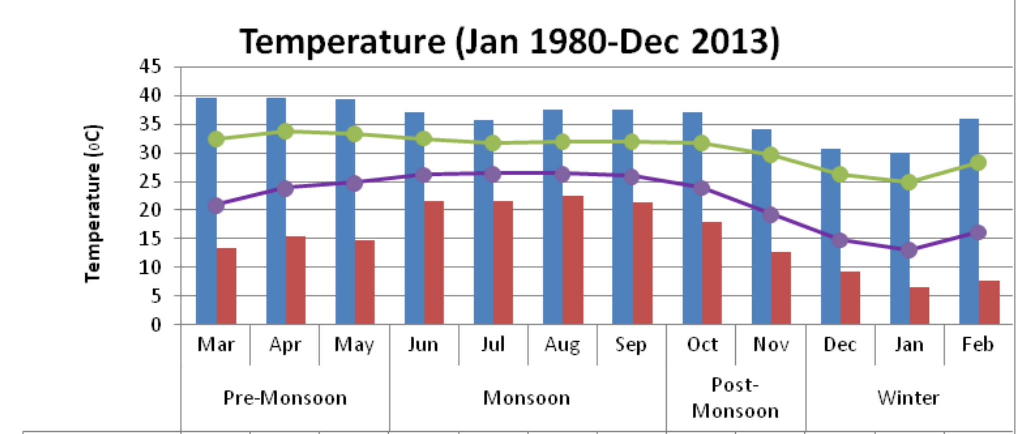


Figure 6-13: Climatic zone of the proposed plant location

319. The summary of the analysis of the climatic and meteorological parameters are discussed in the following sections:

320. Temperature: Temperature data of Dhaka Station from Bangladesh Meteorological Department (BMD) for 34 years (from January 1980- December 2013) has been analyzed to see the monthly variation of the average maximum temperature which is between 39.6^{0}C to 30.1^{0}C. The monthly variation of the average minimum temperature is 22.5^{0}C to 6.5^{0}C. The maximum recorded temperature in Dhaka station was 39.6^{0}C, which occurred on March, 1999 and April, 2009. On January 1995, the minimum temperature was recorded as 6.5^{0}C in

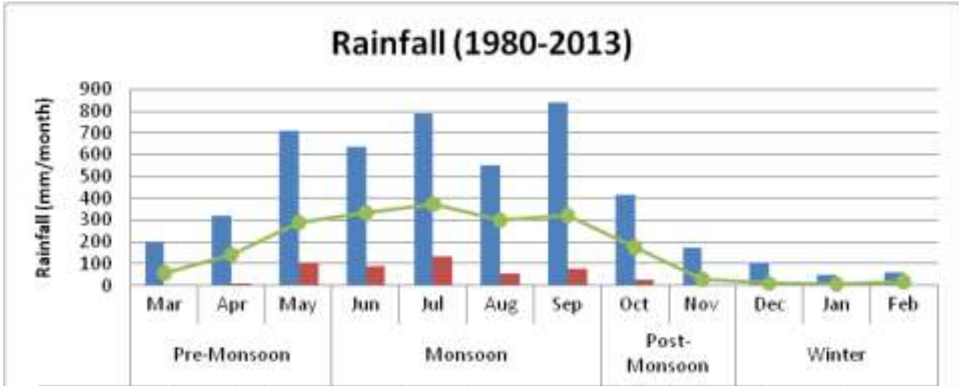
Dhaka. The warmest month of the year is April and the coldest month of the year is January. Figure 6-14 shows the maximum, minimum, average of maximum and average of minimum temperature of Dhaka station from 1980 to 2013.



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Max	39.6	39.6	39.4	37	35.7	37.5	37.5	37	34.2	30.6	30.1	35.9
Min	13.5	15.5	14.7	21.5	21.5	22.5	21.4	18	12.8	9.4	6.5	7.8
Avg of Max	32.476	33.870	33.335	32.553	31.800	32.032	32.054	31.775	29.701	26.389	24.936	28.345
Avg of Min	20.934	23.870	24.736	26.257	26.333	26.426	25.958	23.970	19.321	14.853	13.089	16.218

Figure 6-14: Monthly maximum, minimum and average temperature

321. Rainfall: Monsoon is a prominent season in this area. The average monthly rainfall during monsoon (June-September) season from 1980-2013 is 332 mm/month. The variance in the maximum rainfall during monsoon season is 836 mm/month to 552 mm/month, whereas the variance in the minimum rainfall is 136 mm/month to 59 mm/month. The maximum 836 mm/month rainfall was recorded during September of the year 2004. Annual average rainfall is 2066 mm/year and the highest recorded yearly rainfall was 3028 mm in the year 1984. The driest period of the year is winter when the average monthly rainfall varies from 21 mm/month to 7.21 mm/month. Figure 6-15 shows the maximum, minimum and average rainfall from 1980-2013.



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Max	195	318	707	637	789	552	836	417	172	106	49	61
Min	0	13	109	89	136	59	81	30	0	0	0	0
Avg	59.44	140.8	289.3	333.8	372.9	297.7	323.3	177.6	31.35	11.29	7.205	20.76

Figure 6-15: Monthly Maximum, Minimum and Average Rainfall

Humidity

322. **Humidity:** The average relative humidity remains higher during the monsoon season. The variance in the average relative humidity throughout the year is 83.77% to

62.47%, whereas during monsoon the variance is 83.77% to 82.40%. Figure 6-16 shows the maximum, minimum and average relative humidity of Dhaka station from January 1980 to January 2013.

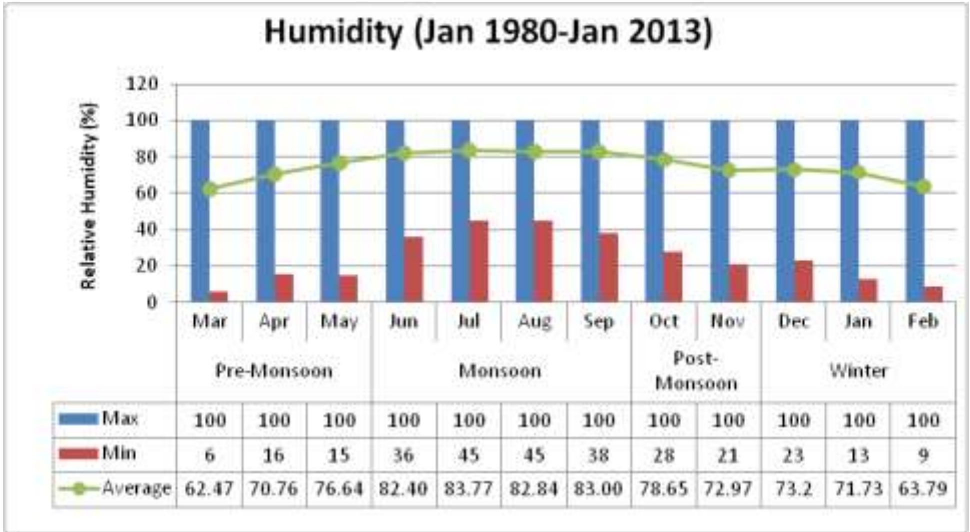
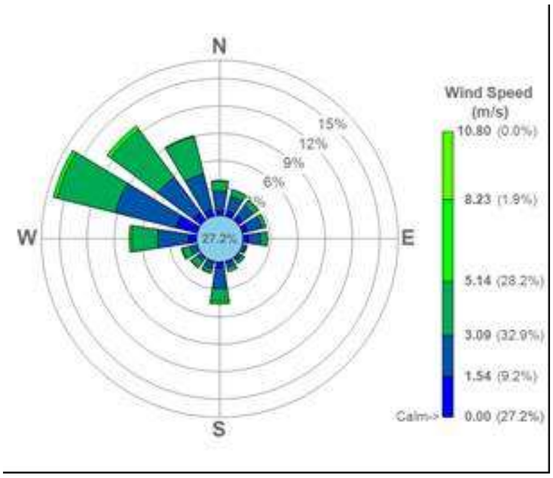


Figure 6-16: Maximum, Minimum and Average Relative Humidity

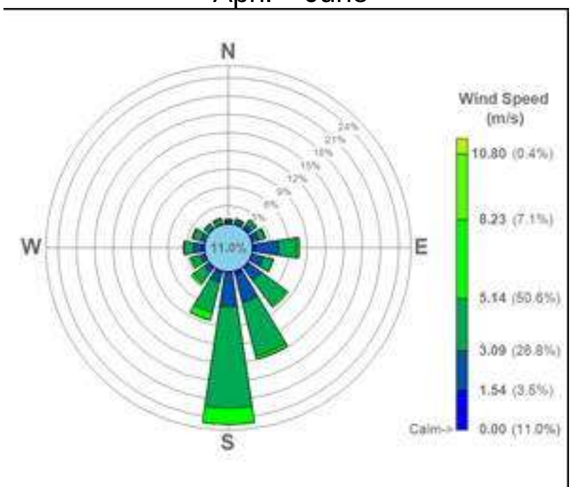
323. Wind Speed and Direction: The direction of wind varies depending on the seasons. Therefore, whole year has been categorized into four clusters of months and these are: Cluster-1: December-March, Cluster 2: April-June, Cluster 3: July to September, and Cluster 4: October to December. Wind speed data and direction have been collected from the Dhaka BMD station at a height of 10 m from the ground level. During clusters 1 and 4 months wind direction is predominantly from northwest to southeast direction, inclined towards east and for clusters 2 and 3 it is predominantly from south and southeast to north and northwest. In cluster 1 calm wind prevails for 27.2% of total period, similarly it is 11.0% for cluster 2, 12.5% for cluster 3, and 56.9% for cluster 4, respectively. Figure 6-17 (a, b, c and d) present wind speed and direction graphically round the year.

December – March



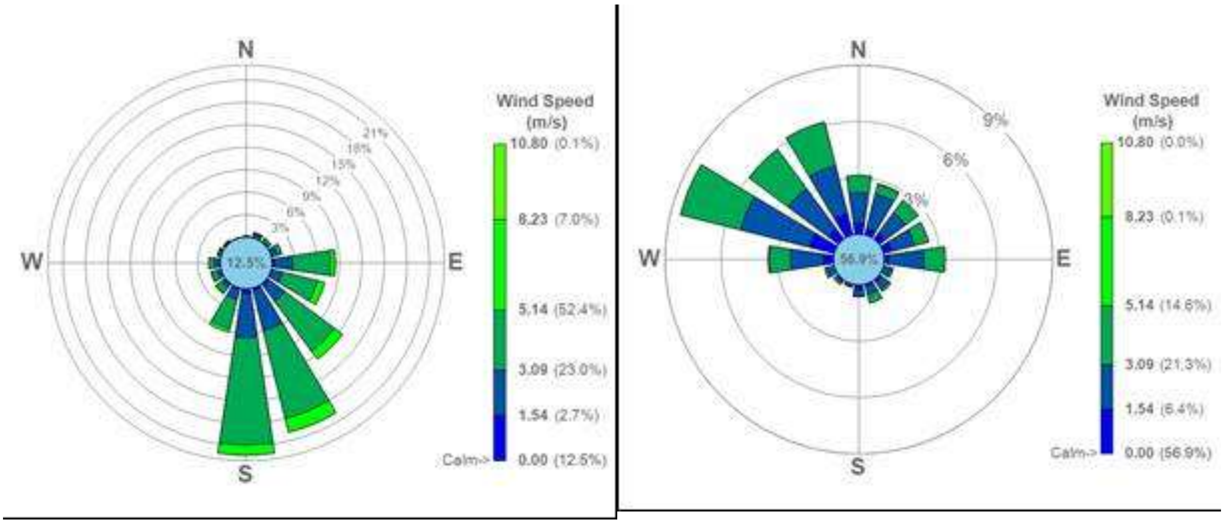
(a): Wind rose diagram for December-March

April – June



(b): Wind rose diagram for April-June

July – September October – December



(c): Wind rose diagram for July-September (d): Wind rose diagram for October-December

Figure 6-17: Wind rose at Dhaka station

324. The Figure 6-18 shows wind speed and direction round the year for 2014 based on data collected at Dhaka Station and calm wind prevails for 24.8 % time of the year.

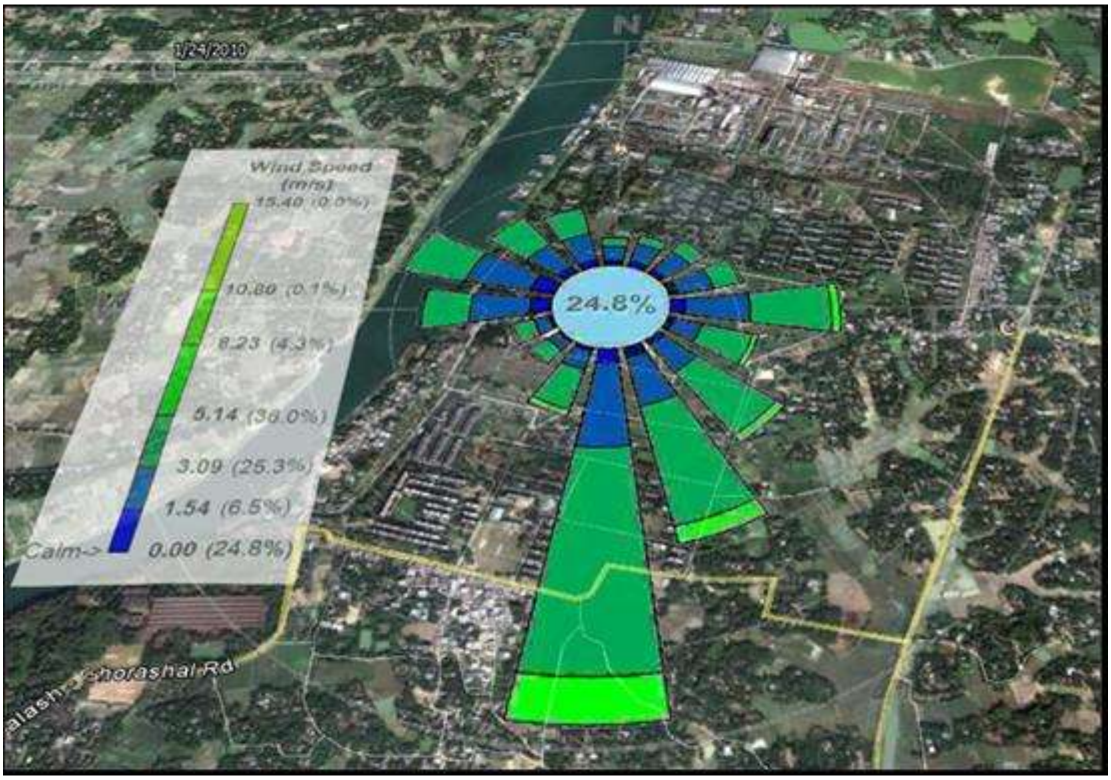


Figure 6-18: Annual wind rose for 2014

6.9 Ambient Air Quality

325. Air quality monitoring data from the Continuous Ambient Monitoring Station (CAMS) in Narayanganj is used to establish the ambient air quality in the project site. The usage of

this data was deemed appropriate since Narayanganj is located approximately 30 km away from the project site and shares the same airshed. Hourly measurements for NO_2, CO, O_3, PM_{10} and $PM_{2.5}$ were available from November 2012 to May 2015. USEPA NAAQS guidelines along with other guidelines were used to refine the data and find ambient concentrations for 8-hr, 24-hr and annual averaging periods (Table 6-2).

326. Table 6-2 shows the results of the ambient air quality measurements along with applicable standards and guidelines. The ambient concentrations for NO_2, CO and O_3 in the airshed were found to be within the ECR 1997 (amended in 2005) and WHO guidelines. The ambient concentrations for PM_{10} and $PM_{2.5}$ exceed Bangladesh National standards and WHO Guidelines for both 24-hr and annual averaging periods. The ambient 24-hr SO_2 concentration exceeds WHO guidelines but is in compliance with Bangladesh National standard.

327. Sampling locations of ambient air along with other environmental quality and ecological and fisheries survey points are presented in Figure 6-19.

Table 6-2: Ambient air quality in the project area

Pollutant	***Averaging Time***		***µg/m³***		
		Measured Value	***Standard Deviation***	***WHO Guidelines***	***Bangladesh NAAQS***
PM_{10}	*24 hour*	488.0	-	50	150
	Annual	204.0	160.5	20	50
$PM_{2.5}$	*24 hour*	311.8	-	25	65
	Annual	106.6	104.3	10	16
SO_2	*24 hour*	113.0	-	20	365
	Annual	25.4	37.0	-	80
NO_2	*1 hour*	93.0	-	200	-
	Annual	22.6	19.9	40	100
CO	*1 hour*	5,969	-	30,000	40,000
	8 hour	4,056	-	10,000	10,000
O_3	*1 hour*	87.3		-	235
	8 hour	66.5		120	157

Notes:

1) Annual average for $PM_{2.5}$, PM_{10}, SO_2 and NO_2 found by taking arithmetic mean of hourly data from November 2012 to May 2015.

2) 24-hour average for $PM_{2.5}$, PM_{10} and SO_2 found by taking 98^{th} percentile of maximum daily values from November 2012 to May 2015.

3) 1-hour average for NO_2 found by taking the 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years.

4) 1-hr and 8-hr average for CO and O_3 found by taking 2^{nd} highest value of measured data for 2015.

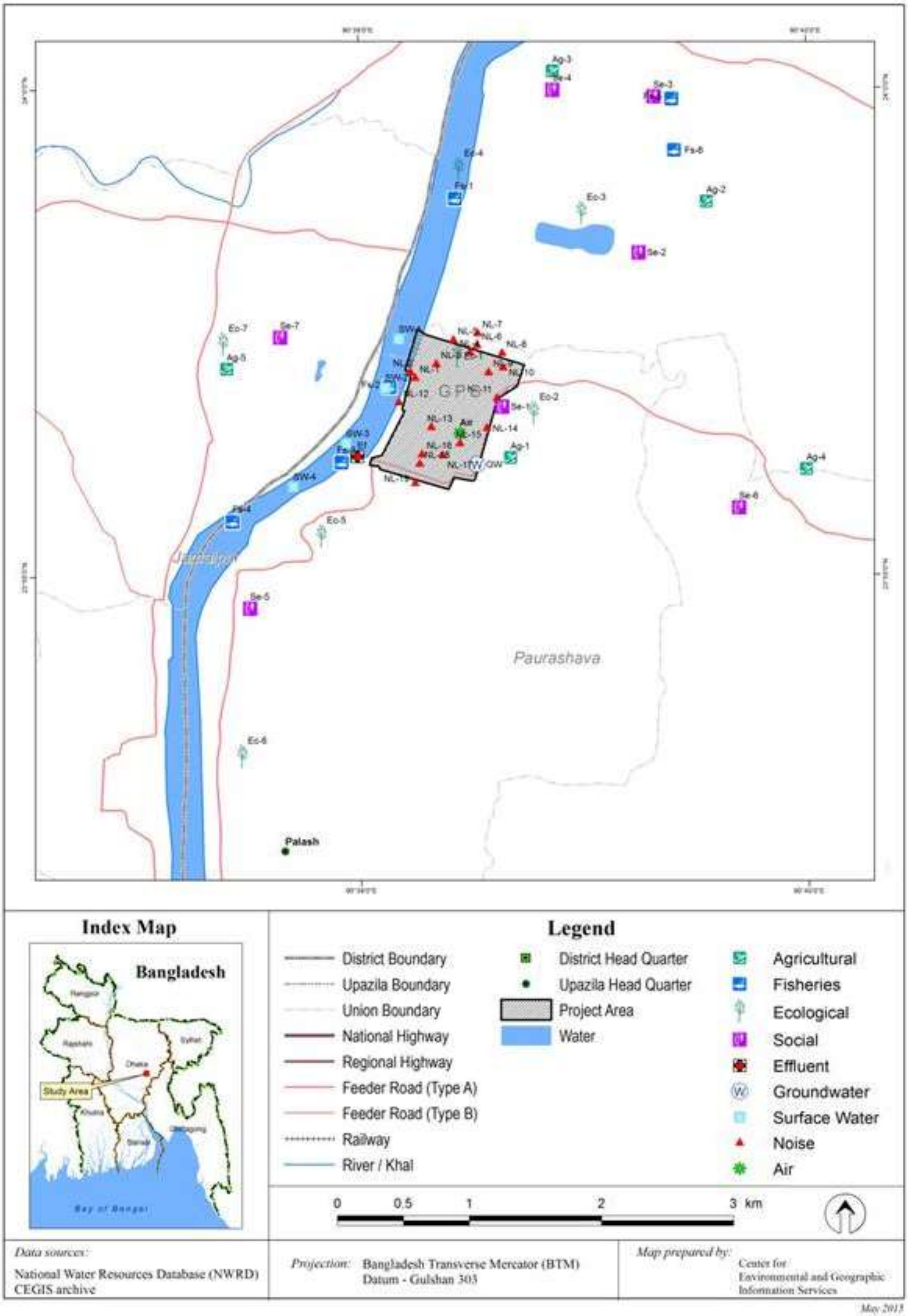


Figure 6-19: Sampling locations of environmental components

6.10 Acoustic Environment

328. Ghorashal power plant has six units among which 5 units were functional during the collection of baseline noise data. These 5 units, 2 RMS units, construction work of Max-power plant and operation of Aggreko power plant were the major sources of noise in the area. Noise levels were measured at 23 locations including 19 sensitive receptors inside and outside GPS. The locations are shown in Figure 6-19. The measured baseline noise levels are depicted in Table 6-3.

329. The permissible level of noise as per ECR 1997 for industrial area is 75 dBA (as per WBG Guidelines it is 70 dBA) during day (7:00-22:00) and 70 dBA during night time (22:00-7:00) and for residential/institutional/educational zone are 50 dBA during day time (as per WBG Guidelines it is 55 dBA) and 40 dBA during night time (as per WBG Guidelines it is 45 dBA).

330. The measures noise levels in the project area are compared with both ECR 1997 and WBG Guidelines and are presented in Table 6-3 (marked red are non-compliant by either ECR 1997 or WBG Guidelines).

Table 6-3: Baseline noise level at different location around Ghorashal Power Plant

<table>
<tr><th rowspan="3">Place</th><th rowspan="3">Notation</th><th rowspan="3">Type</th><th colspan="6">Noise Level (LAeq)</th></tr>
<tr><th rowspan="2">Day</th><th colspan="2">Day time standard (dBA)</th><th>Night</th><th colspan="2">Night time standard (dBA)</th></tr>
<tr><th>WBG Guideline</th><th>Bangladesh standard</th><th></th><th>WBG Guideline</th><th>Bangladesh standard</th></tr>
<tr><td>Administrative building</td><td>SR-1</td><td>Industrial</td><td>68</td><td rowspan="14">70</td><td rowspan="14">75</td><td></td><td rowspan="14">70</td><td rowspan="14">70</td></tr>
<tr><td>Turbine Area</td><td></td><td>Industrial</td><td>91.1</td><td>91.1</td></tr>
<tr><td>Control Room</td><td></td><td>Industrial</td><td>70.2</td><td></td></tr>
<tr><td>Mosque/Accounts office of GPS</td><td>SR-2</td><td>Industrial</td><td>58.6</td><td>58.2</td></tr>
<tr><td>Near RMS</td><td>SR-3</td><td>Industrial</td><td>91</td><td></td></tr>
<tr><td>Near Fertilizer Factory</td><td>SR-4</td><td>Industrial</td><td>71</td><td>71.6</td></tr>
<tr><td>Ghorashal boundary near Aggreko</td><td>SR-9</td><td>Industrial</td><td>68.1</td><td>67.3</td></tr>
<tr><td>Inside Aggreko-Max</td><td>SR-10</td><td>Industrial</td><td>69.2</td><td></td></tr>
<tr><td>Aggreko Gate</td><td>SR-11</td><td>Industrial</td><td>69.6</td><td>67.6</td></tr>
<tr><td>Outside the plant (Commercial)</td><td>SR-12</td><td>Industrial/ Commercial</td><td>54.3</td><td>60.6</td></tr>
<tr><td>Corner of Substation</td><td>SR-14</td><td>Industrial</td><td>59.7</td><td>60.7</td></tr>
<tr><td>Bazar</td><td>SR-19</td><td>Industrial/ Commercial</td><td>68.8</td><td>66.7</td></tr>
<tr><td>Near Titas RMS</td><td></td><td>Industrial</td><td>73.5</td><td></td></tr>
<tr><td>Kathali Para</td><td></td><td>Industrial/ Commercial</td><td>64.1</td><td></td></tr>
<tr><td>Residence in Fertilizer Factory (FF) (West side)</td><td>SR-5</td><td>Residential</td><td>63.3</td><td rowspan="6">55</td><td rowspan="6">55</td><td></td><td rowspan="6">45</td><td rowspan="6">45</td></tr>
<tr><td>Resident Fertilizer Factory (Outside Boundary)</td><td>SR-6</td><td>Residential</td><td>65.1</td><td></td></tr>
<tr><td>Residence Mosque FF</td><td>SR-7</td><td>Residential</td><td>60</td><td></td></tr>
<tr><td>Residence FF Near Aggreko</td><td>SR-8</td><td>Residential</td><td>67.7</td><td></td></tr>
<tr><td>Army Residence</td><td>SR-13</td><td>Residential</td><td>55.4</td><td>56.1</td></tr>
<tr><td>Residential Area</td><td>SR-15</td><td>Residential</td><td>49.3</td><td>58.5</td></tr>
</table>

<table>
<tr><th rowspan="3">Place</th><th rowspan="3">Notation</th><th rowspan="3">Type</th><th colspan="6">Noise Level (LAeq)</th></tr>
<tr><th rowspan="2">Day</th><th colspan="2">Day time standard (dBA)</th><th rowspan="2">Night</th><th colspan="2">Night time standard (dBA)</th></tr>
<tr><th>WBG Guideline</th><th>Bangladesh standard</th><th>WBG Guideline</th><th>Bangladesh standard</th></tr>
<tr><td>School-Hospital</td><td>SR-16</td><td>Residential</td><td>53.8</td><td></td><td></td><td>49.6</td><td></td><td></td></tr>
<tr><td>Central Residential Mosque</td><td>SR-17</td><td>Residential</td><td>51.6</td><td></td><td></td><td>51</td><td></td><td></td></tr>
<tr><td>Ghorashal Residence</td><td>SR-18</td><td>Residential</td><td>51.4</td><td></td><td></td><td>55.5</td><td></td><td></td></tr>
</table>

6.11 Surface Water Quality

331. All water usage at GPS including Unit 4 are withdrawn from the Shitalakhya River using symphonic technology. The current water requirement for Unit 4 is about 8.971 m^3/s for condenser cooling, auxiliary cooling, producing demineralized water and other Plant uses. On the contrary, water requirement for same purposes for the entire GPS is about 40.3 m^3/s. The estimated waste water coming from above mentioned usages Unit 4 is about 0.6.05 m^3/s (detailed out in Section on Water Balance). Out of which about 0.003 m^3/s is being sent to the neutralization pond and generated sludge from this pond are being kept in the wastewater pond. The condenser cooling water discharges into the river after passing through a 1-km long concrete canal (Photo 6-1) where it loses about 2 to 3^{0}C before the disposal at the outfall near the Palash Bazar Bridge (Photo 6-2).

Photo 6-1: Condenser cooling water discharge canal

Photo 6-2: Condenser cooling water outfall at Palash Bazar

332. Baseline water quality samples were collected (during February 27 to 28, 2015) for laboratory analysis and the sampling locations are shown in Figure 6-19. Water sampling locations are shown in Photo 6-3. The results of the analysis are presented in Table 6-4. From the result, it is observed that only 3 parameters out of 12 were beyond the ECR 1997 and WBG Guideline values in selected samples and they were DO, COD and iron levels. The concentration of Nitrate in the Shitalakhya River is very high due to human excreta, industrial activities and agrochemicals. A study was conducted by Alam, et. al.

Photo 6-3: Water sampling

(2012)[21] in Shitalakhya River water quality from Ghorashal bridge to Narayanganj and found that total ammonia concentrations (expressed as NH_3-N) varied from 0.05 to 13.42 mg/l along the Shitalakhya River in dry season (Figure 6-20). Location of GPS is upstream of Ghorashal Bridge. Higher concentrations of ammonia were observed in dry season (7.95 mg/l) than in wet season (0.07 mg/l) near Saidabad WTP intake point along with the Bridge point. Generally, nitrate concentration (expressed as NO_3-N) varied from 0.2 to 1.8 mg/L. However 14.5 mg/l of NO3-N was recorded upstream of Kanchpur bridge on 6th April 2009. This was probably due to oxidation of large amount of ammonia just prior to sampling. Concentrations of nitrate were found to be higher during dry season than in wet season. Dissolved oxygen varied from 0.07 to 7.52 mg/l along the Shitalakhya River in dry season. Maximum DO of 7.52 mg/l was found near Kanchan Bridge in April 2008 and minimum DO of 0.07 mg/l was found near and downstream of Saidabad WTP intake in March 2009. It is observed from Figure 6-20 that NH_3-N, COD, and BOD levels in Ghorashal bridge and upstream are lower (close to GPS) than the downstream range. On the other hand, DO and NO_3-N concentrations show higher level close to GPS compared to the downstream range.

[21] Alam, M. A., Badruzzaman, A. B. M., and Ali, M. A. (2012) Spatiotemporal Assessment of Water Quality of the Sitalakhya River, Bangladesh, Int'l Journal of Engineering and Technology Volume 2 No. 6, pp. 953-962.

Table 6-4: Baseline water quality data

Parameters	Unit	2015 Sample*					2013 Sample**		WBG Effluent Guidelines, 2008	ECR 1997 Standards for Inland Surface Water (water usable by various process and cooling)
		Sampling Location								
		Jetty point [N-23°59'0.9" E-90°38'0.2"] (SW-1)	Intake point (in front of pump 7 and 8) [N-23°58'48.9" E-90°37'56.5"] (SW-2)	Discharge point [N-23°58'32.0" E-90°37'49.0"] (Effluent)	Mid river (near discharge point) [N-23°58'35.2" E-90°37'46.0"] (SW-3)	Mid river (500 m d/s from discharge point) [N-23°58'24.6" E-90°37'31.7"] (SW-4)	Intake point	Discharge point		
Temperature	˚C	30.4	30.8	38.9	32.5	36.0				
pH		8.3	8.6	7.9	8.2	7.6			6-9	6.5-8.5
BOD	mg/L	2.4	5.0	6.5	6.2	6.1				≤10
Dissolved Oxygen	mg/L	7.3	6.5	4.2	4.5	5.7				≥5
Total Dissolved Solid (TDS)	mg/l	213	239	224	210	212				-
Ammonia (NH_3)	mg/l	0.12	0.12	0.12	0.12	0.12				-
Nitrate (NO_3)	mg/l	66	64	60	62	63				-
Chemical Oxygen Demand (COD)	mg/l	32	16	20	20	20			12	-
Arsenic (As)	mg/l	0.002	0.002	0.003	0.003	0.002	0.001	0.002	0.5	-
Iron (Fe)	mg/l	1.04	0.28	0.37	0.32	0.34	0.35	0.73	1.0	-
Lead (Pb)	mg/l	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.5	-
Mercury (Hg)	mg/l	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015	0.005	-

**Source: DPHE, Dhaka for CEGIS, 2015; **Source: DPHE, Dhaka for CEGIS, 2013; ***Source: Ghorashal 3rd Unit Repowering Project done by CEGIS, August, 2012*

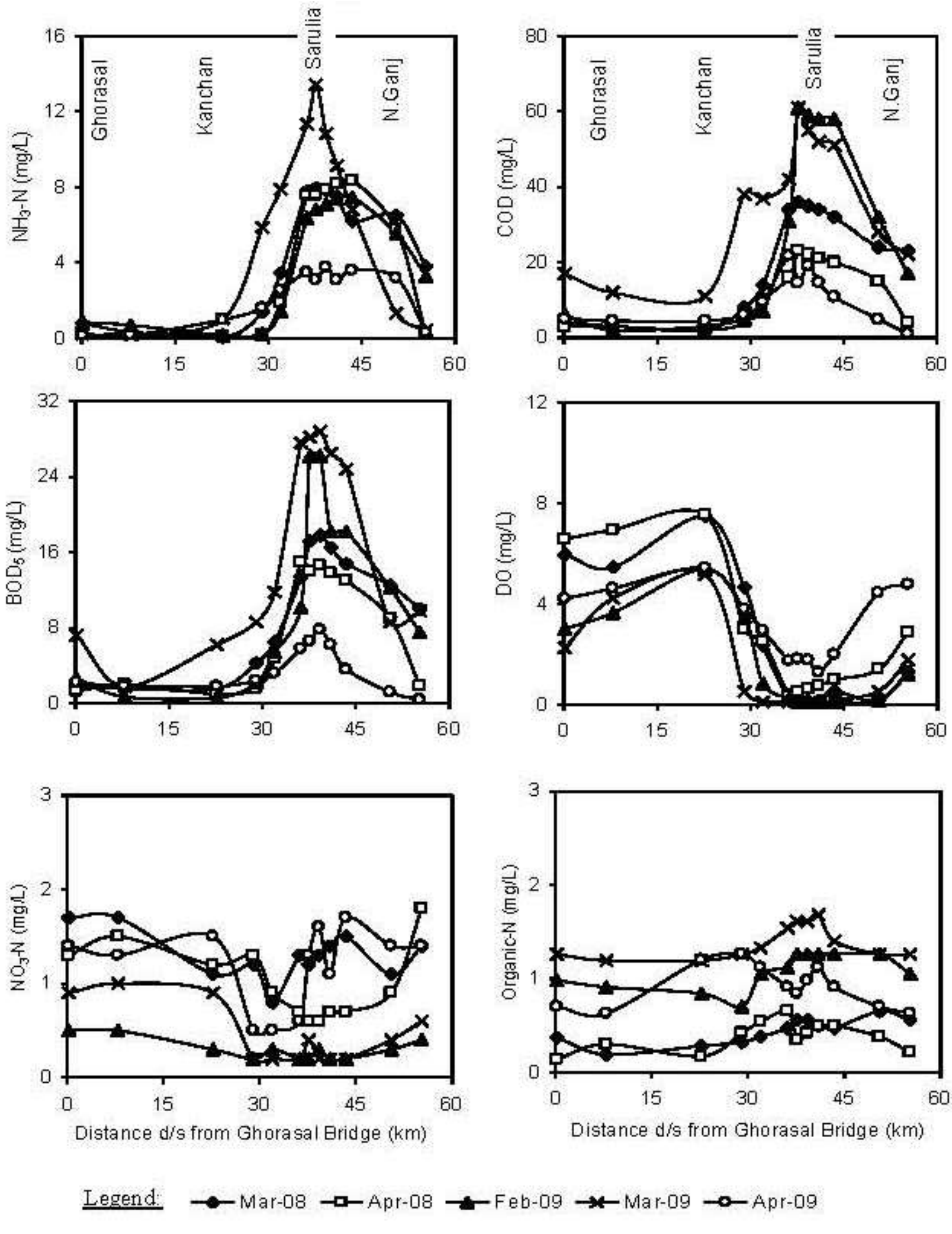


Figure 6-20: Spatial variation of NH3-N, COD, BOD5, DO, NO3-N and Organic-N along the Shitalakhya River

Ground Water Quality

333. Groundwater samples were collected and laboratory analyzed and the result is presented in Table 6-5. Most of the parameters of groundwater fall within or less than the Bangladesh Standards. However, iron level exceeds Bangladesh Standards. It should be noted that, on a previous test conducted for Ghorashal 3rd Unit Re-powering project, the

level of iron on the groundwater was much lower and was below the Bangladesh Standards. However, since iron concentration in ECR 1997 is not a health-based standard and rather an acceptability-based standard (aesthetic consideration), intake of water with this iron concentration will not pose any health effect. Groundwater will not be used in this plant feedwater. In any case, demineralization plant will remove all TDS in the HRSG's feedwater system.

Table 6-5: Measured ground water quality at Ghorashal Power Plant Complex

Parameters	Unit	Sampling Location (2015)* [N-23⁰58'30.0" E-90⁰38'21.05"] (GW)	Nearby Project site (2012)**	Ghorashal Power Plant Complex (2012)**	ECR 1997
Temperature	°C	27.4			20-30
pH		7.2	7.1		6.5-8.5
Dissolved Oxygen	mg/L	18.5			6
Turbidity	NTU	2.7			4
Alkalinity (HCO3-)	mg/L	190	78.0	135	-
Total Hardness	Mg/L	205	68	95	200-500
Total Dissolved Solid (TDS)	mg/L	162	90.0		1000
Phosphate (PO4)	mg/L	1.22			6
Chloride (Cl-)	mg/L	10	16.4	12	150-600
Ammonia (NH3)	mg/L	0.12			0.50
Nitrate (NO3)	mg/L	<0.10			10.0
Chemical Oxygen Demand (COD)	mg/L	16			4
Arsenic (As)	mg/L	<0.001		<0.001	0.05
Calcium (Ca)	mg/L	19			75.0
Iron (Fe)	mg/L	1.29	0.8	.29	0.3-1.0
Lead (Pb)	mg/L	0.010		<0.002	0.05
Magnesium (Mg)	mg/L	13			35.0
Mercury (Hg)	mg/L	<0.00015		<0.00015	0.001
Potassium (K)	mg/L	2			12.0
Sodium (Na)	mg/L	23			200

Source: DPHE, Dhaka for CEGIS, 2015

6.12 Soil quality

334. In general, most of the top soils are acidic and sub-soils are neutral to slightly alkaline. On the other hand, in AEZ 9 top soils are very strongly acidic to neutral and sub soils are neutral in reaction, in AEZ 16, top soils are strongly acidic to neutral in medium low and low land soils and the sub soils are slightly acidic to slightly alkaline and in case of AEZ 28 the top soils are mainly very strongly acidic in reaction but ranges up to slightly acidic with low to medium status of organic matter, low moisture holding capacity and low fertility level. General fertility level is low to medium organic matter content and very high CEC and K status. There are limitations of high exchangeable Na and low Ca / Mg ratio. The Zn status is low to medium and the B and S status is medium to optimum. Details are presented in Table 6-6.

Table 6-6: Detailed soil quality of soils of AEZ 9, AEZ 16 and AEZ 28

Major land type	Soil pH	Soil OM	Nutrients status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
High land	3.8-6.5	L-M	VL-L	VL-L	L	VL-L	M-Opt	M-Opt	L-M	VL-L	Opt
Medium highland	4.5-7.2	L-M	VL-L	VL-L	L-M	VL-L	M-Opt	M-Opt	VL-L	VL-L	Opt
Lowland	4.0-6.7	L-M	VL-L	L-M.	L-M	L-M	M-Opt	M-Opt	L-M	L	Opt

OM=Organic matter; VL=Very low; L=Low; M=Medium; Opt=Optimum
Source: Fertilizer Recommendation Guide, BARC, 2012

6.13 Transportation System

335. The proposed Project site is accessible by three different modes of communication. These are: roads, railway and waterway. One of the major regional highway (R-301) from Tongi to Ghorashal via Kaliganj passes through the project area. Another important regional highway adjacent to the project area is the Dhaka Bypass road which is a shorter route between Dhaka-Chittagong highway and the Jamuna Bridge. From these regional roads, there are Upazila roads to access the GPS.

336. Ghorashal Railway Station is the nearest railway facilities from the GPS and the distance from the site is about 5 km in the south. The Shitalakhya River is a scheduled navigation route which provides 22 km of water ways. Figure 6-21 shows the different communication systems to access the project area.

Photo 6-4: Village road communication system

Photo 6-5: Water way beside the proposed Project site

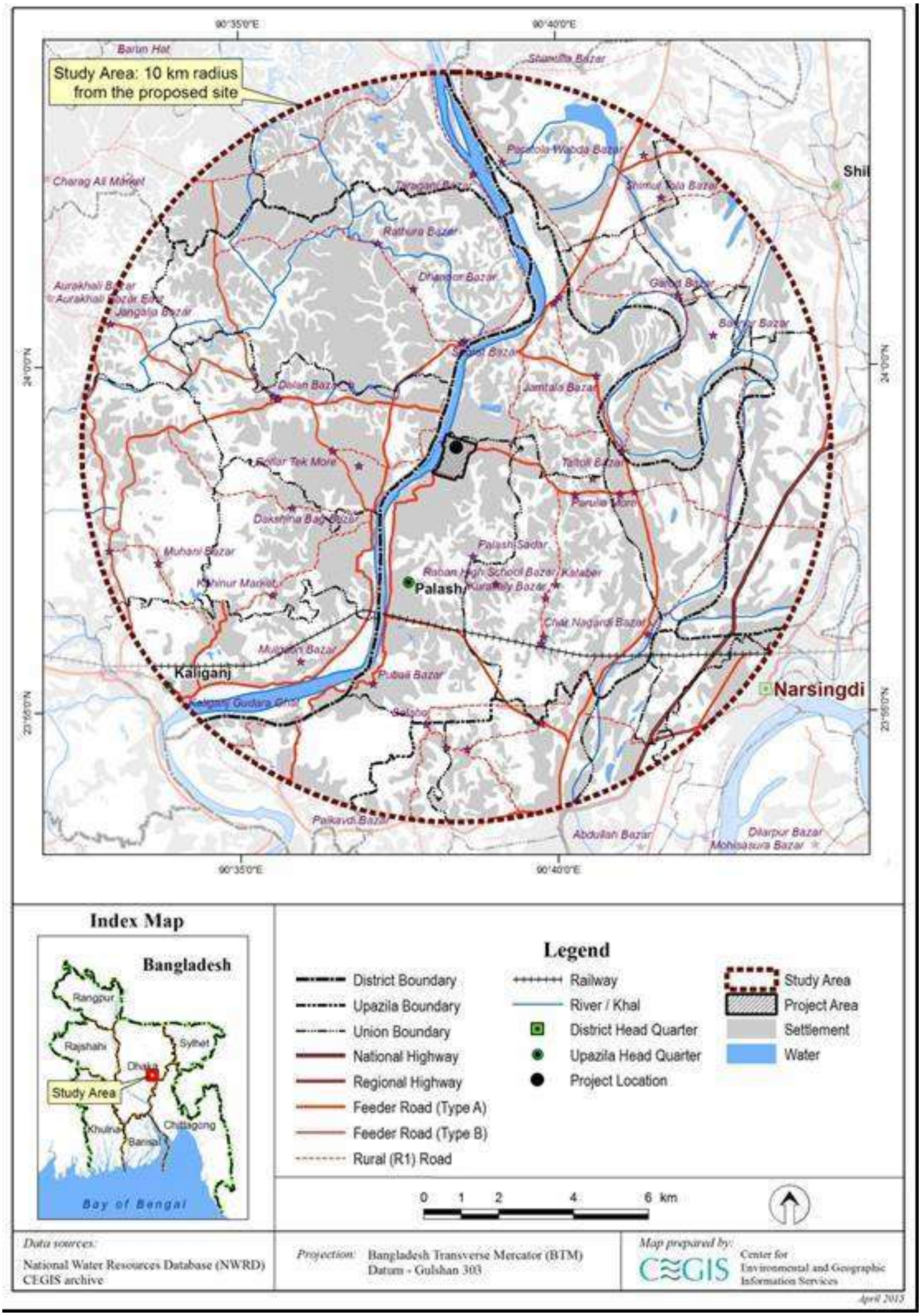


Figure 6-21: Road, railway and water ways networks of the study area

6.14 Agriculture Resources

6.14.1 Cropping pattern and intensity

337. The most prominent cropping pattern of the study area is Fallow - Fallow - HYV Boro which covers about 21% of net cultivated area (NCA), then Fallow – T Aman –HYV Boro which covers about 20% followed by others as shown in Table 6-7. The project site is a fallow land having warehouses, trees etc. The single, double and triple cropped area is about 21%, 69% and 10% of the NCA, respectively. Cropping intensity of the study area is about 189%.

Table 6-7: Cropping pattern of the study area

Study Location	Land type	Kharif-I (Mar-Jun)	Kharif-II (Jul-Oct)	Rabi (Nov-Feb)	Area (ha)	% of NCA
Study Area	High land (F_0)	Vegetables	Fallow	Vegetables	773	5
		Vegetables	HYV Aman	HYV Boro	773	5
		Fallow	HYV Aman	HYV Boro	2,164	14
		Lt. Aus	Fallow	HYV Boro	155	1
		HYV Aus	HYV Aman	Vegetables	773	5
		Fallow	HYV Aman	Vegetables	1,546	10
	Medium high land (F_1)	Jute	Fallow	HYV Boro	618	4
		Fallow	Lt. Aman	Mustard	1,082	7
		Fallow	Lt. Aman	Wheat	464	3
		Fallow	Lt.Aman	Kheshari	773	5
		Fallow	Lt. Aman	HYV Boro	3,091	20
	Low land (F_3)	Fallow	Fallow	HYV Boro	3,246	21
		Total			**15,457**	**100**
Project Area	-	Fallow	Fallow	Fallow	3	**100**
Cropping intensity-189%						

Source: CEGIS estimation based on field information, March, 2015

6.14.2 Crop production and damage

338. The Project site is surrounded by fertilizer factory and its colony, Shitalakhya River, bazaar, residents, jute mills etc. Crop fields are located around 1.5 to 2 km away from the site. In the study area, total cropped area is about 29,214 ha of which rice is about 74% and the non-rice is about 26%. Total crop production is about 129,335 tons. The annual total rice production is about 59,717 tons after the loss of 4,739 tons due to manmade pollution like industrial wastes, drought, shortage of surface water, pest and disease infestation etc. Among the rice crops, Lt Aman, HYV Aman, HYV Aus and HYV Boro is contributing about 14%, 24%, 3% and 59% of the total rice production respectively. Annual non-rice production is about 69,618 tons, of which Jute 2%, Mustard 2%, wheat 2%, Kheshari 1%, winter vegetables 67% and summer vegetables 27%. Details are presented in Table 6-8.

Table 6-8: Crop production and damage of the study area

Crop name	Crop Area (ha)	Damage free area		Damaged area		Total production (ton)	Producti on lost (ton)	Production %
		Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)			
Study area								

Crop name	Crop Area (ha)	Damage free area		Damaged area		Total production (ton)	Production lost (ton)	Production %
		Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)			
Lt. Aman	5,410	4,598	1.6	811	1.1	8,250	406	14
HYV Aman	5,255	4,467	2.9	788	1.5	14,137	1,104	24
Lt. Aus	155	131	1.4	23	1.1	209	7	0
HYV Aus	773	657	2.8	116	1	1,955	209	3
HYV Boro	10,047	8,540	3.8	1507	1.8	35,165	3,014	59
Total rice crops	**21,640**	**18,394**	**0**	**3,246**	0	**59,717**	**4,739**	**100**
Jute	618	618	2.6	0	0	1,608	0	2
Mustard	1082	1082	1	0	0	1,082	0	2
Wheat	464	464	2.5	0	0	1,159	0	2
Kheshari	773	773	1.1	0	0	850	0	1
W. vegetables	3,091	3091	15	0	0	46,371	0	67
S. vegetables	1,546	1546	12	0	0	18,548	0	27
Non-rice crops	**7,574**	**7,574**	**0**	0	0	**69,618**	0	**100**
Total	**29,214**	**25,968**	**0**	**3,246**	**0**	**129,335**	**4,739**	0

*Source: Estimation from field information; 2015 *Indicates cleaned rice*

6.15 Fisheries resources

6.15.1 Habitat characteristics

339. The seasonal and perennial Beels (depressions) along with floodplains of the study area become connected to the Shitalakhya River during pre-monsoon through a number of drainage canals (Khals). Connectivity is usually restored on the onset of monsoon and Beels become inundated earlier followed by the vast floodplains. These seasonal and perennial water bodies function as fresh water fish habitats. Open water fish habitats that are found in the study area are; (i) river, (ii) Khal, (iii) Beel and (iv) floodplain (Figure 6-6). A number of Beels such as Chinadi Beel, Buri Beel, Nali Beel, are perennial in nature as well as many seasonal Beels, e.g Bagdi Beel, Nargana Beel, etc. serve as fish over wintering refuges, mother fishery, feeding and breeding grounds of the study area.

340. The dominant fish culture practice of the study area is the improved extensive culture in commercial fish ponds though there is a recent introduction of excavated pond merely for intensive fish culture. Statistics of Palash Upazila fisheries is given in Table 6-9.

Table 6-9: Fisheries statistics of Palash Upazila

Particulars	Quantity	Particulars	Quantity	Particulars	Quantity
Pond	2,718 nos.	Fish production	3,170 tons	Fish whole seller	03 nos.
River	02 nos.	Fish demand	3,474 tons	Fish retailer	12 nos.
Drainage canal	02 nos.	Fishermen	350 nos.	Fry seller	15 nos.
Beel (depression)	15 nos.	Fish farmers	1,987 nos.	Fish Arat	09 nos.
Nursery farm	09 nos.	Fisher Assoc.	01 no.	Hat/Bazar	21 nos.
Fry production/yr	41.9 Lakh	Farmer Assoc.	08 nos.	Ice factory	04 nos.

Source: Upazila Fisheries Office, Palash, 2014

341. The estimated overall fish habitats of the study area accounts for 4,412 ha. Capture fishery constitutes about 3,767 ha (about 85%) and the rest is shared by the culture fishery. Among the fish habitats, floodplain occupies the most, about 71%, followed by cultured fish pond (12%), river and Khal (9%), Beel (5%) and culturable pond (3%). Of the capture habitats, floodplain occupies the most around 84%, followed by river and Khal, 10% and Beel 6%. The Table 6-10 presents the distribution of fish habitats.

6.15.2 Fish production

342. The yearly production of the capture fishery resources in the study area is derived from river and Khal, Beel and floodplain. The yearly production of culture fishery resources is derived mainly from the cultured pond and culturable pond. The estimated total fish production of the study area is about 2,337 tons, where culture fishery contributes the most amounting to 72% and the rest is shared by the capture fishery. The yearly production of different fish habitats is presented in Table 6-10 for 2014.

Table 6-10: Fish habitat and production assessment

Sl. No.	Fishery Types	Habitat Types	Study Area		
			Habitat Area (Ha)	Yield/ Production (MT)	% of Production
1	Capture	River & khal	390	29	1
2		Beel	219	71	3
3		Floodplain	3,158	553	24
Sub-Total=			*3,767*	*653*	*28*
4	Culture	Fish pond	516	1,496	64
5		Culturable pond	129	187	8
Sub-Total=			*645*	*1,683*	*72*
Grand Total=			4,412	2,337	100

Source: CEGIS analysis using FRSS, 2013-14 published data and on-field calculation

6.15.3 Fisheries Diversity - Species composition and biodiversity

343. Local fishermen reported that fish biodiversity has been declining over the years. Major factors responsible for the downturn of the species diversity are: (i) abstraction of river water for different industrial use; (ii) reduction of fish habitats; (iii) deteriorating water as well as habitat quality; (iv) increasing fishing pressure; (iv) obstruction in fish migration routes; (vi) aggradation of riverine habitats due to geo-morphological processes; (viii) alteration of fish breeding grounds; (ix) transformation of beel habitat into paddy fields, and (x) expansion of culture fishery. The capture habitats of the study area are dominated by small indigenous species (SIS) of fish. It is reported that the Shitalakhya river's major carp and SIS fishes which were once in abundance is now rather meager. Indicative fish species of the study area is given as follows:

344. The riverine major fish species are: Kalibaus *(Labeo calbasu*), Chital (*Notopterus chitala*), Juary/Joya (*Aspidoparia jaya*), Tit punti (*P. ticto*), Boro baim (*Mastacembelus armatus*), Batasi (*Pseudeutropius atherinodes*), Golsha (*Mystus cavasius*), Narkali chela (*Salmostoma bacaila*), Kaski (*Corica soborna*), Tengra (*Mystus tengara*), Ayer (*Sperata aor*), Kajoli (*Ailia punctata*), Ghero (*Clupisoma garua*), Kaikya (*Xenontedon cancila*), Chanda

(*Chanda nama*), Bele (*Glossogobius giuris*), Golda chingri (*Macrobrachium rosenbergii*), Gura chingri (*Leander styliferus*), Taki (*Channa punctatus*).

345. The floodplain and beel fish species include: Meni (*Nandus nandus*), Shol (*Channa striatus*), Taki (*C. punctatus*), Punti (*Puntius spp*.), Shingi (*Heteropneustes fossilis*), Magur (*Clarias batrachus*), Bujuri tengra (*Mystus vitatus*), Foli (*Notopterus notopterus*), Guchi baim (*Mastacembelus pancalus*), Kolisha/chopra (*Colisa fasciatus*), Boicha (*C. lalia*), Boal (*Wallago attu*), Koi (*Anabas testudineus*), Rui (*L. rohita*), Katol (*Catla catla*), Gura chingri (*Leander styliferus*), etc.

346. Culture fish species include: Rui (*Labeo rohita*), Katol (*Catla catla*), Kalibaus (*Labeo calbasu*), Mrigel (*Cirrhina mrigala*), Silver carp (*Hypophthalmichthyes molitrix*), Grass carp (*Ctenopharyngodon idela*), Mirror carp (*C. carpio.*), Common carp (*Cyprinus carpio*), Thai pangus (*Pangasius sutchi*), Tilapia (*Tilapia mossambicus*), Nilotica (*Tilapia nilotica*), Sharpunti (*Puntius sarana*), etc.

347. Rarely available fish species are: Rani, Tara baim, Baghayer, Shilong, Kajoli, Chital, etc.

6.15.4 Fish habitat degradation

348. River water quality has been degrading due to discharge of untreated or improperly treated effluents of cement factory, fertilizer factory, paper and pulp industry, dying factory, etc. Power plant also contributes in deteriorating water quality by raising effluent water temperature higher than the allowable limit. At the same time, it entertains some fish species those prefer velocity. The industrial discharge of effluents and municipal sewages into the neighboring rivers, dust and cement from the cement factory contaminate river water. Cumulative effects of all contaminants along with the untreated effluents of the industries and power plants cause fatality to fish species along with other aquatic eco-elements. Local people as well as fishermen reported that suffocating fishes are seen occasionally particularly during dry season when water remains very low and suspected the release of untreated effluents and gaseous substances from the fertilizer factory are responsible for such death toll of fish. Mostly affected fish include carps, Bata, Ayeer etc.

6.15.5 Fishermen status and effort

349. There are several fishermen villages around the study area, namely (i) Alinagar; (ii) Betua; (iii) Raban; (iv) Nasra all situated along the Shitalakhya River. There are about 350 fishermen carry their livelihood by catching fish in different habitats. Pollutants come from various point and non point sources are responsible for the decline of fish growth and fish production. The water quality of Shitalakhya is very poor for fish to survive during dry season and this has been the case for an extended period of time. Decline of capture fishery is a countrywide challenge and not specifically relevant to GPS (especially to Unit 4 repowering). Thus, it may not be appropriate to prepare compensation plan for the fisherman. Various types of gears that are used for catching fish are seine net, cast net, lift net, push net, pull net, gill net etc.

6.16 Ecological Resources

350. Ecological resources considered eco-elements in the range of vegetation to wildlife of the aquatic and terrestrial ecosystems. The study area contains general types of eco-elements with low to medium biodiversity and does not possess any kinds of specialized

habitat or hot spot. The identified major ecosystems include homestead/settlements, crop-field, roadside, woodland, Sal forest, riverine, seasonal wetlands, etc.

6.16.1 Ecologically Critical Areas

351. The Government of Bangladesh in 2009 declared 4 rivers around Dhaka city (Buriganga, Shitalakhya, Balu and Turag) as Ecologically Critical Areas (ECAs). Most of the ECAs are suffering from encroaching, pollution and management problems in terms of sustainability. ECAs are already degraded areas and needs special protection and care. There are government restrictions on setting-up polluting industries in ECAs. By repowering of GPS Unit 4, there will be improvements in effluent quality to Shitalakhya River by introducing closed-cycle cooling system (and therefore, minimizing thermal effluent) and installation of a CETP.

6.16.2 Ecological and conservation designations

352. The designation of tracts of land for ecology and landscape conservation is an important consideration of many national policies. Conservation agenda is also being embedded in land use strategies to response to changing social needs and environmental conditions. Field investigation revealed that there is no ecological hot-spot within the study area.

6.16.3 Ecosystems

353. The entire study area possesses both terrestrial and aquatic ecosystem having moderate to low floral and faunal diversity.

a) Terrestrial Ecosystem

354. The major terrestrial ecosystems of the area are as follows: (i) Homestead/settlements; (ii) Crop-field; (iii) Roadside; (iv) Woodland; and (v) Sal forest.

b) Homesteads/Settlement Ecosystem

355. This type of ecosystem is usually evolved by the interaction of vegetation planted by the owners for their interests and the dependent wild fauna.

Homestead Flora

356. The major plant species of this ecosystem are: Tal (Borassus flabelifer), Kanthal (Artocarpus heterophyllus), Narikel (Cocos nucifera), Pepey (Carica papaya), Aam (Mangifera indica), Jarul (Lagerstomia speciosa), Rendi Koroi (Albizia saman), Akashmoni (Acacia auriculiformis), Euc alyptus (Eucalyptus citriodora), Bansh (Bambusa Spp.) etc. Besides these, there ecologically important herbs and shrubs also exist in this ecosystem.

Homestead Fauna

357. The homestead vegetation plays an important role in sheltering a variety of wild animals. Among them, the major ones are: Common Toad (Duttaphrynus melanostictus), Cricket Frog (Fejervarya limnocharis), Common Tree Frog (Polypedates maculates) under amphibian group; House Gecko (Hemidactylus frenatus), Common Garden Lizard (Calotes versicolor), Bengal Monitor (Varanus bengalensis), Common Skink (Mabuya carinata) as reptiles; Common Myna (Acridotheres tristis), Asian Pied Starling (Sturnus contra), Red-vented Bulbul (Pycnonotus cafer), Oriental Magpie Robin (Copsychus saularis), Spotted Dove (Streptopelia chinensis), Blue Rock Pigeon (Columba livia), Coppersmith Barbet

(Megalaima haemacephala) and Black-hooded Oriole (Oriolus xanthornus) under avifauna; Common Mongoose (Herpestes edwardsii), Small Indian Mongoose (Herpestes auropunctatus), Asian Palm Civet (Paradoxurus hermaphroditus), Common House Rat (Rattus rattus), Irrawaddy Squirrel (Callosciurus pygerythrus), Greater Short-nosed Fruit Bat (Cynopterus sphinx) and Indian Pipistrelle (Pipistrellus coromandra) as mammals.

358. Functionally, this ecosystem provides various goods and services, such as bamboos are inevitable elements for engraving the corpse of the villagers and also contribute in earning of the villagers. In addition, the homestead vegetation supports in meeting food, fuel, medicine and other household requirements.

c) Crop-field Ecosystem

359. This ecosystem is developed by the cultivation of crops and by the interaction of vegetation grows in that field supported with favorable wildlife.

Crop-field Flora

360. This ecosystem supports vegetation in association with the crop varieties like rice, jute, pineapple, etc. Detail information on cropping pattern is discussed in the agricultural section. The crop-field vegetation under ecology has considered the different species of weeds: Echinochloa colonum, Paspalum distichum, Heliotropium indicum, Drypopteris Sp, Nicotiana plumbaginifolia, Croton bonplandianum, Chynodon dactylon,Panicum repens, Cheratopteris Sp, Heliotropium indicum, Amaranthus spinosus, Centipeda orbicularis, Cyperus Sp. etc. This type of vegetation provides feeding habitats to wildlife.

Crop-field Fauna

361. The faunal diversity of this ecosystem is a mixture of terrestrial and aquatic wildlife as the crop fields possess both terrestrial and aquatic habitats. The major wild fauna of this ecosystem are: Indian Bullfrog (Hoplobatrachus tigerinus) as amphibian; Checkered Keelback (Xenochrophis piscator) and Buff-striped Keelback (Amphiesma stolata) under reptiles; of the avian fauna Black Drongo (Dicrurus macrocercus), Crested Serpent Eagle (Spilornis cheela), Brahminy Kite (Heliastur indus), White-breasted Kingfisher (Halcyon smyrnensis), Pied Kingfisher (Ceryle rudis) and Brown Fish Owl (Ketupa zeylonensis) available in this type of ecosystem. Among them Brown Fish Owl considered as vulnerable (VU) as well as Crested Serpent Eagle categorized as Critically Endangered (CR) species. Of the mammals, Little Indian Field Mouse (Mus booduga), Common Mongoose (Herpestes edwardsii) and Bengal Fox (Vulpes bengalensis) have seen during the major field investigation.

d) Roadside Ecosystem

362. The roadside vegetation is part of a web of life in which there are intimate and essential relationships between plants and the road, between plants and other plants, between plants and animals. This vegetation represents ecologically meaningful examples of human-created ecosystem. Interactions between plant and soil communities (hereafter plant-soil interactions) are of major importance in understanding the role of biotic control in ecosystem functioning.

Roadside Flora

363. The slopes and edges of top of the roads are functioned as roadside ecosystem and supports with moderate diversity of species. The forest department and villagers plant trees under social forestry concept with the aim of financial benefits as well as protection of roads from soil degradation. Strip plantation with the mixture of exotic and local species on both

sides of the rail line is implemented by the Bangladesh Railway. The major species are Rendi Koroi (Albizia saman), Mahogany (Swietenia mahagoni), Eucalyptus (Eucalyptus citriodora), Goraneem (Melia azadirachta), Sil Koroi (Albizia procera), Bansh (Bambusa tulda), Akashmoni (Acacia auriculiformis) and Sisu (Dalbergia sissoo). The roadside vegetation supports a variety of wildlife.

Roadside Fauna

364. This ecosystem consists of following wildlife such as Common Tree Frog (Polypedates maculates) and Ornate Microhylid (Microhyla ornata) under amphibians; Common Garden Lizard (Calotes versicolor), Bengal Monitor (Varanus bengalensis), Common Skink (Mabuya carinata), Checkered Keelback (Xenochrophis piscator) and Buff-striped Keelback (Amphiesma stolata), etc. under reptiles; Common Myna (Acridotheres tristis), Asian Pied Starling (Sturnus contra), Red-vented Bulbul (Pycnonotus cafer), Oriental Magpie Robin (Copsychus saularis), Spotted Dove (Streptopelia chinensis), Blue Rock Pigeon (Columba livia), Coppersmith Barbet (Megalaima haemacephala) and Black-hooded Oriole (Oriolus xanthornus), etc. under avifauna; and Common Mongoose (Herpestes edwardsii), Oriental Civet (Viverra zibetha), Little Indian Field Mouse (Mus booduga), Irrawaddy Squirrel (Callosciurus pygerythrus), and Indian Pipistrelle (Pipistrellus coromandra), etc. as mammals.

e) Woodland Ecosystem

365. Woodland is a habitat where trees are the dominant plant form. The individual tree canopies generally overlap and interlink, often forming a more or less continuous canopy which shades the ground to varying degrees. Depending on the amount of light reaching the ground through the tree canopy, there will be a great variety of other plants. These will include mosses, ferns and lichens, as well as small flowering herbs, grasses and shrubs. The more different kinds of plants there are, the greater the animal diversity will be in the woodland.

Woodland Flora

366. Woodland ecosystem is generally observed in the premises of industrial units, power plants, offices within the study area. This ecosystem supports a limited variety of exotic and local plant species. These are: Mahogony (Swietenia mahagoni), Rendi Koroi (Albizia saman) and Akashmoni (Acacia auriculiformis). This ecosystem also possesses mosses, ferns and lichens of different species. This ecosystem supports the community with providing timber, fuel wood and safeguarding natural disaster like Tornado, cyclone, etc. Some woodland developed with a single species as practice of monoculture which resulted less diversification of this ecosystem.

Woodland Fauna

367. The major woodland fauna includes Common Garden Lizard (Calotes versicolor), Common Skink (Mabuya carinata), etc. under reptiles; Common Myna (Acridotheres tristis), Asian Pied Starling (Sturnus contra), Red-vented Bulbul (Pycnonotus cafer), Oriental Magpie Robin (Copsychus saularis), Spotted Dove (Streptopelia chinensis) under avifauna; and Irrawaddy Squirrel (Callosciurus pygerythrus) and Indian Pipistrelle (Pipistrellus coromandra) as mammalian species.

f) Sal Forest Ecosystem

368. Geomorphologically, Madhupur Garh is a part of the Madhupur Tract and topographically it is raised a few metres above the level of the surrounding flood plains. This

ecosystem is situated in Gazipur district falls under the study area and the prominent species of this forest is Sal (Shorea robusta). Until beginning of the 20th century Sal forests existed as a large continuous belt with rich biological resources, but increasing human pressure has triggered the decline of such ecosystem by around 70%.

Sal Forest Flora

369. It is a deciduous forest comprising of Sal or Gajari as a major species but due to poor coppicing capability and poor management practices there population is now very restricted. Majority of the area has been replanted by short rotation exotic species and some have been brought under social forestry or participatory agroforestry schemes. Biodiversity has declined rapidly and many animal species have become locally extinct. The abundant plant species of this ecosystem may include: Sal (Shorea robusta), Koroi (Albizzia spp.), Raintree (Albizzia saman), Sissoo (Dalbergia sissoo), Bohera (Terminalia belerica), Horitaki (Terminalia chebula), Kanchan (Bauhinia acuminata), Polash (Butea monosperma) etc.

Sal Forest Fauna

370. This ecosystem supports a variety of wildlife, such as Monkey (Macaca mulatta), Barking deer (Muntiacus muntjac), Spotted deer (Axis axis), Langur, Fishing cat, Marbled cat, Jackel (Canis aureus), Common Mongoose (Herpestes edwardsii), Irrawaddy Squirrel (Callosciurus pygerythrus), and Indian Pipistrelle (Pipistrellus coromandra), and Bengal Fox (Vulpes bengalensis) etc. under mammals; Common Garden Lizard (Calotes versicolor), Bengal Monitor (Varanus bengalensis), under reptiles; Common Myna (Acridotheres tristis), Asian Pied Starling (Sturnus contra), Oriental Magpie Robin (Copsychus saularis), Spotted Dove (Streptopelia chinensis) and Black-hooded Oriole (Oriolus xanthornus), etc. under avian fauna;. Common Palm Civet habituated in forests, and plantations, farmed areas and human habitations, sal and mixed-evergreen forests in the study area. The Common Palm Civet and Common Mongoose considered as vulnerable (VU) species respectively to the country (IUCN-Bangladesh, 2000).

Homesteads vegetation

Crop-field vegetation

Road-side vegetation

Woodland vegetation

Sal forest

Photo 6-6: Terrestrial vegetation of the study area

371. The aquatic ecosystem consists of different wetlands like rivers, canals, ponds and ditches. The wetlands are divided into two types based on the duration of inundation namely- i) Seasonal wetland, and ii) Perennial wetland.

Shitalakhya River System

Wetland in Kanthaliapara of Palash

Photo 6-7: Views of aquatic ecosystem

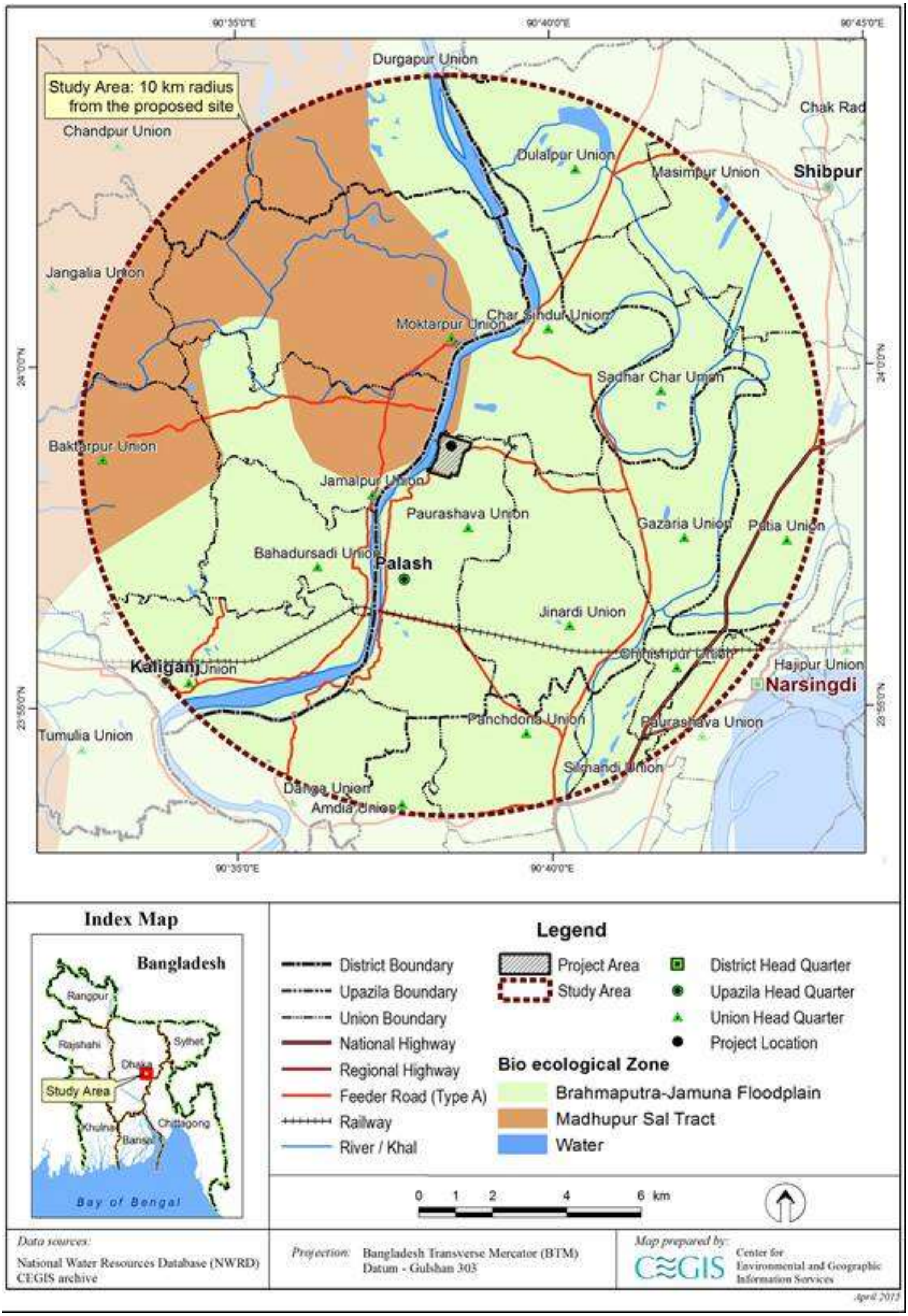


Figure 6-22: Bio-ecological zone of the study area

Aquatic Flora

372. The inundated area supports numerous hydrophytes in this study area i.e Shapla (Nymphaea nouchaali), Helencha (Enhydra fluctuans), Padma (Nelumbo nucifera) etc. Shapla and Padma are the main aquatic plants of the seasonal wetlands during the monsoon. The dominant aquatic species are Kachuripana (Eicchornia crassipes), Helencha (Enhydra fluctuans), Dhol Kolmi (Ipomoea carnea), Keshordam (Ludwigia repens), Topapana (Pistia strateotes), Tetulpana (Salvinia natans) and Kutipana (Azolla pinnata).

Aquatic Fauna

373. The life cycle of aquatic fauna depends on the natural fluctuations of water and connection with the Sitalakshya River and other closer wetlands during monsoon. The Skipper Frog (Euphlictys cyanophlytis), Indian Pond Heron (Ardeola grayii), Little Egret (Egretta garzetta), Cattle Egret (Bubulcus ibis), White-throated Kingfisher (Halcyon smyrnensis), Common Kingfisher (Alcedo atthis), Asian Openbill (Anastomus oscitans), Little Cormorant (Microcarbo niger) and River Dolphin (Platanista gangetica) were seen during the field investigation.

6.17 Socio-Economic Resources

6.17.1 Introduction

374. Baseline scenario of the socio-economic environment is assessed based on primary and secondary data considering 22 unions of five (5) upazilas of Narsingdi and Gazipur.

6.17.2 Population

375. Demography: The study area is the home of 526,463 people belonging to 114,503 households. Of the total population; 261,856 (49.7%) are male and 264,607 (50.3%) female. The average household size is 4.6, which is slightly higher than the national average of 4.50 [BBS, (HIES) 2010[22]]. The average population density is 2,088 per square kilometer which is more than double compared to national average of 1,055 (Table 6-11).

Table 6-11: Basic demographic profile of the study area

District	Upazila	Unions/ Paurasavas	HHs[23]	Population			HH size	Population density [sq. km]
				Male	Female	Total		
Gazipur	Kaliganj	Bahadursadi	6,659	15,511	16,303	31,814	4.8	1709
		Baktarpur	3,325	6,957	7,421	14,377	4.3	1111
		Jamalpur	7,323	16,400	16,404	32,804	4.5	1652
		Jangalia	1,088	2,535	2,657	5,192	4.8	785
		Kaliganj Paurashava	8,219	20,580	17,842	38,422	4.7	1456
		Moktarpur	8,691	19,400	19,735	39,135	4.5	1049
	Kapasia	Chandpur	601	1,408	1,380	2,788	4.6	732

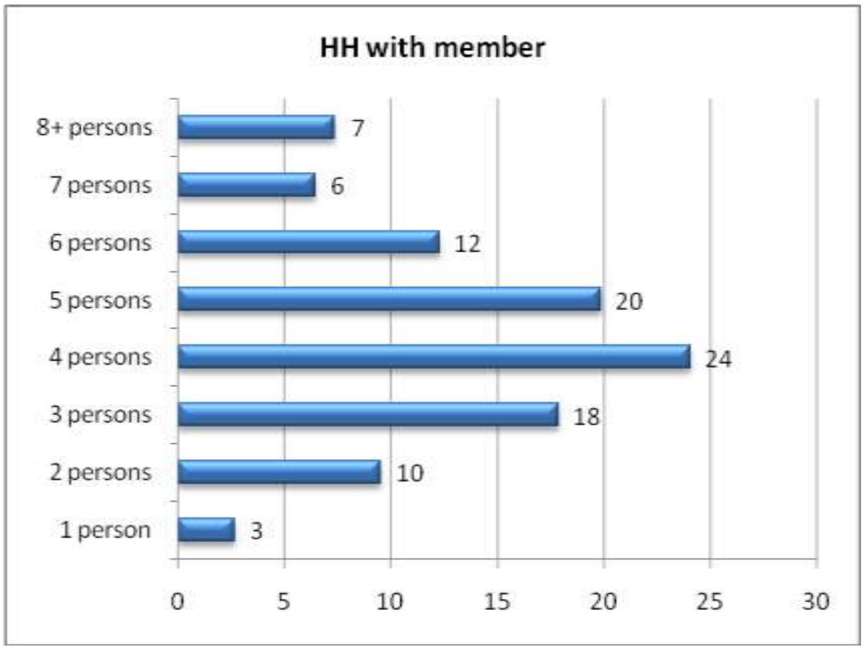
[22] HIES 2010 refers to Household Income and Expenditure Survey conducted by the Bangladesh Bureau of Statistics (BBS) in 2010.

[23] HHs refers to households

District	Upazila	Unions/ Paurasavas	HHs[23]	Population			HH size	Population density [sq. km]
				Male	Female	Total		
		Durgapur	3,574	7,681	8,326	16,007	4.5	956
Narsingdi	Narsingdi Sadar	Amdia	1,922	4,731	4,644	9,375	4.9	2078
		Chinishpur	5,516	12,880	12,559	25,440	4.6	10672
		Narsingdi Paurashava	6,804	15,873	16,150	32,024	4.7	2150
		Panchdona	5,720	13,507	13,168	26,675	4.7	2491
		Silmandi	3,276	7,848	7,277	15,125	4.6	3301
	Palash	Char Sindur	5,959	12,817	13,354	26,171	4.4	1902
		Danga	4,916	11,609	11,191	22,800	4.6	2659
		Gazaria	5,693	12,829	13,330	26,159	4.6	1968
		Ghorashal Paurashava	6,755	14,803	15,447	30,250	4.5	2250
		Jinardi	6,755	14,803	15,447	30,250	4.5	1190
	Shibpur	Dulalpur	4,648	10,187	11,030	21,218	4.6	475
		Masimpur	3,076	6,938	7,508	14,446	4.7	1587
		Putia	9,533	21,412	21,800	43,212	4.5	2458
		Sadhar Char	4,449	11,146	11,633	22,779	5.1	1302
Total/Average			**114,503**	**261,856**	**264,607**	**526,463**	**4.6**	**2088**

Source: Housing and Population Census, BBS, 2011

376. In the study area, households with four members are the dominant. 24% households belong to this category (Figure 6-23). Although average household size is 4.6, 45% households have 5 or more than five members.



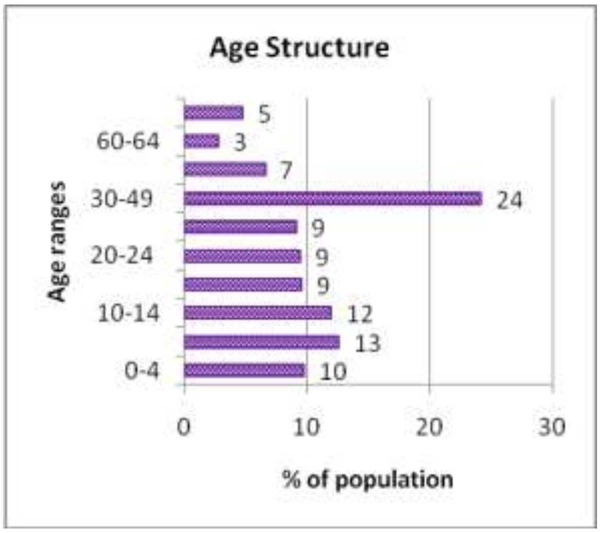
Source: Housing and Population Census, BBS, 2011

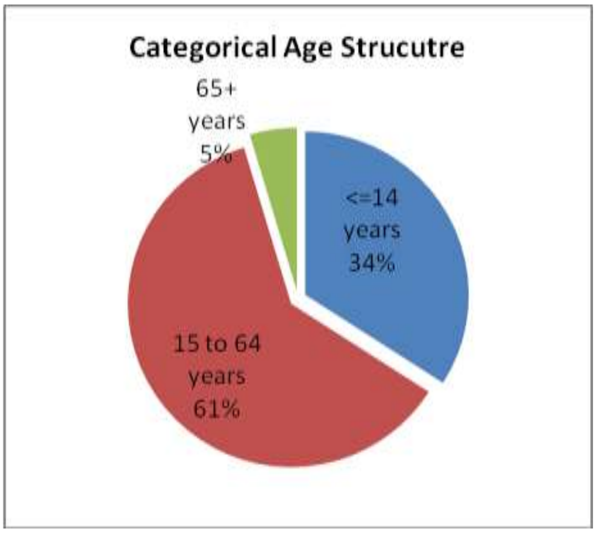
Figure 6-23: Distribution of households comprising member in each house

377. Age Structure: In the study area, the highest number of population (24%) belongs to age category of 30 to 49 years old. Only 3% people are in 60 to 64 years category. The young population (under age 15) would need more investment in schools, while size of older populations (ages 65 and over) would call for more invest in health sector.

378. According to the International Labour Organization (ILO) the population of 15 to 64 years is categorized as labor force whereas populations below 14 years and above 65 years are considered as dependent.

379. Therefore, the population data when analyzed to ascertain the size of (potentially) active working population then it appears that 61% percent population who are in the age bracket of 15-64 can be classified under this category. A small percentage (5%) is over 65 years old. The total dependency ratio[24] is 63 in which child dependency ratio is 56 and aged dependency ratio is 8. It illustrates that total 63 persons are dependent on 100 labour forces in which 56 are children and 8 are elderly people.





Source: Housing and Population Census, BBS, 2011

Figure 6-24: Age structure of the studied population

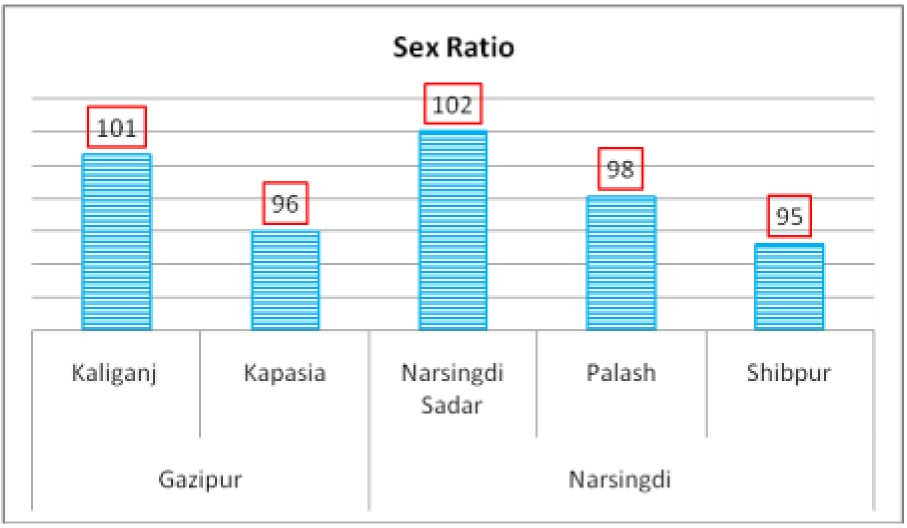
Figure 6-25: Categorical distribution of studied population

380. Sex Composition: Sex ratio when analyzed per Upazila appears to be almost similar. According to BBS (2011) data in the study area overall male-female sex ratio is 99, which means females are comparatively higher (100) than that of males (99). Male population is higher in Kaliganj (101) and also in Narsingdi Sadar Upazila (102), when the lower ratio is in Kapasia (96) Palash (98) and Shibpur (95) upazilas. The data indicates that like national average (100.3), the discrepancy between male-female numbers is gradually decreasing. However, in unions there is higher ratio of female population over male population.

[24] Total dependency ratio= $\frac{\textit{number of people aged } 0-14\ \&\ \textit{those } 65 \textit{ and above}}{\textit{number of people aged } 15-64} \times 100$

Child dependency ratio= $\frac{\textit{number of people aged } 0-14}{\textit{number of people aged } 15-64} \times 100$

Aged dependency ratio= $\frac{\textit{number of people aged } 65 \textit{ and above}}{\textit{number of people aged } 15-64} \times 100$



Source: Housing and Population Census, BBS, 2011

Figure 6-26: Sex ratio among the studied population

6.17.3 Public Health

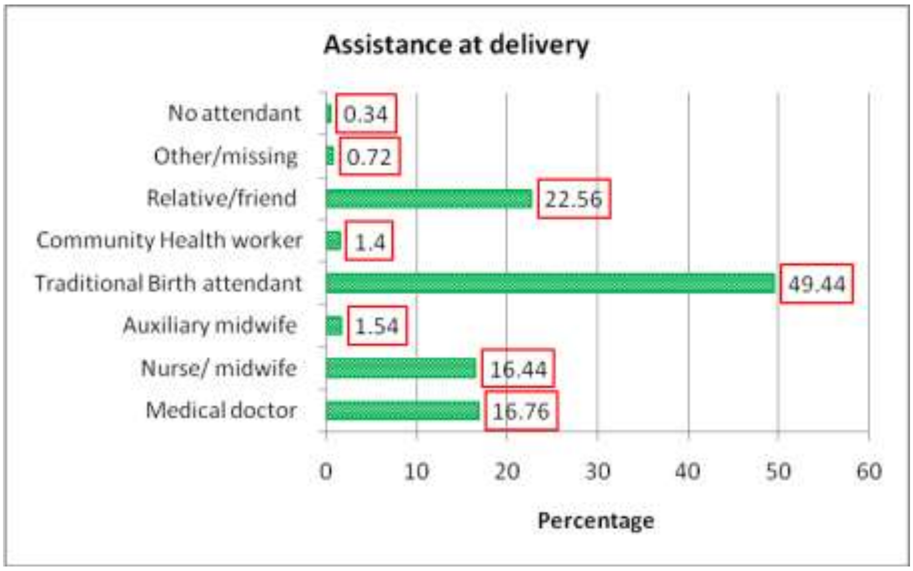
381. Access to Health Services: Access to health services and facilities refer to availability and adequacy of supply, affordability, physical accessibility and socio-cultural acceptability. Field data shows that there are 4 Upazila Health Complexes (UHC) at Upazila level and one district hospital in Narsingdi Sadar. Besides, there are few community clinics at union level and several private health service providers also provide services to the local people. People stated that the existing services are almost inaccessible to rural poor therefore, a substantial number of population tends to receive services from the local chemists and/or “village doctors” either self educated or locally trained who have some basic knowledge about health and medicines. They stated that most of the community clinics are located at preferable location of local political leaders therefore; remote villagers have limited access than that of these adjacent villagers. However, people complained that no hospitals/community clinics have special unit for treating respiratory diseases although this disease is predominant in the Ghorashal Paurashava area; even the fertilizer industry has no such facility for the affected people.

382. Child and Mothers’ Health: In the study area infant mortality rate (IMR) is 46. IMR is defined as the number of deaths of infants under one year old per 1,000 live births. On the other hand, the under five mortality rate (U5MR) is 59.40; it also indicates the number of deaths of infants under five years old per 1,000 live births. This rate is comparatively lower than that of national average which is 49 for IMR and 64 for U5MR (source: Progoti Pathey, MICS, 2009). The child mortality is due to malnutrition, having scarcity of trained attendants at delivery, lack of timely initiation of breast feeding etc.

383. Field findings show that respiratory disease such as Asthma is alarming in Ghorashal Paurashava particularly in Ward #1. The disease became epidemic due to contaminated air with ammonia absorbent led by the fertilizer industry particularly at the time of releasing gas. This contamination infests preferably children and pregnant mother. Local people stated a few cases of child deaths due to respiratory syndrome.

384. The following figure confirms that about 49% women aged 15-49 years with a birth in the 2 years preceding the survey can breastfeed their baby within one hour of birth and

about 91% can breastfeed within one day of birth. Data also shows that the highest percentage (49%) of delivery was assisted by traditional birth attendant, about 17% by medical doctor and about 16% by nurse/midwife. It is noticeable that assistance to mother during child birth is still provided mostly by traditional untrained birth attendants and relatives.



Source: Progotir Pathey, MICS, 2009

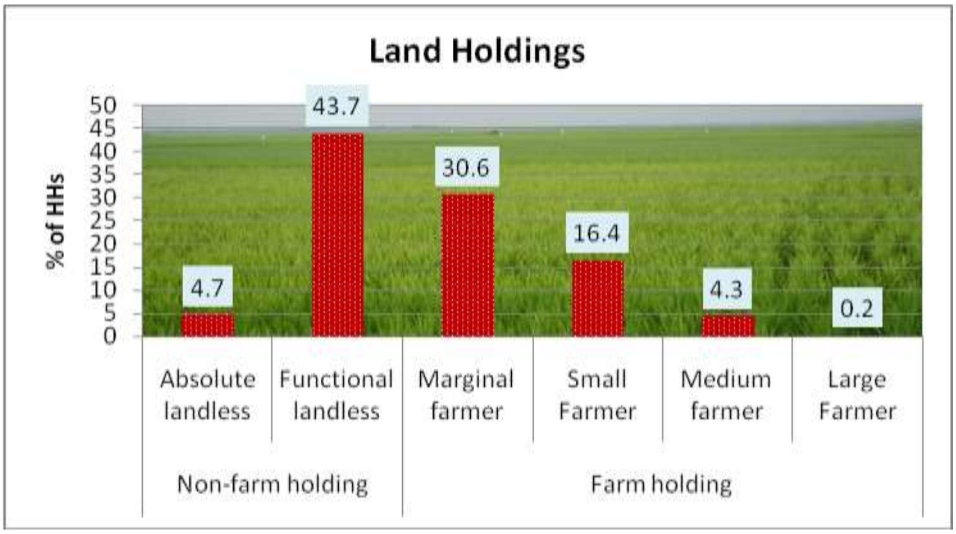
Figure 6-27: Percentage of women aged 15-49 with a birth by assistance during delivery

385. Assistance at delivery by the untrained personnel also leads to higher mortality rate. The household size (Figure 6-23) indicates household vulnerability leading to poor socioeconomic development which also leads to child and maternal mortality.

6.17.4 Ownership and utilization of land

386. The Census of Agriculture, 2008 conducted by BBS classified land holdings into two broad categories- one is farm-holdings and another is non-farm holdings. A farm holding is defined as being an agricultural production unit having cultivated land equal to or more than 0.05 acre. Conversely, non-farm holding includes landless households and households having lands up to 0.04 acre. The study area shows that out of total holdings 51.5% is farm-holder and the rest 48.5% is non-farm holders.

387. According to BBS 2008 data on land holding distributions, in the study area 4.7% households are absolute landless i.e. they have no lands either homesteads or cultivated. 43.7% households belong to functional landless category, who have land up to 0.04 acres. Among them 41.7% households have only homestead lands and 2% have homestead plus farm land within the limit of 0.04 acre These households mainly own land adjacent to their homestead and being used as kitchen garden that are primarily used by the female members for household consumption.



Source: The Census of Agriculture, 2008, BBS

Figure 6-28: Households by land holdings

388. On the other hand, farm holding distribution shows that 30.6% households belong to marginal farmer (0.05 to 0.99 acre), 16.4% belong to small farmer (1.00 to 2.49 acre), 4.3% belong to medium farmer (2.5 to 7.49 acre) and 0.2% belong to large farmer (7.5+ acre) categories. It is evident that land fragmentation decreases the holding size therefore; large and medium farmers are gradually being converted to marginal farmers.

389. In land tenure arrangement of farm holdings, it was found that 66.7% households belong to owner category, and they belong to various landownership categories such as marginal (61.5%), small (29.1%), medium (8.9%) and large (0.5%) land holders. It is evident that most of the owners are marginal and small landowners therefore; their lands are usually operated by themselves. A few from medium and large owners tend to lease out their lands to the tenants.

Table 6-12: Land tenure arrangement in the study area

Tenancy type	Farmer by holding category (%)				Total
	Marginal	Small	Medium	Large	
Owner	61.5	29.1	8.9	0.5	66.7
Owner-cum-Tenant	54.7	37.7	7.4	0.2	32.3
Tenant	81.8	16.7	1.5	0.0	1.0

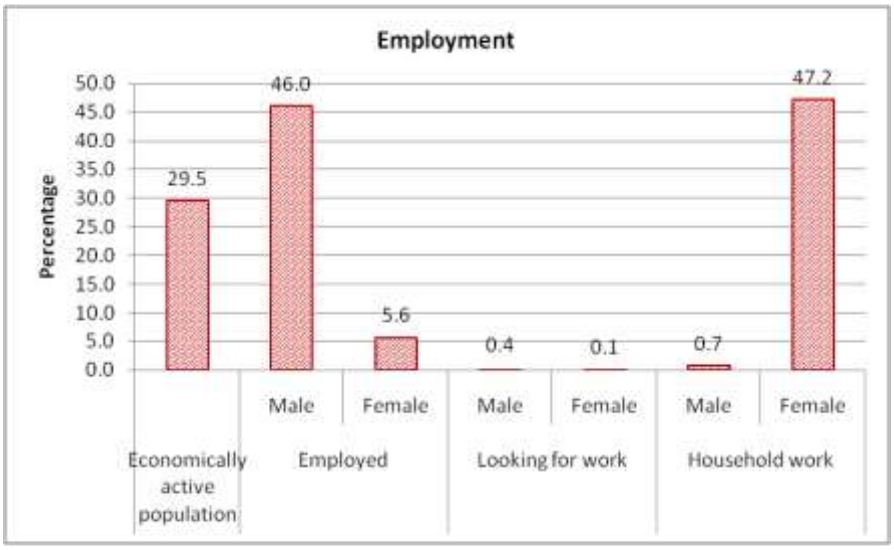
Source: The Census of Agriculture, 2008, BBS

390. The second dominant category is owner-cum-tenant which accounts 32.3% of the households. It comprises of 54.7% marginal, 37.7% small, 7.4% medium and 0.2% large land holders. As it is documented that small and marginal farmer is predominant (47% out of total farm holding), this owner-cum-tenant farm holder is to operate by leasing and or sharecropping to maintain their livelihoods. However, it is surprising that although the study area has a substantial percentage of landless households (48.5%) (both absolute and functional), only 1% is tenants those are belonging mostly to marginal category. Field data proved that this large numbers of landless populations usually adopt alternative livelihood options, for instances; farm and non-farm laboring, driving, working for industries and other manual works.

391. Field findings show that increasing industrial initiatives have purchased and/or acquired local lands which in turn, decreased the large and medium holdings and pushed many households into small and marginal categories. The same also contributed to marginalization of small landowners many leading to the status of landless. In the process of land acquisition by industrial houses the land losers often failed to purchase another parcel of land with the compensated money, as the value of land drastically went up with the advent of industries to the region.

6.17.5 Occupations and livelihoods

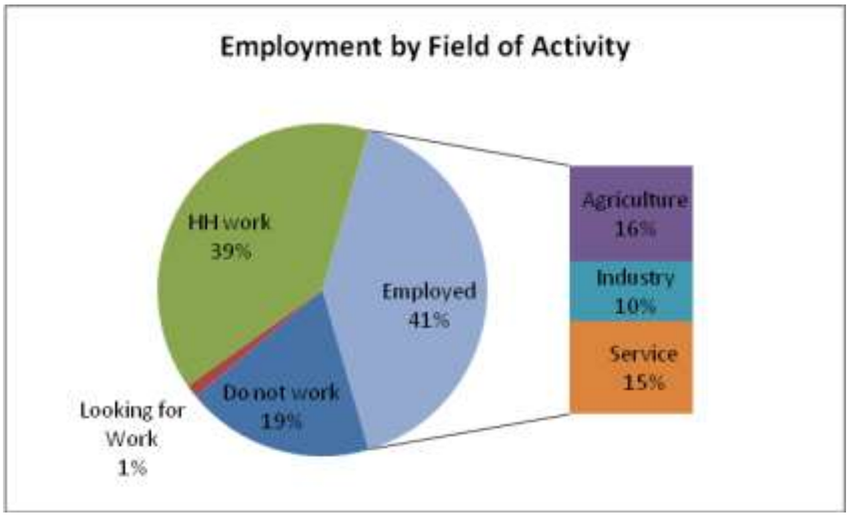
392. Out of total 526,463 population, 155,331 (29.5%) are economically active which include 80,139 (41.4%) employed, 836 (0.4%) are looking for work, and 74,356 (38.4%) engaged in household work.



Source: Housing and Population Census, BBS, 2011

Figure 6-29: Employment Status

393. Distribution of employed population at reference period of the 2011 census shows that 16% are engaged in agricultural activities, 10% in industry and 15% in service.



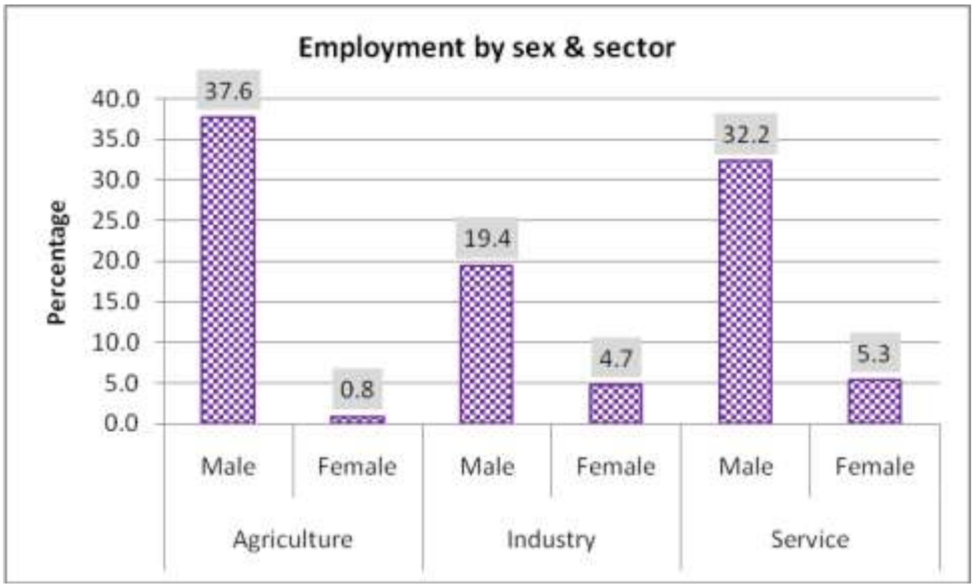
Source: Housing and Population Census, BBS, 2011

Figure 6-30: Employment status by field of activities

6.17.6 Labor Market

394. The employment[25] rate[26] in the study area is 51.6 whereas the unemployment rate[27] is 48.4. It is evident that about half of the total economically active population is still unemployed. Most of the unemployment populations are females who are solely involved in household work, and only 0.5% populations are looking for work.

395. There are a number of trained groups who are working contractually for power plant projects for instances, as plumber, mechanic, earth-worker etc. These trained laborers are organized and work under a group leader called "*sarder*". Although these groups were originally formed to work in the Ghorashal power plant, currently they work for other power plants located outside the region.



Source: Housing and Population Census, BBS, 201

Figure 6-31: Distribution of population by sex and field of activity

396. The above figure demonstrates that female participation in industry and service sectors is higher (10%) than that of agriculture (0.8%). According to our field research women involved in the industrial sector mostly work in textile industries.

397. Wage level varies regarding type of work. In agricultural sector laborers get daily wages in the range of Taka 300-400, whereas in industrial sector mostly textiles workers receive per day/per production basis. However, the trained group working for power plant received comparatively higher wages.

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[25] The ILO defines employed persons of those who, (1) do any work at all as paid employees, work in their own business or profession or on their own farm, or work 15 hours or more as unpaid workers in a family-operated enterprise; and (2) all those who do not work but had jobs or businesses from which they were temporarily absent due to illness, bad weather, vacation, childcare problems, labor dispute, maternity or paternity leave, or other family or personal obligations — whether or not they were paid by their employers for the time off and whether or not they were seeking other jobs.

[26] Employment Rate = $\frac{Employed\ Population}{Total\ labour\ force} X\ 100$

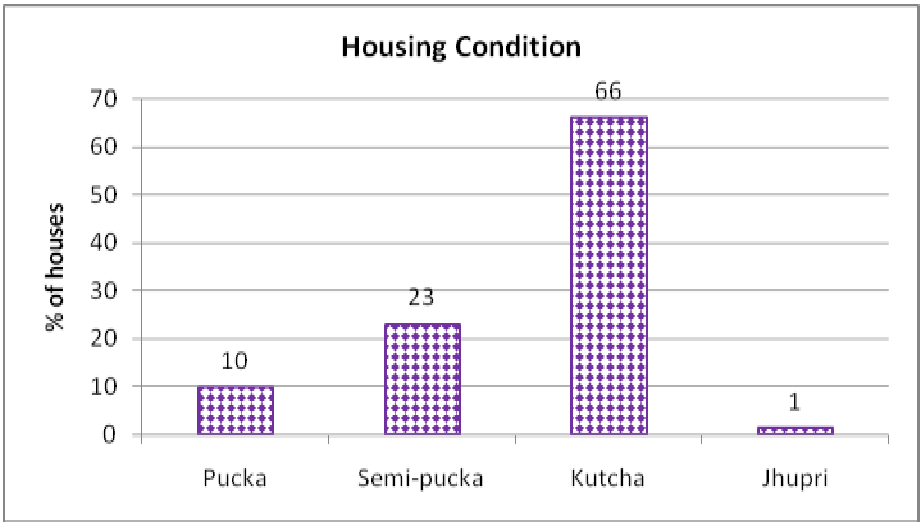
[27] Unemployment Rate= 100-Employment Rate

398. During field visit, people stated that there is no in-migration of laborers for agricultural sector. However, in the industrial sector a number of in-migrant laborers are working, but this trend is gradually increasing.

6.17.7 Standard of living

399. Data shows that about 84.5% households are under electricity coverage. It is evident that the GPS is the major power generation center of BPDB. It generates power and distributes through Power Grid Company Bangladesh Ltd. (PGCB). Besides, there is a private power producer (quick rental) within the study area. The study area has access to both and benefited from generated power which in turn improved the standard of living.

400. The study area shows the predominance of kutcha houses (66%) compared to other three types of houses such pucka, semi-pucka and jhupri. 23% houses are semi-pucka, 10 pucka and one percent is still jhupri. Most of the pucka houses are located in municipal areas, whereas semi-pucka are predominant at the peripheral areas of municipality. Kutcha houses are predominant in the rural area (Figure 6-32).



Source: Housing and Population Census, BBS, 2011

Figure 6-32: Housing condition in the study area

401. In the study area 33% households use non-sanitary latrines, 44% use non water-sealed sanitary latrines and 19% use sanitary water-sealed latrines. However, there are 4% houses, which have no sanitation facilities but tend to use sanitary facilities on shared basis and in some cases use open spaces (Figure 6-33).

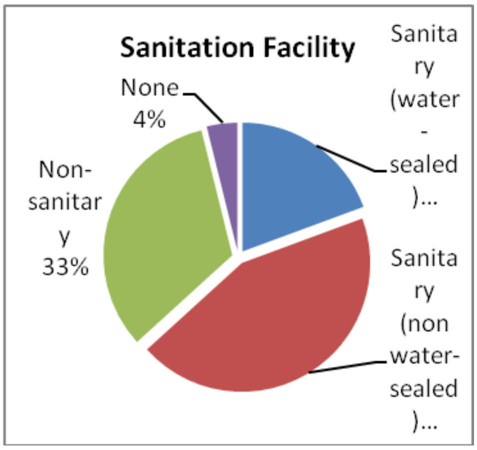


Figure 6-33: Distribution of households by sanitation facilities

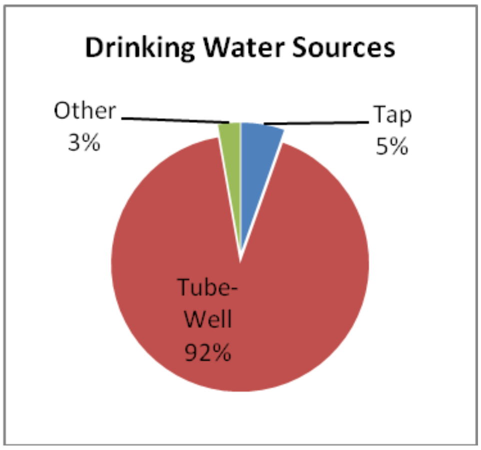


Figure 6-34: Distribution of households by sources of drinking water facilities

Source: Housing and Population Census, BBS, 2011

402. Collection of drinking water from tube-well is predominant (92%) throughout the study area. Supply of “tap water” is mainly used in municipal areas on rental basis. This supply system is dependent on abstraction of ground water. However, 3% households are still depending on open water bodies as sources of drinking water.

403. Fuel consumption shows that almost all houeholds located within the municipal area have gas supply. Titas Gas Transmission and Distribution Company Ltd. is the service provider that maintains two separate lines for transmission; one is for Ghorashal power plant and another for domestic distribution. However, hoseuholds in rural area usually use firewood, cowdung, chips for fuel etc.

6.17.8 Poverty

404. In the study area, poverty has been measured following the Multidimensional Poverty Index (MPI) method. The indicator and the thresholds for defining poverty are presented in Table 6-13.

Table 6-13: Indicators thresholds along with data sources for MPI calculation

Dimensions	Indicators	Definitions/threshold	Data sources
Education	School attainment	No household member has completed at least six years of schooling.	Housing and Population Census, 2011, BBS
	School attendance	A school-age child (up to grade 8) is not attending school.	Housing and Population Census, 2011, BBS
Health	Child mortality	A child has died in the household within the five years prior to the survey	Progothir Pathey, MICS, 2009, BBS
Standard of living	Electricity	Not having access to electricity	Housing and Population Census, 2011, BBS
	Drinking water	Not having access to clean drinking water or if the source of clean dirking water is located more than 30 minutes away by	Housing and Population Census, 2011, BBS

Dimensions	Indicators	Definitions/threshold	Data sources
		walking	
	Sanitation	Not having access to improved sanitation or if improved, it is shared	Housing and Population Census, 2011, BBS
	Cooking fuel	Using "dirty" cooking fuel (dung, wood or charcoal)	Field investigation, CEGIS, 2015
	Housing	Having a home with dirt floor	Housing and Population Census, 2011, BBS

405. Analyzing poverty status, it is found that about 27% households are multidimensional poor (index value 0.27 out of 1= **MPI**). About 53% populations are living in these poor households (poverty head count=**H**) and on average 52% poor people are deprived of any indicator (intensity of deprivation=**A**).

Table 6-14: State of Multidimensional poverty

Dimensions	Indicators	Deprivation per indicator (%)	Contribution of deprivation in dimension to overall poverty (%)
Education	School attainment	53	22.6
	School attendance	17	
Health	Child mortality	11	14.7
Standard of living	Electricity	15	70.6
	Drinking water	3	
	Sanitation	81	
	Cooking fuel	56	
	Housing	67	

Source: CEGIS calculation

406. Illustrating contribution of deprivation in dimension to overall poverty, the highest deprivation (70.6%) found in standard of living dimension as 81% populations have no access to improved sanitation facility (water-seal sanitation), 67% are living on dirt floored households (considering semi-pucca, kutcha and jhupri), 56% are using dirt fuel (considering all types of fuel except gas facilities), 15% households have no grid electricity coverage and 3% households still collect drinking water from unsafe sources (ponds, river etc.).

6.18 Other facilities in the Project Area

407. The site is surrounded by the Ghorashal Fertilizer Factory on the north, the Shitalakhya River on the west, Unit-5, 6, Agrekko Quick Rental and Max Power Rental Power Plant on the east and administrative buildings within the GPS boundary and Jute mills on the south. Following Figure 6-35 showing the establishments and settlements around the study area are presented on image as below:

Figure 6-35: Surrounding land use and associated communities

408. The establishments around the proposed area are stated below (all the distances are measured from Google Earth):

1. Pran factory is 1.81 km away on the southwest from the site.
2. Janata Jute mill is 1.17 km away on the southwest from the site.
3. Ghorashal 108 MW Rental power plant is 1.16 km away on the southeast from the site.
4. Palash Urea Fertilizer factory is 0.86 km away on the north from the site.
5. Palash Bus Stand and Palash Upazila Heath Complex respectively are 0.93 km and 2.37 km away on the east side of the site.
6. Palash Jam-e-Mosque is 1.34 km away on the northeast from the site.
7. Desh Bandhu Sugar mill is 3.0 km away on the north from the site. and
8. There are six units of steam turbine gas based power plant along with two rental plants within the Ghorashal Power Plant Complex.

7. Environmental Impacts

7.1 General

409. The existing GPS Unit 4 is a simple cycle power plant and has been in operation for more than 25 years. The proposed repowering of Unit 4 will augment the current electricity generation and enhance operational regime of the system. The proposed major activities will involve renting labor accommodation, site preparation, transportation of machinery and ancillaries, storage of equipment and materials for construction, civil works (in-terms of construction of foundation structures), erection of GT, boiler decommissioning (including removal of foundation), segregation of hazardous materials and their transportation to on-site disposal pit, construction of gas pipeline, erection of HRSG and operation of the CCPP. Land acquisition is not required for the construction of the GT and HRSG, and for the improvement of access road along the right bank of the Shitalakhya River. These activities will have diversified impacts on the environment and socio-economy with various natures and magnitudes. Among the impacts from the proposed activities, some are temporary or short-term in nature and limited to pre-construction and construction period, and others are permanent in nature during the operation period. Based on the experience of other similar power generation projects, many of the environmental issues are mainstreamed in the project design (e.g., minimize NOx emission by using low NOx burner, lower the relative water requirement for condenser cooling and minimize thermal effluent using closed-cycle cooling, decrease specific-relative fuel requirement, etc.). Inhalation of airborne asbestos fiber during boiler decommissioning, elevated noise level from the operation of heavy equipment, felling of trees during site preparation, and labor camp induced sanitation and social stress are the significant impacts of the construction works. A small number (about 25) wood tree will be cut which may have ecological fragmental effect and lead to loss of bird habitats. . The overall positive impact of the project during operation is the augmentation of the generation capacity of the electricity and improving the socio-economic condition and lifestyle of the country's population, reduction in thermal effluent in Shitalakhya River, which will facilitate in restoring habitats of fish species and easing habitat for others aquatic organisms along with benthic habitats.

7.2 Impact Assessment Methodology

410. Potential environmental and social impacts were identified on the basis of the review of feasibility reports, field visits, environmental quality baseline monitoring, ecological and fisheries surveys, and stakeholder consultations. The significance of potential impacts was assessed using the criteria and methodology given below.

7.2.1 Impact Magnitude

The potential impacts of the project have been categorized as major, moderate, minor or nominal based on consideration of the parameters such as: i) duration of the impact; ii) spatial extent of the impact; iii) reversibility; iv) likelihood; and v) Compliance to Legal Standards before Mitigation Measures.

The magnitude of potential impacts of the Project has generally been identified according to the categories outlined in Table 7-1.

Table 7-1: Parameters for Determining Impact Scale

Parameter	Major	Moderate	Minor	Minimal
Duration of potential impact	Long term (more than 15 years)	Medium Term (5 to 15 years)	Limited to construction period	Temporary with no detectable potential impact
Spatial extent of the potential impact	Widespread far beyond project boundaries	Beyond immediate project components, site boundaries or local area	Within project boundary	Specific location within project component or site boundaries with no detectable potential impact
Reversibility of potential impacts	Potential impact is effectively permanent, requiring considerable intervention to return to baseline	Potential impact requires a year or so for recovering with some interventions to return to baseline	Baseline returns naturally or with limited intervention within a few months	Baseline remains almost constant
Compliance to Legal Standards before Mitigation Measures	Breaches national standards and or international guidelines/ obligations	Complies with limits given in national standards but breaches international lender guidelines in one or more parameters	Meets minimum national standard limits or international guidelines	Not applicable
Likelihood of potential impacts occurring	Occurs under typical operating or construction conditions (Certain)	Occurs under worst case (negative impact) or best case (positive impact) operating conditions (Likely)	Occurs under abnormal, exceptional or emergency conditions (occasional)	Unlikely to occur

7.2.2 Sensitivity of Receptor

411. The sensitivity of a receptor has been determined based on review of the population (including proximity / numbers / vulnerability) and presence of features on the site or the surrounding area. Each detailed assessment has defined sensitivity in relation to the topic. Criteria for determining receptor sensitivity of the Project's potential impacts are outlined in Table 7-2.

Table 7-2: Criteria for Determining Sensitivity

Sensitivity Determination	Definition
Very High	Vulnerable receptor with little or no capacity to absorb proposed changes or minimal opportunities for mitigation.
High	Vulnerable receptor with little or no capacity to absorb proposed changes or limited opportunities for mitigation.
Medium	Vulnerable receptor with some capacity to absorb proposed changes or moderate opportunities for mitigation
Low	Vulnerable receptor with good capacity to absorb proposed changes and/or good opportunities for mitigation

7.2.3 Assigning Significance

412. Following the assessment of magnitude, the quality and sensitivity of the receiving environment or potential receptor has been determined and the significance of each potential impact established using the impact significance matrix shown in Table 7-3.

Table 7-3: Significance of Impact Criteria

Magnitude of Impact	Sensitivity of Receptors			
	Very High	High	Medium	Low
Major	Critical	Major	Moderate	Minimal
Moderate	Major	Major	Moderate	Minimal
Minor	Moderate	Moderate	Minor	Minimal
Minimal	Minimal	Minimal	Minimal	Minimal

7.3 Summary of Assessed Impacts

413. The project's potential impacts and their significance have been assessed using the methodology described in Section 7.2 above. A summary of these impacts and their significance is presented in Table 7-4.

Table 7-4: Potential impacts and their significance

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
Environmental impacts during boiler decommissioning					
A. Ecosystem					
A1. Terrestrial vegetation	Vegetation clearance due to temporary storage of boiler parts, segregation and scientific disposal of insulation materials after demolition of boiler.	Medium	Moderate	Moderate adverse	
A2. Wildlife habitat	Vegetation clearance will affect dependent wildlife habitat.	Medium	Moderate	Moderate adverse	
B. Ambient Air					
B1. Airborne asbestos fiber	Inhalation of airborne asbestos fiber during segregation of hazardous materials and their transportation is injurious to lung leading to lung cancer and other lung diseases or respiration complexity. Skin and eye irritation of the workers may cause due to contact with dust particles.	Very High	Major	Critical adverse	WHO Air Quality Guidelines for Asbestos in Europe, 2000
C. Ambient noise					
C1. Noise pollution	Elevated noise level due to cutting boiler parts using gas cutter, grinding, loading boiler materials on truck/lorry and its transportation.	Medium	Moderate	Moderate adverse	ECR 1997
D. Water bodies					

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
D2. Water quality	Contamination of nearby water bodies by asbestos containing effluent generated during the water spray to control airborne asbestos fiber.	High	Major	Major adverse	WBG's Good Practice Note: Asbestos: Occupational and Community Health Issues, 2009
E. Soil					
E1. Soil quality	Contamination of soil by asbestos containing effluent generated during the water spray to control airborne asbestos fiber.	High	Major	Major adverse	WBG General EHS Guidelines
E2. Top soil	Loss of topsoil due to earthworks for creating asbestos disposal pit which will impact the fertile top soils that are enriched with nutrients required for afforested and naturally grown plant growth.	Medium	Minor	Minor adverse	
F. Occupational Health and Safety					
F1. Pressure on existing sanitation facilities	Stressing existing sanitation facilities of the rented accommodations, in which 50-60 workers for boiler decommissioning may co-locate.	Medium	Minor	Minor adverse	Labour Law, 2006 WBG General EHS Guidelines
F2. Occupational health and safety	Space constraint in the rented accommodation may cause the break out of contagious disease like diarrhea, dysentery, skin diseases, scabies, etc. Belongings or stuffs insecurity may be a concern for	Medium	Moderate	Moderate adverse	

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
	the workers.				
	Injuries leading to casualty, or death may be caused from the wrecking activities of the boiler as it involves cutting, grinding, lifting of heavy machineries, segregating solid wastes, working at heights, etc.	High	Major	Major adverse	WBG General EHS Guidelines
F3. Safety, security, and vandalism	Inadequate construction site security poses a significant risk to assets, construction materials and property. Theft/vandalism of assets, materials and property would increase construction costs and cause delays in project completion.	Medium	Moderate	Moderate adverse	
	Improper security measures may pose security risk for construction workers and especially foreign staff on construction sites.	Medium	Moderate	Moderate adverse	
G. Solid Waste Disposal					
G1. Hazardous solid waste disposal	Generation of hazardous solid wastes from the boiler decommissioning containing mostly asbestos fiber, rock and glass wool in insulation materials. Airborne asbestos particles, rock and glass wool fiber are harmful for human health.	Very high	High	Critical adverse	WBG General EHS Guidelines, 2007, WBG's Good Practice Note: Asbestos: Occupational and Community Health Issues, 2009
G2. Non hazardous solid waste	Generation of huge quantity of metals as scrap may cause aesthetic hazards.	Medium	Moderate	Moderate adverse	WBG General EHS Guidelines, 2007

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
H. Social Impacts due to boiler decommissioning					
H1. Increased pressure on accommodation	Extra burden on human habitation, religious places, purchasing capacity due to migrant workers accommodation in the nearby communities.	Medium	Minor	Minor adverse	
H2. Labor migration	Aggravated risks of HIV/AIDS and STI due to the flow of migrant workers.	Medium	Moderate	Moderate adverse	WHO Guideline
H3. Cultural conflicts	Possible cultural conflicts between migrant workers, and communities. Migrant workers will come from different parts of the country and abroad having diverse cultural background.	Medium	Minor	Minor adverse	
H4. Movement of construction vehicles and heavy equipment	Congestion in local roads due to increased construction traffic will affect access to the trading center and, houses close to the road, deteriorate safety (especially for the school children), spillage of fuels and chemicals, and damage to infrastructures and properties due to vibration.	Medium	Minor	Minor adverse	
H6. Employment of local people	Generation of employment of local population will bring positive impression towards the Project.	Medium	Minor	Minor beneficial	
Environmental impacts during construction stage:					
I. Ecosystem					
I1. Aquatic habitat quality	During transportation of machinery and ancillaries, disposal of waste water like ballast and bilge water from the ship/cargo into the river having oil and grease	High	Minor	Moderate adverse	

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
	contaminants might affect the local aquatic habitat quality.				
	Impact on aquatic habitats including benthic habitat due to dredging operation for creating sufficient navigation channel for ship carrying heavy plant equipment.	High	Minor	Moderate adverse	
I2. Terrestrial vegetation	Felling of about 25 hard wood trees along with clearance of a large number of naturally grown vegetation including herbs and shrubs for the construction of gas pipeline, RMS, machinery unloading area and storing of imported machinery and ancillaries would be an environmental concern.	Medium	Moderate	Moderate adverse	
I3. Wildlife habitat	In consequence of vegetation clearance, dependent wildlife will lose their abodes and shift to nearby bushes and create pressure on the wildlife of the new area and its quality.	Medium	Minor	Minor adverse	
J. Ambient Air					
J1. Dust and gases generated from excavation, construction equipments, and vehicles	Emissions of dust and gases will be generated from excavation of trenches for laying gas pipes; RMS, turbine and HRSG foundation, operation of construction equipment and vehicles, and material transport, which is injurious to human health.	Medium	Moderate	Moderate adverse	ECR 1997 WBG General EHS Guidelines, 2007
K. Ambient noise					

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
K1. Noise level	Noise will be generated from the moving and idling vehicles, welding operations during laying of gas pipes, and heavy machineries.	Medium	Moderate	Moderate adverse	ECR 1997 WBG General EHS Guidelines, 2007
L. Water bodies					
L1. Water pollution	Improper storage and handling of fuels, lubricants, chemicals, hazardous goods/materials on-site, wash down of plant and equipment, and potential spills may harm the environment or health of construction workers.	Medium	Moderate	Moderate adverse	
M. Soil					
M1. Top soil	Loss of topsoil due to earthworks for creating space for gas turbine which will impact the fertile top soils that are enriched with nutrients required for afforested and naturally grown plant growth.	Medium	Minor	Minor adverse	
N. Occupational Health and Safety					
N1. Health and safety hazard	Injuries leading to casualty, or death may be caused during transportation of machinery and equipments from the ship to site, and their installation/erection, lifting heavy materials, working at heights, etc. .	Medium	Moderate	Moderate adverse	Labour Law, 2006 WBG General EHS Guidelines
N2. Fire hazards	Welding operations during laying of pipeline may cause fire accidents if proper care is not taken	Medium	Moderate	Moderate adverse	Labour Law, 2006 WBG General EHS Guidelines

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
O. Key Point Installations & others					
O1. Security issue	During construction a large number of workers will be engaged inside the GPS. Security matters will be of concern for the Key Point Installation.	Medium	Minor	Minor adverse	
P. Solid Waste Disposal					
P1. Storage space and visual effect	Poor aesthetic view due the storage and disposal of old and used equipments and materials. Moreover, spillage and leakage from improper storage can result in contamination to soil.	High	Minor	Moderate adverse	
Q. Social Impact					
Q1. Increased pressure on accommodation	Extra burden on human habitation, religious places, purchasing capacity due to 100-125 migrant workers accommodation in the nearby communities.	Medium	Moderate	Moderate adverse	
Q2. Labor migration	Aggravated risks of HIV/AIDS and STI due to the flow of migrant workers.	Medium	Moderate	Moderate adverse	WHO Guideline
Q3. Cultural conflicts	Possible cultural conflicts between migrant workers, and communities. Migrant workers will come from different parts of the country and abroad having diverse cultural background.	Medium	Minor	Minor adverse	
Q4. Movement of construction vehicles and heavy equipment	Congestion in local roads due to increased construction traffic will affect access to the trading center and, houses close to the road, deteriorate safety (especially for the school children), spillage of	Medium	Minor	Minor adverse	

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
	fuels and chemicals, and damage to infrastructures and properties due to vibration.				
Q5. Employment of local people	Generation of employment of local population will bring positive impression towards the Project.	Medium	Moderate	Moderate beneficial	
R. Transportation of construction materials					
R1. Public safety	Uncontrolled transportation of construction materials may cause safety and health hazard due to increased traffic and flying objects, sand and dust from the carriers, etc.	Medium	Moderate	Moderate adverse	
Environmental impacts during operation stage:					
S. Ecosystem					
S1. Disturbance to local aquatic habitat	Raw water abstraction through intake pumps may destabilize habitats of aquatic organisms including fish and causing the alterations to substrates and aquatic community structure and diversity. Low velocity tolerant species become trapped and died. This will continue.	Medium	Moderate	Moderate adverse	
S2. Restoration of aquatic habitat by eliminating thermal pollution	Restoration of aquatic habitat for fish and other aquatic organisms by eliminating a significant quantity thermal effluent discharge in Shitalakhya	High	Major	Major beneficial	WBG's EHS Guidelines for Thermal Power Plants, 2008
S3. Irrigation of farmland	Reduction of 6.04 m^3/s condenser cooling water to the irrigation canal due to the introduction of closed-cycle	Medium	Moderate	Moderate adverse	

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
	cooling system in Unit 4 repowering. The water can still be made available from operating Units 1, 2 and 5.				
T. Ambient air					
T1. Maximum ground level concentration of pollutants	Emission of exhaust gas from the stack may contribute elevated ground concentration of NOx, PM_{10}, and $PM_{2.5}$ etc. at the downwind direction.	Medium	Moderate	Moderate adverse	ECR 1997 WBG General EHS Guidelines
U. Ambient noise					
U1. Noise level	Hearing complexity and loss along with increase blood pressure, disturbances and discomfort to the technicians and workers and surrounding communities due to noise generated from rotator machineries at exceedance level.	High	Moderate	Major adverse	ECR 1997 WBG General EHS Guidelines
V. Water bodies					
V1. Pollution of receiving water bodies	Sludge generated from the chemical assisted raw water at pretreatment and water treatment plants may impact groundwater quality and receiving water bodies if come in contact to sludge.	Very high	Moderate	Major adverse	ECR 1997 WBG General EHS Guidelines
V2. Storm water runoff	Typically storm water runoff contains suspended sediments, metals, petroleum hydrocarbons, coliform, etc. may contaminate waterbodies.	Medium	Moderate	Moderate adverse	
V3. Thermal plume in receiving water bodies	Temperature increase by thermal plume from condenser cooling water discharge in receiving water body is violating WBG Effluent Guidelines.	Medium	Moderate	Moderate adverse	WBG Environmental, Health, and Safety

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
					Guidelines for Thermal Power Plants, 2008
W. Occupational Health and Safety					
W1. Work at height	Fall from height may cause casualty and life loss of the workers in GPS.	Medium	Moderate	Moderate adverse	Labour Law, 2006 WBG General EHS Guidelines
W2. Working in tight and confined spaces	Working in tight and confined spaces, low light conditions and other specialized work space may pose threats due to oxygen deficiency and others.	Medium	Moderate	Moderate adverse	Labour Law, 2006 WBG General EHS Guidelines
W3. Working with live electrical equipment	Worker hazard due to higher Exposure to electric and magnetic fields	Medium	Moderate	Moderate adverse	Labour Law, 2006 WBG General EHS Guidelines
W4. Working in heated areas	Worker hazard due to heat exposures especially in the turbine halls	Medium	Moderate	Moderate adverse	Labour Law, 2006 WBG General EHS Guidelines
X. Waste Disposal					
X1. Disposal of non-hazardous solid waste	Solid wastes in terms of institutional waste, kitchen waste, human waste, etc. generated from GPS and staff colony may cause environmental impacts if not managed properly.	Medium	Moderate	Moderate adverse	

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
X2. Disposal of hazardous waste	Generation of hazardous solid wastes, condensate from RMS, and petrochemicals from plant operation are harmful for human health	Very high	Minor	Moderate adverse	WBG General EHS Guidelines
X3. Disposal of liquid effluents containing toxic chemicals like hydrazine and resin	Improvement in water quality in Shitalakhya River by eliminating the use of hydrazine as scavenger chemicals in feed water system and resin based demineralization, which are threats to food processing industries up and downstream which use river water	Very high	Major	Extremely beneficial	
Y. Risks and emergency					
Y1. Accidental risks	Accidental firing, explosion of gas pipeline may cause casualty and life loss of the workers in GPS	Medium	Moderate	Moderate adverse	WBG General EHS Guidelines
Y2. Operational emergency	Immediate medical evacuation due to personnel injury, leakage of hazardous materials (asbestos), civil disturbance/riot, and gas leak/explosion.	Medium	Moderate	Moderate adverse	WBG General EHS Guidelines
Y3. Corrosion of gas pipes	Corrosion on the internal wall of a natural gas pipeline can occur when the pipe wall is exposed to water and contaminants in the gas, such as O_2, H_2S, CO_2, or chlorides	High	Moderate	Major adverse	WBG General EHS Guidelines
Y4. Gas compressor fouling	Polymer deposits on compressor internals which increases frictional losses and alters flow pattern and lead to loss of compressor efficiency, pressure drop increase in after coolers, potential for unbalancing, rotor, and seal damage.	Medium	Moderate	Moderate adverse	

Issues	Potential Impacts from various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to laws, regulation or accepted national or international standards, protected status of site or species
Y5. Gas pipeline leak	Poor tieing-in may cause leak of significant amount of gas from the pipe	Medium	Moderate	Moderate adverse	
Z. Social Impacts					
Z1. Contribution of the Project to the local livelihoods and economy of the country	Increased power generation due to repowering of the unit, reducing energy shortfall and reviving associated economy.	Very high	Moderate	Major beneficial	
Z2. Employment generation	Additional employment opportunities, resulting in increased prosperity and wellbeing due to higher and stable incomes of employed people.	High	Moderate	Major beneficial	
Z3. Availability of irrigation water	By introducing close cycle cooling system, total available condenser cooling water discharge will be reduced from 27.22 m^3/s to 21.18 m^3/s	Medium	Moderate	Moderate adverse	

7.4 Sustainability of Quality of Gas and Continuity of Supply

414. Natural gas is the only fuel for the proposed repowering of Unit 4, Ghorashal Power Plant. The gas requirement of existing Unit 4 is 49.17 MMSCFD, after repowering the requirement will be increased to 67.28 MMSCFD. This means with an additional 18.11 MMSCFD of gas will be required for the proposed repowering. This additional gas consumption will augment about 224 MW of power generation and supply to national grid. This implies the specific consumption of gas will be low. On the other hand, the present fuel (natural gas) requirement of Units 1-5 is 183 MMSCFD. After the proposed repowering of Unit 4, the new gas demand will be about 201 MMSCFD without Unit 6 which is currently under maintenance and Unit 7 which is under construction.

415. Additional gas supply has been confirmed verbally by MOPEMR via the existing gas supply arrangement (Annex 7-1) and through the proposed RMS with booster from TGTDCL of Petro bangla for meeting the turbine manufacturer's requirements. The gas shortfall for the power plant will be alleviated by fuel diversification including the introduction of LNG, coal fired power generation, and the Government incentive plan for switching from natural gas to other fuels. Through these measures, the gas shortfall issue is expected to be resolved by 2016 (PSMP, 2010). So, sustainability of gas supply could be ensured by TGTDCL to the Ghorashal Power Station. But there are some risk associated to maintain the gas supply, allocated for the existing units along with the proposed units. These are: slow gas exploration by the BAPEX, non-availability of gas resulting from Political Force Majeure Events, or interruption of the supply of gas by the gas supplier and other usages.

7.5 Impact of hazardous waste

7.5.1 Hazardous Solid Waste

416. It is expected that during the decommissioning of the existing boiler, one of the major hazardous materials that may come out as solid waste is asbestos containing material (ACM). As per the ToR of this study, the total weight of the boiler installation is expected to be several thousand tons with ACM probably more than 50 tons. Unit 4 boiler consists of various insulation materials like mineral wool, glass fiber, asbestos, aluminum powder, glass, and steel. A partial list of insulation materials were retrieved from the erection reports[28] available in the GPS library. A partial list of ACM indicate 17 tons of asbestos containing materials (ACM) in the insulation pipes. Asbestos is considered as a hazardous material (CAS# 1332-21-4) and its use is banned in many countries especially in developed nations. The airborne asbestos fiber when inhaled may cause various respiratory ailments including 'asbestosis' with long term exposure leading to the development of cancerous tumors in the lungs. Thus, abatement measures to control airborne asbestos fiber must be taken before boiler demolition. Airborne fibers generated from other toxic materials include metal rust, rock and glass wool may also cause respiratory difficulties when breathed in high quantity.

7.5.2 Hazardous effluents

417. Spraying of water is usually done on insulation materials, such as asbestos, rock and glass wool, metal rust, etc. in order to prevent the release and dispersion of such fibers or

[28] TPP Ghorashal (Bangladesh) 2nd Phase: Power Unit #4 Working Project of Heat Insulation. Code 087-04-11-TN, Book I- Explanatory note. Volumes of Work and materials.

dusts in the ambient air. Therefore, contaminated sprayed waters may pollute soil and the nearby water bodies through leaching. Since asbestos and other insulating materials are not soluble in water, they might be ingested by fishes or may be ingested by the local residents when untreated contaminated water is disposed to receiving water bodies. The potential toxic effluent may include hydrazine which is used for deoxygenation of feed water, resin for demineralization of raw water and acids and alkalis, which are used to maintain the pH level of various water usage as well as removing any dissolved impurities. Hydrazine is a carcinogen if disposed in river water untreated, may affect food processing industries, which use Shitalakhya water up and downstream. Some oily substance, such as lube oil, used in rotatory parts, may also leak from them and get into the river via effluent discharge. These materials, when discharged into the river in large quantities, may affect the growth and development of aquatic ecosystem, including fishes, frogs and other aquatic flora and fauna. Other terrestrial animals and plants those are dependent on the river may also be affected.

7.6 Environmental impacts during boiler decommissioning stage

7.6.1 Impact on Ecosystem

418. Vegetation clearance from the space required for storing boiler parts, segregation and scientific disposal of insulation materials after demolition of boiler would be an environmental concern. The vegetation constitutes mainly naturally grown herbs and shrubs which have multiple functions, such as habitation for birds and other wildlife, supplying of fire wood, protecting soil from erosion and overall keeping the natural balance for human-living. As such clearance of or damage to vegetation has wide range of adverse environmental impacts. These are: loss or shifting of habitats for dependent birds and wildlife to nearby bushes and create pressure on the wildlife of the new area and its quality; invading of affected wildlife to the nearby locality may cause annoyance to the inhabitants. This impact is characterized as Moderate Adverse, as given in Table 7-4**.**

7.6.2 Impact on Ambient Air

419. Airborne asbestos fibers or dusts generated from various activities like, decommissioning of boiler, segregation and isolation of insulation materials, excavation work, and removal of boiler foundation, transportation of scrap and insulation materials, and construction of asbestos pit are health sensitive. The major hazardous waste is the airborne asbestos fiber that comes out from the asbestos containing materials, such as steam carrying pipes, boiler drum roof and boiler walls. Other toxic materials also include metal rust, rock and glass wool fibers, which have air contamination potential when mixed with the local air. Inhalation of such fiber or dust particles generated from the above mentioned sources during segregation of hazardous materials and their transportation is injurious to lungs and may cause ‘asbestosis’ leading to lung cancer or tumor and other lung diseases or respiratory complexity. Skin and eye irritation of the workers may cause due to acute contact with such dust particles. This impact is characterized as Critical Adverse, as given in Table 7-4**.**

7.6.3 Impact on Ambient Noise

420. High noise level may cause hearing related disturbances, increase in blood pressure, amnesia, distaste to food, etc to the workers and nearby residents due to excessive noise generated from different activities of boiler decommissioning. Among the major activities, cutting of boiler parts using gas cutter, grinders, loading of boiler materials on truck/lorry, and

its transportation are important. This impact is characterized as Moderate Adverse, as given in Table 7-4.

7.6.4 Impact on Water Bodies

421. Fibers or dusts generated from the hazardous waste materials, having potential to affect human being, are friable particles that can be easily dispersed in ambient air. Spraying of water is usually done on insulation materials, such as ACM, rock and glass wool, metal rust, etc. to prevent the release and dispersion of such fibers or dusts. Thus, contaminated sprayed waters may pollute receiving water bodies if not treated. Since, asbestos and other insulating materials are not soluble in water, they might be ingested by fishes or may be ingested by the local residents when untreated contaminated water is disposed to receiving water bodies.. Ingestion of high amounts of asbestos may lead to intestinal polyps or tumors. This impact is characterized as Major Adverse, as given in Table 7-4.

7.6.5 Impact on Soil

422. Fibers or dusts generated from the hazardous waste materials, potential to affect human being, are friable particles that can be easily dispersed in ambient air. Spraying of water is usually done on insulation materials, such as ACM, rock and glass wool, metal rust, etc. to prevent the release and dispersion of such fibers or dusts. Thus, contaminated sprayed waters may pollute soil and the nearby water bodies through leaching if not collected in a lined pond and treated. Asbestos may stay deposited in soil and, if not managed properly, the dry asbestos particles may be blown away by winds during dry season and may pose threat of being inhaled by nearby bystanders. This impact is characterized as Major Adverse, as given in Table 7-4.

7.6.6 Impact on Occupational Health and Safety of Workers

423. Safety issues that are concerned with decommissioning of boiler include cutting and welding, segregation of solid waste, and transportation of insulation materials and metals, working at heights, and lifting of heavy materials,. Workers may be susceptible to injuries, such as burns and cuts, from cutting and welding activities; lung disease and eye irritation while segregating insulation materials; broken bones, and casualties. Working at heights and falling rubbles may cause accidents and casualties. This impact is characterized as Major Adverse, as given in Table 7-4.

7.6.7 Hazardous Solid Waste Disposal

424. Aesthetic hazards and dispersion contaminants (e.g., airborne fiber or dust, rust mixed water, etc..) from the likely prolonged piling up of solid wastes, such as asbestos, rock and glass wool, metal rust, metals, etc. due to decommissioning of boiler. Environmental contamination of chrysotile asbestos and its toxic effects on growth and physiological and biochemical parameters of plant species (e.g., *Lemna gibba*, a duck weed) is evidenced[29].

These particles may be dispersed into the environment during segregation of the hazardous materials. These airborne fibers or dust particles may be deposited on soil, leaves of plants and fruits, limiting photosynthesis. Chrysotile asbestos may cause oxidative stress and phytotoxicity to vegetation leading to retardation of plant growth. Apart from these small toxic

[29] [29] http://www.ncbi.nlm.nih.gov/pubmed/15386121

particles, other metals will be coming out as scrap, which would be sold to recycling companies. This impact is characterized as Critical Adverse, as given in Table 7-4.

7.6.8 Social Impacts

425. Sexually transmitted diseases like HIV/AIDS, etc., which might become epidemic due to the engagement of engineers, technicians and workers from abroad for boiler decommissioning if not taken preventive measures. This impact is characterized as Moderate Adverse, as given in Table 7-4.

7.7 Construction Stage Impact

7.7.1 Impact on Landform

426. Natural landform of the Project site and adjoining area covered with bushes and grasses might be affected due to excavation of trenches, construction of buildings and sheds, movement of traffic, widening and improvement of existing earth road, etc.

7.7.2 Impact on Natural Resources

427. Gas as fuel and water for cooling of different Plant components are the major natural resources used in power generation in GPS. No extra pressure will be created on gas as electricity needed for construction activities will be taken from existing distribution system. Water from the nearby river using low lift pump (LLP) or ground water using shallow tube well may be used for civil construction, washing, cooking and sanitary purposes for the stationed construction workers and staff members. Apart from these, the construction process would not cause any burden on the natural resources.

7.7.3 Impact on Ecosystem

Impact on terrestrial vegetation

428. The ecological survey in the Project site did not recorded any tree species which have national and international conservation significance. Impact on terrestrial vegetation is discussed in Section 7.6.1. This impact is characterized as Moderate Adverse, as given in Table 7-4.

Impact on fisheries and their habitat

429. The ship/cargo that will carry machineries and ancillaries may discharge ballast and bilge waste water into the river. This ballast and bilge water may have oil, grease, food waste and other contaminants which might affect the fisheries resources and their habitat quality. Having disposed of such harmful substances into the river water a localized and temporary disturbance to fish breathing may lead some species to die. Dredging for accessing ship to the jetty may also disturb the benthic habitat which may require a substantial time to recover. Discharge of wash water from the construction site may increase the turbidity of the local fish habitat. This would affect the food supply for fishes temporarily.

7.7.4 Impact on Ambient Air

430. Fugitive dust particles may be generated due to site preparation, material transport, piling up of construction materials, excavation of trenches for gas pipes and preparation of foundations for HRSG, RMS and new gas turbine, operation of batch mixing plant, etc. In

addition to these, operation of construction equipment and vehicles may generate CO, CO_2, NOx, SOx, etc. Prolonged inhalation of dusts by the site engineers and workers will suffer from lung diseases with symptoms of shortness of breath, coughing, wheezing; chest pain; loss of appetite; tiredness etc. This impact is characterized as Moderate Adverse, as given in Table 7-4.

7.7.5 Impact on Ambient Noise

431. Noise and vibration during construction period may be generated due to operation of different machineries and equipment, and welding during tieing-in of gas pipes. The generated noise and vibration from stationary and mobile sources may have an impact on existing acoustic environment. Prolonged exposure to such high noise, the staffs of offices, construction workers, site engineers, residents and school children close to the construction site may feel disturbances like hearing difficulties, discomfort, loss of concentration, high blood pressure, etc. This impact is characterized as Moderate Adverse, as given in Table 7-4.

7.7.6 Impact on Water Bodies

432. Construction material wash-water and spillage of oils and lubricants from machineries may leach into the surface water and contaminate it particularly during wet season. These contaminants may turbid water around the discharge point and may create oil slick both of which is detrimental to the aquatic organisms including fisheries. This impact is characterized as Moderate Adverse, as given in Table 7-4.

7.7.7 Impact on Soil

433. During site preparation, earthworks will impact the fertile top soils that are enriched with nutrients required for afforested and naturally grown plant growth. This impact is characterized as Moderate Adverse, as given in Table 7-4.

7.7.8 Impact on worker's health and safety

434. During transportation of machinery and heavy equipments from the ship to site, lifting heavy machineries and equipments using cranes and their erection and working at heights, during welding of pipe tieing may cause injuries to the workers, even casualty. The major health risk may come from the toppling of structures or falling of heavy machineries/equipments from high heights. This impact is characterized as Moderate Adverse, as given in Table 7-4.

7.7.9 Impact on Key Point Installations & others

435. During construction stage, the noise generated from the construction activities may affect the residents of the colony of Fertilizer Factory closed to the site. Loud noise will also affect the daily activities of the residents of the GPS. Educational institutes including school, madrasah and mosque, situated inside the GPS. This impact is characterized as Minor Adverse, as given in Table 7-4.

7.7.10 Solid Waste Disposal

436. A variety of solid waste may be generated from construction activities. These wastes may include cleared vegetation from the site, construction debris, excavated spoils, abandoned or broken machine parts, etc. Moreover, food waste, plastic, papers, cock sheet,

carton, metal or plastic binders, etc.. Space for storage and disposal of materials generated during construction along with existing solid wastes is limited. Unarranged piling up of such materials and equipments will cause poor aesthetic and spillage and leakage from improper storage may contaminate soil. This impact is characterized as Moderate Adverse, as given in Table 7-4.

7.7.11 Social Impacts

437. The construction of GT and HRSG would require recruitment of foreign erectors and skilled technicians. The flow of concerned manpower from abroad mean that they might bring with them diseases such as sexually transmitted diseases, e.g., HIV/AIDS, which might become epidemic if not taken preventive measures from the beginning.

438. Problems associated with maintaining 100-125 skilled, semi-skilled and non-skilled workers being, accommodating them in the community settlements outside the project boundary on rental basis might create extra burden on human habitation, worship places, purchasing capacity, etc. Migrant workers coming from different parts of the country would have cultural diversity. So, there might be cultural conflicts between workers and communities. Increased traffic on access road due to movement of construction vehicles might also affect easy access of the inhabitants to the local market and houses close to the road, deteriorate safety (especially the school children). Labor migration and associated impact of HIV/AIDS is characterized as Moderate Adverse, as given in Table 7-4.

7.7.12 Impact due to transportation of raw materials

439. Natural gas, would be supplied by TGTDCL via underground pipelines and hence it would not have any impact. However, the transportation of construction materials may have impact In-terms of spillages and leakages of construction materials while being transported to the construction site. The vehicles carrying the construction materials might also get into an accident. The resultant construction materials might be spilled to nearby water bodies, affect the environment. Explosion/fire caused by the accident, might damage nearby properties, buildings, people and the ambient environment itself. This impact is characterized as Moderate Adverse, as given in Table 7-4.

7.8 Operation Stage Impact

7.8.1 Impact on Natural Resources

440. The natural resources used by the Unit 4 are water and natural gas. Operation of the Plant with close cycle technology would reduce the current Plant water requirement (8.971 m^3/s) drastically to about 95% (0.4686 m^3/s) . In terms of saving resources, this will result as the conservation of water resources which is already under stressed condition. Moreover, current temperature increase by thermal discharge from cooling system of 7-9^{0}C from the ambient water temperature would be minimized under the proposed repowering due to closed-cycle cooling system. So, water resource would be relieved from the effect of increased temperature.

441. Repowering of the proposed unit from 180 MW to 403.5 MW will require an additional gas requirement of 18.11 MMSCFD which will be supplied from TGTDCL. As a result Gas consumption will be reduced in this Project for the same quantity of augmented power.

7.8.2 Impact on Ecosystems

Impact on fisheries and their habitat

442. Small amount of water (0.4686 m^3/s) will be withdrawn from Shitalakhya River under repowering. In the intake pump, local fish habitats may be destabilize due to alteration of substrates of the intake area in the river. As a result, aquatic community structure and diversity may be affected. This impact is characterized as Moderate Adverse, as given in Table 7-4.

Restoration of aquatic habitat

443. Shifting of technology, from once through cooling system to close cycle cooling system will require less water, leading to no discharge of condenser cooling water to the river. Under the proposed system, water will be recycled and stress will be reduced on river, the fish habitats and other aquatic organisms by reducing thermal discharge in Shitalakhya. This impact is characterized as Major Beneficial, as given in Table 7-4.

7.8.3 Impact on irrigation facility

444. Currently, diversion of condenser cooling water through irrigation canal established by BADC covers the irrigation of about 1,619 ha of farmlands. With this irrigation, about 6,000 tons of rice is produced annually from the irrigated field. This is very much cost effective for the farmers as they are paying only about Tk. 800/ha/season, while for using low lift pump (LLP) from the Shitalakhya River the cost is about Tk. 6,500/ha/season. In addition, this irrigation indirectly benefiting vegetation growth, bird wading area, aquatic and amphibian habitats, fish aquaculture, etc.

445. Transformation of once through cooling system to close cycle cooling system will reduce the quantity of condenser cooling water discharge (about 22.2%) from Unit 4 to overall GPS discharge of 27.22 m^3/s. However, condenser cooling water discharge from other operating units can continue supplying irrigation water to BADC irrigation network. Hence, the crop production of the area will be continued. GPS will bear 6 years of pump operating costs (3 years during construction and 3 years during operation). However, BADC will take responsibility from the 7th year of operation to maintain the pumps. This impact is characterized as moderate adverse, as given in Table 7-4.

7.8.4 Impact on Air quality (including dispersion modeling)

a) Pollutants of Concern

446. Pollutants of concern released from natural gas fired power stations are nitrogen oxides (NO_x), Carbon Monoxide (CO) and VOC's. Particulate Matter is generally not of major concern from the combustion of natural gas. The combustion of gaseous fuels does not result in a high production of particulates. Particulate matter resulting from natural gas combustion is mostly less than 1 micrometer (□m) in diameter[30]. However, currently no regulations and standards exist for particles of this fine, therefore emissions from the power plant will be evaluated and compared to applicable standards for $PM_{2.5}$ (Particles $\leq$ 2.5 µm in size) and PM_{10} (Particles $\leq$ 10 µm in size). The pollutant of most concern from natural gas fired power plants is NO_x. The formation of thermal NO_x is dependent on 3 factors during

[30] USEPA AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, 2009.

combustion; (i) oxygen concentration, (ii) peak temperature, and (iii) time of exposure at peak temperature[30]. Natural gas combustion releases NO_x which is composed of NO and NO_2. NO_2 is of particular concern and is considered a criteria pollutant. NO_2 is used as the indicator for the larger group of nitrogen oxides (NO_x). In addition to contributing to the formation of ground-level ozone, and fine particle pollution, NO_2 is linked with a number of adverse effects on the respiratory system. Significant health risks are associated with high levels of ambient NO_2, CO and $PM_{2.5}$ concentrations. Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O) are the major greenhouse gases that are emitted from the power station.

447. Emissions from the power plant are estimated for two scenarios (i) Baseline scenario and (ii) Re-powering scenario (after the re-powering of Units 3 and 4).

b) Air quality modeling input data and methodology

448. The latest version of the USEPA regulatory model AERMOD was used to predict and simulate the effects of criteria pollutants from major emission sources in the project area and analyze the effect on ambient air quality for NO_2, CO, $PM_{2.5}$ and PM_{10}. Since there was very little information available on the power plant emissions, criteria emissions were calculated based on plant fuel consumption and emission factors from USEPA AP 42 and other sources. This is considered a conservative approach to modeling. Greenhouse gas emissions were calculated using fuel consumption and IPCC greenhouse gas emission factors. A Tier-1 and Tier-2 (Ambient Ratio Method) modeling approach was used for NO_2 prediction as per USEPA guidelines[31]. In the Tier-1 approach it is assumed that 100% of the NO_x emissions are converted into NO_2, this approach gives the most conservative results and tends to over predict maximum ground level concentrations. In the tier-2 (ARM) a regional NO_2/NOx ratio representative of area wide quasi-equilibrium conditions is applied to the model predicted values, this gives more realistic results for maximum ground level NO_2 concentration. NO_2 is the pollutant of concern and is used as an indicator for nitrogen oxides (NO_x) in general.

I. Project Area

449. An area, 50 km by 50 km centering the stack of Ghorashal Power Station Unit 4 was selected for the air quality analysis. A digital elevation model (DEM) of the area was prepared based on ground elevations for input into the AERMOD Software. The DEM of the model area is shown in the Figure 7-1.

[31] USEPA: Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the N02 National Ambient Air Quality Standard, 2014.

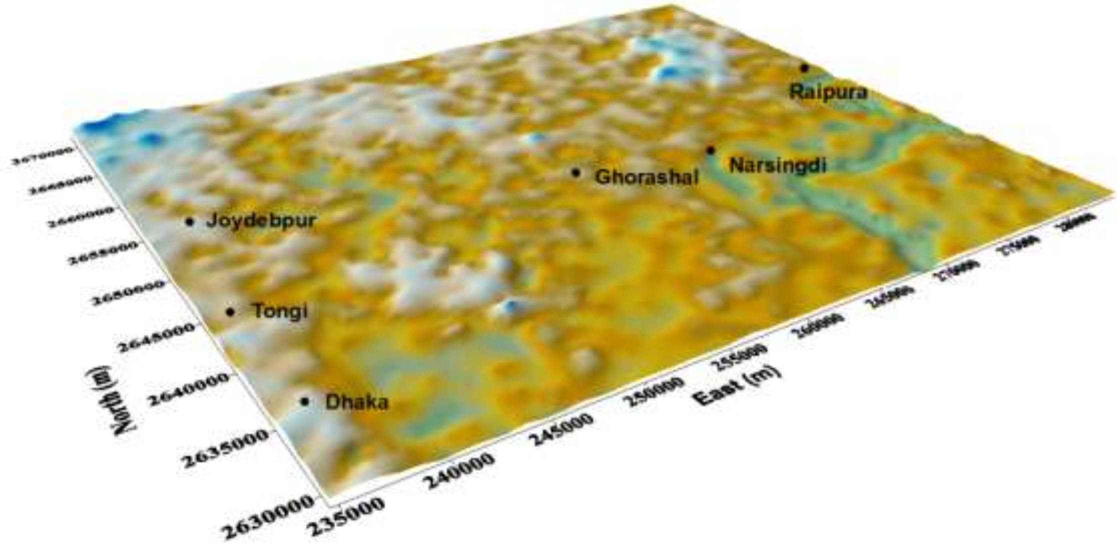


Figure 7-1: Digital elevation model of the AERMOD Model Area

II. Ghorashal Power Station Emission Parameters

450. The stack emissions and parameters for the power plant (baseline and repowering) are given in Table 7-5 below.

Table 7-5: Power Plant Emission Parameters

Power Plant	No. of Stack	Capacity (MW)	Stack Height (m)	Inner Dia. (m)	Flu Gas Temp. (K)	Emission Rate (g/s)			
						NO_2	CO	$PM_{2.5}$	PM_{10}
Ghorashal Power Station –Unit 1	1	55	40	2.5	398	8.62	7.25	0.66	0.66
Ghorashal Power Station –Unit 2	1	55	40	2.5	398	8.62	7.25	0.66	0.66
Ghorashal Power Station –Unit 3	1	210	50	3	383	46.07	20.35	1.85	1.85
Ghorashal Power Station –Unit 3 (After Re-powering)	1	411.65	50	3	363.8	33.23	5.05	0.06	0.87
Ghorashal Power Station –Unit 4	1	210	50	3	383	46.07	20.35	1.85	1.85
Ghorashal Power Station –Unit 4 (After Re-powering)	1	411.65	50	3	363.8	33.23	5.05	0.06	0.87
Ghorashal Power Station –Unit 5	1	210	50	3	398	46.07	20.35	1.85	1.85
Ghorashal Power Station –Unit 6	1	210	50	3	398	46.07	20.35	1.85	1.85

III. Meteorological Data

451. Pre-processed hourly meteorological data for 2012, 2013 and 2014 from the Dhaka Airport (WMO number 419220, symbol VGHS, location at 23.85N, 90.40E, elevation 9.0 meters) and upper air surrounding data from an upper air station at 23.78N, 91.18E was purchased and used in the model. A monthly summary of the meteorological data is given in Table 7-6 and wind roses data was presented in Chapter 6.

Table 7-6: Summary of 2012, 2013 and 2014 Meteorological Data Input to AERMOD

Month	Wind		Temperature (°C)		Relative Humidity (%)	
	Max. Speed (m/s)	Predominant Direction	Min	Max	Min	Max
Jan	7.7	ESE	8	30	30	100
Feb	8.2	ESE	13	34	20	100
Mar	15.4	N	20	40	13	94
Apr	11.3	N	20	43	9	100
May	12.9	N	22	40	35	100
Jun	10.3	N	25	38	41	100
Jul	9.3	N	27	36	51	94
Aug	9.3	N	26	36	58	94
Sept	12.9	N	24	36	40	100
Oct	10.3	N	22	36	37	100
Nov	6.2	SE	16	33	20	100
Dec	5.1	E	12	31	23	100

IV. Receptors

452. A uniform Cartesian grid was used to model the receptors in the model. The 50km by 50 km model area was divided into a grid with an interval of 1,000 m, where receptors are located on the corner of each grid for plotting of air quality data for the model project area. Sensitive receptor areas close to the project site were also included in the grid area. The effects on air quality at these sensitive sites were also assessed in more detail. The list of sensitive receptors, their locations and details are given in Table 7-7.

Table 7-7: Details of Sensitive Receptors

SI	Name of Sensitive Receptors	Location	
		Latitude	Longitude
1	Residential (Ghorashal PP)	23.97538	90.63505
2	School (Ghorashal PP)	23.97519	90.6357
3	School	23.97667	90.6315
4	School	23.97122	90.62837
5	School	23.98772	90.65382
6	School	23.9836	90.6482
7	School	23.96726	90.64661

8	Hospital (Palash)	23.97955	90.65019
9	High School	23.9771	90.65495
10	Thana Health Complex (Palash)	23.97455	90.66035
11	Madrasa (Garapara)	23.97031	90.6399
12	School (Dhaladia)	23.95751	90.63963
13	Madrasa (Dakshin Palash)	23.95167	90.62877
14	School	23.95075	90.62414
15	Hospital	23.94438	90.61981
16	Girls' school (Ghorashal Palash)	23.94406	90.62147
17	Dakhil Madrasa (Paiksha)	23.94473	90.62343
18	RFL Public school (RFL, Palash)	23.93835	90.62951
19	School (10 No. Ghorashal)	23.94279	90.63733
20	College (Kaliganj)	23.92651	90.5553
21	School	23.92108	90.56616
22	Primary School	23.94437	90.61508
23	Kindergarten School	23.9614	90.61517
24	Madrasa (Sahida Mohila)	23.97711	90.60766
25	School	23.97828	90.60637
26	Madrasa	23.98084	90.60397
27	School	23.99052	90.58494
28	Madrasa	23.98956	90.58004

c) *Air Quality Modeling*

453. In this section, the predicted maximum ground level concentration results and contour maps for maximum concentration levels in ambient air are presented for NO_2, $PM_{2.5}$, PM_{10} and CO for both the baseline and repowering scenario. Only emissions from the Ghorashal power station (Units 1 to 6) were modeled and a measured ambient background concentration was added to the modeled results to predict the concentration at the sensitive receptors.

I. Background Concentrations

454. Background ambient NO_x and CO measurements[32] were obtained for a location close to the Ghorashal power station from the EIA of Unit 3 Report[33]. The background ambient

[32] Background data from *EIA of Unit 3 Report* was used instead of baseline air quality data from Chapter 6 because *Unit 3 Report* measurements were taken further away from the power station and considered to be more representiive of actual background concentrations. Where as the baseline data meaursements are from within the power station complex.

NO_2 and CO concentrations were measured to be 28 and 204 µg/m^3 respectively for an 8-hour averaging period. This ambient concentration has contribution from the GPS as well. Thus, to adjust for the contribution to the background NO_2 and CO by the power plant emissions, AERMOD was used to assess the contribution of each pollutant from the power plant at this location during the period of measurement. The modeling was done for Units 1 to 5; unit 6 was not included since it was not operational at the time the ambient measurements were taken. The model results were then subtracted out to obtain a more accurate representation of the ambient background concentration excluding the plant emissions (Table 7-8).

455. Measurements for PM_{10} were taken inside the GPS under this EIA study. The background ambient PM_{10} concentration was then found by taking the average of the values. The background ambient $PM_{2.5}$ concentration was calculated based on measured PM_{10} and Narayanganj CAMS data factor for $PM_{10}/PM_{2.5}$ as discussed in section *6.9 Ambient Air Quality*. The background ambient $PM_{2.5}$ and PM_{10} concentrations were calculated to be 57 and 115 µg/m^3, respectively for a 24-hour averaging period. This ambient concentration has contribution from the GPS as well, so the values were adjusted using the same methodology as for NO_2 and CO presented in Table 7-9.

Table 7-8: Ambient Background Concentrations (NO_x and CO)

Pollutant	Concentration (µg/m^3)			Coordinates	
	Measured Ambient value (8-hr averaging period)	Power plant contribution - AERMOD (8-hr averaging period)	Adjusted Ambient value (8-hr averaging period)	East (m)	North (m)
NO_2	28	9.94	18.06	259982.45	2652954.92
CO	204	6.36	197.7	259982.45	2652954.92

Table 7-9: Ambient Background Concentrations ($PM_{2.5}$ and PM_{10})

Pollutant	Concentration (µg/m^3)			Coordinates	
	Ambient value (24-hr averaging period)	Power plant contribution - AERMOD (24-hr averaging period)	Adjusted Ambient value (24-hr averaging period)	East (m)	North (m)
$PM_{2.5}$	57	1.77	55.23	259663.08	2653707.50
PM_{10}	115	1.90	113.1	259663.08	2653707.50

456. The NO_2 and CO ambient background concentration values are for an 8-hour averaging period and have to be converted to 1-hour and annual averaging periods. While the $PM_{2.5}$ and PM_{10} measurements are for a 24-hour averaging period and have to be converted to an annual averaging period. Conversions were done using the power law relationship given below:

$$C_{long} = C_{short} (t_{short}/t_{long})^P$$

where:

C_{long}= the concentration for the longer averaging time

C_{short}= the concentration for the shorter averaging time

[33] Environmental Impact Assessment (EIA) of Re-Powering of Ghorashal Existing 3rd Unit With Gas Based Combined Cycle Capacity of 400 MW Site Conditions, June 2014.

T_{short} = the shorter averaging time (in minutes)

T_{long} = the longer averaging time (in minutes)

p = the power law exponent

457. For ambient air assessments a p value of 0.28 is used. This methodology is deemed to give conservative estimates and thus is deemed appropriate for this case. The converted background ambient pollutant values are given below (Table 7-10).

458. The background ambient concentration values were added to the modeled 1-hr, 8-hr and annual concentration values.

Table 7-10: Converted Ambient Concentration Values

Pollutant	Concentration (μg/m³)			
	Average Adjusted Ambient value (8-hr averaging period)	Converted Ambient Concentration (1-hr averaging period)	Converted Ambient Concentration (24-hr averaging period)	Converted Ambient Concentration (Annual averaging period)
NO_2	18.06	32.2	-	2.5
CO	197.7	353	-	-
$PM_{2.5}$	-	-	55.23	10.6
PM_{10}	-	-	113.1	21.68

459. Note the background $PM_{2.5}$ and PM_{10} values for 24-hour and annual averaging period are within the Bangladesh National standards. The 24-hour average concentration of $PM_{2.5}$ meets the Interim target-1 (75 μg/m³) but is above the guideline of 25 μg/m³ for 24-hour averaging period. The $PM_{2.5}$ annual average meets the WHO interim target-3 (15 μg/m³) but is above the guideline of 10 μg/m³. The PM_{10} value for 24-hour and annual averaging meet WHO Interim target-1 (150 μg/m³) and Interim target-2 (30 μg/m³), respectively. However, both values are above the WHO guidelines. Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines for developing countries. An air shed is considered to have poor air quality if the guideline value is exceeded significantly. Thus the air shed can be considered degraded with respect to ambient particulate matter concentrations.

II. Concentration of Nitrogen Dioxide (NO_2)

460. For NO_2 the maximum ground level concentrations were modeled for 1-hour averaging period and annual averaging period to compare with the national standards (ECR 1997, amended in 2005) and WHO Guidelines.

461. For short-term compliance modeling, percentiles are used in order to account for unusual metrological events and AERMOD's tendency to overestimate concentrations on low wind days. There are two distinct methods to model 1-hr NO_2 compliance concentrations; USEPA method and EU method. Both methods were used to predict maximum ground level NO_2 concentrations.

462. In the USEPA compliance method, the 1-hour NO_2 modeled value is based on the 98th percentile of the maximum daily 1-hour values, which is represented by the eighth-highest of the maximum daily 1-hour values across the year (averaged over 3 years). In the EU method, the 99.8 percentile of the max NO_2 value is taken. The annual average is the same for both methods, it is simply the arithmetic mean averaged over a 3 year period.

463. Preliminary modeling results indicated high maximum ground level concentrations of NO_2 close to the power plant. Also numerous residents who live close to the power plant complained of breathing issues and surveys showed high levels of asthma and other respiratory issues in the communities surrounding the project site. Therefore, a refined grid analysis was conducted for NO_2 emissions. A refined grid (4 km by 4 km) was modeled with receptors every 150 m apart in the project area.

464. Table 7-11 shows the Bangladesh, World Bank, EU and USEPA standards for NO_2.

Table 7-11: Important NO_2 Compliance Standards

Pollutant	Averaging Time	Concentration (µg/m³)			
		ECR 1997 (as amended in 2005)	WHO Guidelines	EU Guidelines	USEPA Standards (NAQQS)
NO_2	1-hr	N/A	200	200	188
	Annual	100	40	40	100

465. Table 7-12 below shows the Tier-1 predicted results for 1-hour average (using both EU and USEPA method) and the annual average concentration. The predicted results include the background concentration. Tier-1 assumes 100% conversion of hourly NO_x emissions into NO_2.

Table 7-12: Tier-1 Predicted maximum ground level concentration of NO_2 (Baseline & Repowering)

Scenario	Averaging Time	Concentration (µg/m³)		Coordinates of Max Point (UTM)	
		Max Value (USEPA Method)	Max Value (EU Method)	East (m)	North (m)
Baseline	1-hr	253.17	231.8	259107	2654110
	Annual	21.3	21.3	259557.1	2654710
Re-powering	1-hr	227.2	210.8	259107	2654110
	Annual	19.2	19.2	259557.1	2654710

466. The predicted results indicated exceedances for the 1-hour averaging period for both baseline and repowering case. Since the Tier-1 approach tends to over predict concentrations, a Tier-2 (Ambient Ratio Method) was applied to the predicted 1-hr maximum ground level concentrations to get more realistic results.

467. The ARM uses the ratio of the average NO_2 and NOx ambient concentrations measured at a representative site. It uses an ambient equilibrium NO_2/NO_x ratio (annual average) which is calculated based on local monitoring data[34]. Theoretically, equilibrium occurs when the rate of NO_2 formation (from oxidation of NO) equals the rate of dissociation

[34] Journal of the Air and Waste Management Assocaition: The Plume Volume Molar Ratio Method for Determining NO2/NOx Ratios in Modeling—Part I: Methodology, 2011.

of NO_2 by sunlight[35]. This ratio is different for different climates and regions of the world. As per USEPA guidelines, NO_2 and NO_x hourly data was analyzed for 3 years (2013, 2014 and 2015) from the Narayanganj CAMS monitoring station. The highest ratio (from 2015) was used for the ARM method. The NO_2/NO_x ratio from the 2015 data was found to be 0.65. This indicates that on average 65% of the NO_x is converted into NO_2 in the air shed.

468. Table 7-13 below show the Tier-2 (ARM) predicted results, where predicted concentrations are multiplied by the regional NO_2/NO_x equilibrium ratio and then background concentrations are added.

Table 7-13: Tier-2 Predicted maximum ground level concentration of NO_2 (Baseline & Repowering)

Scenario	Averaging Time	Concentration (µg/m³)		Coordinates of Max Point (UTM)	
		Max Value (USEPA Method)	Max Value (EU Method)	East (m)	North (m)
Baseline	1-hr	175.8	161.9	258647	2654148
	Annual	21.3	21.3	259647	2655148
Re-powering	1-hr	159.0	148.3	258647	2654148
	Annual	19.2	19.2	259647	2655148

469. From Table 7-13, it is evident that both 1-hr average and annual average values for both baseline and repowering case are in compliance with the national and WHO Guidelines. The USEPA method shows a higher concentration then the EU method for 1-hour averaging, but the values are still in compliance with all standards.

470. There is a significant reduction in NO_2 concentration values from the baseline to the repowering case (for both 1-hr and annual averaging periods). This reduction in NO_2 concentration is directly due to the change in technology for the repowering case. For the baseline case steam boilers are used with no NOx control technology. Whereas after repowering combined cycle gas turbines with a dry low NOx combustion system will be introduced.

471. The max predicted NO_2 concentration values for the sensitive receptor sites close to the power plant for both the baseline and repowering case are presented in Table 7-14.

Table 7-14: Predicted NO_2 concentration at Sensitive Receptors

S.I	Name of Receptor	Concentration (µg/m³)			
		(1-hr Averaging)		(Annual Averaging)	
		Baseline	Repowering	Baseline	Repowering
1	Residential (Ghorashal PP)	114.52	105.55	8.02	7.46
2	School (Ghorashal PP)	112.66	104.13	7.76	7.22

[35] Use of Ambient Ratios to Estimate Impact of NOx Sources on Annual NO2 Concentrations. In Proceedings of the 84th Annual Meeting & Exhibition, Air & Waste Management Association, 1991

3	School	117.16	107.43	8.93	8.25
4	School	72.19	67.72	5.50	5.17
5	School	60.57	57.32	4.57	4.34
6	School	89.82	83.22	7.34	6.81
7	School	67.80	63.73	5.32	5.01
8	Hospital (Palash)	91.37	84.68	8.38	7.74
9	High School	72.49	68.01	6.49	6.05
10	Thana Health Complex (Palash)	59.85	56.68	5.26	4.95
11	Madrasa (Garapara)	80.87	75.21	6.09	5.69
12	School (Dhaladia)	48.07	46.11	3.60	3.48
13	Madrasa (Dakshin Palash)	42.19	41.02	3.20	3.12
14	School	42.78	41.52	3.26	3.18
15	Hospital	41.03	40.04	3.16	3.09
16	Girls' school (Ghorashal Palash)	40.78	39.76	3.13	3.06
17	Dakhil Madrasa (Paiksha)	40.64	39.80	3.11	3.04
18	RFL Public school (RFL, Palash)	38.30	37.65	2.95	2.90
19	School (10 No. Ghorashal)	39.68	38.81	3.07	3.00
20	College (Kaliganj)	38.56	37.81	2.97	2.92
21	School	37.64	36.97	2.94	2.89
22	Primary School	41.28	40.48	3.20	3.13
23	Kindergarten School	45.98	44.46	3.65	3.52
24	Madrasa (Sahida Mohila)	54.17	51.73	4.73	4.49
25	School	54.25	51.67	4.77	4.53
26	Madrasa	55.13	52.88	4.68	4.44
27	School	41.96	40.81	3.40	3.29
28	Madrasa	42.84	41.71	3.42	3.32

**Tier-2 (ARM) 1-hr averaging values calculated by EU method (99.8 percentile value)*

472. Table 7-14 shows that the NO_2 concentration for 1-hr and annual average is within the compliance limit for both the baseline and repowering case, there is no exceedance of standards. There is a reduction in the NO_2 at all sensitive receptor sites after the repowering case. The highest NO_2 was found at a school located close to the power plant, although this is still within the standards and guideline values.

473. Figure 7-2 and Figure 7-3 show the 1-hr and annual averaging contour diagrams for the baseline and repowering case, respectively.

474.

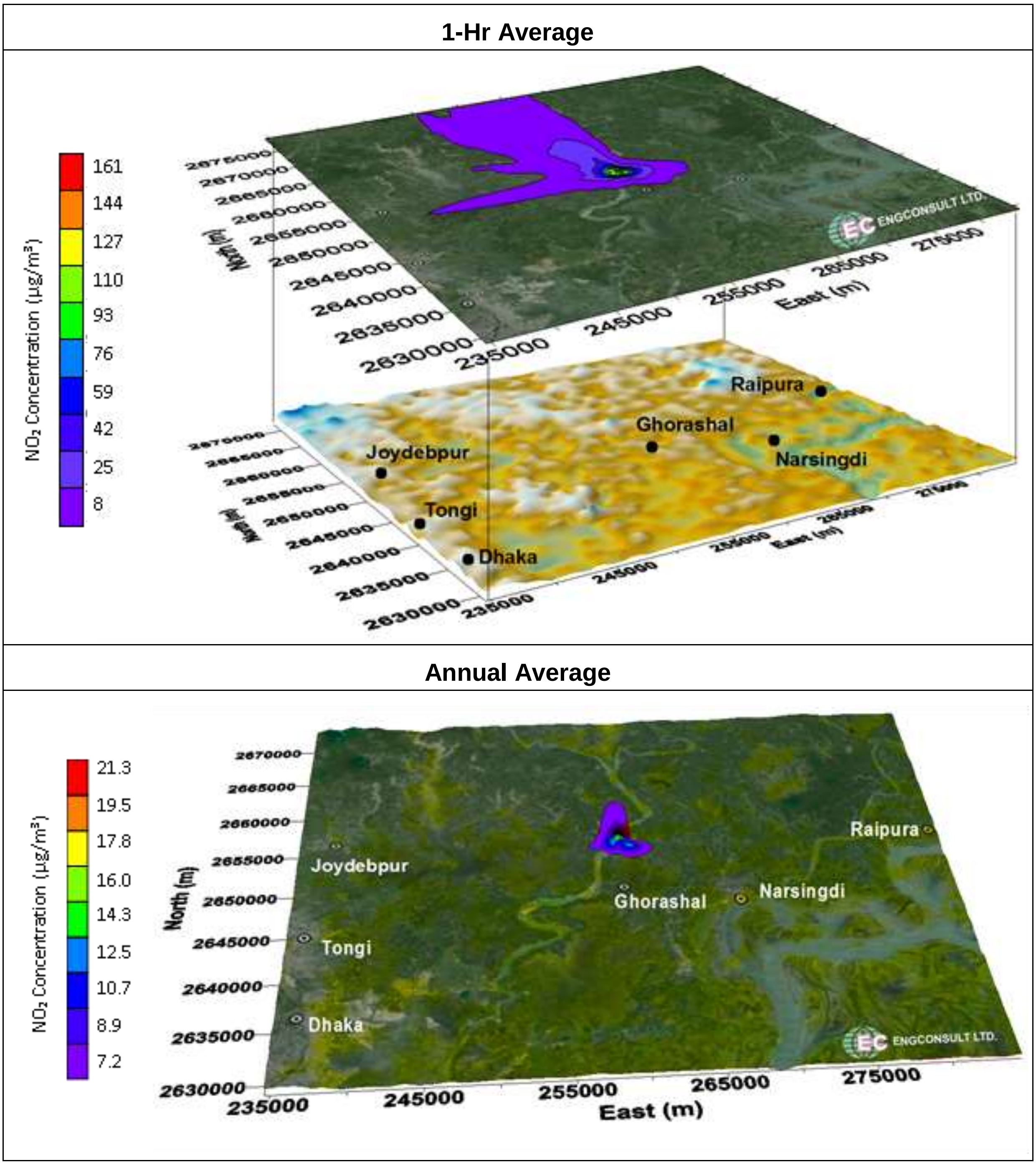
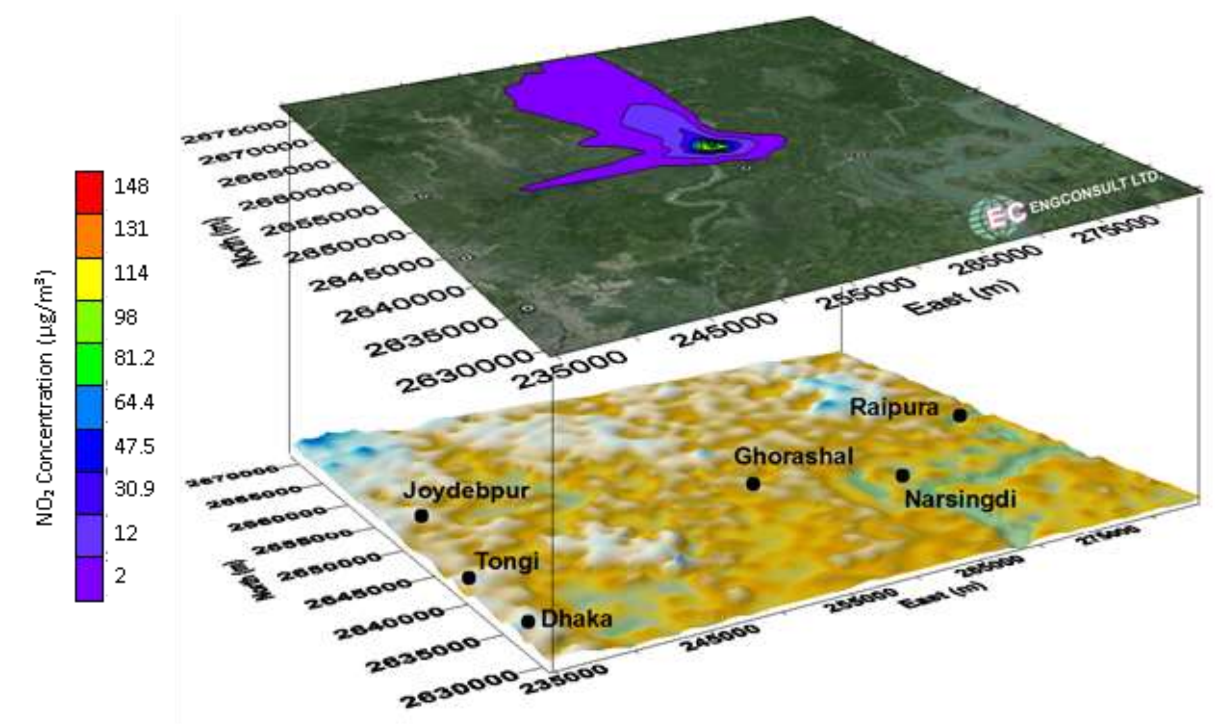


Figure 7-2: Predicted NO_2 Concentration (baseline scenario)

1-Hr Average



Annual Average

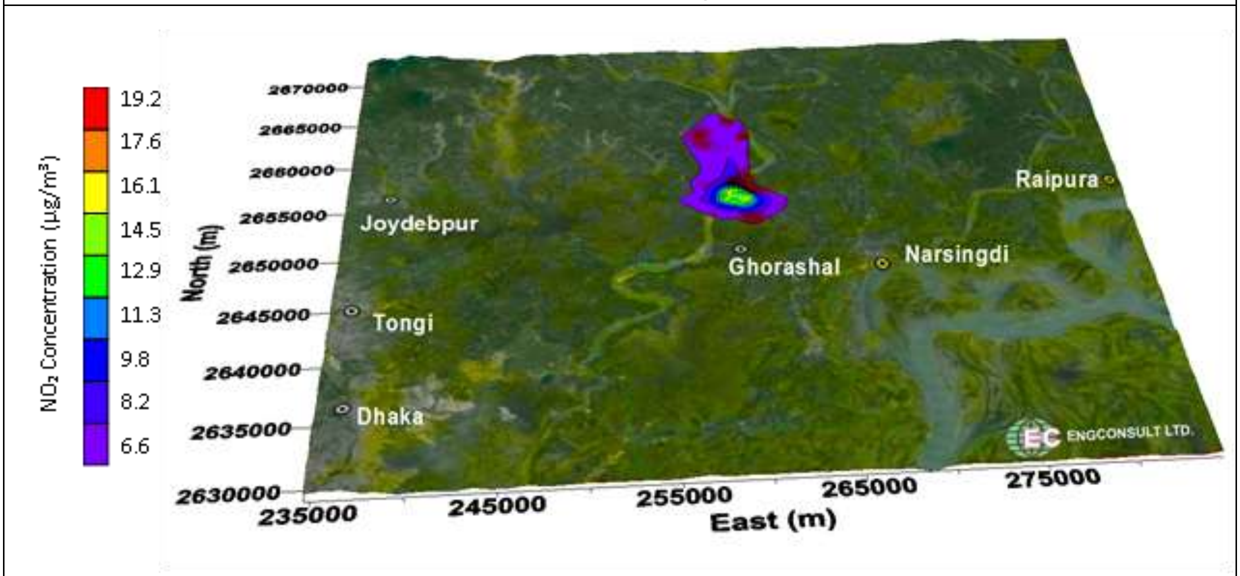


Figure 7-3: Predicted NO_2 Concentration (repowering scenario)

475. In Figure 7-2 and Figure 7-3, it is seen that the plume is predominately towards the north, this is expected as this is predominate wind direction. The highest predicted maximum ground level concentration areas occur close to the power plant. There is a decrease in concentrations from the baseline to repowering case. The wind carries the plume away from the major population centers of Dhaka and Ghorashal as seen in the contours.

III. Concentration of Carbon Monoxide (CO)

476. For CO the predicted maximum ground level 1-hr and 8-hr averaging values are given in Table 7-15, the highest predicted concentration reached for a particular averaging period (1-hr or 8-hr) based on 3 years meteorological data as per the Bangladesh standards. There is no WHO Guidelines for CO.

Table 7-15: Air Quality Modeling – CO (Baseline & Repowering)

Pollutant	Concentration (µg/m³)				Coordinates of Max Point (UTM)	
	Averaging Time	ECR 1997 (as amended in 2005)	WHO Guidelines	Max Value	East (m)	North (m)
Baseline	1-hr	40,000	N/A	487.55	259366.2	2653520
	8-hr	10,000	N/A	270.64	259647	2655148
Repowering	1-hr	40,000	N/A	441.67	259007.1	2653669
	8-hr	10,000	N/A	245.24	259647	2655148

477. For both the baseline and repowering case the 1-hr and 8-hr averaging values are well below the Bangladesh standards. There is a reduction in the CO concentration from the baseline to repowering case. This reduction is expected since the repowering case will employ more up to date combined cycle technology – even though the repowered system will use more fuel and generate a much higher amount of electricity.

478. The predicted CO concentration at the sensitive receptors for both baseline and repowering cases are given in Table 7-16.

Table 7-16: Predicted CO concentration at sensitive receptors

S.I	Name of Receptor	Concentration (µg/m³)			
		(1-hr Averaging)		(8-hr Averaging)	
		Baseline	Repowering	Baseline	Repowering
1	Residential (Ghorashal PP)	487.55	440.75	261.23	240.19
2	School (Ghorashal PP)	483.67	439.06	254.60	236.31
3	School	485.78	441.67	265.32	242.81
4	School	437.84	409.95	229.84	219.48
5	School	428.89	403.91	218.60	211.84
6	School	458.89	424.25	246.07	230.41
7	School	422.30	399.50	220.43	213.09
8	Hospital (Palash)	437.56	409.55	240.15	226.47
9	High School	437.59	409.70	235.11	222.98
10	Thana Health Complex (Palash)	446.04	415.14	227.78	218.10
11	Madrasa (Garapara)	443.23	411.84	237.99	224.62

12	School (Dhaladia)	404.13	387.04	209.04	205.39
13	Madrasa (Dakshin Palash)	391.71	378.83	208.83	205.23
14	School	388.00	376.58	209.18	205.40
15	Hospital	381.45	371.78	207.73	204.47
16	Girls' school (Ghorashal Palash)	382.20	372.33	207.81	204.53
17	Dakhil Madrasa (Paiksha)	382.09	372.29	207.98	204.65
18	RFL Public school (RFL, Palash)	380.98	371.55	203.83	201.88
19	School (10 No. Ghorashal)	403.76	386.63	206.24	203.38
20	College (Kaliganj)	372.62	366.28	207.60	204.37
21	School	371.83	365.72	203.86	201.84
22	Primary School	381.57	372.14	207.97	204.50
23	Kindergarten School	395.29	381.41	216.41	210.29
24	Madrasa (Sahida Mohila)	410.00	391.44	213.62	208.43
25	School	416.10	395.47	217.18	210.79
26	Madrasa	421.12	398.71	219.76	212.42
27	School	400.75	384.98	205.66	203.03
28	Madrasa	398.39	383.09	205.26	202.72

479. The table above shows that the CO concentration for 1-hr and 8-hr average is well within the compliance limit for both the baseline and repowering cases. There is a reduction in the CO concentration at all sensitive receptor sites after the repowering case.

IV. Concentration of $PM_{2.5}$

480. For $PM_{2.5}$ the predicted maximum ground level 24-hr and annual concentrations for various averaging time are given in Table 7-17. As was noted above, the background $PM_{2.5}$ concentration for 24-hour and annual averaging time exceeds WHO guidelines but meet the WHO interim target-1 and interim target-3, respectively. The background concentration for the 24-hour and annual averaging period was found to be 55.23 and 10.6 µg/m³, respectively. This indicates that for baseline and repowering case the power station's contribution to ambient $PM_{2.5}$ concentration is fairly low.

Table 7-17: Predicted maximum concentrations of $PM_{2.5}$ (Baseline & Repowering)

Pollutant	Concentration (µg/m³)				Coordinates of Max Point (UTM)	
	Averaging Time	ECR 1997 (as amended in 2005)	WHO Guidelines	Max Value	East (m)	North (m)
Baseline	24-hr	65	25	58.71	259647	2655148
	Annual	15	10	11.23	259647	2655148
Repowering	24-hr	65	25	57.15	259647	2655148
	Annual	15	10	10.96	259647	2655148

481. After repowering both 24-hour and annual averaging values show a decrease in the $PM_{2.5}$ concentration. Thus, the repowering case brings the ambient concentration closer to the WHO standards and is an improvement over the baseline condition.

482. The predicted concentration at the sensitive receptor sites for both baseline and repowering cases are given in Table 7-18.

Table 7-18: Predicted $PM_{2.5}$ concentration at sensitive receptors

S.I	Name of Receptor	Concentration (µg/m³)			
		(24-hr Averaging)		(Annual Averaging)	
		Baseline	Repowering	Baseline	Repowering
1	Residential (Ghorashal PP)	57.28	56.42	10.85	10.75
2	School (Ghorashal PP)	57.02	56.28	10.84	10.74
3	School	57.88	56.76	10.89	10.77
4	School	56.62	56.04	10.74	10.68
5	School	56.11	55.74	10.69	10.65
6	School	56.98	56.24	10.82	10.72
7	School	56.21	55.79	10.73	10.67
8	Hospital (Palash)	56.86	56.18	10.86	10.75
9	High School	56.55	56.00	10.78	10.70
10	Thana Health Complex (Palash)	56.27	55.84	10.72	10.67
11	Madrasa (Garapara)	56.68	56.06	10.76	10.69
12	School (Dhaladia)	55.71	55.50	10.65	10.63
13	Madrasa (Dakshin Palash)	55.53	55.40	10.63	10.62
14	School	55.60	55.44	10.63	10.62
15	Hospital	55.61	55.45	10.63	10.62
16	Girls' school (Ghorashal Palash)	55.59	55.43	10.63	10.62
17	Dakhil Madrasa (Paiksha)	55.56	55.42	10.63	10.62
18	RFL Public school (RFL, Palash)	55.41	55.34	10.62	10.61
19	School (10 No. Ghorashal)	55.56	55.42	10.63	10.61
20	College (Kaliganj)	55.47	55.37	10.62	10.61
21	School	55.46	55.36	10.62	10.61
22	Primary School	55.66	55.48	10.63	10.62
23	Kindergarten School	55.87	55.60	10.65	10.63

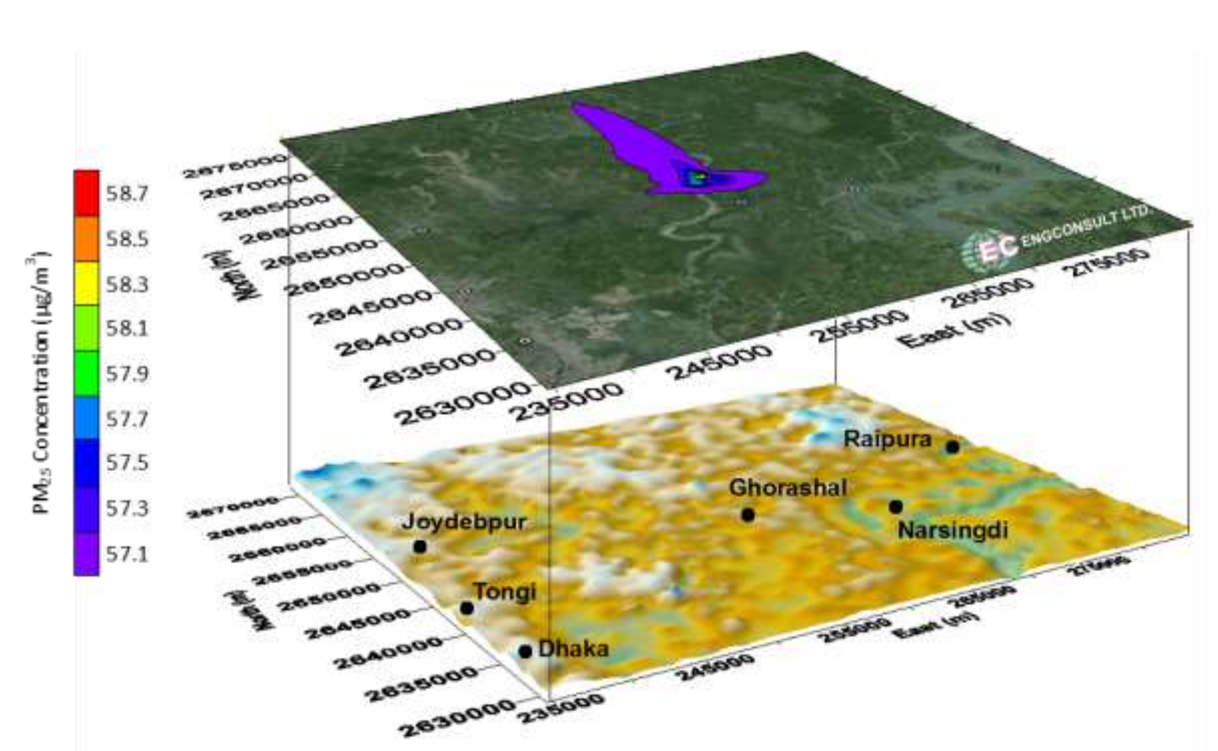
24	Madrasa (Sahida Mohila)	55.99	55.67	10.70	10.66
25	School	56.03	55.69	10.70	10.66
26	Madrasa	56.14	55.75	10.70	10.66
27	School	55.51	55.39	10.64	10.62
28	Madrasa	55.55	55.41	10.64	10.62

483. Table 7-18 shows that the predicted daily and annual average $PM_{2.5}$ concentration at sensitive receptors is within the Bangladesh national standards and meet the WHO Interim-1 and interim-3 target, respectively. There is a reduction in the $PM_{2.5}$ concentration at all sensitive receptor sites after the repowering case.

484. The combustion of gaseous fuels such as natural gas does not produce a significant amount of particulate matter pollution. Also, natural gas from Bangladesh is naturally very low in contaminants such as sulfur and is considered pure. It is estimated that a significant portion of the $PM_{2.5}$ concentration in Bangladesh is trans-boundary in nature (secondary pollutants formed from NO_x and SO_x after chemical transformation in the ambient air), predominately from West Bengal and North India.[42] Studies show that on average 35% of the $PM_{2.5}$ concentration is trans-boundary in nature and can be as high as 67% depending on the season and direction of the wind.[42]

485. Figure 7-4 and Figure 7-5 show the predicted daily and annual average contour diagrams for the baseline and repowering cases, respectively.

24-Hr Average



Annual Average

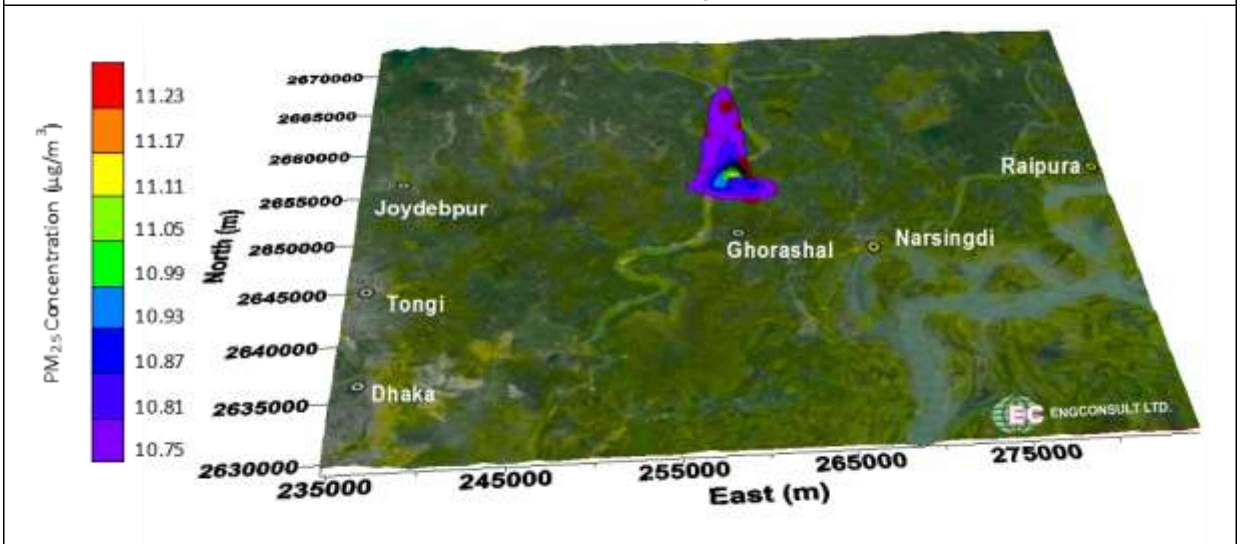


Figure 7-4: Predicted $PM_{2.5}$ concentration - Baseline case

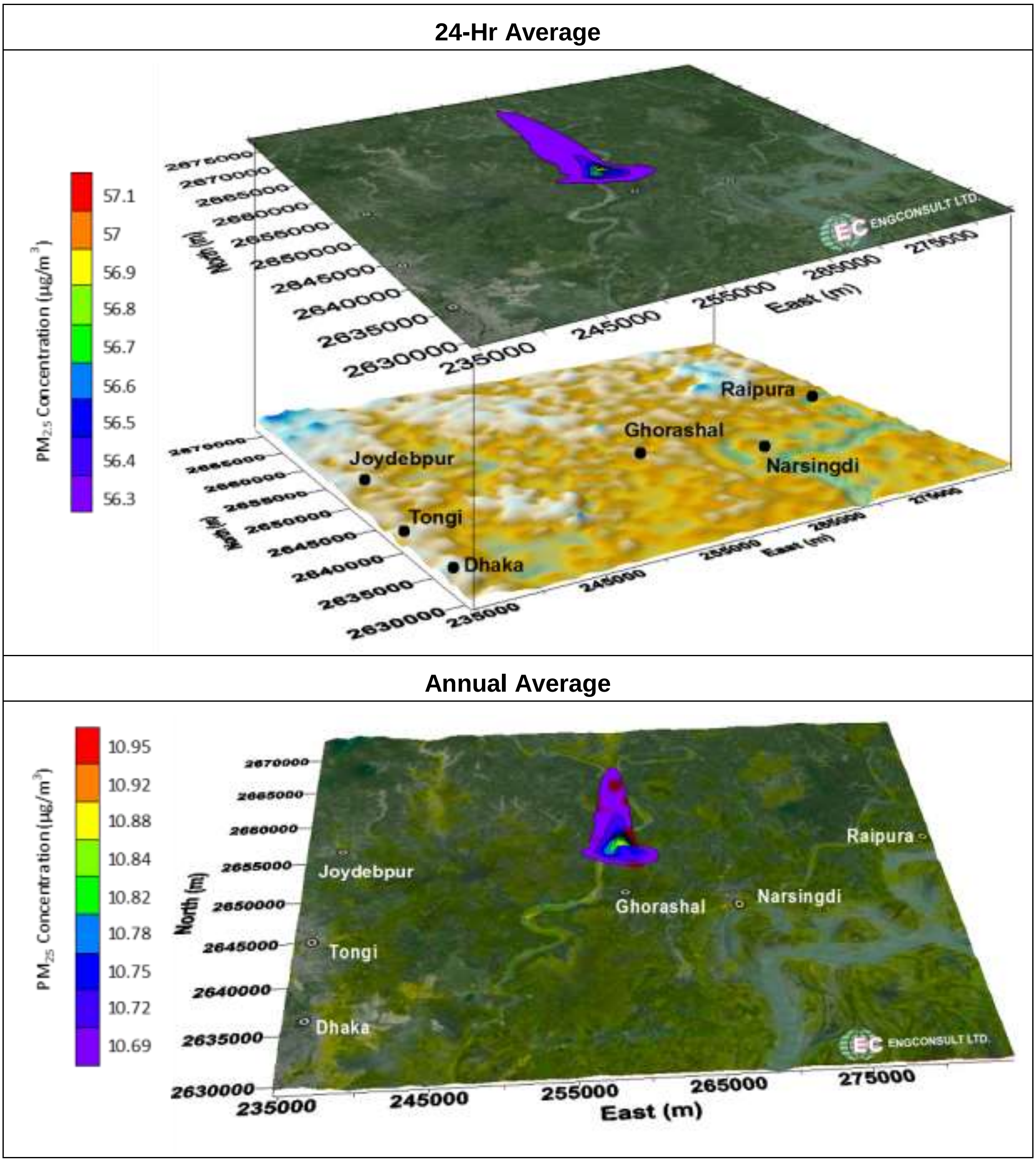


Figure 7-5: Predicted annual average $PM_{2.5}$ concentration - Repowering case

486. From the diagrams above, it is seen that the plume dispersion is predominately towards the north as was the case for NO_2. The highest concentration areas occur close to the power station. There is a decrease in concentrations from the baseline to repowering case. The wind carries the plume away from the major population centers of Dhaka, Narsingdi and Ghorashal.

V. Concentration of PM_{10}

487. For PM_{10} the predicted maximum ground level 24-hr and annual concentrations for various averaging times are given in Table 7-19. As was noted above, the background concentration of PM_{10} values for 24-hour averaging and annual averaging time exceeds

WHO guidelines but meet the WHO interim target-1 (150 µg/m³) and interim target-3 (30 µg/m³), respectively. The modeling results indicate that for both baseline and repowering condition the power station's contribution to ambient PM_{10} concentration in the air shed is fairly low. The predicted 24-hour averaging and annual PM_{10} concentration for both baseline and repowering cases are within national Bangladesh standards.

Table 7-19: Predicted maximum concentrations of PM_{10} (Baseline & Repowering)

Pollutant	Concentration (µg/m³)				Coordinates of Max Point (UTM)	
	Averaging Time	ECR 1997 (as amended in 2005)	WHO Guidelines	Max Value	East (m)	North (m)
Baseline	24-hr	150	50	116.73	259647	2655148
	Annual	50	20	22.29	259647	2655148
Repowering	24-hr	150	50	115.9	259647	2655148
	Annual	50	20	22.16	259647	2655148

488. After repowering both 24-hour and annual averaging concentration values show a slight decrease in the PM_{10} concentration. The predicted concentration at the sensitive receptor sites for both baseline and repowering cases are given in Table 7-20.

Table 7-20: Predicted PM_{10} concentration at sensitive receptors

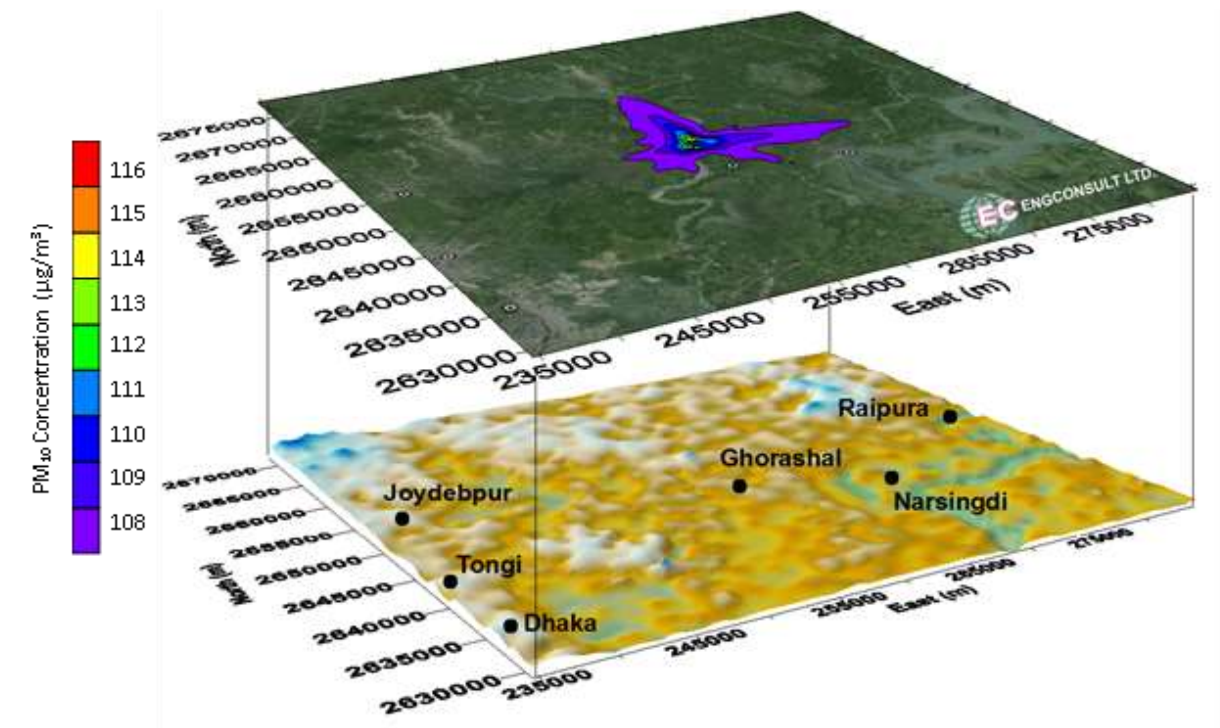
S.I	Name of Receptor	Concentration (µg/m³)			
		(24-hr Averaging)		(Annual Averaging)	
		Baseline	Repowering	Baseline	Repowering
1	Residential (Ghorashal PP)	115.49	114.99	21.92	21.87
2	School (Ghorashal PP)	115.15	114.73	21.91	21.87
3	School	116.16	115.50	21.97	21.91
4	School	114.55	114.24	21.81	21.78
5	School	114.30	114.04	21.77	21.75
6	School	115.16	114.73	21.89	21.84
7	School	114.13	113.91	21.80	21.78
8	Hospital (Palash)	114.85	114.48	21.93	21.88
9	High School	114.59	114.27	21.85	21.82
10	Thana Health Complex (Palash)	114.30	114.04	21.80	21.77
11	Madrasa (Garapara)	114.62	114.29	21.84	21.80
12	School (Dhaladia)	113.65	113.54	21.73	21.72

13	Madrasa (Dakshin Palash)	113.47	113.39	21.71	21.70
14	School	113.51	113.44	21.71	21.71
15	Hospital	113.61	113.51	21.71	21.70
16	Girls' school (Ghorashal Palash)	113.57	113.48	21.71	21.70
17	Dakhil Madrasa (Paiksha)	113.50	113.42	21.71	21.70
18	RFL Public school (RFL, Palash)	113.32	113.27	21.70	21.70
19	School (10 No. Ghorashal)	113.47	113.39	21.70	21.70
20	College (Kaliganj)	113.44	113.36	21.70	21.70
21	School	113.37	113.32	21.70	21.70
22	Primary School	113.67	113.56	21.71	21.70
23	Kindergarten School	113.90	113.74	21.73	21.72
24	Madrasa (Sahida Mohila)	113.96	113.79	21.78	21.76
25	School	114.11	113.91	21.78	21.76
26	Madrasa	114.16	113.94	21.78	21.76
27	School	113.38	113.32	21.72	21.71
28	Madrasa	113.42	113.35	21.72	21.71

489. Table 7-20 shows that the predicted daily average and annual average PM_{10} concentration at sensitive receptors is within the Bangladesh standards and meets the WHO Interim-1 target and Interim -3 target, respectively. However, the power station's contribution to the PM_{10} concentration is minimal at the sensitive receptor sites and high values are due to the high background concentration. There is a slight reduction in the PM_{10} concentration at all sensitive receptor sites after the repowering case.

490. Figure 7-6 and Figure 7-7 show the predicted daily and annual average PM_{10} contour diagrams for the baseline and repowering cases, respectively.

24-Hr Average



Annual Average

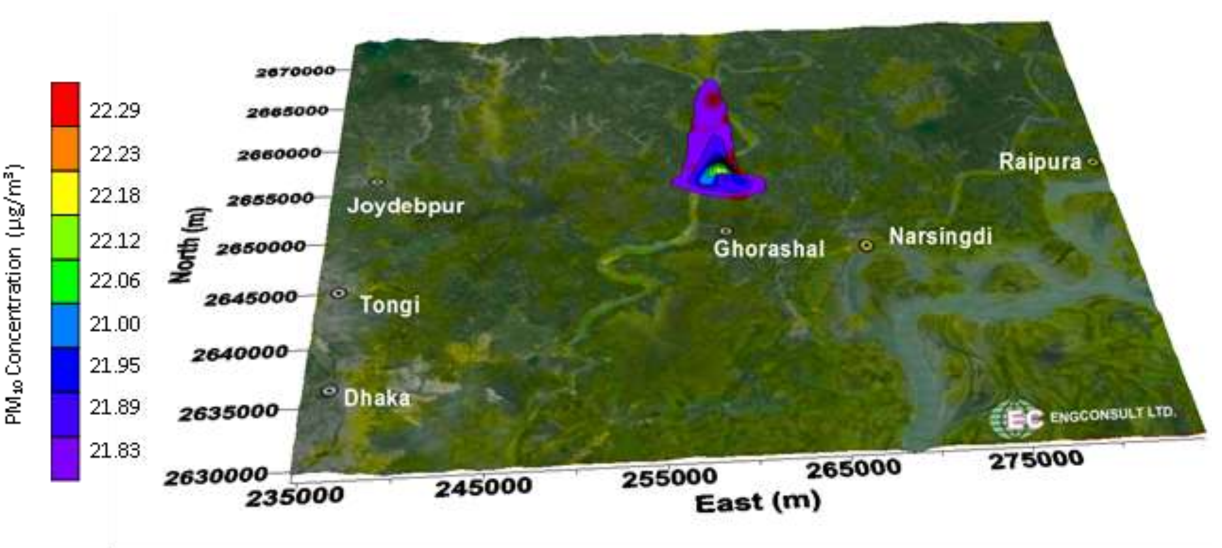
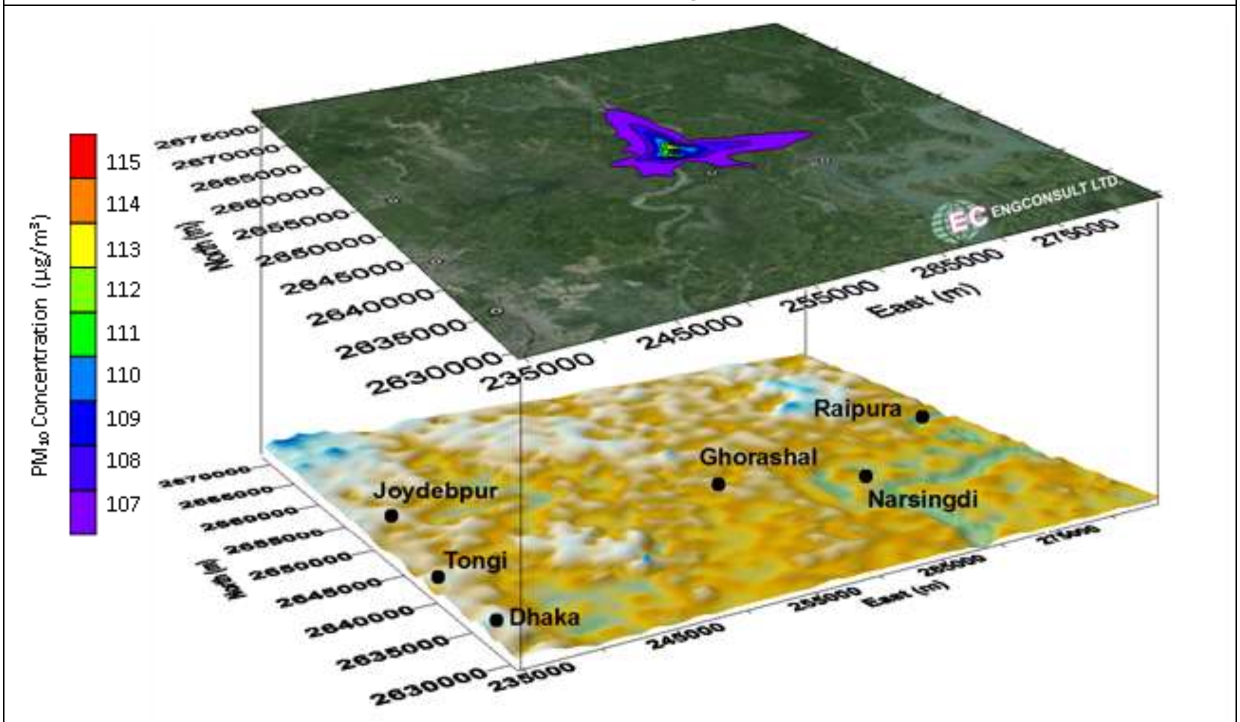


Figure 7-6: Predicted PM_{10} concentration - Baseline case

24-Hr Average



Annual Average

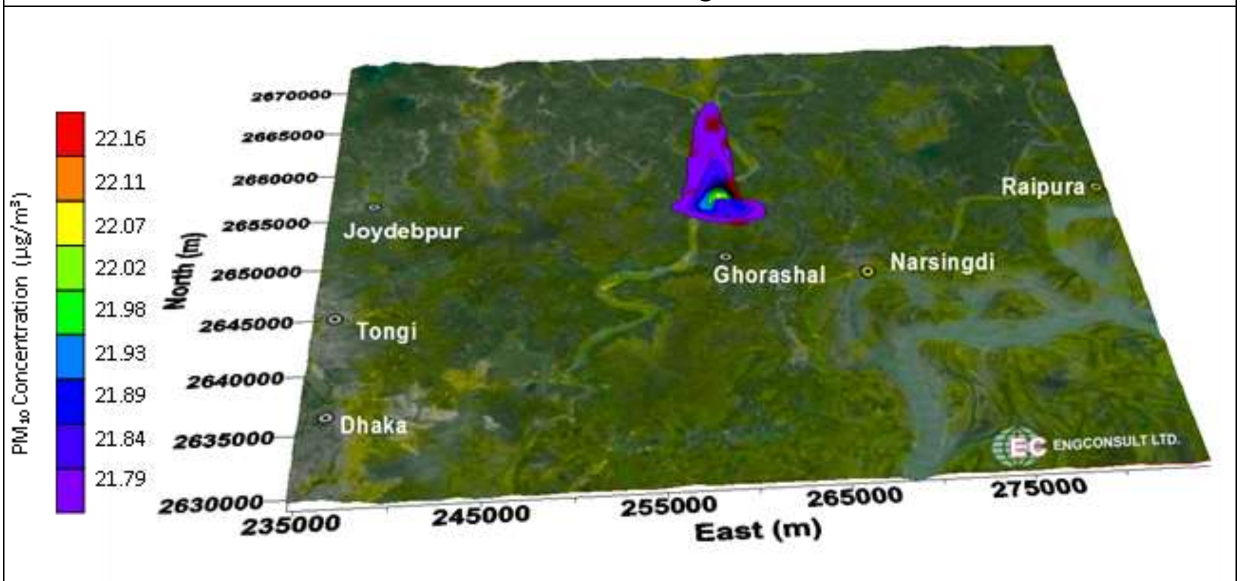


Figure 7-7: Predicted annual average PM_{10} concentration - Repowering case

491. From the diagrams above, it is seen that the plume dispersion is predominately towards the north as is the case for the other pollutants. The highest concentration areas occur close to the power station. There is a slight decrease in concentrations from the baseline to repowering case. The wind carries the plume away from the major population centers of Dhaka, Narsingdi and Ghorashal.

d) Maximum Ground Level Concentrations

492. The distance emissions disperse from the stack depends on various factors, including the height of stack, wind speed, direction, mixing heights, temperature of the flue gas and air, flue gas exit velocity, and surrounding air. Figures 7-8, 7-9, 7-10 and 7-11 present the distance vs. maximum ground level concentration (MGLC) baseline and re-powering cases for NO_2, CO, $PM_{2.5}$ and PM_{10} respectively.

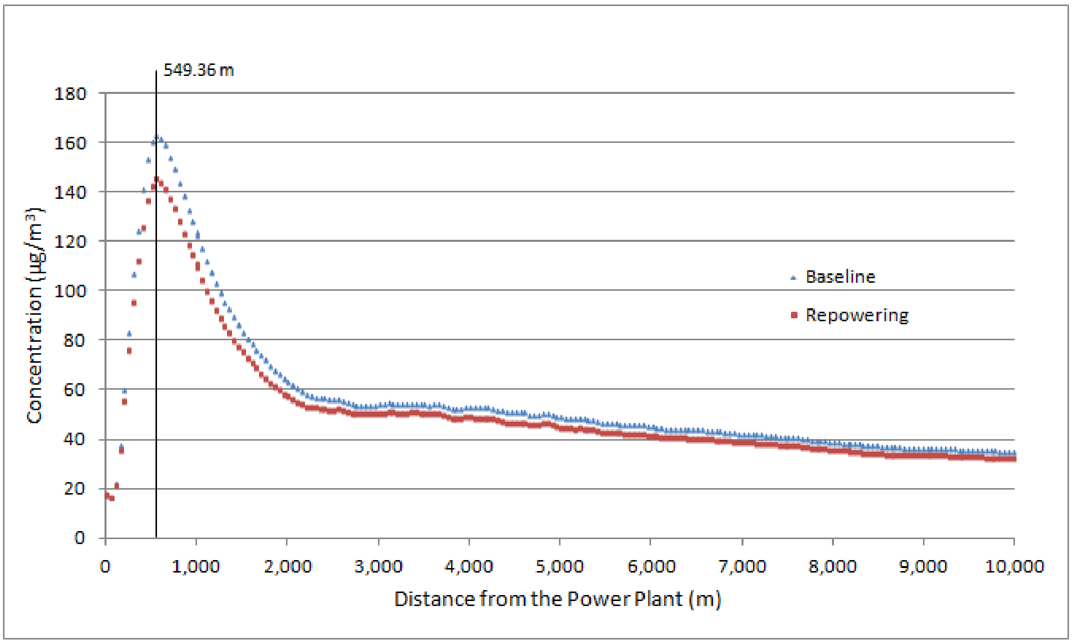


Figure 7-8: MGLC of NO2 versus distance from the Power Plant

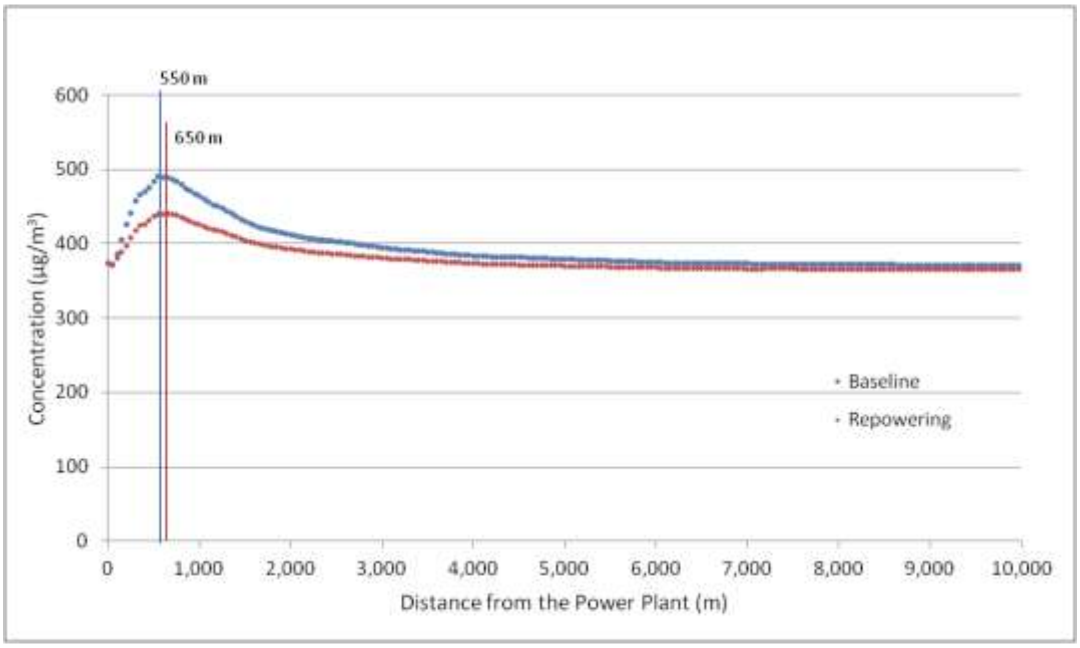


Figure 7-9: MGLC of CO versus distance from the Power Plant

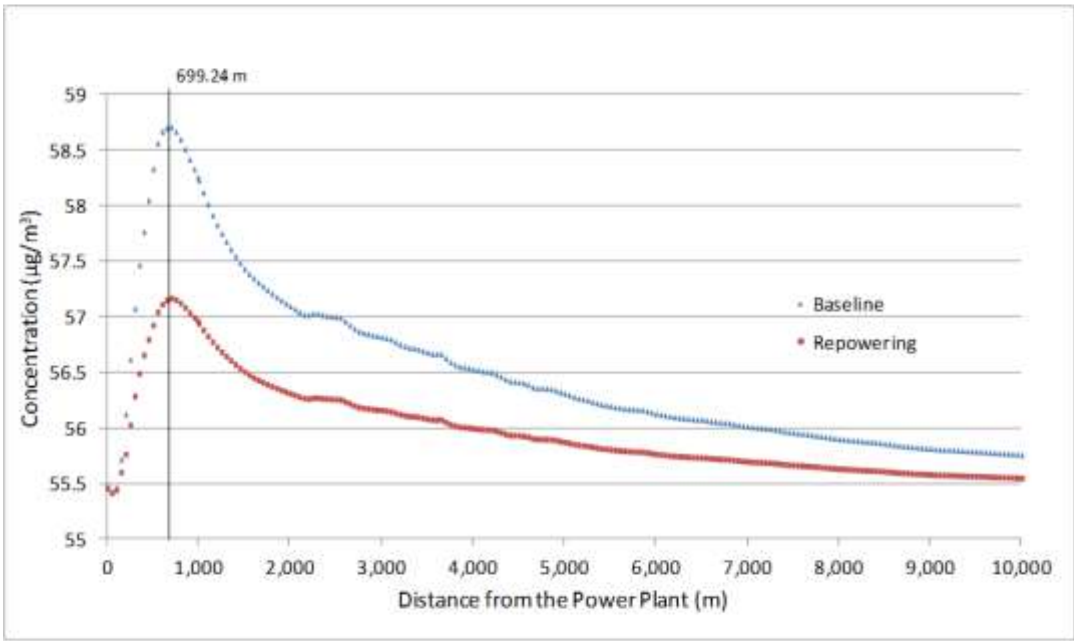


Figure 7-10: MGLC of $PM_{2.5}$ versus distance from the power plant

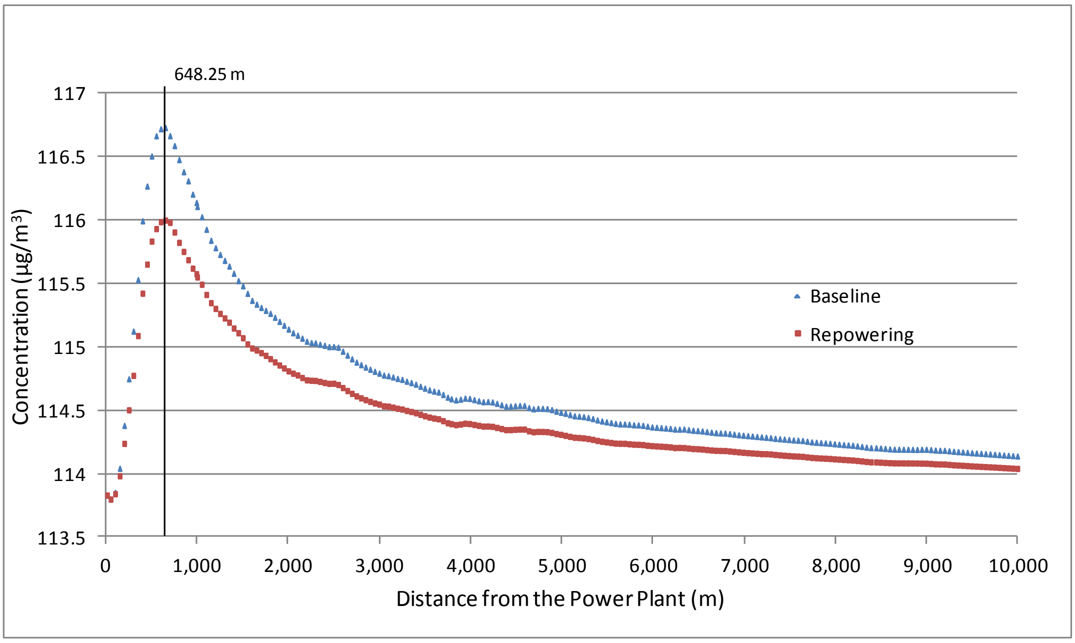


Figure 7-11: MGLC of PM_{10} versus distance from the power plant

493. The distance of maximum concentration was the same in the baseline and repowering cases for the pollutants NO_2, $PM_{2.5}$ and PM_{10} at 549.6 m, 699.24 m and 648.25 m, respectively. For CO, the maximum concentration for baseline was found at a distance of 550 m, whereas for repowering it was found to be at 650 m. All four pollutants hit a maximum concentration at a certain distance away. The maximum ground level concentration then gradually decreases and plateau's as the distance from the power station increases.

e) *Sensitivity Analysis for Stack Height*

494. A sensitivity analysis was conducted by varying stack heights to predict maximum concentrations using both USEPA and EU methods (Tier-2 Method), to assess the effects of

increasing stack heights on the maximum predicted ground level concentration. Table 7-21 shows sensitivity of stack height to predicted concentration for only Unit 4 and Table 7-22 shows for both Units 3 and 4.

Table 7-21: Sensitivity Analysis for Stack Height (Unit 4)

Stack Height (m)	USEPA Method (1-hr average)	EU Method (1-hr average)	Coordinates of Max Point (UTM)	
	(µg/m³)	(µg/m³)	East (m)	North (m)
50	159.0	148.3	258647	2654148
60	157.8	146.3	260720.5	2654408.2
70	156.2	144.1	260720.5	2654408.2

Table 7-22: Sensitivity Analysis for Stack Height (Units 3 and 4)

Stack Height (m)	USEPA Method (1-hr average)	EU Method (1-hr average)	Coordinates of Max Point (UTM)	
	(µg/m³)	(µg/m³)	East (m)	North (m)
50	159.0	148.3	258647	2654148
60	156.4	144.18	260720.5	2654408.2
70	154.1	140.6	260720.5	2654408.2

495. When the stack height is increased by 10 m for only Unit 4 there is not much difference in the maximum concentration value. When stack heights are changed for both Units 3 and 4, there are more pronounced decrease in the maximum concentration values. Increasing the stack height by 20 meters for both units lowered the NO_2 concentration by 4.9 and 7.7 µg/m^3 for the USEPA and EU methods, respectively.

Air quality impact is characterized as Major Adverse, as given in Table 7-4.

7.8.5 Impact on Ambient Noise

496. Sensitive receptors of noise were identified close to GPS, which include administrative buildings, residence, education institutions, hospitals and clinics etc. Figure 7-12 presents the distribution of sensitive receptors in the Project area.

Figure 7-12: Location of Sensitive Receptor of Noise during the Project Activities

7.8.6 Noise Generation and Potential Impacts

497. It is envisaged that noise level in the complex would increase during the activities of demolition of the existing Unit 4 boiler and construction and erection of new equipment in Unit 4. Moreover, due to the operation of the existing units and the future repowering units, the power station area would experience a high level of noise. For understanding the level of noise dispersed from the Project activities in different locations of sensitive receptors, noise propagation modelling was conducted for three different scenarios, which are baseline, re-powering, and cumulative impacts of future development and other major sources nearby.

498. In general, persistence exposure to the high level of noise can have adverse health impacts and can increase the level of stress of the susceptible individuals. It can also cause permanent damage to the hearing ability of the exposed person. Next section presents noise modeling output for both baseline and repowering scenarios. Cumulative noise impacts are presented in Section 7.9.

a) <u>*Noise Modelling*</u>

499. A simulation of the noise propagation during the operation of the plant was done by using CUSTIC 3.2 software. CUSTIC noise model was developed by Canarina Environmental Software Solutions, which is widely used for noise propagation modeling and is approved by European Environment agency.

500. For running the model, the average daytime temperature and relative humidity was considered as 30^0C and 70%, whereas average night time temperature and relative humidity was considered as 20^0C and 90%, respectively. A boundary wall of 3 meter height with density of 150-220 kg/m^3 and with sound attenuation level of 34 dBA was considered around the project site. Moreover, the obstacles of trees and other major buildings inside the plant boundary were also kept in consideration. In case of trees, the average height was considered as 6 meter and the sound attenuation level was considered as 10 dBA. In case

of building, the average height was considered as 3 meter with sound attenuation level of 34 dBA.

I. Baseline Scenario

501. The first scenario is the baseline scenario where all six units of the plant and 2 RMS units and their associated pipelines were considered as the source of noise. In this scenario, the noise levels of each of the units of the plant were considered as 90, each of the RMS units were considered as 100 dBA and the associated pipelines were considered as a series of 90 dBA noise source (noise levels were measured during field visit). The result of the modelling in this scenario is presented in the Figure 7-13.

Figure 7-13: Simulation of Noise Propagation during Plant Operation in Baseline Scenario

502. The level of noise predicted in different sensitive receptors for baseline condition is presented in Table 7-23. It can be seen from the table that, in this scenario, 8 (eight) of the sensitive receptors experiences higher level of noise than the standard of ECR 1997 and WHO Guideline values, as marked in red in Table 7-23.

Table 7-23: Noise level in different sensitive receptors in Baseline Scenario

Place	Notation	Type	Noise Level (dBA) [Baseline]
Administrative building	SR-1	Industrial	66.70
Mosque/Accounts Office	SR-2	Industrial	66.70
Near RMS	SR-3	Industrial	91.72
Near Fertilizer Factory	SR-4	Industrial	75.04
Unit-4 boundary	SR-9	Industrial	66.70
Inside Aggreko-Max	SR-10	Industrial	58.37
Aggreko Gate	SR-11	Industrial	58.37
Outside the plant/Commercial	SR-12	Industrial/ Commercial	58.37
Corner of Substation	SR-14	Industrial	58.37
Bazaar	SR-19	Industrial/ Commercial	41.69
Residence in fertilizer factory (West side)	SR-5	Residential	58.37
Residence in Fertilizer Factory (Outside Boundary)	SR-6	Residential	66.70
Residence Mosque Fertilizer Factory	SR-7	Residential	58.37
Residence in FF Near Aggreko	SR-8	Residential	58.37
Army Residence	SR-13	Residential	60
Residential Area	SR-15	Residential	58.37
School-Hospital	SR-16	Residential	50.03
Central Residential Mosque	SR-17	Residential	50.03
Ghorashal Residence	SR-18	Residential	50.03

**Here IS= Insignificant*

II. Re-powering Scenario

503. In the re-powering scenario, noise from unit 1, 2, 5, and 6, proposed repowering Units 3 and 4 and 2 RMS units were considered. The noise level of units 1, 2, 5, 6 and re-powering of Units 3 and 4 were considered. As measured during field visits, the level of impacts of noise from existing units (1, 2, 5, and 6) and of the RMS unit were found 90 dBA and 100 dBA, respectively. The associated pipelines were considered as a series of 90 dBA source of noise (the noise levels were measured during field visit). The noise level from both of the re-powering Units (3 and 4) was considered 90 dBA. The results of the modeling in this scenario are represented in the Figure 7-14.

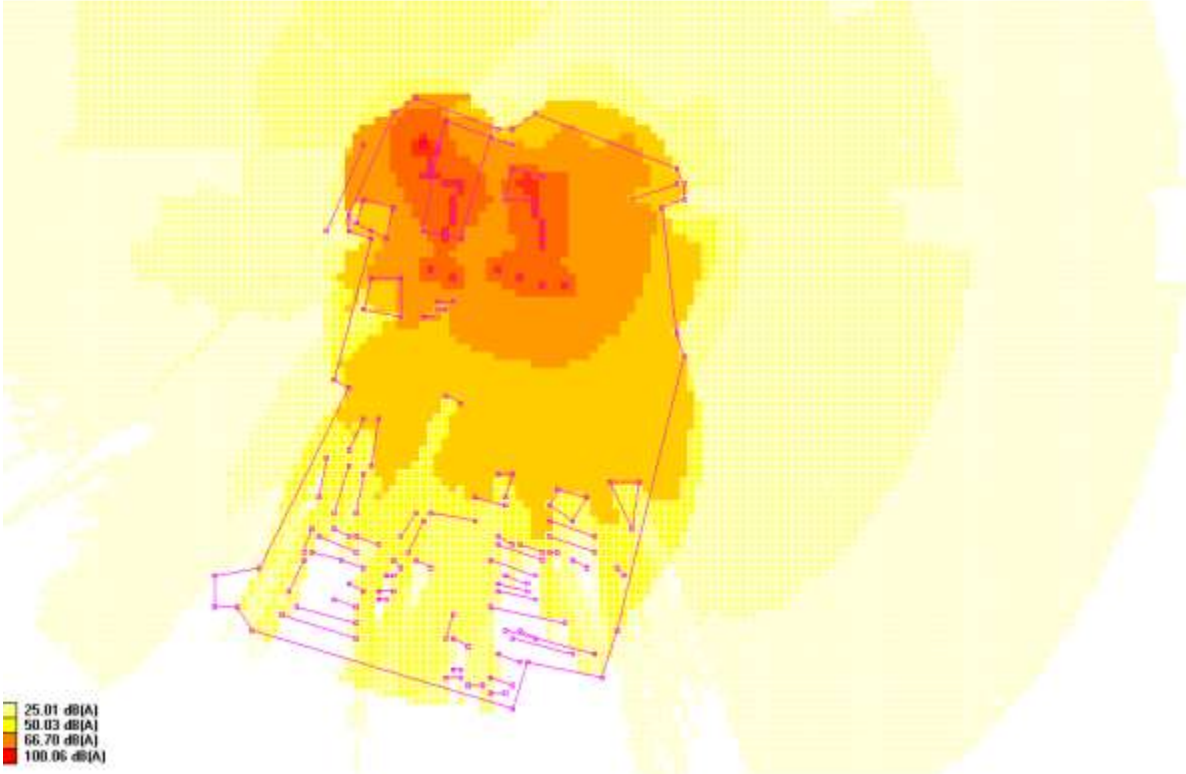


Figure 7-14: Simulation of Noise Propagation during Plant Operation in Re-powering Scenario

504. The predicted noise level in sensitive receptors in this scenario is presented in Table 7-24. It can be seen from the table that, in this scenario, 8 (eight) of the sensitive receptors experience higher level of noise than the standard of ECR 1997 and WHO Guideline values.

Table 7-24: Noise level in different sensitive receptors in Re-powering Scenario

Place	Notation	Type	Noise Level (dBA) [Repowering]
Administrative building	SR-1	Industrial	67.15
Mosque/Accounts Office	SR-2	Industrial	67.15
Near RMS	SR-3	Industrial	92.33
Near Fertilizer Factory	SR-4	Industrial	75.54
Unit-4 boundary	SR-9	Industrial	67.15
Inside Aggreko-Max	SR-10	Industrial	58.76
Aggreko Gate	SR-11	Industrial	58.76
Outside the plant/Commercial	SR-12	Industrial/ Commercial	58.76
Corner of Substation	SR-14	Industrial	58.76
Bazaar	SR-19	Industrial/ Commercial	41.9
Residence in fertilizer factory (West side)	SR-5	Residential	58.76
Resident Fertilizer Factory (Outside Boundary)	SR-6	Residential	67.15
Residence Mosque	SR-7	Residential	58.76

Place	Notation	Type	Noise Level (dBA) [Repowering]
Fertilizer Factory			
Residence FF Near Aggreko	SR-8	Residential	58.76
Army Residence	SR-13	Residential	61
Residential Area	SR-15	Residential	58.76
School-Hospital	SR-16	Residential	50.36
Central Residential Mosque	SR-17	Residential	50.36
Ghorashal Residence	SR-18	Residential	50.36

III. Noise modeling with barrier

505. As the noise levels in the Ghorashal Power Plant Complex exceed the standard of ambient noise level in numerous receptors, additional simulation was conducted considering noise barriers in selected locations to attenuate noise. A brick boundary wall of 3 m height was considered before the residential area with length XX m. Moreover, thick plantation and green cover was also considered in the vacant land immediately before the wall. Some greenbelts were also considered outside the boundary wall of Ghorashal complex in the side of fertilizer factory residence. The resultant noise level in different sensitive receptors considering the barriers is presented in Figure 7-15 and is compared with the re-powering scenario (Table 7-25). With noise barriers noise levels comply with ECR 1997 and WBG Guideline values in most of the receptors but exceeds in three receptor locations. One is close to the RMS and other two (SR-4 and SR-6) are close the the fertilizer factory.

Table 7-25: Comparison of noise level without and with barrier during re-powering scenario

Place	Notation	Type	Noise Level (dBA) [Repowering]	Noise Level (dBA) [with barrier]
Administrative building	SR-1	Industrial	67.15	66.94
Mosque/Accounts Office	SR-2	Industrial	67.15	66.94
Near RMS	SR-3	Industrial	92.33	92.04
Near Fertilizer Factory	SR-4	Industrial	75.54	75.31
Unit-4 boundary	SR-9	Industrial	67.15	66.94
Inside Aggreko-Max	SR-10	Industrial	58.76	58.57
Aggreko Gate	SR-11	Industrial	58.76	58.57
Outside the plant/Commercial	SR-12	Industrial/ Commercial	58.76	58.57
Corner of Substation	SR-14	Industrial	58.76	58.57

Place	Notation	Type	Noise Level (dBA) [Repowering]	Noise Level (dBA) [with barrier]
Bazaar	SR-19	Industrial/ Commercial	41.9	18.74
Residence in fertilizer factory (West side)	SR-5	Residential	58.76	50.21
Resident Fertilizer Factory (Outside Boundary)	SR-6	Residential	67.15	58.57
Residence Mosque Fertilizer Factory	SR-7	Residential	58.76	50.21
Residence FF Near Aggreko	SR-8	Residential	58.76	33.47
Army Residence	SR-13	Residential	61	33.47
Residential Area	SR-15	Residential	58.76	Insignificant
School-Hospital	SR-16	Residential	50.36	
Central Residential Mosque	SR-17	Residential	50.36	Insignificant
Ghorashal Residence	SR-18	Residential	50.36	18.74

Figure 7-15: Simulation of noise propagation with noise barrier

506. This impact is characterized as Major Adverse, as given in Table 7-4.

7.8.7 Solid Waste Disposal

507. Solid wastes in terms of institutional and official daily waste (paper), kitchen waste, human waste, etc. generated from the people involved in official activities and residing in the residences may become burden to environment if not managed properly.

7.8.8 Impact on Soil

508. Accidental falling of solid wastes on the land during transportation to the municipal landfill area may cause damage to soil quality. In addition, during plant operation various scrap metals and other solid wastes both hazardous and non-hazardous will be generated and

7.8.9 Impact of thermal plume (including modelling)

509. Condenser cooling water from Ghorashal Power Station discharges directly into Shitalakhya River after traveling 1 km distance through an open channel. At the outfall of discharge channel, water temperature is recorded as 39°C. Usually, after condenser cooling the outlet temperature would be 6^0-7^0C higher than the intake temperature at the beginning of this power plant. After a long period of operation, a number of equipment like high-pressure steam extractor of unit-4 is not functioning well. Therefore, same volume of intake water is now cooling high amount of steam in condenser results increasing the outlet temperature. Regular tidal variations especially in dry season in Shitalakhya play significant role of thermal plume dispersion.

510. During baseline study, water temperature in the outfall and the mixing zone has been found higher than the ambient temperature. Present thermal plume dispersion is not in compliant with the mixing zone temperature requirements (temperature of wastewater prior to discharge does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone) of international standards[36]. The ambient temperature of the river has been recorded (30.5°C) almost 5 km upstream from the outfall point of Shitalakhya River.

511. In order to predict the thermal plume dispersion properly, Cornell Mixing Zone Expert System (CORMIX3) software is used to predict unsteady and steady-state mixing behavior and plume geometry. It is a USEPA-supported mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones resulting from continuous point source discharge. The model input data both for ambient and discharge parameters have been presented in Table 7-26. In the baseline study, once through cooling is considered (without cooling tower) but after the repowering of unit-4, close cycle cooling (with cooling tower) and refurbishment of the equipments of unit-4 as well as other units are considered. Therefore, water requirements and the effect of thermal plume will reduce for entire GPS.

512. The cooling tower of Unit 4 will be operated to cool the condenser cooling water at the rate of 7.3 m^3/s. At the same time, the condenser cooling systems of other units will be improved which collectively reduce around 2°C of thermal plume temperature. It is assumed

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[36] WBG's General EHS Guidelines: Environmental, Wastewater and Ambient Water Quality, 2007

that, in discharge channel after traveling 1 km distance, thermal discharge will lose around 1^0C temperature. However, thermal plume temperature will be around 36.5^0C at outfall point in future operation of GPS.

Table 7-26: Plume Model Input Parameter

	Unit	Low Tide (Unsteady State)	Slack Period Steady State	Low Tide (Unsteady State	Sources of Data
AMBIENT PARAMETERS:					
Cross-section		bounded	bounded	bounded	Field observation
Width	m	200	200	200	Schematized of Cross section
Channel regularity		2	2	2	Field Survey
Ambient flow rate (Baseline)	m^3/s	64.8	44.8	87.0	H-D model simulated data*
Ambient flow rate (With CT))	m^3/s	72.0	43.4	96.0	
Average depth (Baseline)	m	2.7	2.8	2.9	Schematized of Cross section
Average depth (With CT)		3.0	3.1	3.2	
Depth at discharge (Baseline)	m	2.6	2.7	2.8	Field Survey
Depth at discharge (With CT)	m	2.9	3.0	3.1	
Darcy-Weisbach friction factor		0.051	0.05	0.05	Field Observation
Calculated from Manning's		0.03	0.03	0.03	
Wind velocity	m/s	3.1	3.1	3.1	Wind Rose
TIDAL SIMULATION at time	hours	1h (4:0PM) Before the slack	Avg. of 3 h	1h(9:0PM) After the Slack	
Instantaneous ambient velocity	m/s	0.12	0.07	0.15	H-D model simulated data*
Maximum tidal velocity	m/s	0.17	-	0.17	H-D model simulated data*
Rate of tidal reversal	(m/s)/ hour	0.12	-	0.15	
Period of reversal	hours	12.4	-	12.4	
Surface temperature	^{0}C	30.5	30.5	30.5	Field survey

	Unit	Low Tide (Unsteady State)	Slack Period Steady State	Low Tide (Unsteady State	Sources of Data
Bottom temperature	^0C	30.5	30.5	30.5	Field survey
Calculated FRESH-WATER DENSITY	kg/m^3	995.49	995.49	995.49	
DISCHARGE PARAMETERS:	***Surface Discharge***				
Discharge located on	From bank	left	right	right	Field survey
Discharge configuration	Discharge	flush	flush	flush	Field Observation
Distance from bank to outlet	m	0	0	0	Field survey
Discharge angle	^0C	110	110	110	Field survey
Depth near discharge outlet	m	2	2	2	Field survey
Bottom slope at discharge	^0C	15	15	15	Field survey
Rectangular discharge:					
Discharge cross-section area	m^2	12	12	12	Field survey
Discharge channel width	m	12	12	12	Field survey
Discharge channel depth	m	1	1	1	Field survey
Discharge flow rate (Baseline)	m^3/s	33.02	33.02	33.02	Water balance report
Discharge flow rate (With CT)	m^3/s	25.72	25.72	25.72	
Discharge temperature (Baseline)	^0C	39	39	39	Field survey
Discharge temperature (With CT)	^0C	36.5	36.5	36.5	

(*Note*: *10th January 2005, 5:00 PM-9:00 PM)

*(Note: *10th January 2005, 5:00 PM-9:00 PM)*

513. The thermal plume dispersion to the river depends on the plant operation capacity, seasonal water diversion to the agricultural field and river tidal flow. Renovation and enhancement of existing cooling system will reduce the amount of thermal plume at the rate of 7.3 m^3/s. The worst case scenario is assumed for dry season when the river experience lean flow. During dry season, significant amount of irrigated water has been diverted at the rate of 6.18 m^3/s to agricultural field. Considering all circumstance, the thermal plume will discharge into the river at the rate of 25.72 m^3/s at 36.5^{0}C considering cooling tower in operation.

514. The Hydro-dynamic simulated data of winter (5:00PM – 9:00 PM) 10th January, 2005 has been used for ambient worst case scenario generation after checking years of hydrological data of Shitalakhya River. Slack period has been considered for 3 hrs. CORMIX3 model has been run considering tidal fluctuation before and after 1 hr of the slack period.

515. The plume discharge flow rate 25.72 m^3/s is greater than and equal to the ambient flow rate during the slack period causes insignificant physical dilution. Therefore, steady state condition has been considered for slack period as the dilution value would asymmetrically reach the initial condition of the plume discharge. However, unsteady state has been considered both for before and after the slacks. Figure 7-16 shows for 1-hr before the slack, Figure 7-17 shows for slack period and Figure 7-18 shows for 1-hr after the slack considering the cooling tower. The result of thermal plume modeling has been generated resting on the worst-case scenarios.

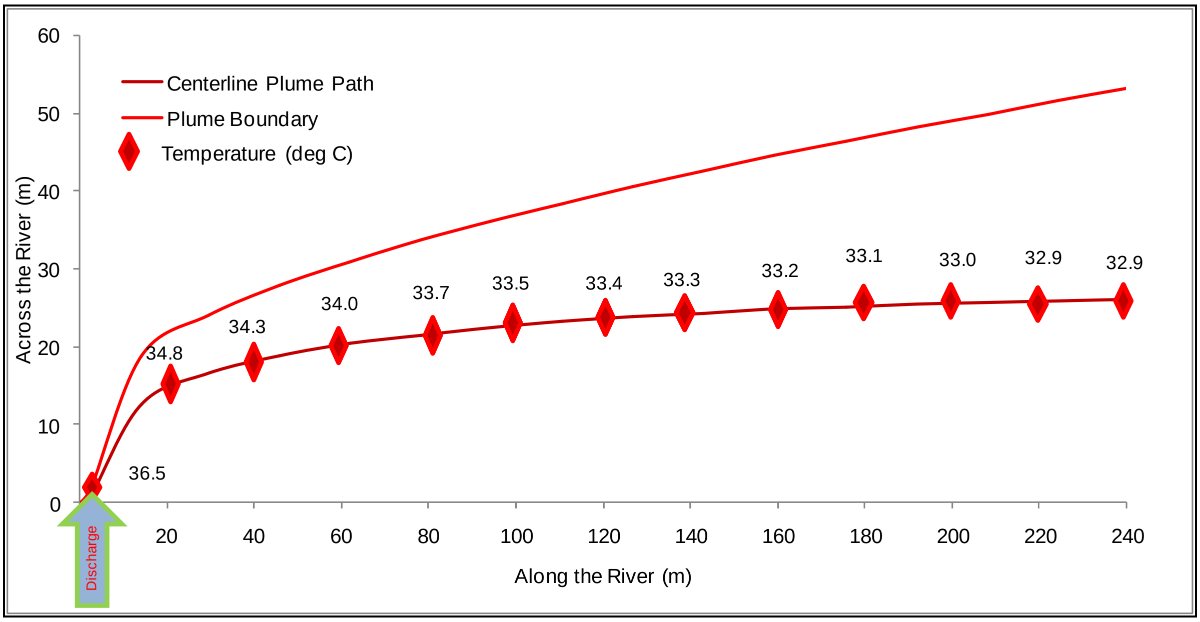

Figure 7-16: Thermal plume dispersion from upstream to downstream during low tide

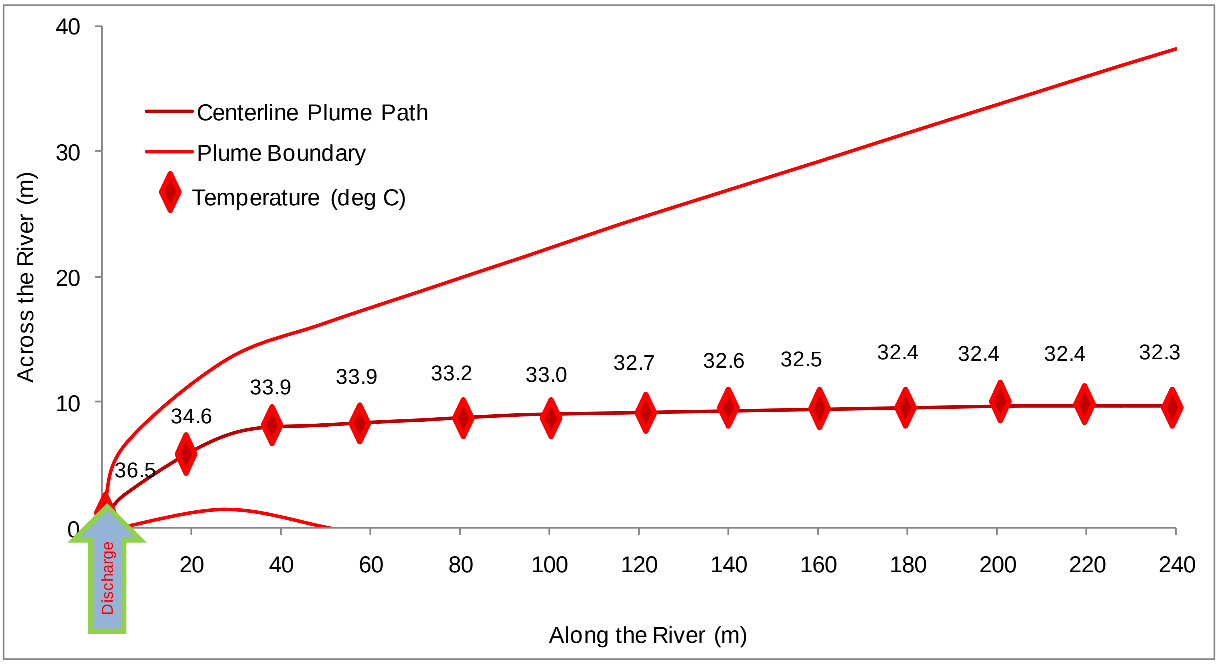

Figure 7-17: Thermal plume dispersion during slack period

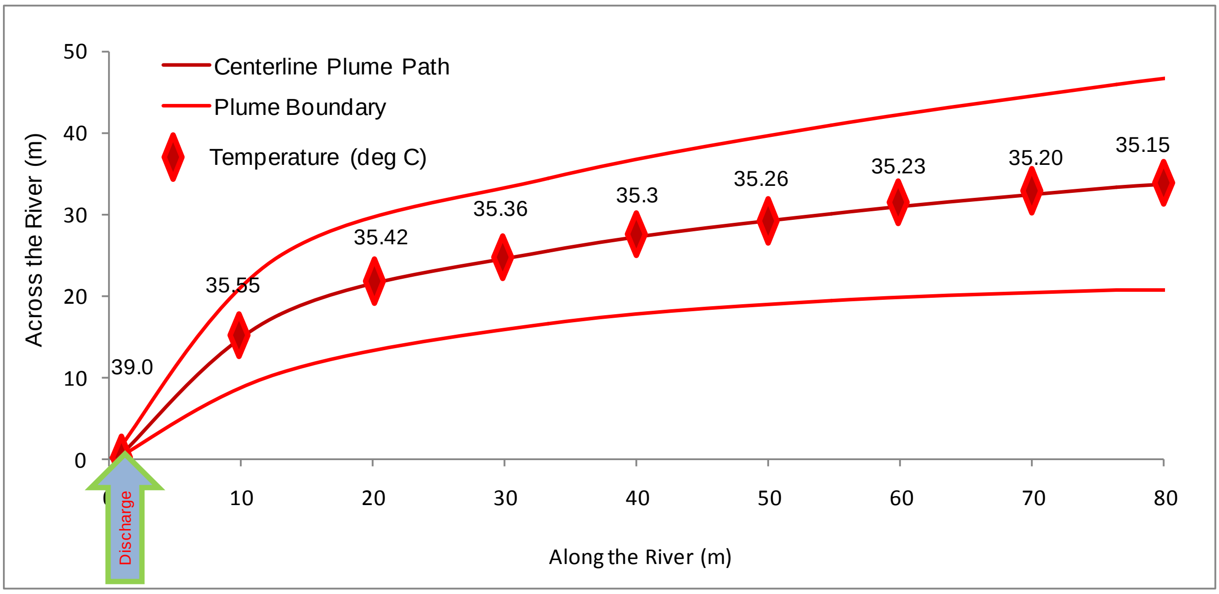

Figure 7-18: Thermal plume dispersion from downstream to upstream during high tide

516. During low tide period e.g., 1-hr before the slack, the plume will dispersed to the downstream and attach to the left bank of the river. At this situation, the centerline temperature will reduce to 33.0 ^{0}C at 100 m distance from the outfall. Without considering the cooling tower, the centerline thermal plume temperature would be 35.1^{0}C at 100 m downstream distance from the outfall.

517. During slack period, the plume will disperse widely upstream of the river. Around 33.0 ^{0}C will be the plume temperature in comparison to 33.7 ^{0}C without using cooling tower at 100m upstream distance from the outfall. After 1-hr slack (initial stage of high tide) tidal water will force the thermal plume to the upstream region. Around 35.1^{0}Cwill be the plume temperature at 85 m for using cooling tower in comparison to 37.4^{0}C at 85m at distance

upstream distance from the outfall at present. For this condition, mixed water from the previous half-cycle becomes re-entrained into the near field of the discharge. However, a pool of mixed water formed at slack tide will be advected downstream in this phase. Therefore, dispersed thermal plume temperature at the intake points which is 500m upstream from the outfall cannot be predicted for considering unsteady state.

518. Without considering the cooling tower, the rate of thermal plume discharge will be 33.02 m^3/when all units run simultaneously. During worst case scenario, irrigation water will not be diverted and other ambient factors considered same as previous one. Table 7-27 shows a comparative assessment of spatial temperature variations with and without close-cycle cooling system in Unit 4. All ambient and discharge parameters are assumed to be the same except the discharge volume. The intake point of the power plant is considered as sensitive receptors for thermal plume dispersion modeling.

Table 7-27: Comparison of plume temperature with and without cooling tower

Sl. No	Parameter	Description	Unit	Without Cooling Tower/ Baseline	Installing Cooling Tower
1	Plume Discharge	Irrigation water is diverted (6.38 m^3/s) in dry season	m^3/s	33.02	25.72
2	Low tide (Unsteady State)	100 m distance from out fall	0C	35.1	33.5
3	Slack Period (Steady State)	100 m distance from out fall	0C	33.7	33.0
4	High tide (Unsteady State)	85 m distance from the out fall	^{0}C	37.4	35.1
5	Intake Point (High tide Steady State)	500 m distance to the Upstream	^{0}C	32.9	31.8

519. The intake point is mainly influenced by thermal plume at the time of high tide period. However, the predicted temperature at intake point would be 31.8ºC after using cooling tower complying with WBG Guideline values (i.e., 33.5^{0}C) at the distance of 100m from the outfall and without using cooling tower the temperature would be 32.9ºC. From the modeling output of thermal plume, it is evident that although the repowering of Unit 4 (with cooling tower) reduces the total heat waste stream by 19%, the effect on the water quality scenario (with respect to the thermal plume) is negligible. There would be some improvement but thermal plume generated from the rest of the units of GPS would still be non-compliant to WBG Guidelines in some cases. It is stressed that in order to improve the water quality scenario (with respect to thermal plume and its effects) the other units need to install cooling towers to minimize the effect of their thermal effluent. The GPS has already started moving in this direction by including closed cooling in its new Unit-7. This option is expected to be considered by GPS in repowering of other units in future. Once repowering is done, Units 1

and 2 will be decommissioned and eventually this will lead to reduction of the thermal load on Shitalakhya River.

7.8.10 Impact on Occupational Health and Safety

520. The operation of the Plant may cause occupational health and safety risk due to explosion caused by gas leak from underground pipes, mechanical failure of machineries, faulty electrical equipments/transmission lines and spillage of flammable chemicals and oily substances. Possible health and safety risk also include contact with fine insulation particles (made of glass wool, asbestos etc.) while repairing old insulated pipelines. These particles could be inhaled by the workers accidentally and may cause breathing difficulties, irritations if proper PPE is not worn. They may also slip and accidentally fall from high heights, resulting in severe injuries and fatalities. Furthermore, health risk may be caused if proper safety measures are not followed.

7.8.11 Impact on Public Health and Safety

In case of any serious accident, the Plant may become a risk factor for those people who are living/working adjacent to it. Particularly, it may cause safety risk to the nearby residential areas, school and offices. It is apprehended that fatalities may take place if any accident occurs.

7.8.12 Impact on Traffic Movement

521. Movement of various Cargoes and Lorries, carrying lube oils, chemicals and other volatile substances, may cause them to spill in the event of an accident. These materials may be then washed away into nearby vegetation area; or could be leached into the river via storm water drainage system, if the spillages are not promptly managed. These chemicals may cause harm to the aquatic ecosystem if they enter into the river. Road accidents due to these spilled chemicals may also cause injuries to passerby, GPS residents and workers. They may even cause damage to properties and structures.

7.8.13 Gas pipeline corrosion

522. Corrosion on the internal wall of buried gas pipeline can occur when the pipe wall is exposed to water and contaminants in the gas, such as O_2, H_2S, CO_2, or chlorides. The nature and extent of the corrosion damage that may occur are functions of the concentration and particular combinations of these various corrosive constituents within the pipe, as well as of the operating conditions of the pipeline. For example, gas velocity and temperature in the pipeline play a significant role in determining if and where corrosion damage may occur. In other words, a particular gas composition may cause corrosion under some operating conditions but not others. Corrosion may also be caused or facilitated by the activity of microorganisms living on the pipe wall. Referred to as microbiologically influenced corrosion, or MIC, this type of corrosion can occur when microbes and nutrients are available and where water, corrosion products, deposits, etc., present on the pipe wall provide sites favorable for the colonization of microbes. Microbial activity, in turn, may create concentration cells or produce organic acids or acid-producing gases, making the environment aggressive for carbon steel. The microbes can also metabolize sulfur or sulfur compounds to produce products that are corrosive to steel or that otherwise accelerate the attack on steel. This impact is characterized as major adverse, as given in Table 7-4.

7.8.14 Gas compressor fouling

523. Compressor fouling is dependent on the quality of the ambient air, inlet filters, and the washing regime. Polymer deposits on compressor internals which increases frictional losses and alters flow pattern and lead to loss of compressor efficiency, pressure drop increase in after coolers, potential for unbalancing, rotor, and seal damage. Initially increasing speed compensates efficiency loss, later it limits plant capacity, energy consumption increases all the time, increase in suction pressure reduces furnace yields, and increase in maintenance efforts and cost. This impact is characterized as moderate adverse, as given in Table 7-4.

7.8.15 Gas pipeline leak

524. Poor tieing-in, old age, aged welds, construction defects, corrosion, third party ruptures, and natural/environmental reasons may cause leak of significant amount of gas from the pipe. Gas leak and subsequent fire outbreak or loss of contaminant being primarily an environmental risk can also escalate to asset damage and loss of life. A small leak undetected can result in enormous damage. This impact is characterized as moderate adverse, as given in Table 7-4.

7.8.16 Social Impact

Impact on Tourism

525. The Project has no direct impact on tourism. However, the development of existing and new units would attract various new industries and entrepreneurs. Development of various industries would facilitate the development of various recreational facilities, such as shops, parks, restaurants etc. in future. This will promote further development of Ghorashal area and might bring people in for tourism.

Impact due to transportation of primary fuels

526. Natural gas, primary fuel for the Plant, will be supplied by Titas Gas Transmission and Distribution Company Ltd. (TGTDCL) via underground pipelines and hence it would not have any impact except accidental explosion.

7.9 Cumulative Impacts

7.9.1 Air Quality

527. The cumulative impact of all major emission sources in the air-shed is assessed. The assessment includes emissions from the proposed 365 MW combined cycle gas turbine power plant which will be located within the property line of Ghorashal power station.

a) *Project Area*

528. An area, 50 km by 50 km centering the stack of Ghorashal Power Station Unit 4 was selected for the cumulative analysis. The DEM[37] of the model area and major emissions sources in the air shed are shown in Figure 7-18.

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[37] DEM data from SRTM, ASTER GDEM and various other sources at 3" resolution from <http://www.viewfinderpanoramas.org/>

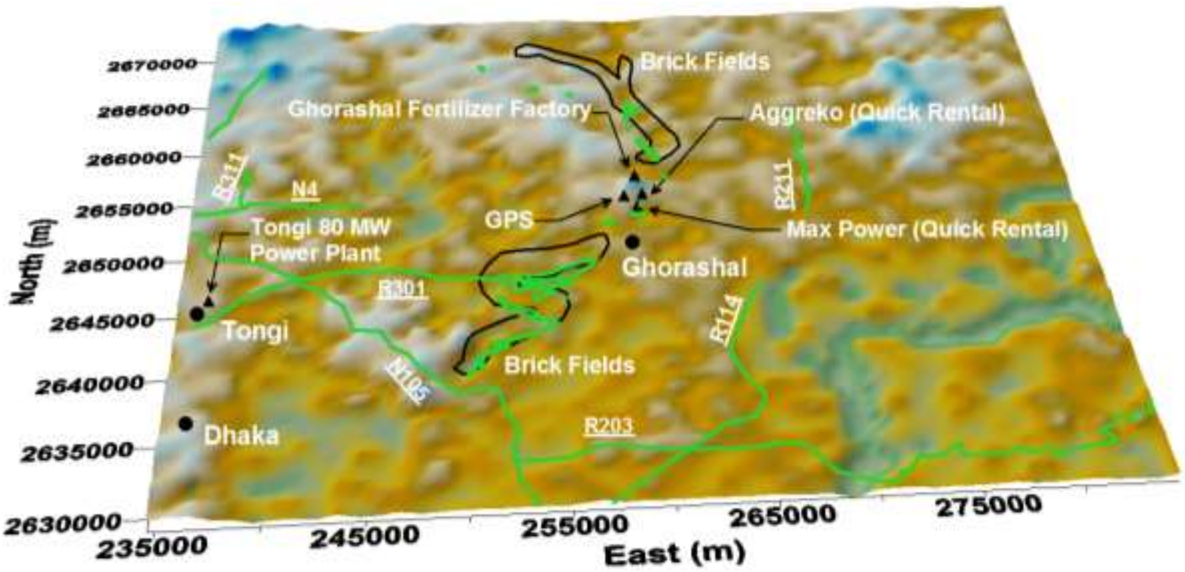


Figure 7-19: Digital elevation model (All Major Sources)

b) Major Emission Sources in the Air shed

529. Emission inventories were prepared for all major point, area, and line sources within the selected airs shed. The major point sources within the model area were identified as follows:

- Ghorashal Power Station (950 MW);
- Ghorashal Quick Rental Aggreko (100 and 45 MW);
- Ghorashal Quick Rental Max Power (78 MW);
- Ghorashal Regent Energy & Power (108 MW);
- Tongi Power Station (100 MW);
- Ghorashal Fertilizer Factory, PP 1, 2 & 3; and
- Palash Urea Fertilizer Factory, PP1 & 2.

530. Major line sources of pollution considered in the model are traffic along the major roads and highways, which include the: N-3, N-105, R-301, R-311, R-302, R-114, R-211, R-310 and R-203. Brick kilns located in the project area were grouped together and modeled as area sources.

531. The stack emissions and stack parameters of all point sources are given in Table 7-26. The stack emissions and parameters of the Ghorashal Power Station were given in Table 7-5.

Table 7-28: Major Point Source Emissions in the Project Area

Power Plant	No. of Stack	Capacity (MW)	Stack Height (m)	Inner Dia. (m)	Flu Gas Temp. (K)	Emission Rate (g/s)			
						NO_2	CO	$PM_{2.5}$	PM_{10}
Ghorashal Quick	120	100	3	0.6	823	18.6	36.57	2.20E-02	3.40E-01

CEGIS

Power Plant	No. of Stack	Capacity (MW)	Stack Height (m)	Inner Dia. (m)	Flu Gas Temp. (K)	Emission Rate (g/s)			
						NO_2	CO	$PM_{2.5}$	PM_{10}
Rental Aggreko -1									
Ghorashal Quick Rental Aggreko -2	54	45	3	0.6	823	8.37	16.47	1.00E-02	1.50E-01
Ghorashal Quick Rental Max Power	2	78	19.5	3.4	723	35.06	8.94	1.90E-02	2.80E-01
Ghorashal Regent Energy & Power	34	108	20	0.67	663.15	13.83	2.10	2.40E-02	3.60E-01
Tongi Power Station	1	100	45	3	773	25.03	6.38	1.30E-02	2.00E-01
Ghorashal Fertilizer Factory PP 1	1	8	25	2	823	2.56	0.65	1.35E-03	2.00E-02
Ghorashal Fertilizer Factory PP 2	1	8	25	2	823	2.56	0.65	1.35E-03	2.00E-02
Ghorashal Fertilizer Factory PP 3	1	18	25	2	823	5.70	1.45	3.01E-03	5.00E-02
Palash Urea Fertilizer Factory PP1	1	6	25	1.7	723	2.20	0.56	1.16E-03	2.00E-02
Palash Urea Fertilizer Factory PP2	1	6	25	1.7	723	2.20	0.56	1.16E-03	2.00E-02
New Proposed Ghorashal CCGT Power Plant	1	365	50	3	393	35.84	5.45	6.00E-02	9.40E-01

532. The emission rate, release height and source area considered for the brick kilns are presented in Table 7-28.

Table 7-29: Major Area Sources in the Project Area

Name	Emission Rate (g/s-m^2)				Source Area (m^2)	Release Height (m)
	NO_2	CO	$PM_{2.5}$	PM_{10}		
Brick Field 1	2.7869E-07	4.37161E-07	4.75412E-07	1.05465E-06	942,494	38.1
Brick Field 2	2.2019E-06	3.4539E-06	3.75612E-06	8.33253E-06	668,033	38.1
Brick Field 3	1.6913E-06	2.65301E-06	2.88515E-06	6.4004E-06	403,788	38.1
Brick Field 4	4.365E-06	6.84705E-06	7.44617E-06	1.65185E-05	72,210	38.1
Brick Field 5	1.279E-06	2.0063E-06	2.18185E-06	4.84019E-06	410,728	38.1
Brick Field 6	4.8222E-06	7.56419E-06	8.22605E-06	1.82486E-05	10,894	38.1
Brick Field 7	7.4493E-06	1.16852E-05	1.27077E-05	2.81906E-05	7,052	38.1

Name	Emission Rate (g/s-m²)				Source Area (m^2)	Release Height (m)
	NO_2	CO	$PM_{2.5}$	PM_{10}		
Brick Field 8	2.5324E-06	3.97244E-06	4.32003E-06	9.5835E-06	62,232	38.1
Brick Field 9	3.3458E-06	5.24834E-06	5.70757E-06	1.26616E-05	15,701	38.1
Brick Field 10	2.0024E-06	3.14102E-06	3.41586E-06	7.57772E-06	157,409	38.1
Brick Field 11	1.033E-05	1.62041E-05	1.76219E-05	3.90923E-05	25,427	38.1
Brick Field 12	1.0143E-06	1.59106E-06	1.73027E-06	3.83842E-06	310,753	38.1
Brick Field 13	2.0446E-05	3.20722E-05	3.48785E-05	7.73742E-05	7,708	38.1
Brick Field 14	1.824E-06	2.86116E-06	3.11151E-06	6.90255E-06	115,204	38.1
Brick Field 15	1.1615E-05	1.82189E-05	1.98131E-05	4.39532E-05	4,523	38.1
Brick Field 16	1.7652E-05	2.76896E-05	3.01124E-05	6.68011E-05	2,976	38.1
Brick Field 17	1.9644E-06	3.08136E-06	3.35098E-06	7.43378E-06	133,714	38.1
Brick Field 18	2.8017E-05	4.39489E-05	4.77945E-05	0.000106027	1,875	38.1
Brick Field 19	2.9534E-06	4.63275E-06	5.03811E-06	1.11765E-05	53,362	38.1

533. The annual average daily traffic data along the highways N-3, N-105, R-301, R-311, R-302, R-114, R-211, R-310, and R-203 that was used in the modeling is given in Table 7-29.

Table 7-30: Annual average daily traffic data used for air quality modeling

Name of Road	(AADT)										
	Heavy Truck	Medium Truck	Large Truck	Large Bus	Medium Bus	Micro Bus	Utility	Car	Auto Ricks-haw	Motor Cycle	Total
N-3	385	6,176	6,331	8,059	6,455	6,906	1,790	10,436	6,492	3,451	56,481
N-105	130	2,045	375	58	60	398	121	294	2,777	289	6,547
R-301	102	759	698	586	284	788	109	989	1,267	495	6,077
R-311		99	145	84	445	308	26	305	961	452	933
R-302		260	218		356	215	119	146	765	320	2,399
R-114		99	80		56	80	4	66	1,920	142	2,447
R-211		231	69	82	339	80	7	85	673	218	1,784
R-310	2	492	666	710	852	1014	369	948	1,419	827	7,299
R203		11	10		0	12	6	10	666	86	800

Source: Roads and Highways Department, http://www.rhd.gov.bd/RoadDatabase/

534. The relative emission contributions from major point, area and line sources in the air shed is given in Figure 7-19. The relative emission contribution of all point source emissions is given in Figure 7-20.

NO_2	CO

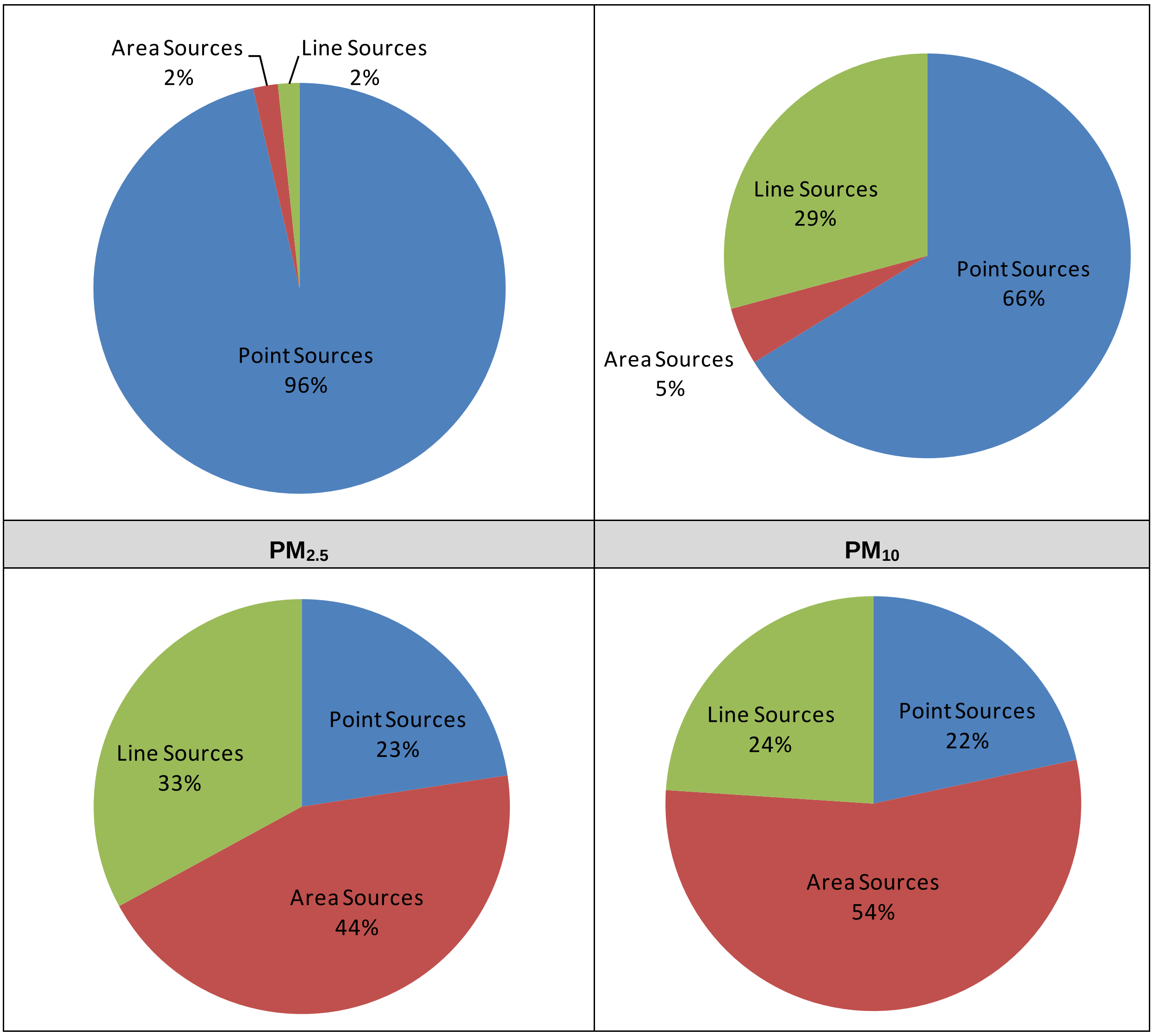


Figure 7-20: Relative Emission Contributions (All Point, Line and Area Sources)

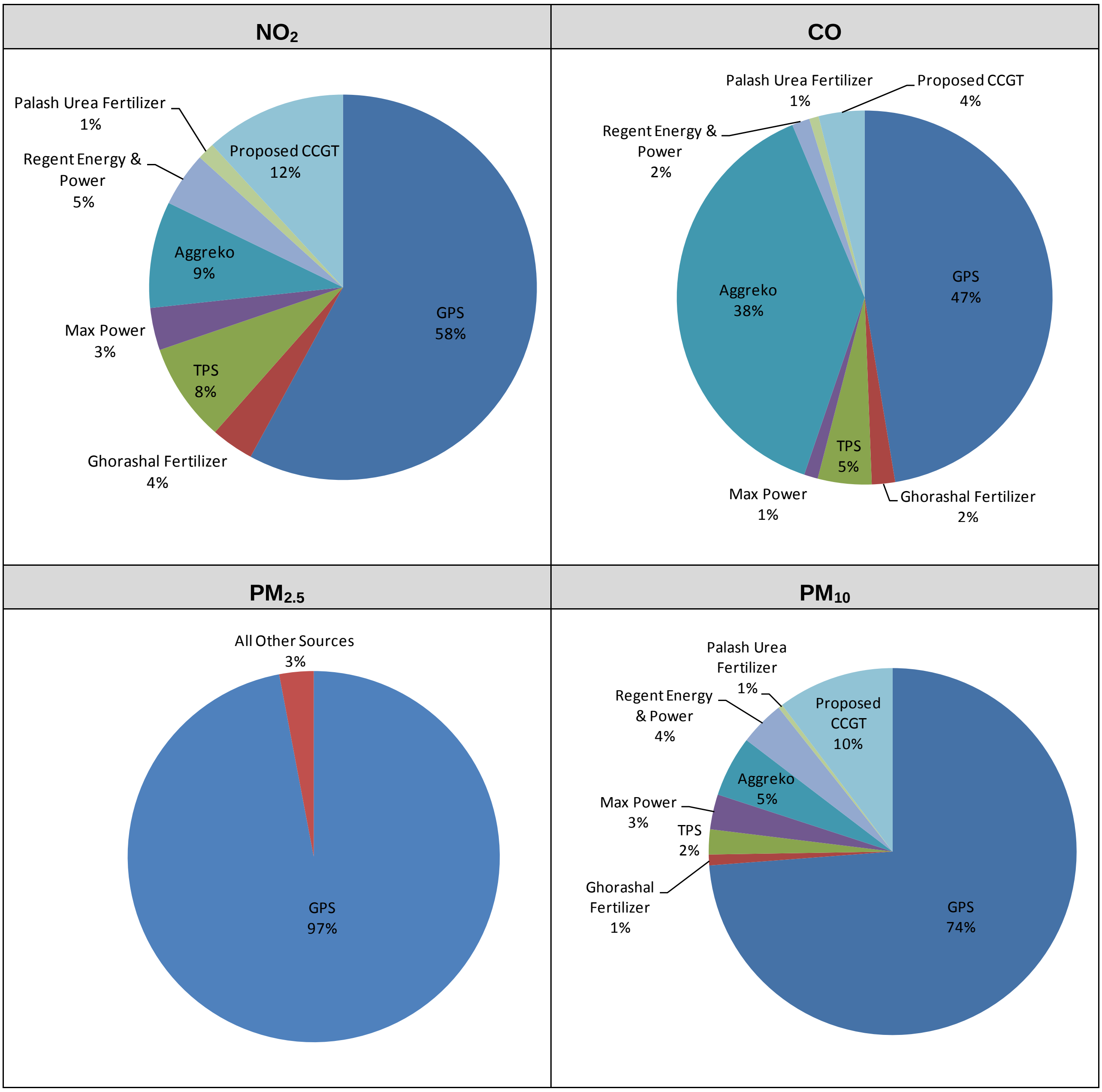


Figure 7-21: Relative Emission Contributions (Major Point Sources)

1) Note: Difference between $PM_{2.5}$ and PM_{10} contributions is due to the fact that for natural gas boilers same emission factor is used for $PM_{2.5}$ and PM_{10} (As per USEPA Guidelines[38]). This is deemed appropriate since most of particulates emitted in natural gas boiler combustion are less than or equal to 1 µm in diameter. For gas turbine combustion, different emission factors are used for $PM_{2.5}$ and PM_{10}.

2) GPS – Ghorashal Power Station, TPS – Tongi Power Station.

[38] USEPA AP 42, Fifth Edition, Volume I: Chapter 1: External Combustion Sources – Natural Gas Combustion, 1998.

c) Cumulative NO_2 Concentration

535. For NO_2 cumulative impact assessment, the maximum ground level concentrations were modeled for 1-hour and annual averaging period to compare with national standards, WHO guidelines and other internationally recognized standards.

536. Preliminary modeling results indicated high maximum ground level concentrations of NO_2 close to the project site, especially close to the Aggreko power plant complex. The Aggreko plant has 120 stacks each only 3 m in height. Therefore, a refined grid analysis was conducted for NO_2 emissions. A fine grid was considered in an area of 4km x 4km close to GPS was modeled with receptors at every 150 m apart and a further fine grid of 500m x 500m area with receptors at every 50 m apart was modeled around the Aggreko power plant.

537. Table 7-30 shows important NO_2 compliance standards and Table 7-31 shows the Tier-2 (ARM) predicted results, where 1-hr predicted concentrations are adjusted by the regional NO_2/NO_x equilibrium ratio. The predicted annual average concentration exceeds the WHO Guideline but meets the Bangladesh National Standard. The maximum predicted 1-hr average concentration exceeds the WHO Guideline and the corresponding EPA standard by a significant amount.

538. As noted previously, the USEPA method models the 1-hour NO_2 value based on the 98^{th} percentile of the maximum daily 1-hour values, which is represented by the eighth-highest of the maximum daily 1-hour values across the year (averaged over 3 years). In the EU method, the 99.8 percentile of the max NO_2 value is taken. The annual average is the same for both methods, it is simply the arithmetic mean averaged over a 3 year period.

Table 7-31: NO_2 Compliance Standards

Pollutant	Averaging Time	Concentration (µg/m³)			
		ECR 1997 (as amended in 2005)	WHO Guidelines	EU Guidelines	USEPA Standards (NAQQS)
NO_2	1-hr	N/A	200	200	188
	Annual	100	40	40	100

Table 7-32: Tier-2 Predicted maximum ground level concentration of NO2 (Baseline & Repowering)

Scenario	Averaging Time	Concentration (µg/m³)		Coordinates of Max Point (UTM)	
		Max Value (USEPA Method)	Max Value (EU Method)	East (m)	North (m)
Cumulative	1-hr	453.88	337.35	260015.5	2654310
	Annual	65.80	65.80	260015.5	2654260

539. Table 7-32 shows the NO_2 contribution from all major sources in the air-shed for the maximum predicted 1-hr and annual averaging concentrations. The Aggreko quick rental plants contribute a significant portion of the 1-hr and annual average NO_2 concentration (76% and 86%, respectively) even though their emission contribution is only 8.6% Contribution from the Ghorashal Power Station is only 17% and 9.8% for 1-hr and annual averaging periods, respectively. The Aggreko quick rental plants contribute such a high percentage to the NO_2 concentration due to their stacks being only 3 m in height and not high enough to adequately disperse the emissions. The new proposed CCGT power plant is expected to contribute 2.2% and 1% to the maximum 1-hr and annual NO_2 concentration.

Table 7-33: NO_2 Source Contribution

S.I	Source	% of Total Emissi-ons	1-hr Averaging		Annual Averaging	
			NO_2 Concentration (μg/m³)	% of NO_2 Contribution	NO_2 Concentration (μg/m³)	% of NO_2 Contribution
1	Ghorashal Power Station	55.8	58.27	17.27	6.45	9.80
2	Ghorashal Quick Rental Max Power (78 MW)	3.4	1.27	0.38	0.11	0.17
3	Ghorashal Regent Energy & Power	4.4	6.11	1.81	1.35	2.05
4	Tongi Power Station	8.0	0.12	0.03	0.014	0.02
5	Ghorashal Fertilizer Factory PP 1, 2 & 3	3.4	3.75	1.11	0.31	0.47
6	Palash Urea Fertilizer Factory PP 1 & 2	1.4	1.95	0.58	0.16	0.24
7	Ghorashal Quick Rental Aggreko (145 MW)	8.6	257.07	76.20	56.65	86.09
8	New Proposed Power Plant (C.C.G.T)	11.4	7.52	2.23	0.64	0.97
9	Brick Fields (All)	1.9	0.44	0.13	0.042	0.06
10	Roads (All)	1.7	0.86	0.25	0.076	0.12
Total		**100.0**	**337.35**	**100.0**	**65.80**	**100.0**

540. Figure 7-21 shows the location of maximum 1-hr averaging and annual concentration points. Both high points are located close to the Aggreko Quick Rental Plant. The highest 1-hr concentration occurs about 62 m North of Aggreko's complex and the maximum annual concentration is about 13 m to the North.

Figure 7-22: Project Area maximum predicted concentration points

541. The maximum NO_2 concentration values for some sensitive receptor sites close to the power plant are given in Table 7-33. NO_2 concentration values at all sensitive receptors are within the applicable standards.

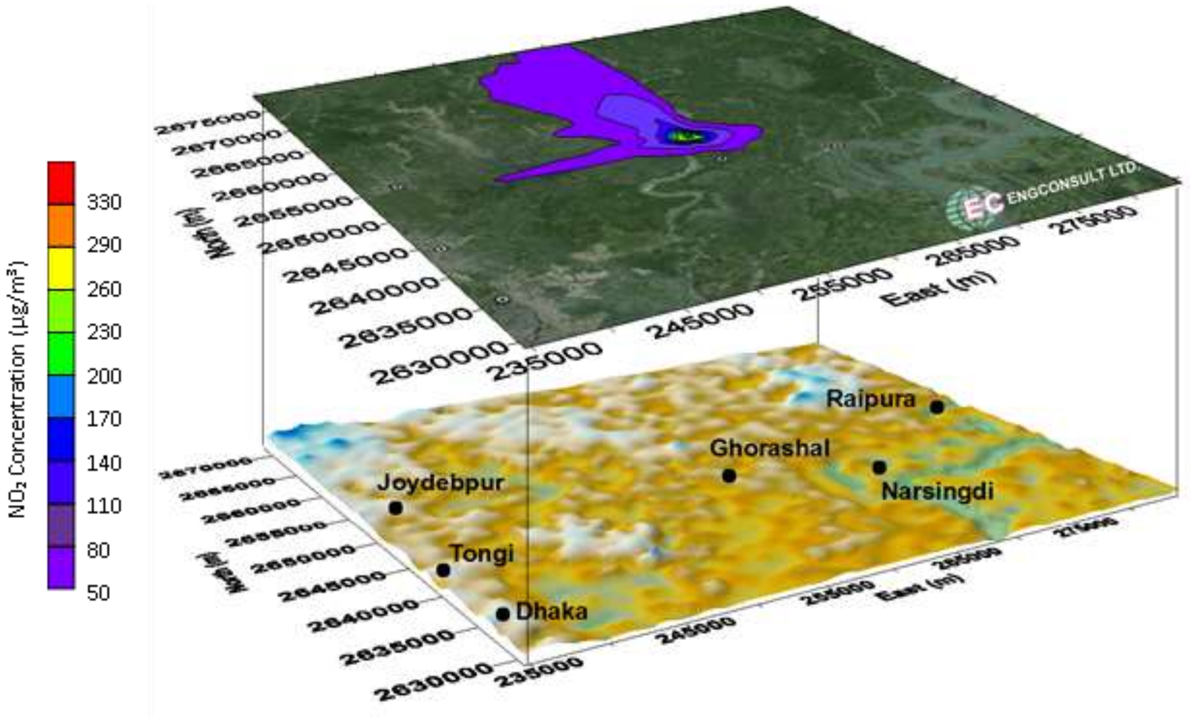
Table 7-34: Cumulative Impact NO_2 concentration – Sensitive Receptors

S.I	Name of Receptor	Concentration (µg/m³)	
		(1-hr Averaging)	(Annual Averaging)
1	Residential (Ghorashal PP)	157.90	11.17
2	School (Ghorashal PP)	148.02	11.07
3	School	147.66	11.49
4	School	79.26	5.90
5	School	69.83	4.24
6	School	130.58	9.18
7	School	86.83	6.87
8	Hospital (Palash)	149.20	11.41
9	High School	97.36	7.76
10	Thana Health Complex (Palash)	73.26	5.70
11	Madrasa (Garapara)	94.94	7.20
12	School (Dhaladia)	39.33	2.21
13	Madrasa (Dakshin Palash)	30.66	1.73
14	School	32.82	1.85

15	Hospital	28.58	1.59
16	Girls' School (Ghorashal Palash)	28.04	1.54
17	Dakhil Madrasa (Paiksha)	27.97	1.52
18	RFL Public school (RFL, Palash)	16.20	1.14
19	School (10 No. Ghorashal)	19.28	1.24
20	College (Kaliganj)	35.95	3.73
21	School	25.78	4.46
22	Primary School	27.21	1.61
23	Kindergarten School	37.08	2.49
24	Madrasa (Sahida Mohila)	69.53	4.80
25	School	74.59	5.00
26	Madrasa	76.30	4.90
27	School	27.50	2.09
28	Madrasa	30.26	2.15

542. Figure 7-22 shows the cumulative impact of 1-hr and annual average NO_2 concentration contour diagrams. The contours show that the maximum concentration area is close to the project site. There is also a high concentration area around the N-3 Highway (Tongi Station Road to Board Bazar).

1-hr Average



Annual Average

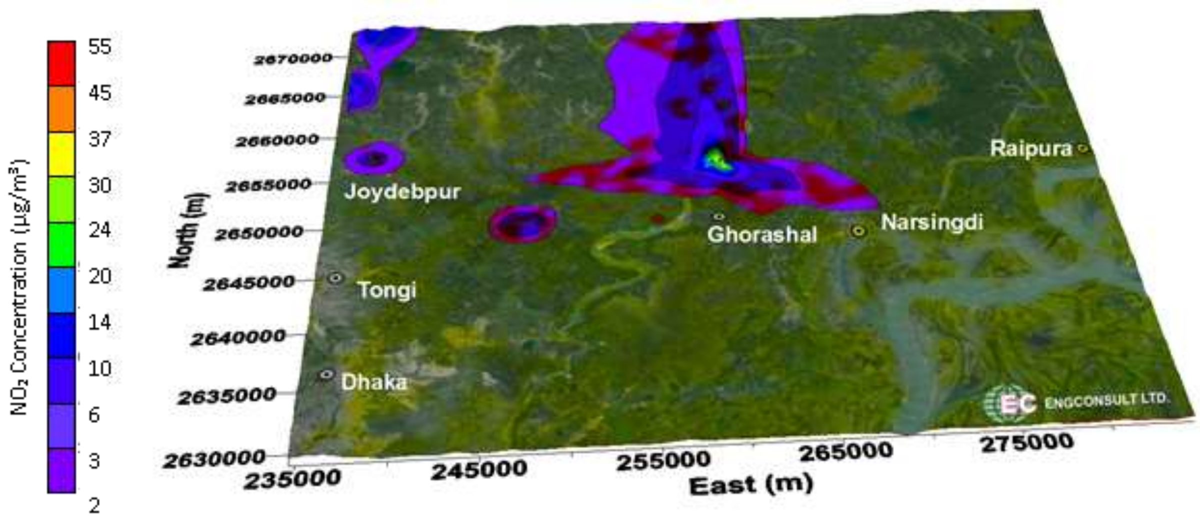


Figure 7-23: NO2 concentration-cumulative impacts

d) Cumulative $PM_{2.5}$ concentration

543. The maximum 24-hr and annual average concentration of $PM_{2.5}$ for the cumulative case are given in Table 7-34. Both the 24-hr and annual average values are above the Bangladesh national standards and WHO Guidelines. Table 7-35 shows that most of the $PM_{2.5}$ at this point is the result of the N-3 highway and all other sources contribute a negligible amount.

Table 7-35: $PM_{2.5}$ concentration (Cumulative)

Pollutant	Concentration (μg/m³)				Coordinates of Max Point (UTM)	
	Averaging Time	Bangladesh National Standards	World Bank Guidelines	Max Value	East (m)	North (m)
Cumulative	24-hr	65	25	67.6	238647	2677148
	Annual	15	10	16.7	238647	2677148

Table 7-36: Source Contribution

S.I	Source	% of Total Emissions	1-hr Averaging		Annual Averaging	
			$PM_{2.5}$ Concentration (μg/m³)	% of $PM_{2.5}$ Contribution	$PM_{2.5}$ Concentration (μg/m³)	% of $PM_{2.5}$ Contribution
1	N-3 Highway	21.9	66.28	98.0	16.53	99.0
2	All Other Sources	78.1	1.32	2.0	0.17	1.0
Total		**100.0**	**67.6**	**100.0**	**16.7**	**100.0**

544. Table 7-36 shows the maximum predicted ground level concentration of $PM_{2.5}$ at the sensitive receptor sites close to the power plant for the cumulative impact case. The $PM_{2.5}$ concentration is very low at the sensitive receptor sites. This is the case since natural gas combustion releases a very small amount of particulate emissions. Receptor sites (#20 and #21) which are further away from the project site and closer to major highways show higher levels of $PM_{2.5}$ concentrations.

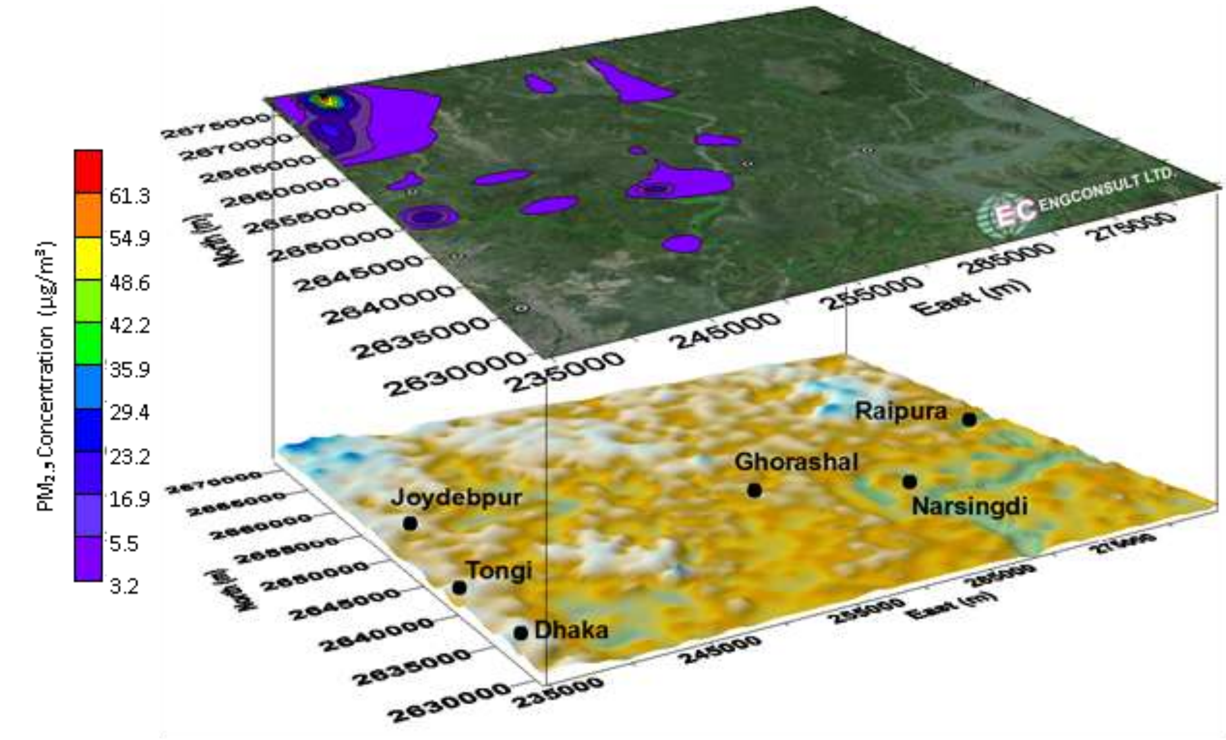
Table 7-37: Cumulative Impact of $PM_{2.5}$ at Sensitive Receptors

S.I	Name of Receptor	Concentration (μg/m³)	
		(24-hr Averaging)	(Annual Averaging)
1	Residential (Ghorashal PP)	3.54	0.65
2	School (Ghorashal PP)	3.78	0.65
3	School	3.06	0.67
4	School	1.94	0.53
5	School	2.00	0.36
6	School	3.93	0.54

S.I	Name of Receptor	Concentration (µg/m³)	
		(24-hr Averaging)	(Annual Averaging)
7	School	3.53	0.46
8	Hospital (Palash)	3.75	0.68
9	High School	3.29	0.51
10	Thana Health Complex (Palash)	2.85	0.43
11	Madrasa (Garapara)	2.48	0.44
12	School (Dhaladia)	1.81	0.28
13	Madrasa (Dakshin Palash)	1.47	0.28
14	School	1.44	0.28
15	Hospital	2.02	0.29
16	Girls' school (Ghorashal Palash)	1.80	0.28
17	Dakhil Madrasa (Paiksha)	1.84	0.27
18	RFL Public school (RFL, Palash)	1.69	0.29
19	School (10 No. Ghorashal)	1.74	0.24
20	College (Kaliganj)	15.64	4.48
21	School	15.52	6.82
22	Primary School	1.87	0.35
23	Kindergarten School	1.94	0.36
24	Madrasa (Sahida Mohila)	2.11	0.55
25	School	2.08	0.57
26	Madrasa	2.23	0.58
27	School	3.38	0.71
28	Madrasa	3.48	0.75

545. Figure 7-23 shows the 24-hr and annual average $PM_{2.5}$ concentration contour diagrams for the cumulative case. As can be seen from the contours the maximum predicted ground level $PM_{2.5}$ concentrations in the air shed are found close to the N-3 highway, which is quite far away from the project site (approximately 28 km). $PM_{2.5}$ concentrations in and around the project site are fairly low and well within the standards.

24-Hr Average



Annual Average

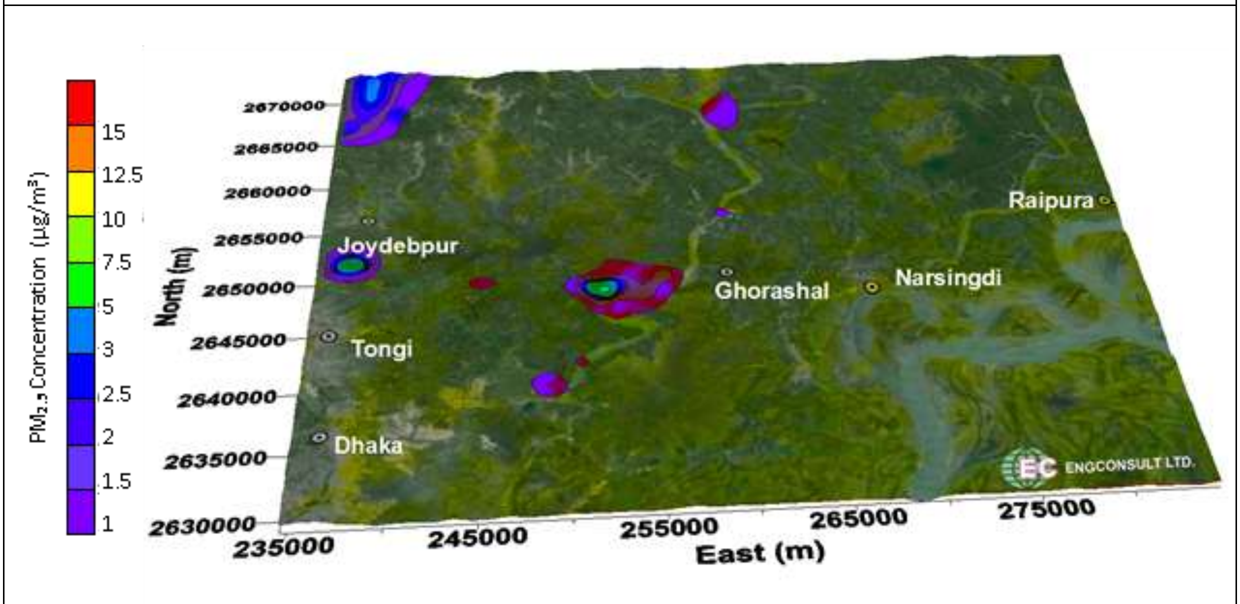


Figure 7-24: $PM_{2.5}$ concentration-cumulative impacts

e) Cumulative PM_{10} concentration

546. The maximum predicted 24-hr and annual average concentration of PM10 for the cumulative case are given in Table 7-37. Both the 24-hr and annual average values are above the WHO guidelines but meet the Bangladesh national standards. Table 7-38 shows that most of the PM_{10} at this point is the result of the N-3 highway and all other sources contribute a negligible amount.

Table 7-38: PM_{10} concentration (Cumulative)

Pollutant	Concentration (µg/m³)				Coordinates of Max Point (UTM)	
	Averaging Time	Bangladesh National Standards	WHO Guidelines	Max Value	East (m)	North (m)
Cumulative	24-hr	150	50	94.88	238647	2677148
	Annual	50	20	22.1	238647	2677148

Table 7-39: Source Contribution

S.I	Source	% of Total Emissions	1-hr Averaging		Annual Averaging	
			PM_{10} Concentration (µg/m³)	% of PM_{10} Contribution	PM_{10} Concentration (µg/m³)	% of PM_{10} Contribution
1	N-3 Highway	15.9	91.65	96.6	21.78	98.6
2	All Other Sources	84.1	3.23	3.4	0.32	1.4
Total		**100.0**	**94.88**	**100.0**	**22.1**	**100.0**

547. Table 7-39 shows the maximum predicted ground level concentration values for the sensitive receptor sites close to the power plant for the cumulative impact case. The PM_{10} concentration is very low at the sensitive receptor sites. This is the case since natural gas combustion releases a very small amount of particulate emissions. Receptor sites (#20 and #21) which are further away from the project site and closer to major highways show higher levels of PM_{10} concentrations.

Table 7-40: Cumulative Impact of PM_{10} at Sensitive Receptors

S.I	Name of Receptor	Concentration (µg/m³)	
		(24-hr Averaging)	(Annual Averaging)
1	Residential (Ghorashal PP)	3.79	0.75
2	School (Ghorashal PP)	3.96	0.74
3	School	3.87	0.78
4	School	3.15	0.77
5	School	2.92	0.50
6	School	4.30	0.63
7	School	5.41	0.56
8	Hospital (Palash)	4.04	0.70
9	High School	3.21	0.58
10	Thana Health Complex (Palash)	3.17	0.52
11	Madrasa (Garapara)	4.40	0.60
12	School (Dhaladia)	3.82	0.42
13	Madrasa (Dakshin Palash)	2.82	0.42
14	School	2.99	0.43
15	Hospital	5.31	0.45

16	Girls' school (Ghorashal Palash)	4.51	0.43
17	Dakhil Madrasa (Paiksha)	4.50	0.42
18	RFL Public school (RFL, Palash)	3.18	0.45
19	School (10 No. Ghorashal)	3.53	0.38
20	College (Kaliganj)	25.58	6.41
21	School	24.79	9.97
22	Primary School	3.81	0.55
23	Kindergarten School	4.28	0.55
24	Madrasa (Sahida Mohila)	5.17	0.77
25	School	4.87	0.79
26	Madrasa	5.31	0.83
27	School	7.53	1.32
28	Madrasa	7.98	1.41

548. Figure 7-24 shows the 24-hr and annual averaging concentration of PM_{10} contour diagrams for the cumulative case. As can be seen from the contours the maximum predicted ground level PM_{10} concentrations in the air shed are found close to the N-3 highway (as was the case with $PM_{2.5}$), which is quite far away from the project site (approximately 28 km). PM_{10} concentrations in and around the project site are fairly low and well within the standards.

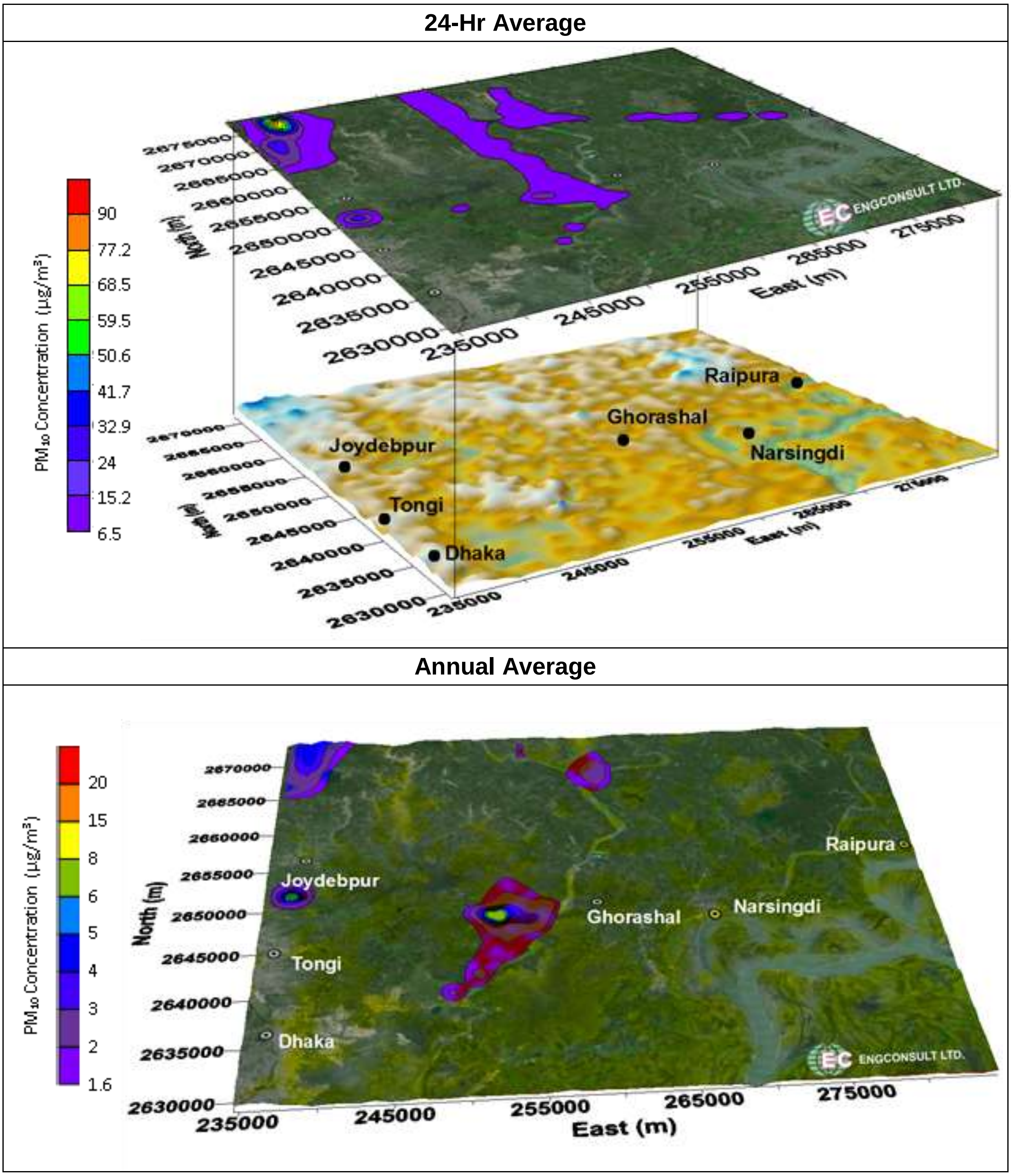


Figure 7-25: PM_{10} concentration-cumulative impacts

f) Cumulative CO Impact

549. The cumulative case maximum 1-hr and 8-hr averaging concentration of CO are given in Table 7-40. The maximum values were found to be well within the standards, thus were not assessed further.

Table 7-41: CO concentration (Cumulative)

Pollutant	Concentration (µg/m³)				Coordinates of Max Point (UTM)	
	Averaging Time	Bangladesh National Standards	World Bank Guidelines	Max Value	East (m)	North (m)
Cumulative	1-hr	40,000	N/A	2,910	238647	2677148
	8-hr	10,000	N/A	1,163	238647	2677148

g) Air shed Assessment

550. The cumulative impact assessment showed that predicted maximum ground level concentrations of NO_2, $PM_{2.5}$ and PM_{10} exceed the Bangladesh standards and WHO guidelines in selected locations only. The high predicted NO_2 concentrations are predicted at receptors very close to Aggreko and the execeedances are due primarily to the stacks of insufficient height to adequately disperse emissions. On the other hand, the high $PM_{2.5}$ and PM_{10} concentrations are predicted at receptors close to the N-3 highway, and primarily caused by heavily congested traffic far from the project site (28 km away)-. The cumulative impact of particulates (both PM_{10} and $PM_{2.5}$) show a lower concentration compared to the baseline and repowering scenario, since, background concentration of these pollutants were included in the baseline and repowering which was very high in Bangladesh (may include the transboundary pollution).

551. As per WBG guidelines an airshed should be considered as having poor air quality if nationally legislated air quality standards or WHO Air Quality Guidelines are exceeded significantly. Therefore, it can be concluded that the airshed is polluted/degraded based on the cumulative assessment results.

552. For degraded airshed the WBG Health, Safety, and Emission Guidelines, 2008 states the following:

- The project should explore and implement site-specific offsets that result in no net increase in the total emissions of those pollutants (e.g., particulate matter, nitrogen dioxide) that are responsible for the degradation of the airshed.
- Suitable offset measures could include reductions in emissions of particulate matter, nitrogen dioxide, as necessary through (a) the installation of new or more effective controls at other units within the same power plant or at other power plants in airshed.
- Wherever possible, the offset provisions should be implemented within the framework of an overall air quality management strategy designed to ensure that air quality in the airshed is brought into compliance with ambient standards.

553. For the rehabilitation of existing plants, WBG Guidelines state that:

- For projects to rehabilitate existing facilities, case-by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.

554. With the implementation of this project the above criteria are being met, in fact there is a significant reduction in emissions from the baseline to repowering case for the Ghorashal power station. After repowering, NO_x, $PM_{2.5}$ and PM_{10} emissions from GPS decrease by 810 tons/yr (13%), 113 tons/yr (41%) and 62 tons/yr (23%), respectively. BPDB (GPS) have taken the initiative for repowering of Unit 3. They will also repower Units 5 and 6 and will decommission of Units 1 and 2 gradually. The Quick rental Aggreko (145 MW) plant will be retired in 2018 according to the present contract. These initiatives, when implemented, will further reduce the cumulative emission.

555. Therefore, with the implementation of this project the air quality in the airshed will be brought closer to compliance with national ambient air quality standards and WHO Guidelines.

7.9.2 Noise

556. In the cumulative scenario, 4 existing units, 2 re-powering units, 2 existing RMS units, 1 proposed RMS unit, Max and Aggreko rental power plants were considered as the major sources of noise. Noise levels from 4 existing units, 2 re-powering units and Max power plant were assigned 90 dBA each. As there is no technical specification available for the Aggreko power plant units, the level of noise generated from this power plant was estimated conducting a back calculation from the model output and measured noise level. It was estimated that Aggreko generates 110 dBA noise level. The result of the modelling in this scenario is represented in Figure 7-25.

557. The analysis of the noise propagation modeling in cumulative scenario is summarized in Table 7-41 which shows the resultant noise level in different sensitive receptors. The locations, where noise level exceeds both day and night time standard according to ECR 1997 and WHO Guideline values, are marked in red in Table 7-41. In places, where only the night time standard is exceeded, noise level is marked in orange color.

Table 7-42: Noise level in different sensitive receptors in Cumulative Scenario

Place	Notation	Type	Noise Level (dBA) [Cumulative]
Administrative building	SR-1	Industrial	51
Mosque/Accounts Office	SR-2	Industrial	51
Near RMS	SR-3	Industrial	68
Near Fertilizer Factory	SR-4	Industrial	51
Unit-4 boundary	SR-9	Industrial	59.5
Inside Aggreko-Max	SR-10	Industrial	102
Aggreko Gate	SR-11	Industrial	51
Outside the plant/Commercial	SR-12	Industrial/ Commercial	35
Corner of Substation	SR-14	Industrial	42.5
Bazaar	SR-19	Industrial/ Commercial	18
Residence in fertilizer factory (West side)	SR-5	Residential	25.5

Place	Notation	Type	Noise Level (dBA) [Cumulative]
Resident Fertilizer Factory (Outside Boundary)	SR-6	Residential	51
Residence Mosque Fertilizer Factory	SR-7	Residential	25.5
Residence FF Near Aggreko	SR-8	Residential	59.5
Army Residence	SR-13	Residential	42.5
Residential Area	SR-15	Residential	34
School-Hospital	SR-16	Residential	34
Central Residential Mosque	SR-17	Residential	34
Ghorashal Residence	SR-18	Residential	18

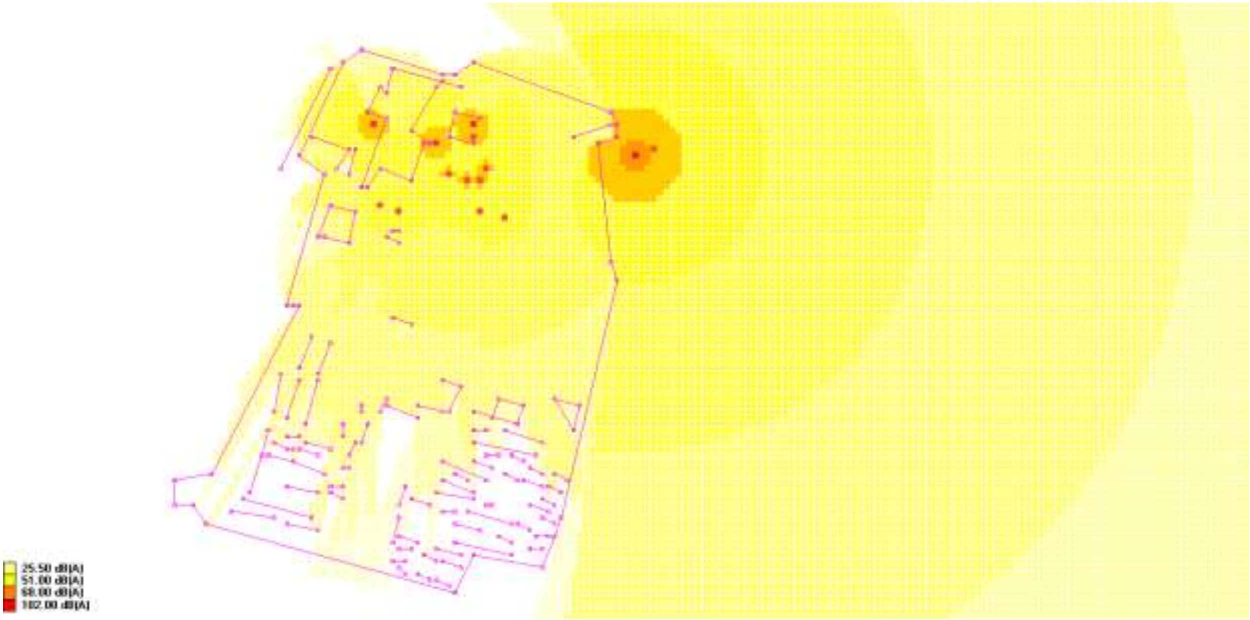


Figure 7-26: Simulation of Noise Propagation during Plant Operation in Cumulative Scenario

7.9.3 Impact on the flow of Water Bodies

a) Option development

558. For assessment of water availability of Shitalakhya River, the models (hydrological and hydrodynamic) has been simulated for four scenarios; baseline condition, future without project, future with project and other developments including the consideration of upstream flow reduction and climate change impacts. The detail description of various scenario is presented in Table 7-42.

Table 7-43: Detail description of option development

Scenario	Condition	Implication
Base condition	Average (1 in 2.33 year return period) of	- Model has been derived for the existing situation considering historical hydrological and

Scenario	Condition	Implication
	last 31 years (1981 – 2012)	meteorological data (water level, GW level and rainfall and air temperature) for the year 1981 through 2012. - Present water demand (agriculture, domestic, industrial etc.) has been assessed and integrated in the model.
Option 01 (Without project scenario)	Future without project scenario considering Climate change	- Model has been simulated for the next 30 years (2015-2045) considering without project with climate change condition. - The change in upstream flow due to climate change has been considered during model setup. - Future domestic, industrial and agricultural water demand has been assessed and incorporated in the model.
Option 02 (With project)	Future with project considering Climate change and future water demand	- Model has been simulated for the next 30 years (2015-2045) considering future climate change condition. - Water abstraction (40.3 m^3/s) for the power plant has been included into the model. - The change in upstream flow due to climate change has been considered during model setup. - Future domestic, industrial and agricultural water demand has also been incorporated in the model.
Option 03 (With project)	Future with project considering Climate change, reduction of upstream flow and future water demand	- Model has been simulated for the next 30 years (2015-2045) considering future climate change condition. - Water abstraction (40.3 m^3/s) for the power plant has been included into the model. - The upstream flow is considered to be reduced by 25 % in future according to the rate of the Old Brahmaputra River. - Future domestic, industrial and agricultural water demand has also been incorporated in the model.

b) Climate change impact on Ganges, Brahmaputra and Meghna basins

559. CEGIS has carried out water availability assessment for the Ganges, Brahmaputra and Meghna basins under different climate change scenarios (A1B, A2 and B1). The study was financed under the Abu Dhabi Dialogue Knowledge Forum Small Grants Program (ADDKF-SGP) of the World Bank and coordinated by the International Centre for Integrated Mountain Development (ICIMOD), Nepal. Based on this study it was found that about 8% of monsoon flow and about 17% dry season flow of the Brahmaputra River will increase by 2050. Change of monthly flow of Brahmaputra River is given in Table 7-43.

Table 7-44: Changes of monthly flow of Brahmaputra River in percentage

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Percentage change of monthly flow	11.1	16.3	24.3	1.6	0.6	-2.6	7.8	14.2	12.8	16.9	17.2	17.8	9

560. From the historical data analysis, it has been found that the annual flow of the Brahmaputra River is increasing due to climate change but flow of the Old Brahmaputra River is decreasing which is mainly due to the change in off-take morphology of the Old Brahmaputra River. It has been estimated that around 268 Mm^3 flow reduced per year in the Old Brahmaputra River (Figure 7-26).

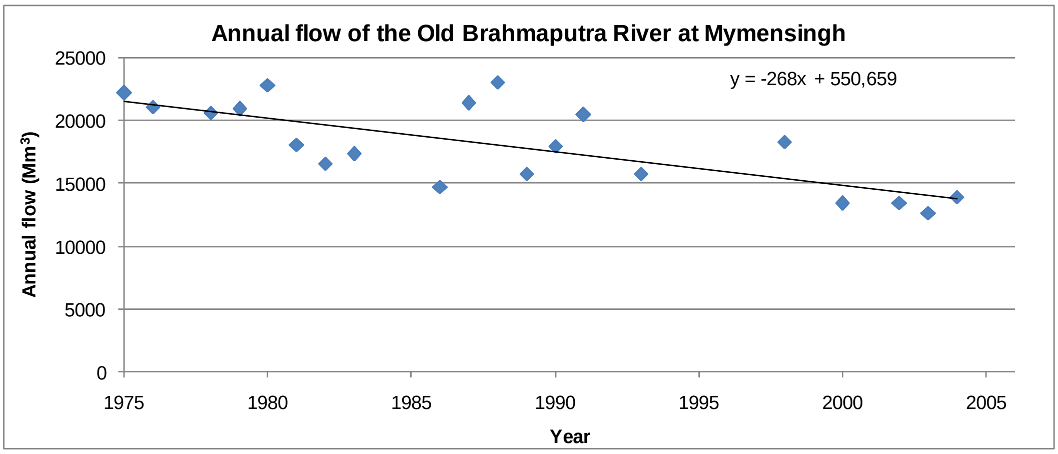


Figure 7-27: Historical annual flow of the Old Brahmaputra River at Mymensingh

561. For assessment of water availability of Shitalakhya River, the models (hydrological and hydrodynamic) has been simulated for four scenarios; base condition, future without project considering climate change, future with project considering climate change and future water demand, and future with project considering climate change, future water demand, and reduction of upstream flow.

c) Climate Change Impact on Water balance

562. The precipitation and temperature are assumed to be changed in future under different climate change scenarios. To understand the climate change impact for the next 30 years (2015 - 2045), the model was run for RCP 4.5 scenario and the results are shown in Table 7-44.

Table 7-45: Climate change impact on water availability in the catchment area

Sl. No.	Hydrological parameters	Base condition (mm)	Climate change condition (mm)	Difference (mm)	Percentage of change
1	Precipitation	2055	2255	(+) 200	(+)10
2	Evapotranspiration	776	795	(+)19	(+) 2.4
3	Percolation	575	593	(+)18	(+) 3
4	Surface Runoff	874	1006	(+)132	(+)15
5	Base flow	83	40	(-) 43	(-) 52

(+) indicates increasing and (-) is for decreasing

563. The climate change impact on annual water balance for the study area is given in Table 7-44 for climate change scenario RCP 4.5 in 2050s.The annual average rainfall for the study area will be 2255 mm which is about 10% more than the base condition. The surface runoff also increases (15%) as there is an increase in annual rainfall. There is a little increase in annual evapotranspiration (19 mm) which is mainly due to the increase of temperature. There is also a bit increase in annual percolation due to climate change. However, base flow will be decreased by 52% as ground water extraction rate will be increased in future.

d) Water yield

564. The generated water yields were estimated and compared with base condition to assess the impact of climate change on water availability. Water yield is the net amount of water that contributes to stream (water yield = surface runoff +lateral flow + base flow- total loss- abstraction). The monthly water yield for the base and climate change condition is given in Figure 7-27.

565. The availability of water will increase during February to June as there is an increase in rainfall during that period. During the dry period (November-January), the water availability will decrease due to climate change by 2050s.

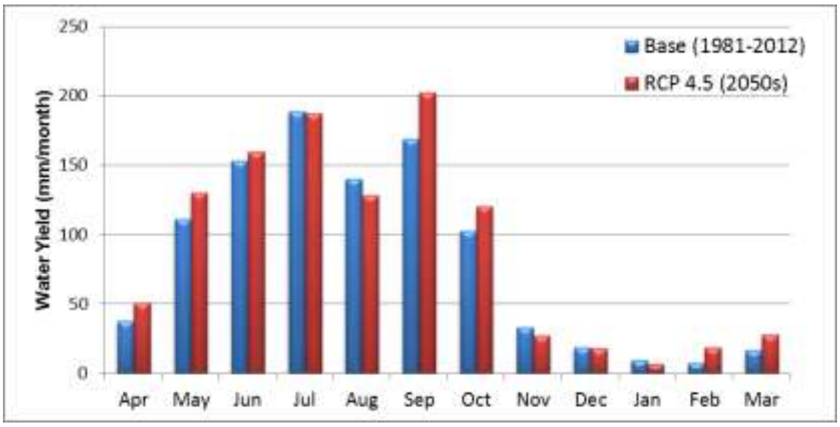


Figure 7-28: Climate change impact on monthly water yield for climate scenario RCP 4.5 by 2050s

566. Variations of seasonal water yield due to climate change scenario RCP 4.5 by 2050s are shown in Table 7-45. The table shows increase in seasonal water yield during dry season and pre-monsoon as 36% and 22%, respectively. Water yields during pre-monsoon and monsoon are almost similar to the base condition.

Table 7-46: Climate Change impact on seasonal water yield by 2050s for scenario RCP 4.5

Season	Water Yield during base (mm)	Change in water yield due to CC (%)
Pre-monsoon (Apr-May)	149	22
Monsoon (Jun-Sep)	651	4
Post-monsoon (Oct-Nov)	135	9
Dry (Dec-Mar)	52	36

567. **Water level:** Frequency analysis has been done using Gumbel Distribution method (Gumbel, 1958)[39] with respect to maximum and minimum water level shown in Table 7-46. The key observation is that this river is tidally influenced under the low flow regimes such that reverse flow (down stream flow) will tend to maintain constant water level despite of surface water (40.3 m^3/s) withdrawal from river for the cooling purpose of GPS. As a result, hydrological analyses for different options indicate that the changes of average minimum water level are insignificant.

Table 7-47: Statistical analysis on maximum and minimum water level for different return period

Return Period (year)	Maximum Water Level (mPWD)				Minimum Water Level (mPWD)			
	Base condition	**Option 1** (Without project scenario)	**Option 2** (with project considering Climate change and future water demand)	**Option 3** (with project considering Climate change, reduction of upstream flow and future water demand)	**Base condition**	**Option 1**	**Option 2**	**Option 3**
2.33	6.62	6.79	6.77	6.29	0.94	0.99	0.92	0.91
5	7.19	7.40	7.40	6.84	0.85	0.90	0.84	0.81
10	7.66	7.89	7.90	7.29	0.78	0.83	0.77	0.74
20	8.12	8.37	8.39	7.72	0.71	0.77	0.70	0.66

[39] Gumbel EJ (1958) Statistics of Extremes, Columbia University Press, New York, USA

30	8.38	8.64	8.67	7.97	0.67	0.73	0.66	0.62
50	8.70	8.98	9.02	8.28	0.61	0.68	0.61	0.57
100	9.14	9.44	9.49	8.69	0.55	0.62	0.54	0.50

e) Monthly average discharge for different scenarios

568. The average monthly discharge of Shitalakhya River at project site varies from about 84 m^3/s to 1181 m^3/s for the base condition. The highest discharge occurs during the month of July and the lowest in January. The average monthly flow of Shitalakhya River at the project site for different condition is given in Table 7-47.

Table 7-48: Average Monthly flow at project area on Shitalakhya River

Month	**Base Condition (Flow, m^3/s)**	**Option 1** (Without project scenario) **(Flow, m^3/s)**	**Option 2** (with project considering Climate change and future water demand) **(Flow, m^3/s)**	**Option 3** (with project considering Climate change, reduction of upstream flow and future water demand) **(Flow, m^3/s)**
January	83.39	100.13	98.96	96.8
February	83.71	100.46	98.95	96.7
March	90.01	107.18	104.27	102.2
April	111.76	125.74	124.98	121.2
May	202.60	211.64	211.75	181.3
June	563.69	555.85	556.03	435.9
July	1181.43	1275.22	1275.12	891.5
August	1177.86	1339.54	1339.38	889.4
September	1066.69	1205.27	1205.42	808.8
October	692.91	807.62	807.45	527.4
November	170.98	192.57	192.26	157.1
December	109.09	125.73	125.19	116.9

569. As the dry season flow of the Brahmaputra River is expected to change due to climate change, the dry season flow to the Shitalakhya River may also change, depending on the off-take morphology. The difference of dry season flow between Option 1, Option 2 and Option 3 is insignificant because after withdrawing 40.3 m^3/s of river water for the power plant, reverse flow will mount up from downstream and maintain the constant water level of the Shitalakhya River. Furthermore, flooding would be increased immediately which may increase the flood flow in the Shitalakhya River for Option 1 and Option 2. However, flood flow will be reduced in Option-3 because Shitalakhya River receives 25% less water from old Brahmaputra River.

f) Assessment of Environmental flow (E-flow)

570. The increasing demand for river water conflicts with the environmental needs for sustaining flows during drought and low flow periods, leads to competition between water demand and river flow needs. Tennant (or Montana) method (1976) is the most common

hydrological method to assess the environmental flow requirements as percentage of mean annual flow. According to Bari and Marchand (2006)[40], the monsoon flow requirement with respect to environmental flow for flushing is 200% of the mean annual flow, while dry season requires 20% of mean annual flow for the good condition of aquatic habitat.

571. E-flow requires for flushing is about 922 m^3/s for the base condition, while about 1,181 m^3/s (21.9 % more) flow is available shown in Table 7-48. Similarly, during monsoon E-flow will also adequate for Option 1, Option 2 and Option 3.

572. During dry season, E-flow for base condition is 92.2 m^3/s whereas 83.4 m^3/s is available which is partially sufficient for the good condition of aquatic habitat. However, due to climate change impact in 2050s, dry season flow of Shitalakhya River will be increased for Option 1 and Option 2. Consequently, environmental flow will be increased in that period. Dry season flow for those scenarios (Option 1 and Option 2) is fairly available to meet the E-flow in future.

573. Besides, Option 3 is considered as worse scenario whereas, E-flow is also sufficient (31% more flow is available) during dry period.

Table 7-49: Environmental flow requirement of Shitalakhya River

Seasons	Base condition		Option 1		Option 2		Option 3	
	E-flow (m^3/s)	Available flow (m^3/s)	E-flow (m^3/s)	Available flow (m^3/s)	E-flow (m^3/s)	Available flow (m^3/s)	E-flow (m^3/s)	Available flow (m^3/s)
Dry season (20%)	92.2	83.4	102.4	100.1	102.3	98.9	73.8	96.7
Monsoon (200%)	922.4	1181.4	1024.5	1339.5	1023.3	1339.4	737.6	889.4

574. The environmental flow for the Shitalakhya River during dry season is expected not to be a major concern as there is a tidal influence during that period. Even, if water is diverting from this river, downstream flow (tide) will even out the withdrawal and maintain a constant water level. Besides, the major part of the diverted amount will return to the river as return flow after the condenser cooling process.

The observations on above analyses as follows:

- Flow of Shitalakhya River is expected to be increased in near future due to climate change and adequate flow will be available at the project site.
- Current abstraction of surface water at the rate of 40.3 m^3/s for condenser cooling and other operational purposes will have no or slight impact on availability of water in Shitalakhya River for the next 30 years.
- Monsoon flow will be increased in 2050s which may intensify the flood level in and around the study area.

[40] Bari, M F and Marchand, M. 2006. Introducing Environmental Flow Assessment in Bangladesh: Multidisciplinary Collaborative Research. BUET-TUDelft.

- Dry season flow and water level will also increase in future which will further facilitate the navigation.
- In options 2 and 3, without considering climate change, both dry and wet season flows will roughly be reduced by 10%. The E-flows in option 2 would be 920.7 m^3/s (available flow 1,205 m^3/s) and in option 3 would be 664 m^3/s (available flow 800 m^3/s). So even without climate change, the flow would be sufficient during monsoon season and dry period (considering tidal impact).

8. Mitigation Measures

8.1 Preamble

575. The proposed repowering of Unit 4 is environmentally friendly refurbishments of old technology as described in Chapter 4. Since, the Unit is part of an existing operating power plant, which contain other old units, it requires particular attention to harmonize with the existing and other proposed operations in the facility. Specific design changes proposed in this project are presented in the following sections.

8.2 Change in the project layout

576. It is proposed to include the following items in the project layout developed by the engineering consultant:

- An on-site secured hazardous waste (asbestos) disposal facility near the existing Jetty,
- Gas insulated sub-station (GIS) near the pond and Jetty,
- A storm water drainage system around the new plant and the hazardous waste disposal facility and link it with the existing drainage network of the plant, and
- A temporary storage area for scrap materials of boiler-4 by demolishing the existing old structure in the north east side of Unit 4.
- Central water/effluent treatment plant.

8.3 Engineering design

577. *Enhancement of condenser cooling system:* The existing open cycle cooling system supported by cooling tower has been proposed to a full closed cycle cooling system with new cooling towers.

578. It is learnt from the operation staffs during site visit that the existing cooling tower is inadequate, only to provide support to the existing open cycle cooling system by cooling a small portion of hot water and adding the same to cold water channel during dry season (when Shitalakhya River flow is minimal) and occasionally during cooling water pump maintenance. The condition of existing cooling towers is poor and requirement major refurbishments. Most of its blower fans including the induced draft fan are not working mainly due to the defective motors and other mechanical problems. With all these equipment defects the present cooling system is unable to reduce impacts of the thermal plume generated from Unit 4. Although the availability of Shitalakhya water for next 25 years is confirmed, the adverse impacts of the thermal plume will be a continuous threat to the river and its eco-system. Considering this factor it is proposed to replace the present open cycle cooling system to close cycle cooling system constituting refurbishment of existing cooling towers and addition of new cooling towers to meet the capacity of the repowering of Unit 4 and other Units' requirements. This will drastically reduce the present cooling water demand of 7.64 m^3/s to 0.38 m^3/s and bring the Unit under compliance with WBG Guidelines on thermal plume discharge.

579. *Central Water/Effluent Treatment Plant:* The existing water treatment plant at GPS is an old plant with low capacity. It has no effluent treatment and sludge treatment systems. It uses Hydrazine as oxygen scavenger in the boiler feed water system, resin based demineralization and aluminum sulfate for raw water treatment.

580. It is proposed that the repowering of Unit 4 include a central water treatment plant containing effluent treatment plant, a sludge treatment plant, and a reverse osmosis plant for de-mineralized water with two cells in service and one in standby. The plant will use more environment friendly chemicals, such as, Sodium Erythorbate or Helamin as alternatives to hydrazine to treat feed water and reverse osmosis technology to replace resin based demineralization.

8.4 Mitigation measures for major impacts

581. The following sections present the mitigation measures for the major impacts identified in Chapter 7 of the EIA report. Minor and some moderate impacts will be managed and mitigated using environmental code of practices (presented in Annex 9.1) and Contractors' good practice.

8.4.1 Decommissioning Phase

B. Ambient Air

B1. Airborne asbestos fiber

582. *Mitigation Measures:* The decommisioning area must be protected by temporary peripherial G.I sheet fence of 3 m height both for existing boiler and asbestos disposal site for regulating trespassing of unauthorized people. The decommsioning workers shall use appropriate personal protective equipments (PPEs) during decommisioning of existing boiler. They should be prevented from consuming food and smoking inside the protected boundary. They must follow the OHSAS 18000/18001 guidelines. The worker must always adhere to the guidelines of the decommisioning plan. Water sprinkling should be done before comencing the work. Under this study a separate supplementary report captioned Vol. 3: Boiler Decommisioning Plan has been prepared in which asbestos risk and associated mitigation measures are presented to combat untoward situation, which may arise during boiler decommisioning as well as handling of asbestos and ACM. This Plan could be treated as a guideline for the EPC Contractor/Proponent for avoiding/reducing the magnitude of accidental events.

D. Water Bodies

D2. Water quality

583. *Mitigation Measures:* Waste containing more than 0.1 percent asbestos is classed as **hazardous/special** waste.[41] Therefore, the project will deal with this waste as hazardous waste. Proper drainage system must be developed at the decommisioning premises before starting the decommision activities. Waste water from the decommisioning site will be collected at a sump for temporary storage and treated in effluent treatment plant (ETP) before final disposal to the proposed on-site asbestos facility.

584. Chemical substances and scrap will be kept on a specified covered areas so that contaminants from thse substances are not come into the natural environment. The Contractor will train workers on handling abnormal or emergency sitution like oil spill, asbestous release, chemical spill etc., as detailed in Vol 5: Emergency Response Plan.

[41] Asbestos Essentials Task Manual (2001); www.hse.gov.uk/asbestos/essentials/index.htm

E. Soil

E1. Soil quality

585. *Mitigation Measures:* Asbestos containing effluent water could degrade soil quality if allowed to flow into the soil. A leak-proof sump will be constructed and the asbestos containing effluent water will be drained safely into the sump for collection. The boundary of the sump will be protected so that effluent waters does not wash away to the nearby vegetation or into the surface water during heavy rainfall.

F. OCCUPATIONAL HEALTH AND SAFETY

F2. Occupational health and safety

586. *Mitigation Measures:* Decommissioning activities , such as boiler dismantling, cutting, grinding, lifting heavy machineries, segregating materials, working at heights, etc. may lead to injuries, casualties or deaths of the workers involved in these activities. Proper health and safety training on how to handle equipments and hazard identification must be assessed before starting the decommissioning activities. Use of appropriate PPEs will be made mandatory during decommisioning of existing boiler.The Contractor's Occupational health and safety (OHS) officer, entrusted with worker's safety, should follow the Vol. 4: Occupational Health, Safety and Environment Plan as a guildeline and must ensure that the equipments and safety control mechanisms are working properly before the workers start their work. In case of the discovery of faulty equipments and safety harness, they must be replaced promptly. They must also ensure workers hygiene and health status. An on-site medical team will be set up and emergency first-aid medical kit will be at hand in case of any accidental injuries (burns, cuts, broken bones etc.). They will also conduct monthly health check up to check the worker's health condition and provide appropriate treatment for any ailments. Finally, the contractors will ensure all compliance issues for the workers during the course of the decommissioning and construction process, as per Bangladesh Labour Act, 2006.

G. SOLID WASTE DISPOSAL

G1. Hazardous solid waste

587. *Mitigation Measures:* Decommisioning of boiler will be done following the specialized guidelines provided in the decommisioning plan (Vol. 3). Special handling methods will be followed for segragating asbestos from insulation and other boiler materials. At first, asbestos containing waste will be segregated from demolished material before disposal. The contractor will establish a means to prevent any visible emissions outside the temporary and on-site asbestos disposal pit during handling, segregation, and final disposal operations. They must maintain the integrity of leak-tight containers and/or packaging at all times during the handling and disposal operations. Minimize the release and exposure of asbestos containing material after placement in the asbestos pit without compaction of the waste prior to application of cover. Finally, in presence of the official of BPDB the asbestos pit will be sufficiently covered to ensure complete coverage of the disposed asbestos and prevent re-exposure during continuing disposal operations. During the operation, the worker must follow the guidelines of WBG's Good Practice Note: Asbestos: Occupational and Community Health Issues, 2009 on hazardous materials management.

H. SOCIAL IMPACT

H2. Labor migration

588. *Mitigation measures:* The flow of migrant workers may aggravate the risk of HIV/AIDS and STI. Awareness programs on HIV/AIDS infection through well-designed campaign needs to be implemented; targeting all risk prone groups. Acclimatization with the customs and rituals of local people can also reduce the chances of spreading the infection. Adopting and carrying out Behavior Change Communication (BCC) among target groups may also reduce the spread of the disease. The EPC Contractor will put in place a referral healthcare facility to deal with medical aspects of HIV/AIDS treatment with specialized services. The in-house medical facility will diagnose for STD/STI and TB infection in workers and provide treatment as necessary. Serious cases of infection may be referred to specialized treatment facilities of the region. Women are also an integral part in curbing the spread of STD infection. Creating awareness on HIV infection amongst the women involved in construction activities may prevent the spread of the infection.

8.4.2 Construction Stage

I. ECOSYSTEM

I1. Aquatic habitat quality

589. *Mitigation measures:* Dredging operation would gravely impact aquatic habitats, particularly the benthic habitats. Dredging operation will be carried out in the routes having minimum aquatic habitats. Appropriate benthic survey will be carried out prior to the dredging activities. Various ships/cargos navigating in these routes might also disturb aquatic habitats and thus the shipping companies must ensure that the ship/cargo carrying machineries and ancillaries, construction materials and other raw materials, obey the appropriate International Maritime Laws .

J. AMBIENT AIR

J1. Generation of dust and pollutants

590. *Mitigation measures*: During excavation of trenches for laying gas pipes; RMS, turbine and HRSG foundation, operation of construction equipment and vehicles, and material transport, will generate dust and pollution which is injurious to human health. Casing will be used when buried pipes cross a road. The minimum depth of cover shall be measured from the top of the pipe to the surface of the working grade. Crown materials along the surface of the ground level will not be considered as a part of the depth of cover. The specified depth of trench can be varied as suggested by the Engineer or his representatives considering the site condition. The trench shall be carefully cut so that the pipe is evenly bedded throughout its length with sufficient joint holes and trial holes made where necessary. Before any back filing is performed, the pipeline will be evenly bedded upon the bottom of the trench throughout its length and will be correctly positioned. Holiday detector shall be used to detect holiday if any and shall be repaired before backfilling. Compaction of back filling material shall be performed by an approved method to prevent any subsequent settlement. Pipes should be strung only on the right-of-way which has been cleared and where grading has been completed. The Contractor shall ensure that the pipe is strung for proper placement of the pipe size. Pipes shall be raised on sandbags.

K. Ambient noise

K1. Noise level

591. *Mitigation measures:* During construction activity, noise might be generated from welding operation, the moving and idling vehicles and operation of heavy machineries. The machines/equipments/vehicles, thus, will be turned off in idle status, to minimize noise generation. The workers working in the construction site will also use PPEs during work close to noisy operation.

L. Water bodies

L1. Water pollution

592. *Mitigation measures:* Improper storage and handling of fuels, lubricants, chemicals, hazardous goods/materials on-site; wash down of plants and equipments; and potential spills may contaminate the water bodies and harm the environment and health of construction workers. Oils, lubricants and other hazardous materials will be bunded and stored separately to minimze spills. Workers will be trained on safety precautions on using/handling hazardous materials. They will also be encouraged to use PPEs everytime when handling petro-chemicals and other hazardous materials.

N. Occupational Health and Safety

N1. Health and safety hazard

593. *Mitigation measures:* Transportation of machineries and equipments from the ship to the site; their installation/erection; lifting of heavy materials; handling of hazardous materials, working at heights and other construction-related activities may lead to casualties or deaths of the workers. Proper health and safety training on hazard identification, handling of hazardous material and equipments, and training of staff who can potentially come into contact with the material to avoid damage and prevent exposure before starting decommissioning and construction activities, as detailed in Vol. 4 OHSE. They should also use the appropriate PPEs during construction activities.The health and safety officer, entrusted with worker's safety, must ensure that the equipments and safety control mechanisms are working properly before the workers start their work. In case of the discovery of faulty equipments and safety harness, they must be replaced promptly. They must also ensure workers hygiene and health status. An on-site medical team will be set up and emergency first-aid medical kit will be available in case of any accidental injuries (burns, cuts, broken bones etc.). They will also conduct monthly health check up to check the worker's health condition and provide appropriate treatment for any ailments.

N2. Fire hazards

Mitigation measures: All arc welding and cutting operations shall be shielded by noncombustible or flameproof screens which will protect welders and other persons working in the vicinity from the direct rays of the arc. In addition, the welders should use (i) hand shields to protect against flashes and radiant energy, (ii) see his skin is covered completely to prevent burns and other damage by ultraviolet rays, (iii)Welding helmets shall be free of leaks and openings, and free of highly reflective surface, and (iv) welding trucks shall be equipped with approved fire extinguishers and first aid.

P. Solid Waste Disposal

P1. Storage area and visual effect

594. *Mitigation measures:* Unplanned disposal of old and used equipments and other solid wastes can lead to poor aesthetic view. Moreover, spillage and leakage from improper storage can result in contamination of soil. During construciton, rubbles generated from the construciton site will be stored in approriate bins/skips; will be well-covered and later buried in an approved landfill sites. All solid wastes generated from the decommissioning and construction site, both hazardous and non-hazardous, will be disposed off in on-site asbestos pit and a designated space, respectively. Food waste and other bio-degradable waste, generated by workers and power plant staff memebers, will be placed at designated site prior to final collection and disposal by local municipality.

8.4.3 Operation Phase

T. AMBIENT AIR

T1. Maximum ground level concentration of air pollutants

595. *Mitigation measures:* The present repowering of Unit 4 will reduce emission of criteria pollutants (NO_2, CO, $PM_{2.5}$, and PM_{10}). Built-in Low-NO_x burner in GT will reduce the NO_x emission below 25 ppmv. All modern GT manufacturers give the guaranty of having NO_x less than 25 ppmv with their dry low-NO_x burner. BPDB will take initiative at the policy level to limit the emission of NO_2 of the adjacent Aggreko Rental Power Plant . This Power Plant is the most polluting source in the airshed due to their low height stacks (3 m) and requires to raise their stacks either individually or collectively for reducing the generated heat wave to the adjacent areas as well as reducing NO_x level to the sensitive receptors.

U. AMBIENT NOISE

U1. Noise level

596. *Mitigation measures:* Based on the measured and predicted noise level from the plant operation, it has been confirmed that elevated noise levels are observed and predicted at sensitive receptors. Based on the baseline noise measurements presented in Table 6-3 and forecasted noise leval at selected receptors (Table 7-24), it is observed that noise levels exceed both ECR 1997 and WHO Guidelines. Higher noise level can lead to hearing complexity and loss along with increased blood pressure; disturbances and discomfort to the technicians, workers and surrounding communities. The machines/ equipments/vehicles, which are not is use, will be turned off to limit noise generation. Install acoustic enclosures for equipment (turbines, pumps, fans etc.) casing radiating noise. Noise attenuation measures (barriers such as brick walls and thick vegetation) are recommended around the RMS and gas pipes, to limit ambient noise at plant property lines, especially where sensitive noise receptors are present. In Section 7.8.6, it is indicated that with noise barriers noise levels comply with ECR 1997 and WBG Guideline values in most of the receptors. However, exceedance of noise standard values are still expected in some receptors. Therefore, it is receommended to conduct periodic noise monitoring during operation. If the monitoring found constant exceedance of the noise standards, additional noise measures will be considered and implemented. Workers working inside the power plant must use appropriate PPEs (soundproof earpiece, mufflers etc.). Replace two doors in the control room and install proper insulation in other doors and windows of the control room to attenuate noise to the ECR 1997 recommended level.

V. WATER BODIES

V1. Pollution of receiving water bodies

597. *Mitigation measures:* Sludge generated from the chemical assisted raw water at pretreatment, water, and effluent treatment plants may impact groundwater quality and receiving water bodies if come in contact to untreated sludge**.** Construction of a leak-proof sump will be made to store sludge temporarily and limit the spills. Effluent will then be transferred to sludge treatment plant for treatment. The sump will be monitored and maintained by GPS chemists and technicians and ensure the quality of effluent and spill control.

598. GPS through their waste treatment action plan will practice the following to reduce the generation of other waste and subsequent treatment:

- Establish waste management priorities at the outset of activities based on an understanding of potential Environmental, Health, and Safety (EHS) risks and impacts and consider waste generation and its consequences;
- Establish a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes;
- Avoid or minimize the generation of waste materials, as far as practicable;
- Recover and reuse when waste generation cannot be avoided; and
- Treat, destroy, and dispose of waste in an environmentally sound manner, when cannot be recovered or reused.

599. If waste materials are still generated after the implementation of feasible waste prevention, reduction, reuse, recovery and recycling measures, waste materials will be treated prior to disposal. Selected management approaches should be consistent with the characteristics of the waste and DoE regulations, and may include one or more of the following:

600. On-site or off-site biological, chemical, or physical treatment of the waste material to render it nonhazardous prior to final disposal

601. Treatment or disposal at permitted facilities specially designed to receive the waste. Examples include: composting operations for organic non-hazardous wastes; properly designed, permitted and operated landfills or incinerators designed for the respective type of waste; or other methods known to be effective in the safe, final disposal of waste materials such as bioremediation.

V3. Thermal plume in receiving water bodies

602. Close cycle cooling system in Unit 4 will reduce the thermal plume in Shitalakhya River. However, other units in GPS will continue discharging warm water and thermal plume from other operating units of GPS will be non-compliant to WBG Guidelines. Therefore, it is recommended that BPDB consider a combined close cycle cooling system for all current and future units to bring the plant in compliant to WBG Guidelines in thermal plume discharge.

Y. Risks and emergency

Y3. Corrosion of gas pipes

603. *Mitigation measures*: The pipeline will be coated using 3 layer polyethylenes (3 LPE). Buried pipes and fittings shall be protected against corrosion by means of external coating and wrapping. Holiday detector shall be used to detect any holiday and shall be repaired. Cathodic protection test points shall be installed and connected to temporary cathodic

protection facilities in accordance with the specification as the final operation of lowering or tieing-in is in progress. The installation shall require inspection before back-fill is placed.

Y4. Gas compressor fouling

604. *Mitigation measures*: A cleaning regime in Bangladesh would be a combination of on-line cleaning and semi-annual off-line washing. On-line cleaning is intended to avoid the build-up of a layer of dirt. The first measures to be implemented after the start of commercial operation should include daily washing of the compressor with fully demineralized water. As the unit accumulates more operating hours, the owner will have to decide whether an optimum cleaning interval can be achieved by taking into account all possible influences. The on-line nozzle system comprises nozzles that are mounted on the inner cone upstream of the spider which supports the compressor bearing in the casing. The hollow cone spray nozzles in the on-line nozzle system generate a water spray that covers the full airfoil height. On-line nozzles are connected to a distribution ring line mounted in the inner cone.

605. Off-line cleaning with an appropriate cleaner will result in more intensive cleaning at crank speeds. Depending on the kind of fouling, the cleaning cycle can be repeated to improve the cleaning effect with the aim to achieve a further increase in output and efficiency. If practicable under the existing operating conditions, off-line cleaning should be performed once per month or on appropriate occasions (but at least 4 to 6 times per year). The off-line nozzle system comprises the nozzles that are mounted on the inner cone upstream of the spider that supports the compressor bearing in the casing. The spray nozzles in the off-line nozzle system generate a water spray, which covers the full airfoil height. Off-line nozzles are connected to a distribution ring line mounted in the inner cone.

Y5. Gas pipeline leak

606. *Mitigation measures*: Separate welded joint sections of the pipeline shall be tied into a continuous system in such a manner that no stress will be induced into the pipe as a consequence of the tieing-in operation. The pipeline shall be commissioned following hydrostatic testing, pigging and dewatering. All installation facilities shall be purged with Nitrogen prior to commissioning and provision shall also be made for Nitrogen to be used in the pipeline commissioning phase. Upon completion of the commissioning and appropriate reinstatement and clean up of the ROW including installation of cathodic protection test points, ROW markers and aerial markers etc in accordance with the programme and procedures, to the satisfaction of the engineer, the pipeline system will be taken over for operation by the company.

Z. SOCIAL IMPACTS

Z3. Availability of irrigation water

607. *Mitigation measures:* In Unit 4 repowering, close cycle cooling is recommended. In addition, all future repowering projects may follow the same recommendation, which would mean that condenser cooling water supply for irrigation may not be made available. This is detrimental to the current irrigation practices in the project area. Under the close cycle cooling the water demand from Shitalakhya River will be significantly reduced and some of the pumps may become redundant. Considering, the severance of the issue and the significant benefits to the communities, it is recommended that one pump will be dedicated for the irrigation water for at least three years of project operation. GPS should coordinate with BADC to handover the pumps and watermain for irrigation services. The operation and maintenance costs after three years should be borne by BADC.

9. Environmental Management Plan

608. The Environmental Management Plan (EMP) includes several plans for implementing mitigation and enhancement measures, emergency response, occupational health and safety, and Environmental Code of Practices. Generally, the impacts, which are minor or moderate, are to be mitigated by adopting Environmental Code of Practices (ECP) and Contractor's good practices during project implementation. On the other hand, impacts and risks which are critical or major will be mitigated or prevented by adopting mitigation measures discussed in Chapter 8 and specific plans discussed in this Chapter.

9.1 Objectives of EMP

609. The basic objective of the EMP is to manage adverse impacts of project interventions in a way, which minimizes the impacts on the environment and people of the Project area. The specific objectives of the EMP are to:

- Facilitate the implementation of the mitigation measures identified during the present EIA to comply with regulatory requirements and discussed earlier in the document.
- Maximize potential project benefits and control negative impacts.
- Draw responsibilities for project proponent, contractors, consultants, and other members of the Project team for the environmental management of the Project; and
- Maintain essential ecological process, preserving biodiversity, and where possible restoring degraded natural resources.

610. The EMP will be managed through a number of tasks and activities. One purpose of the EMP is to record the procedure and methodology for management of mitigation and enhancement measures identified for each negative impacts of the Project. The management will clearly delineate the responsibility of various participants and stakeholders involved in planning, implementation, and operation of the Project.

9.2 Various Categories of mitigation measures

611. The EMP includes various categories of mitigation measures and plans: (i) general and non-site-specific measures in the form of environmental codes of practices (ECPs) presented in Annex 9-1 to address general construction and operation matters identified as moderate and minor in significance prior to mitigation in Table 7-4; (ii) project specific and to the extent possible, site-specific mitigation measures discussed in Chapter 8 and summarized in Table 9-2; (iii) Boiler Decommissioning Action Plan to be prepared by the Contractor, and (iv) Construction Environmental Action Plan (CEAP) with site-specific and contract-specific management plans to be prepared by the contractor, which include pollution prevention, occupational health, safety and environment, and emergency response.

9.3 Inclusion of EMP in Contract Documents

612. In order to make the Contractors fully aware of the implications of the EMP and responsible for ensuring compliance, technical specifications in the tender documents will include compliance with mitigation measures proposed in the EIA as well as WBG's General Environmental Health and Safety Guidelines. The Contractor must be made accountable

through contract documents for the obligations regarding the environmental and social components of the project.

9.4 Environmental Code of Practices

613. A set of environmental code of practice (ECPs) has been prepared for various environmental and social management aspects: ECP 1: Waste Management; ECP 2: Fuels and Hazardous Goods Management; ECP 3: Water Resources Management; ECP 4: Drainage Management; ECP 5: Soil Quality Management; ECP 6: Erosion and Sediment Control; ECP 7: Top Soil Management; ECP 8: Topography and Landscaping; ECP 9: Quarry Areas Development and Operation; ECP 10: Air Quality Management; ECP 11: Noise and Vibration Management; ECP 12: Protection of Flora; ECP 13: Protection of Fauna; ECP 14: Protection of Fisheries; ECP 15: Road Transport and Road Traffic Management; ECP 16: Construction Camp Management; ECP 17: Cultural and Religious Issues; ECP 18: Workers Health and Safety, and ECP 19: Construction and Operation Phase Security. The Contractors will be contractually obligated to comply with these ECPs, presented in Annex 9-1.

614. The Contractors will prepare one Boiler Decommissioning Action Plan based on terms and conditions provided in Vol. 3: Boiler Decommissioning Plan and one Construction Environmental Action Plan to address pollution prevention, occupational health, safety and environment, and emergency response including the requirements of ECPs and EMP. These will be reviewed and approved by Owner’s Engineer (OE), EHSU Circle, and PIU before implementation of construction works.

9.5 Environmental Management Plans during Construction

9.5.1 Site Preparation

615. The site preparation would require base stripping, felling of 25 wooden trees and clearance of some bushes. The contractor will prepare a site preparation plan on the basis of ECP 4, ECP 5, ECP 7, ECP 8, ECP 12, and ECP 13 to ensure safeguarding of environment. This plan must be submitted to OE for review and approval.

9.5.2 Boiler decommissioning plan

616. One of the major components of the proposed repowering is decommissioning of the existing boiler. Asbestos containing materials (ACM) are available in the insulation material of the boiler and associated steam pipes. Therefore, environmental safeguard including control of asbestos contamination has to be ensured. A detail Plan of boiler decommissioning, asbestos handling and safety operation has been prepared and provided in Volume 3: Boiler Decommissioning Plan. The general principle on which the boiler decommissioning plan is based on is safe handling and disposal of asbestos and safety procedure. ‘Wet removal’ approach will be strictly applied during removing of asbestos containing insulation from boiler and steam pipes. In general the plan includes the following:

- Preparedness for removing ACM
- Measures to avoid soil and water contaminations, i.e., confining the boiler area with water proofed barrier, polythene sheet cladding to arrest stray asbestos dust, drainage system for managing effluent water (Figure 9-1)

- Measures to avoid air pollution, i.e., use of thick plastic sheet to confined the boiler structure, water spray system, concrete water proof system for collected sprayed contaminated water, asbestos contaminated water collection system, treatment and final disposal of effluent water (Figure 9-1)
- Asbestos disposal plan
- Code of Practices for Asbestos Handling, Removal and Disposals
- Procedure of permits to work
- Safety measures for personnel
- Process of Dismantling of boilers
- Managing Asbestos in Working Place
- Monitoring Plan (continuous groundwater monitoring using monitoring well and periodic soil quality using borehole samples)

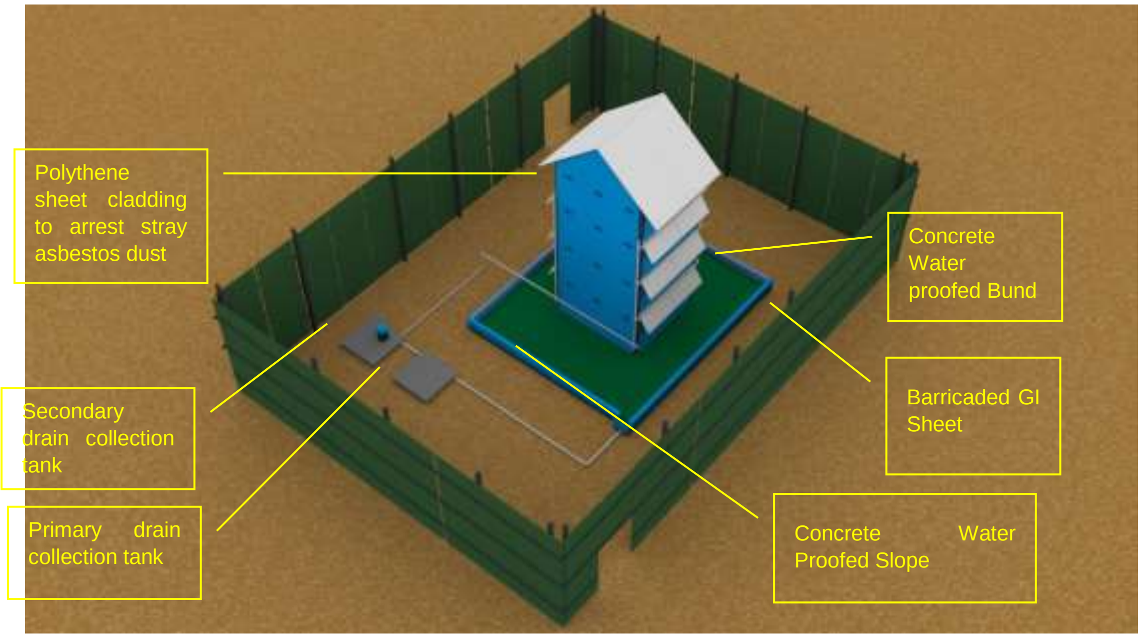


Figure 9-1: Asbestos removal preparedness during Boiler Decommissioning

9.5.2.1 Statutory Requirements

617. The statutory clearances are required before starting Decommissioning work of Boiler. Statutory compliance shall be divided into two broad categories:

- Owner’s statutory requirements
- Contractor’s statutory requirements

618. Detailed list of permits required covered in the full report presented in Volume 3.

9.5.2.2 Safety Preparation before starting removal of Asbestos

619. During decommissioning of boiler first activity will be removal of insulation from main boiler and steam piping. The unit was installed in year 1989, insulations contain asbestos containing material. Hence, due precautions are required to be implemented before starting removal of asbestos. Following implementation measures are explained in detailed in the full report.

- Asbestos related health risks.
- Measures to avoid soil contamination
- Measures to avoid Air Pollution.
- Measures to avoid Noise pollution.
- Base line data collection.

9.5.2.3 Pre- Requisite before taking Dismantling of Boiler

620. Before taking up actual dismantling of boiler all necessary perquisite were covered in report along with responsibility matrix, mainly,

- Minimum permits requirement
- Development of the mass balance and disposal concept(s)
- Development of dismantling strategy
- Detailed Engineering study
- Tender document preparation and floating of enquiry
- Awarding decommissioning contract.
- Safety requirements during entire Decommissioning process.

9.5.2.4 Dismantling of Boiler

621. As existing boiler becomes redundant and has to be demolished and removed. Once the boiler decommissioned same area will be utilized for installation of HRSG. Main parts of the boiler are,

- Heavy oiler drum
- Economizer
- Water tubes
- Steam pipes
- FD, ID & recirculating Fans
- Chimney
- Air ducts, etc.
- Insulation sheets and material

622. The boiler parts mentioned above and its auxiliary systems shall have to be removed one by one, and stored at designated site(s). The last item is the demolishing of the foundations.

623. It is estimated that time required to implement the demolishing and removal of the existing boiler will be critical. The implementation and inter - connection of existing Steam Turbine with the Heat Recovery Steam Generator. Dismantling should be so synchronized that the site is clear as scheduled and steam pipes to and from turbine are cut and isolated at the entrance point of turbine hall to be welded with the new pipes from HRSG.

624. It is necessary to adopt very careful handling of the dismantling sequence and removal of heavy parts safely. Considering these a sequence of dismantling the existing boiler has been prepared. The sequence has shown interrelated activities in critical path.

9.5.2.5 Asbestos handling, asbestos removal standards

625. Asbestos is recognized as a cause of various diseases and cancers and is considered a health hazard if inhaled. Therefore, it is very important to implement necessary precautions to safeguard workers, ambient air, soil and every effect of it in future.

626. Because of the major health risks associated with exposure to asbestos fiber, global health and worker organizations, research institutes, and some governments have enacted bans on the commercial use of asbestos and they urge the enforcement of national standards to protect the health of workers, their families, and communities exposed to asbestos through an International Convention.

627. The full boiler decommissioning plan report lists all important international standards and details of International Convention held for working with Asbestos.

9.5.2.6 WBG's Approach to Asbestos Health Risk

628. The WBG's General EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice.

629. The WBG's EHS Guidelines specify that the use of ACM should be avoided in new buildings and construction or as a new material in remodeling or renovation activities. Existing facilities with ACM should develop an asbestos management plan that clearly identifies the locations where the ACM is present, its condition, procedures for monitoring its condition, procedures to access the locations where ACM is present to avoid damage, and training of staffs who can potentially come into contact with the material to avoid damage and prevent exposure.

630. The plan should be made available to all persons involved in operations and maintenance activities. Repair or removal and disposal of existing ACM in buildings/industry should be performed only by specially trained personnel following host country requirements or, if the country does not have its own requirements, internationally recognized procedures. Decommissioning sites may also pose a risk of exposure to asbestos that should be prevented by using specially trained personnel to identify and carefully remove asbestos insulation and structural building elements before dismantling or demolition.

9.5.2.7 How to manage and control Asbestos in work place

631. The Code of Practice on how to manage and control asbestos in the workplace is an approved code of practice of the Workplace Health and Safety Act (the WHS Act).

632. An approved code of practice is a practical guide to achieving the standards of health, safety and welfare required under the WHS Act and the Workplace Health and Safety Regulations (the WHS Regulations).

633. A code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice would achieve compliance with the occupational health and safety duties in the WHS Act, in relation to the subject matter of the code. Like regulations, codes of practice deal with particular issues. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

634. The full report covers in detailed the following aspects of how to manage asbestos related risk:

- Managing risk associated with asbestos.
- Asbestos register
- Asbestos management plan
- Managing other asbestos related risks
- Managing exposure to the asbestos
- Controlling the risk.
- Sampling process
- Examples of warning signs and labels
- Templates on asbestos register

9.5.2.8 Asbestos Management Plan

635. GPS management must ensure that a written asbestos management plan is prepared for the facility, which can be applied during decommissioning and dismantling of boiler, construction of asbestos pit, managing existing asbestos burial site, etc. The identification of asbestos or asbestos containing material has to be done before starting Boiler Decommissioning and updated as the work proceeds.

636. The asbestos management plan must be maintained to ensure the information is up-to-date. The full report covers detailed procedure and practices for asbestos management plan.

9.5.2.9 Asbestos Disposal Procedure

637. In the EIA study, it is recommended that due to the absence of specialized contractor to handle ACM in Bangladesh, an on-site asbestos disposal pit is developed with sufficient capacity to accommodate all ACM generated from current and future repowering and plant refurbishment work. There exists free space at the jetty site for disposal of asbestos. A pit will be designed and constructed for disposal of present operating plant, asbestos generated during repowering of Unit 4 and 3, to accommodate any future disposal need.

638. Asbestos handling and disposal procedure, packaging and labeling and documentation procedure, precaution to be taken during transportation are covered in Vol. 3: Decommissioning Plan.

639. Based on the Unit 4 EIA ToR, approximately 50 tons of asbestos exists in the boiler insulation materials. The Consultant after spending substantial time in GPS library identified some old erection report of Unit 4 and estimated the existence of about 17.65 tons of asbestos, however, this is a partial list of the asbestos in Unit 4 boiler.Considering the total amount referred in the TOR, the decommissioning of Unit 4 boiler may produce 50 tons and repowering of Unit 3 will also generate similar quantity and in future other Units may also be repowered and as a result more asbestos containing material (ACM) will be generated. Presently, some hazardous waste (including asbestos) has been buried and placed two meter below the top soil in the form of trench. The trench has concrete pad at the bottom but no synthetic liners are placed and there are neither storm water diversion channels nor any arrangement for collection and treatment of the leachates. Therefore, it is essential that all these issues require consideration while developing an on-site asbestos pit. Since, the total quantity of asbestos containing material is unknown, it is recommended that boiler

decommissioning contractor shall study carefully the ACM in the boiler and in consultation with GPS make the final judgement on the capacity of on-site asbestos pit.

9.5.2.10 Asbestos Disposal Location and Arrangement

640. In the EIA study, it is recommended that due to the absence of specialized contractor to handle ACM in Bangladesh, an on-site asbestos disposal pit is developed with sufficient capacity to accommodate all ACM generated from current and future repowering and plant refurbishment work. There exists free space at the jetty site for disposal of asbestos (Figure 9-2).

641. A pit of required capacity will be constructed for disposal of ACM. There will be three compartments to accommodate all ACM. One compartment will be reserved for operating plant waste.

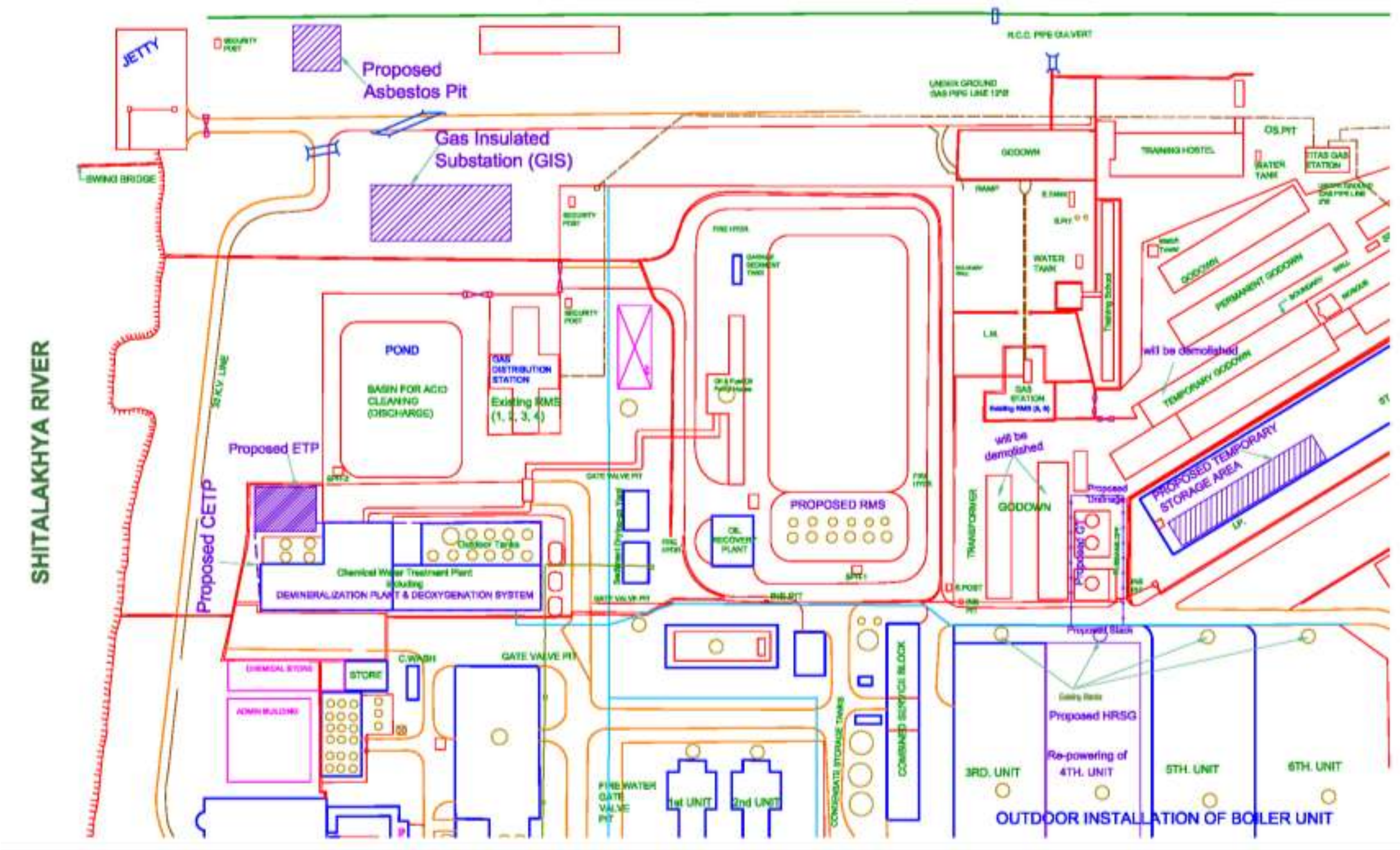


Figure 9-2: Proposed plant layout with the location of asbestos disposal pit (top left corner)

642. Typical design for Asbestos pit is shown in Figure 9-3. As the location of the pit is close proximity to the river it is recommended to have “Double Composite Liner”, while designing the pit. Third pit for operating plant solid disposal may be designed as single composite wall lining (Figure 9-4), to economize the investment cost.

643.

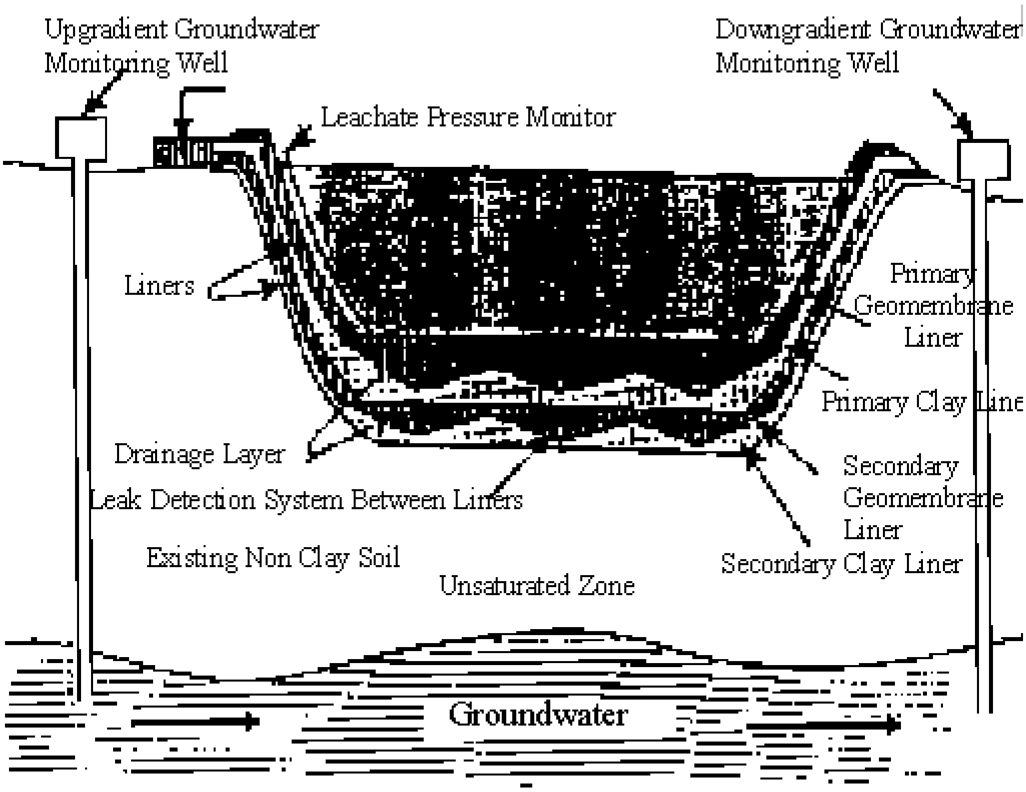


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Figure 9-3: Pit with double composite liner

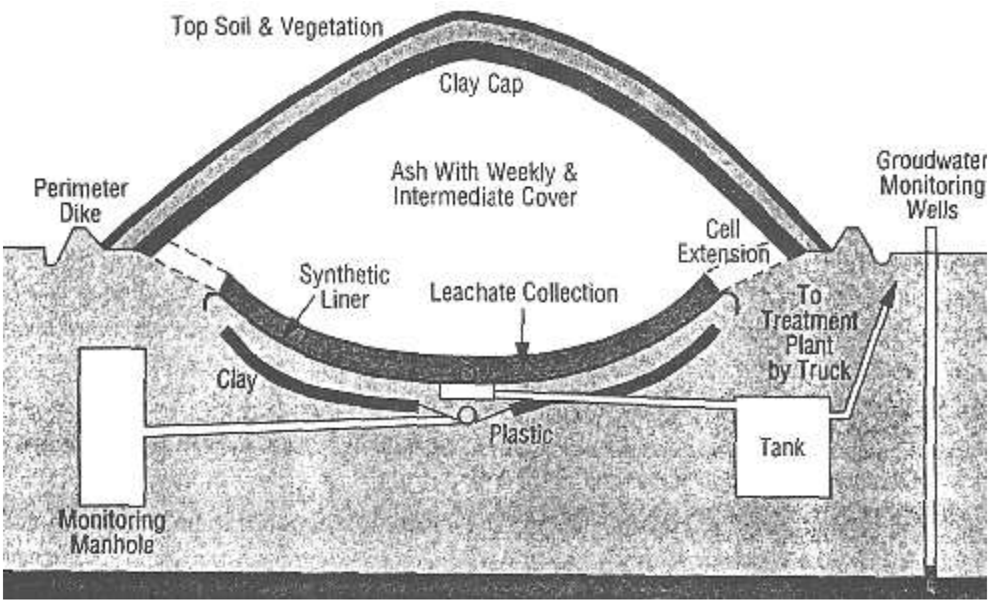

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Figure 9-4: Single Composite Wall Liner Land Fill

646. Department of Environment Bangladesh has no asbestos handling and disposal standards especially for secured asbestos disposal and landfill. As Bangladesh has rivers

flowing all over and especially Shitalakhya River is close to Ghorashal plant the water table is quite high. Similar situation is observed in countries like the Netherlands as it is located at sub sea level. Hence, it is advisable to follow Standards of Asbestos Waste Disposal of the Netherlands.

9.5.2.11 Occupational health and safety during asbestos management

647. The full report on boiler decommissioning covers in detail the workers' occupational health and safety procedures at work place while handling ACM. Necessary International standards are also referred in the report. The following are few of the highlights on the occupational health and safety procedures while managing asbestos:

- All employees must wear respiratory protection on-site during the preparation of work areas for asbestos removal.
- The respiratory protection must have a minimum protection factor of 50, and be approved by NIOSH for protection against asbestos.
- When using respirators, follow the procedures of the equipment manufacturer
- Employees shall be properly trained about using and fitting of respirator.
- The respirator must be fitted so that there is an effective seal between the respirator and the employee's face.
- Where practicable, assign a respirator to an employee for the employee's exclusive use.
- Reusable respirators must be cleaned, disinfected and inspected: after use; at least once each shift.
- When not in use, maintain and store reusable respirators in a clean and sanitary location.
- Respirator shall be provided by the employer.
- Every employee who enters the work site; consists of full body covering, including head covering, with snug fitting cuffs at the wrists, ankles and neck, (disposable coveralls are strongly recommended).

648. Following special precautions will be taken for workers inside the removal area:

- Eating, drinking, chewing or smoking inside the change room, shower room, hall ways, storage room(s) or removal area are strictly prohibited.
- Complete decontamination is required prior to eating, drinking, chewing or smoking when come out of working area.
- Respiratory protective equipment is not removed inside the asbestos work area.
- Employees take coffee breaks and have lunch in an area completely separate from the asbestos removal area.

649. The following medical check-up of workers will be conducted during boiler decommissioning:

- Employees shall be periodically checked for asbestos effect.
- If an employee found affected by asbestos he shall be immediately stopped working in asbestos removal area and necessary treatment shall be extended to him.
- Employee's family shall be periodically checked for asbestos effect.
- Provide proper medication to every employee such as tonic tablets, etc. during execution of work.

9.5.2.12 Schedule of Plan and Sequence of Dismantling of the Existing Boiler

650. Schedule of plan and sequence of dismantling of the existing boiler are presented below:

Sl	Activities	Duration input in Months					
		1	2	3	4	5	6
1	Remove the insulation from all around the boiler and store them at the designated place						
2	Disassemble the air duct, bring down and store them at the designated place						
3	Disassemble the Gas recirculation duct/ gas duct, bring down and store them at the designated place						
4	Disassemble the RAH, bring down and store them at the designated place and remove the foundation						
5	Disassemble and remove the chimney and remove the foundation						
6	Remove the FD fans, ID fan & Gas recirculation Fans and store them at the designated place and remove the foundation						
7	Disconnect all pipes to and from the boiler drum						
8	Disconnect the down corner pipes from boiler drum and from water wall headers down and bring them down and store them at the designated place						
9	Bring down the boiler drum and store them at the designated place						
10	Disconnect the feed water pipe from the economizer with proper support						
11	Dismantle, bring down the economizer and store them at the designated place						
12	Disconnect the miscellaneous pipes						
13	Disconnect interconnection between headers of different super heater coils and reheater coils						
14	Disconnect the Main Steam pipes line, reheater inlet and outlet pipe lines providing proper supports						
15	Remove the ceiling super heater and store them at the designated place						
16	Remove the other super heater coil (SH & RH) and store them at the designated place						
17	Remove the Boiler condenser (Right & Left) and store the designated place						
18	Remove the Steam desuperheater (Right and Left) and store at the designated place						
19	Remove the water walls and store them at the designated place						
20	Remove the scaffoldings, stairs etc and store them at the designated place						
21	Remove the supporting structures, if necessary and store them at the designated place						
22	Remove the foundations of Boiler, if necessary.						

9.5.3 Construction Environmental Action Plan

The following are some of the plans proposed in this EMP to guide the Contractor to prepare a Construction Environmental Action Plan (CEAP). The Contractor will expand the plan to address site specific measures.

9.5.3.1 Erosion, sediment and drainage control plan

651. An Erosion, sediment and drainage control plan will be necessary to manage rainfall run off in the construction site. This plan will be prepared by each contractor on the basis of ECP 4 and 6, and the mitigation measures given in EIA. The Plan will be submitted to the OE for review and approval before contractor mobilization.

9.5.3.2 Pollution Prevention Plan

652. Pollution Prevention Plan will be prepared and implemented by the Contractor on the basis of ECP 1, ECP 2, ECP 11, and WBG General EHS Guidelines (2007), as well as the

mitigation plans given in EIA. The Plan will be submitted to the OE for review and approval before contractor mobilization.

9.5.3.3 Waste Disposal and Effluent Management Plan

653. Waste Disposal and Effluent Management Plan is mandatory to manage the construction waste and effluent including waste and effluent from labor sheds. A detail plan will be prepared and implemented by the Contractor on the basis of ECP 1, ECP 4, and WBG EHS Guidelines (2007), as well as the mitigation plans given in this EIA. The Plan will be submitted to the OE for review and approval before contractor mobilization.

9.5.3.4 Traffic Management Plan

654. During construction a number so vehicle will be running from/to construction site. To avoid the impacts of this additional traffic there must be a management plan for traffic operation. A detail plan will be prepared by each Contractor on the basis of ECP 15 and also the mitigation plans given in this EIA, after discussion with PMU and authorities responsible for roads and traffic. The Plan will be submitted to the OE for their review and approval before contractor mobilization. The OE will facilitate the integration and coordination of the plans prepared by various contractors to prepare an overall Plan.

9.5.3.5 Borrow Area Management and Restoration Plan

655. An environmental plan for management and restoration of borrow areas will be prepared by the Contractor on the basis of ECPs 8 and 9 and other requirements described in the mitigation plans. This Plan will aim at minimizing the environmental and social impacts during borrowing activities and restoring as much as possible the original natural situation of these sites by various measures (refill, levelling or smoothening). Restoration methodologies will be included in the Plan. The Plan will be approved by the OE and PMU.

9.5.3.6 Drinking Water Supply and Sanitation Plan

656. A Separate water supply and sanitation provisions might be needed for the temporary facilities, labor camp and workshops, in order not to cause shortages and/or contamination. A Plan will be prepared by the Contractor on basis of ECP 3. The Plan will be submitted to the OE for review and approval before contractor mobilization.

9.5.3.7 Good Handling and Operation of Construction Equipment

657. The equipments and machinery from construction activities should be handled and operated in a way that would ensure low noise, low emission of SOx, NOx, smoke, no oil leaks, no accidental event, etc. A detail plan of handling and operation of construction equipment will be prepared by each Contractor on the basis of ECP 2, 10 and 11. The Plan will be submitted to the OE for review and approval before contractor mobilization.

9.5.3.8 Fuel and Hazardous Substances Management Plan

658. The plan will be prepared by each Contractor on the basis of ECP 2 as well as the mitigation plans given in this EIA and in accordance with the standard operating procedures, relevant guidelines, and where applicable, material safety data sheets. The Plan will include the procedures for handling oils and chemical spills. The Plan will be submitted to the OE for review and approval before contractor mobilization.

9.5.4 Communication Plan

659. A communication plan has been prepared and presented in Table 9-1 While carrying out the communication plan modifications of process and planning may be done as per the projects requirement.

Table 9-1: Communication Plan Adopted for the Project

Stakeholder	Information/Message	Communication Means	Timing/Frequency	Responsibility
PAPs	Project awareness (general project information, etc.)	Consultations	Scoping session in the preparation of Draft EIA	EIA Consultant, supervised by Project Implementation Unit (PIU)-BPDB
	Project findings (environmental and social concerns)	Disclosures: World Bank through Info seek website; DoE through presentation; public through BPDB website and formal consultations	Immediately after preparation of Draft EIA	EIA Consultant, WB, BPDB, supervised by PIU
	Employment opportunities	Government procedure: for new recruitment at AE position informed public by TV, radio, newspaper (English / Bangla); for others, BPDB internal system.	4 weeks before recruitment / job opening	PIU, BPDB
	Implementation of Repowering Project	Consultations	At the start of re-powering plant implementation and boiler decommissioning	EPC, OE, independent monitor, supervised by PIU-BPDB
	Operation of the proposed Plant (grievance redress)	Consultations	At the commissioning of the Plant	Independent monitor, supervised by PIU-BPDB
General population (Local)	Skilled and unskilled labour employment opportunities	Poster, local daily newspaper	3 to 4 weeks before recruitment	PIU-BPDB
Fire Service	Incidents of disasters	Telephone, cell phone	Immediately when any incident is detected	Shift Engineer (PIU)
Police Station	Incidents of disasters and security issues	Telephone, cell phone	Immediately when any incident is detected	Shift Engineer (PIU)

9.6 EMP during operation phase

660. With reference to the possible significant environmental impacts during operation stage identified in Chapter 7, impact specific Environmental Management Plans have been prepared to address those impacts. The plans are prepared on the basis of mitigation measures proposed in Chapter 8. In the following sections these plans are discussed.

9.6.1 Wastewater Management

661. Presently rejected water, sludge and slurry from different water treatment plants (e.g. coagulation, clarification, demineralization, etc.) are drained to a central neutralization pond for neutralization and disposal. A Central Water/Effluent Treatment Plant (CETP) is proposed for Unit 4 repowering to treat raw and effluent water generated from Unit. The CETP will include a central Effluent Treatment Plant, Sludge and Slurry Treatment Plant, Sludge and Slurry disposal system, Treatment facilities for feedwater using environment friendly oxygen scavenger (e.g., Helamin, Sodium Erythorbate) and demineralization water using reverse osmosis process, domestic waste water treatment facilities, etc. The Contractor will design the plant according to the type, characteristics, quantity, and regulatory guideline of DoE and WBG EHS Guidelines on Water and Sanitation. All waste water generated from various processes of Unit 4, and liquid wastes will be treated in the CETP before discharging or disposing to the natural environment.

662. BPDB may consider increasing the capacity of the CETP to treat raw and effluent water of other units of GPS and nearby industries, and Power Plants by charging a fee to others. BPDB may take this matter to the policy level with the support of DoE.

9.6.2 Solid waste management

663. GPS shall develop a waste prevention strategy, which will significantly reduce the total amount of waste. The strategy will focus on recycling and the facility wise implementation of recycling plans, considering the following items (as per WBG Guidelines):

- Evaluation of waste production processes and identification of potentially recyclable materials
- Identification and recycling of products that can be reintroduced into the operation of the plant
- Investigation of external markets for recycling by other power plant operations located in the neighborhood or region of the facility (e.g., waste exchange)
- Establishing recycling objectives and formal tracking of waste generation and recycling rates
- Providing training and incentives to employees in order to meet these objectives.

9.6.3 House keeping

664. GPS should implement a good house-keeping practice, such as the sorting and placing loose materials or demolition debris in established areas away from common workspace, cleaning up excessive waste debris and liquid spills regularly, locating electrical cords and ropes in common areas and marked corridors.

9.6.4 Occupational health safety and environment

665. A detail Occupational Health, Safety and Environment (OHSE) Plan has been prepared and presented in Volume 4. The Plan includes the following:

- Occupational Hazard Identification and Control Plan
- Inspection and Auditing Plan
- Leadership and Administration Plan
- OHSE Communication Plan
- Required PPEs
- Site Security Plan
- HSE Program for the Contractors/Sub-Contractors
- Preventative Maintenance Plan
- Incident Investigation Mechanism
- Safe Work Practices and Procedures.

666. The plan has been prepared in a way, which will be applicable for entire life cycle of the project. Application of the OHSE plan is responsibility of all including management, employee, contractors, sub-contractors, vendors in their daily activities. The plan also proposes a management and administration system (organogram) for OHSE Plan application. It is suggested that BPDB develops an OHSE Management System program activities and commitment and ensure the program are implemented during each phases of the repowering project. Table 9-2 presents OHSE management systems and key responsibilities, for detailed information specific Section number in the detailed report are referenced.

Table 9-2: OHSE Management Systems and key responsibilities register

OHSE program activities **EHSU Manager-BPDB** **(to implement)**	**OHSE program activities** **Superintendent Engineer –BPDB** **(to ensure)**	**Employees** ***(Includes EPC and other contractors)*** ***(to follow)***
1. Policy and commitment		
Make a draft OHSE Policy for Project director for approval (Guideline-refer to Section 2)	• Communicate policy. • Provide leadership in line with policy commitments. • Assess any changes to organization structures, activities, processes, etc. for OHSE implications.	• Feedback ideas for changes to policy. • Understand policy and follow intent. • Follow OHSE processes.
Collate changes and publish.	• Assist with important changes.	
2. Legal & other requirements (Guideline-Refer to Section 1.4 and Section 1.5, Vol. 4)		
Monitor legal requirements and produce a monthly report to communicate relevant changes to the business.	• Implement actions required to ensure legal compliance. • Communicate requirements, including any changes to work programs or practices, to staff.	• Follow procedures, work instructions etc. as these should be in compliance with legal and other requirements. • Report issues where procedures / work instructions may not be in compliance with legal requirements to Manager or OHSE representatives.
Develop corrective and preventative actions to ensure that relevant changes to legal requirements are incorporated into OHSE documentation.		
Update OHSE processes.	• Assist with important changes.	
3. Hazard identification & risk management (Guideline- Refer to Section 7 and chapter 10 of EIA report)		
Coordinate strategic risk assessment process within lines of business.	• Ensure risk assessments are carried out and registers are updated. • Understand key risks and mitigation measures.	• Understand key risks and mitigation measures relevant to their own areas. • Report new risks and hazards. • Participate in risk reviews. • Report potential gaps in controls.
Facilitate Site Hazard Register development and maintenance.	• Coordinate Site Hazard Register development and maintenance, including providing adequate resources.	
Provide OHSE technical advice on the development of project risk assessments and plans.	• Ensure controls are in place to control identified risks.	
Provide technical advice on the development of operational risk assessments and plans.	• Coordinate development and implementation of operational risk assessment and plans, including providing adequate resources.	
4. Planning & objectives (Guideline- Refer to Section 3, Vol. 4)		
Coordinate the development of strategic OHSE plans.	• Engage and provide resources to enable strategic assessment and subsequent plans to be developed.	• Be involved in the development and implementation of OHSE objectives, targets and programs.
Advise and propose OHSE objectives, targets and		

OHSE program activities **EHSU Manager-BPDB** **(to implement)**	**OHSE program activities** **Superintendent Engineer –BPDB** **(to ensure)**	**Employees** ***(Includes EPC and other contractors)*** ***(to follow)***
improvement activities.		
Facilitate the development of OHSE programs and advise on OHSE strategy.		
5. Accountability & Leadership (Guideline- Refer to Section 4, Vol. 4)		
Ensure that OHSE accountabilities, roles and responsibilities are clearly documented in OHSE documentation and communicated in OHSE training.	• Ensure OHSE accountabilities and requirements are identified and documented in Work Plans and Position Descriptions. • Lead and support OHSE system requirements. • Provide adequate supervision and leadership to staff (especially new starters).	• Ensure OHSE requirements are understood and met • Participate in the continual improvement of the OHSE system.
6. Awareness, training & competency (Guideline- Refer to Section 5, Vol. 4)		
Coordinate OHSE training needs analysis for the development of a comprehensive training requirements register.	• Conduct OHSE training needs assessment for the team. • Ensure teams' training requirements are communicated to OHSE representatives for inclusion in the OHSE training program.	
Incorporate core OHSE training requirements in the training requirements register.		
Facilitate OHSE training program.	• Understand training and competency requirements for personnel they are responsible for (including contractors).	• Sign up to and attend training. • Understand competency requirements and make sure they are met.
Coordinate and deliver some in house training (e.g. OHSE system training, OHSE inductions, OHSE risk management, etc.).	• Ensure staff (including contractors) are trained and competent to do the work assigned to them.	
Maintain records of training required, training attendance and competencies awarded (via HR).	• Incorporate OHSE training requirements into data management system. • Make people available to attend training. • Ensure records of training and competency requirements, training attendance and competencies awarded are documented within their jurisdiction.	• Provide evidence of prior learning, licences or other relevant competencies required to do the assigned work. • Provide feedback on training suitability and quality.
7. Communication, consultation & involvement (Guideline- Refer to Section 6, Vol. 4)		

OHSE program activities **EHSU Manager-BPDB** **(to implement)**	**OHSE program activities** **Superintendent Engineer –BPDB** **(to ensure)**	**Employees** ***(Includes EPC and other contractors)*** ***(to follow)***
Ensure that management and staff are consulted when changes are made to the OHSE system.	• Ensure staff are consulted when change are made to assets and operations that might effect OHSE policies and procedures.	• Participate in team meetings and communicate/raise OHSE concerns, issues, key learning and wins. • Participate in OHSE policies / procedures review.
Provide monthly OHSE report with key learning.	• Communicate OHSE issues at team meetings (e.g. monthly stats and key learning).	• Engage with and discuss monthly reports and key learning.
Compose and circulate OHSE alerts.	• Respond to OHSE issues / concerns.	
Compose and circulate program newsletters and updates.		• Read OHSE communication items and attend communication sessions.
Communicate changes to OHSE policies and procedures to management.	• Communicate relevant information on OHSE system changes to staff.	
Develop and maintain OHSE Essentials web portal.		
8. Document & record management (Guideline- Refer to section 8, Vol. 4)		
Maintain OHSE documentation, including: • Filing OHSE records such as assessments, plans and reports. • Developing and distributing monthly report for project director. • Developing and maintaining internet sites to enable ease of access to OHSE documents and information • Reviewing and updating OHSE documentation. • Maintaining OHSE documents and records in accordance with OHSE system requirements.	• Ensure resources are available to manage documents and records. • Ensure documents and records are adequately managed.	• Manage documents and records as required.

OHSE program activities **EHSU Manager-BPDB** **(to implement)**	**OHSE program activities** **Superintendent Engineer –BPDB** **(to ensure)**	**Employees** ***(Includes EPC and other contractors)*** ***(to follow)***
Manage OHSE document change requests.	• Ensure area-specific OHSE process requirements are appropriately documented.	• Provide input into development of OHSE documents. • Raise OHSE document change requests where gaps or issues are identified.
9. Assets & operations (Guideline- Refer to Vol. 3: boiler decommissioning plan)		
Administer OHSE operational control processes.	• Identify OHSE risks associated with assets and operations, ensuring they are recorded in OHSE risk registers. • Ensure controls and processes are implemented to adequately manage OHSE risks.	• Be involved in the development of OHSE risk management programs, plans and processes.
Facilitate strategic and operational risk management processes to enable the development and implementation of appropriate control measures.	• Document all monitoring and measuring processes implemented in order to demonstrate that controls are effective.	• Implement / follow OHSE risk control measures.
Provide professional advice to business units on OHSE management and improvement initiatives.		
10. Project management (Guideline- Refer to Section 6, Vol. 4)		
Provide advice and support to project managers in the development and implementation of project OHSE Management Plans.	Project Team Managers: • Ensure that OHSE Risk Assessments are conducted for all projects. • Understand their OHSE accountabilities.	Project Managers: • Ensure that project OHSE management plans are developed and implemented.
Lead and participate in project-related OHSE initiatives.	• Participate in, and inform staff of, project-related OHSE initiatives.	
Ensure other OHSE procedures support project management (e.g. Hazard ID and Risk Management, Audit, Management of Contractors & Suppliers)		
11. Management of contractors & suppliers (Guideline- Refer to section 11, Vol. 4)		
Document process to ensure OHSE risks associated with contractors and suppliers comply with legal requirements (OHSE and Contracts & Procurement	• Ensure process for managing contractors and suppliers are in place and followed. • Ensure relevant personnel are trained in contractor and	• Follow OHSE processes around contractors and suppliers. • Monitor contractor / supplier

OHSE program activities **EHSU Manager-BPDB** **(to implement)**	**OHSE program activities** **Superintendent Engineer –BPDB** **(to ensure)**	**Employees** ***(Includes EPC and other contractors)*** ***(to follow)***
processes)	supplier management, as required (e.g. project managers).	compliance with OHSE system requirements.
12. Emergency preparedness		
Facilitate strategic emergency assessment and planning processes. Guideline- Refer to Emergency management Plan that attached in the EIA report	• Identify potential OHSE emergency situations.	• Understand roles and responsibilities in Emergency Response Plan situations
Provide advice on assessing emergency risk and planning adequate responses.	• Ensure adequate response plans are resourced, developed and maintained • Ensure adequate drills, training and response equipment are resourced, maintained and in place.	• Attend OHSE emergency training and participate in drills. • Be involved in debriefs and response plan improvements.
Facilitate the development of emergency response plans, when required.		
13. Monitoring & measuring (Guideline- Refer to Section 10, Vol. 4)		
Provide data to measure OHSE performance	• Review performance data and agree on improvement programs	
Recommend programs based on review of OHSE performance	• Ensure equipment used to monitor OHSE performance is maintained , calibrated etc people are trained e.g., gas detectors	• Ensure relevant procedures are followed
14. Incident management (Guideline – Refer to Section 15, Vol. 4)		
Provide technical advice on incident investigations and the development of corrective actions.	• Ensure OHSE incidents are reported and investigated as per the procedure. • Ensure root causes are identified and actions implemented to prevent recurrence.	• Complete and submit incident reports for all health, safety or environmental incidents, hazards and near-misses. • Participate in incident investigations as required.
Lead Severity 3 incident investigations. Audit the Incident Management procedure. Analyze incident data to identify trends and communicate them to management.		
15. Audit (Guideline- Refer to Section 9, Vol. 4)		
Develop and facilitate annual internal OHSE audit programs	• Consider audit requirements and nominate projects or processes to be audited.	

OHSE program activities **EHSU Manager-BPDB** **(to implement)**	**OHSE program activities** **Superintendent Engineer –BPDB** **(to ensure)**	**Employees** ***(Includes EPC and other contractors)*** ***(to follow)***
Conduct OHSE audits	• Participate in audits. • Make staff and resources available to auditors. • Develop and implement actions from audits.	• Participate in audits. • Develop and implement actions from audits
Facilitate OHSE certification process (ISO 14001 and OHSAS 18001)		
16. Management review (Guideline- Refer to Section 17, Vol. 4)		
Facilitate OHSE management review processes.	• Conduct OHSE management reviews. • Develop actions and programs aimed at continual improvement of OHSE performance. • Communicate and implement OHSE improvement programs.	• Participate in OHSE management review process through employee representatives attending Executive Safety Team meetings. • Participate in relevant improvement programs.
Provide data analysis and information for OHSE management review processes.		

667. EPC contractors will prepare site specific OHSE plans based on the guidelines provided in the OHSE plan presented in Volume 4 and present to OE and PIU for approval. The plan should address all pertinent issues to create a work place that protects worker health and safety with due respect to the environment, and promote an atmosphere to grow employee learning and opportunity in a way that is fulfilling, recognized and fairly rewarded during decommissioning and construction phase of the project. Table 9-3 presents general expectations from the EPC contractor while implementing the OHSE plan.

Table 9-3: Expectation from the EPC Contactors

Commitment and Leadership	Management shall provide strong visible commitment, leadership and personal involvement in health, safety and the environment. Management shall make available the resources necessary to achieve BPDB's OHSE objectives
Policies and Objectives	Develop and communicate policies demonstrating a commitment to OHSE that is consistent with, and at least equal to, other business aims. Supporting objectives shall be defined, deployed and maintained at all organizational levels
Organization, Resources and Documentation	Define, document and communicate the roles, responsibilities and accountabilities to enable every individual to fulfill their role in improving OHSE performance
Risk Evaluation and Management	Continually evaluate the OHSE risks to the workforce, customers and the environment. Continually evaluate processes and activities for specific hazards- assess potentials, record and control the subsequent risk to a tolerable level.
Planning	OHSE considerations shall be integral to all aspects of business planning or changes in the design, development, purchasing and delivery of our products and services.
Implementation, Recording and Monitoring	Determine and record whether those actions are effective. Activities shall be conducted in accordance with defined standards, and continuous improvement shall be promoted and monitored through active employee participation
Audit and Review	Audits and reviews shall be conducted to verify the implementation and effectiveness of the OHSE Management System and its conformation to this specification.

9.6.5 Thermal Pollution Management

668. On the basis of the findings of the Impact Assessment practice discussed in Chapter 7 and mitigation measures in Chapter 8, closed cycle cooling system is recommended with cooling towers to prevent thermal plume discharge into the river. It is recommended that GPS consider converting all existing once through cooling system to close-cycle cooling system. GPS has already started moving to this direction by including closed cycle cooling in

its new Unit 7. Once repowering is done, Units 1 and 2 will be decommissioned and eventually this will lead to reduction of the thermal load on the river.

9.7 EMP to Address Cumulative Impacts

9.7.1 Air Quality Management

669. The proposed repowering would decrease the emission of NO_x, PM and CO from the Unit 4 of GPS. But, other pollutant emitting industries in the airshed include Agrekko and Max Power Quick Rental, Fertilizer Factories, Brick Fields, etc. Based on cumulative impact assessments of ambient air quality, AERMOD dispersion modelling predicted that both $PM_{2.5}$ and PM_{10} concentrations exceed both ECR 1997 (as amended in 2005) and WHO Guidelines and NO_2 concentration meets the ambient air quality standards marginally. Major contributor of NO_2 is Agrekko Quick Rental. Scientific study[42] available, which indicates that $PM_{2.5}$ concentration in Bangladesh is mostly trans-boundary (secondary pollutants formed from NOx and SOx after chemical transformation in the ambient air).The combustion of gaseous fuels such as natural gas does not produce significant particulate matter. Also, natural gas from Bangladesh is naturally very low in contaminants such as sulfur and is considered sweet. This study conclude that on average 35% of the $PM_{2.5}$ concentration is trans-boundary in nature and can be as high as 67% depending on the season. Therefore, BPDB should take initiative at the policy level to reduce emissions from selected facility. DOE can take action to bring specific facility in compliance. In addition, a trade-off between heavy and low polluting industries should be established with the initiative of DoE. For ensuring a sustainable development and pollution free airshed, some policy intervention and strategic initiatives are very much required. For $PM_{2.5}$, Bangladesh Government should coordinate with Indian Government for a possible joint scientific study on trans-boundary pollution to ascertain cause of high $PM_{2.5}$ concentration.

9.7.2 Noise Management

670. A comprehensive plan for noise reduction and attenuation is required to control ambient noise limit within the permissible level. Therefore, the contractor should develop an integrated plan on the basis of ECP 11. The following mitigation measures have been proposed in Chapter 8 that also need to be considered in the Noise Management Plan:

- Development of a Greenbelt near Army Camp that will separate the Plant area and from the residential areas.
- Rise of boundary wall between Fertilizer Factory and GPS, and also development of greenbelt along the boundary wall
- Replace two doors in the control room and install proper insulation in other doors and windows of the control room to attenuate noise to the ECR 1997 recommended level.

671. In addition, BPDB needs to take initiatives to construct a 3 m high brick wall having capacity of noise attenuation at outer boundary of Power Plant of Agrekko Ltd to buffer noise propagating to nearest community.

[42] Billah, M., Chatani, S., and Sudo, K. (2009); Application of WRF-CMAQ Modeling System to Study of Urban and Regional Air Pollution in Bangladesh, 8th Annual CMAS Conference, Chapel Hill, NC, October 19-21, 2009

9.7.3 Central Water Treatment Plant

672. Presently a number of industries are running around GPS and discharging their effluent into the river. The baseline water quality of Shitalakhya River indicate that the water is already degraded (high BOD, low DO and presence of other pollutants). It is not out-of-subject to mention that GPS has an obligation to treat wastewater complying ECR 1997 before disposing to the river, as Shitalakhya River has been designated as an ecologically critical area by DoE in 2009 among four rivers within the close proximity of Dhaka. Existing water and effluent treatment in Unit 4 is done through individual plant and not in an integrated way. Therefore, it is proposed to develop a Central Water/Effluent Treatment Plant (CETP) for Unit 4 repowering. The CETP will be an integral part of the Environmental Infrastructure of the Unit 4. This CETP will meet ECR 1997 and WBG EHS Guidelines. The CETP will be environmentally sustainable and cost viable system for the collection, treatment and ultimate discharge of effluents from the Unit 4. The CETP will consists of, (a) Rawwater supply and treatment system, (b) Waste water treatment system, (c) demineralization plant, (d) effluent treatment system, and (e) sludge treatment and disposal system.

673. As a law enforcement Agency, Department of Environment may take an initiative at policy makers' level to find a way to build a Central Water Treatment Plant. BPDB may also take initiative of constructing a large scale CETP and commercially offer effluent treatment services to different industries. Government may also invite private partnership to construct possible CETP where the industries would contribute as polluter-pay basis (based on the nature and quantity of its effluent) to the CETP authority for treating their water and effluents.

9.8 Mitigation Plan

674. The mitigation plan presented in Table 9-4 is organized around various project activities and includes various actions identified under the mitigation measures discussed in Chapter 8, define responsibilities for implementation as well as supervision of each action, and also indicate the timing of these actions. Should any changes to the Project design or methods of construction and operation take place, post this assessment stage, the impacts and mitigation measures discussed may need to be revised to reflect such changes to allow the environmental and social implications of these changes to be addressed.

Table 9-4: Mitigation Plan

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
1. DECOMMISSIONING PHASE				
B. Ambient Air B1. Airborne asbestos fiber	Inhalation of airborne asbestos fiber during segregation of hazardous materials and their transportation is injurious to lung leading to lung cancer and other lung diseases or respiration complexity. Skin and eye irritation of the workers may cause due to contact with dust particles.	• Boiler area must be protected by temporary peripherial G.I. Sheet fence of 3m height both for existing boiler and asbestos disposal site for preventing trespasserscome close proximity of the decommissioning site. • The workers should use the appropriate PPEs during decommisioning of existing boiler. • Workers must follow the OHSAS 18000 guideline and observe onsite safety precautions regularly. • Water spraying should be done on all asbestos containing materials in the morning especially before commencing the work and subsequently when required to prevent asbestos particles disperse in the ambient air.	Contractor	Owner's Engineer (OE) and Project Implementation Unit (PIU)-BPDB
D. Water Bodies D2. Water quality	Contamination of nearby water bodies by asbestos containing effluent generated during water spray control airborne asbestos fiber.	• Proper installation of water management system i.e., proofed bund, water proofed slope, water drains and tanks as suggested in the boiler decommissioning plan • In addition, a secondary drain and collection tank will be installed at the outskirt of the primary water bund to prevent water leakage to nearby area • The details of the plan is described in Vol. 3: Boiler Decommissioning Plan	Contractor	OE and PIU-BPDB

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
		• Asbestos containing effluent then pump to the effluent treatment plant for treatment. The treated water will finally be discharged to the river and the collected residual asbestos will be buried in the on-site asbestos pit. •		
E. Soil E2. Soil quality	Contamination of soil by asbestos containing effluent generated during the water spray to control airborne asbestos fiber.	• The existing boiler floor has been damaged in many places. The floor requires repair with concrete layer of three inches thickness with slope towards ID fan side. • After proper curing of concrete and finishing, apply a coat of water proofed layer to prevent water seepage through the floor. • On the perimeter of boiler floor, install a side wall of one foot height. After curing, apply water proofed coat to prevent water leakage on nearby area. • On ID fan side of boiler, construct two concrete tanks side by side of size 6 ft x 6 ft x 4 ft. The concrete base as well as all side walls shall be water proofed. One of these tanks shall be connected with proper double valve to collect asbestos laden effluent.	EPC Contractor	Health and Safety Officer, The Proponent
F. OCCUPATIONAL HEALTH AND SAFETY F2. Occupational health and safety	Injuries leading to casualty or death may be caused from the wrecking activities of the boiler as it involves cutting, grinding, lifting heavy machineries, segregating, working at heights, etc.	• Proper health and safety training on how to handle equipments and hazard identification must be provided to the workers before starting with the decommissioning activities. • The health and safety officer will make sure that the equipments and safety control mechanisms are working properly before the workers start their work. If faulty equipments are identified they must be replaced promptly. • An on-site medical team should be available and emergency first-aid kit should be at hand in case of any accidental injuries (burns, cuts, broken bones etc.). • The workers should use the appropriate PPEs and wear appropriate cloths during decommisioning of existing boiler. • Ensure workers hygiene and health status. Conduct	Contractor and Health and Safety Officer	OE/EHSU

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
		monthly health check up to check their health condition and provide appropriate treatment for any ailments. • The contractors should ensure all type of compliance issues for the workers during the course of the decommissioning and construction process, as per Bangladesh Labour Act, 2006.		
G. Solid waste handling and disposal G1. Hazardous solid waste handling	Generation of hazardous solid wastes from the boiler decommissioning containing mostly asbestos fiber, rock and glass wool in insulation materials. Airborne asbestos particles, rock and glass wool fiber are harmful for human health.	• At first, asbestos containing waste should be segregated from other solid wate before disposal. The contractor will establish the means to prevent any potentialdispersion outside the designated asbestos disposal area during handling and disposal operations. • Place two layers of polythene sheet, approximately 200 µm (0.2 mm) thick for packaging, in the cargo-carrying compartment of the vehicle. • Place ACM carefully on polythene sheet to a height of less than 1 m and completely wrap the articles. Seal with adhesive tape. Packages should be small enough to be handled easily. • Workers must maintain the integrity of leak-tight containers and/or packaging at all times during the handling and disposal operations. • Minimize the release and exposure of asbestos containing waste after placement in the disposal area without compaction of the waste prior to use of cover. • Finally, in presence of the official of BPDB, the asbestos containing disposal site is to be sufficiently covered to ensure complete coverage of the disposed asbestos and prevent re-exposure during continuing disposal operations. During this operation, the worker must follow the guidelines of OHSAS 18001 for hazardous waste management.	Contractor	Health and Safety Officer, The Proponent
H. Social impact H2. Labor migration	Aggravated risks of HIV/AIDS and STI due to the flow of migrant workers.	• Create awareness on HIV/AIDS infection and diseases through a well-designed campaign and implementation plan targeting all risk-prone groups • The migrated worker must respect the local customs and	Contractor	BPDB

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
		rituals • Adopting and carrying out Behavior Change Communication (BCC) among target groups; • Put in place a referral healthcare facility to deal with medical aspects of HIV/AIDS treatment with specialized services; • Diagnose and treat STD/STI and TB through in-house medical facility constituted by the Contractor for workers' safety; • Serious cases of infection may be referred to specialized treatment facilities; • Empowering women through employment in the construction work; • Frequent medical check-up would also be helpful in controlling the spreading of diseases. Emergency medical services and adequate first aid facilities should always be available at the site.		
CONSTRUCTION PHASE				
I. ECOSYSTEM				
I1. Aquatic habitat quality	Impact on aquatic habitats, including benthic habitat, due to dredging operation for creating sufficient navigation channel for ship carrying heavy plant equipment.	• Dredging operation should be carried out in the route having minimum aquatic habitats. Appropriate benthic survey must be carried out prior to any dredging activities. • The shipping company must ensure that the ship carrying construction materials and other raw materials, obey the appropriate International Maritime Laws.	Contractor	OE/EHSU
J. Ambient air J1. Dust and gases generated from excavation, construction	Emissions of dust and gases will be generated from excavation of trenches for laying gas pipes; RMS, turbine and HRSG	• Casing will be used when buried pipes cross a road. The minimum depth of cover shall be measured from the top of the pipe to the surface of the working grade. Crown materials along the surface of the ground level will not be considered as a part of the	Contractor	OE/ESHSU

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
equipments, and vehicles	foundation, operation of construction equipment and vehicles, and material transport, which is injurious to human health.	depth of cover. The specified depth of trench can be varied as suggested by the Engineer or his representatives considering the site condition. • Trench shall be carefully cut so that the pipe is evenly bedded throughout its length with sufficient joint holes and trial holes made where necessary. • Pipeline will be evenly bedded upon the bottom of the trench throughout its length and will be correctly positioned, before any back filing is performed. • Compaction of back filling material shall be performed by an approved method to prevent any subsequent settlement. • Pipes should be strung only on the right-of-way which has been cleared and where grading has been completed. • The Contractor shall ensure that the pipe is strung for proper placement of the pipe size. Pipes shall be raised on sandbags.		
K. Ambient noise K1. Noise level	Noise will be generated from the moving and idling vehicles, welding operation, and heavy machineries.	• The machines/equipments/vehicles should be turned off when not in use. • Using PPEs during construction work.	Contractor	OE/EHSU
L. Water bodies L1. Water pollution	Improper storage and handling of fuels, lubricants, chemicals, hazardous goods/materials on-site, wash down of plant and equipment, and potential spills may contaminate the water bodies and harm the environment and health of	• Oils, lubricants and other hazardous materials should be bunded and stored separately so as to limit the spillage. • Workers should be trained on safety precautions on using/handling such hazardous materials. • The workers should be encouraged to use PPEs everytime when handling oils, lubricants, chemicals and other hazardous materials.	Contractor	OE/EHSU

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
	construction workers.			
N. Occupational Health and Safety N1. Health and safety hazard	Injuries leading to casualty, or death may be caused during transportation of machinery and equipments, from the ship to site, and their installation/erection, lifting heavy materials, working at heights, etc.	• Proper health and safety training on hazard identification and how to handle hazardous equipments must be provided to the workers before starting any construction activities. • The health and safety staffof contractor must ensure that the equipments and safety harness are working properly before the workers start their work. In identification of a faulty equipment, they must be promptly replaced. • An on-site medical team should be set up and emergency first-aid kit should be at hand in case of any accidental injuries (burns, cuts, broken bones etc.). • The workers should use the appropriate PPEs. • Ensure workers hygiene and health status. Conduct monthly health check up to monitor their health condition and provide appropriate treatment for any ailments.	Contractor	EHSU
N2. Fire hazards from welding,	Welding operations during laying of pipeline may cause fire accidents if proper care is not taken	• All arc welding and cutting operations shall be shielded by noncombustible or flameproof screens which will protect welders and other persons working in the vicinity from the direct rays of the arc. • In addition, the welders should use (i) hand shields to protect against flashes and radiant energy, (ii) see his skin is covered completely to prevent burns and other damage by ultraviolet rays, (iii)Welding helmets shall be free of leaks and openings, and free of highly reflective surface, and (iv) welding trucks shall be equipped with approved fire extinguishers and first aid.	Contractor	OE/EHSU
P. Solid Waste	Poor aesthetic view due to	• Rubbles generated from the construciton site should be stored in approriate bins/skips, well-covered and later	Contractor	Health and

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
Disposal P1. Storage space and visual effect	the storage and disposal of old and used equipments and materials. Moreover, spillage and leakage from improper storage can result in contamination in soil.	buried in an approved landfill site. • All solid wastes, hazardous and non-hazardous, should be stored in designated sites prior to final disposal		Safety Officer
2. OPERATION PHASE				
T. AMBIENT AIR T1. Maximum ground level concentration of air pollutants	Emission of exhaust gas from the stack may contribute elevated ground level concentration of NO_x, $PM_{2.5}$ etc. at the downwind direction.	• Introduction of Low-NO_x burner in GT machine will reduce NO_x emission below 25 ppmv. • High officials of BPDB should take initiative at policy level to limit emission from the adjacent Power Plants (i.e., Aggreko and Max Power Rental). • Agrekko Power Planthas 134 gas generators with stack height of 3 m, which generates excessive emission and het waves to the the nearby communities. The plant requires raise their stacks individually or collectively for reducing the heat wave as well as NO_x level to the sensitive receptors.	BPDB	EHSU
U. Noise level U1. Noise levelinside the control room, turbine hall	Hearing complexity and loss along with increase blood pressure, disturbances and discomfort to the technicians and workers and surrounding communities due to noise generated from rotator machineries at exceedance level.	• Install 3 m high brick boundary walls and thick plantation to attenuate noise in the sensitive receptors. • Replace two doors of the control room with proper insulation. Insulation in all other doors and windows in the control room and other workspace to attenuate noise. • The machines/equipments/vehicles should be turned off when not in use. • The turbines, pumps, fans etc. should be covered with soundproof dampeners to limit the spread of noise. • Greenbelts should be developed around the power plant area to limit the spread of noise to the nearby community. • Workers should use appropriate PPEs (soundproof earpiece, mufflers etc.) while working close to noise equipment.	Contractor	EHSU
V. Water	Sludge generated from the	• Construction of a leak-proof sump should be made to	BPDB and EHS	BPDB and EHS

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
bodies V1. Pollution of receiving water bodies	chemical assisted raw water at pretreatment and water treatment plants may impact groundwater quality and receiving water bodies if come in contact to sludge.	store sludge temporarily and limit their spillage. They should then be transferred to sludge treatment plant for treatment. • The sump should be monitored and maintained by on board chemist and technicians and make sure everything (e.g. pollutant content, spill control etc.) goes smoothly	officers	officers
Y. Risks and emergency				
Y3. Corrosion of gas pipes	Corrosion on the internal wall of a natural gas pipeline can occur when the pipe wall is exposed to water and contaminants in the gas, such as O_2, H_2S, CO_2, or chlorides	• Pipe will be coated using 3 layer polyethylenes (3 LPE). • Buried pipes and fittings shall be protected against corrosion by means of external coating and wrapping. • Holiday detector shall be used to detect any holiday and shall be repaired. • Cathodic protection test points shall be installed and connected to temporary cathodic protection facilities in accordance with the specification as the final operation of lowering or tieing-in is in progress. • Conduct inspection after all installation before back-filling.	Contractor	OE/EHSU
Y4. Gas compressor fouling	Polymer deposits on compressor internals which increases frictional losses and alters flow pattern and lead to loss of compressor efficiency, pressure drop increase in after coolers, potential for unbalancing, rotor, and seal damage.	• A cleaning regime in Bangladesh would be a combination of on-line cleaning and semi-annual off-line washing.	Contractor	OE/ESHSU
Y5. Gas pipeline leak	Poor tieing-in may cause leak of significant amount of gas from the pipe	• Separate welded joint sections of the pipeline shall be tied into a continuous system in such a manner that no stress will be induced into the pipe as a consequence of the tieing-in operation.	Contractor	OE/ESHSU

9.9 Emergency Response Plan

675. An Emergency Response Plan (ERP) is prepared and presented in Chapter 10 and detailed in Volume 5. Each Contractor after assessing potential emergencies that could be encountered during construction phase should prepare site specific ERPs (guidance can be taken from the ERP proposed in this EIA) and include in their Construction Environmental Action Plan (CEAP). The CEAP will be submitted to the OE for review and approval before contractor mobilization.

676. The ERP proposed for BWDB identified possible emergency events during construction and operational phase. The emergencies could be immediate medical evacuation due to personnel injury, traffic accidents (road), leakage of hazardous materials (airborne asbestos particles), terrorist events/threats and gas leakage/explosion, kidnap and/or extortion, bomb threat, pandemic, significant business loss, pollution incident, fire and explosion, gas leak and structure collapse.

677. The ERP outlines the framework of Emergency Response Strategy which will be followed by the contractor's, operation and maintenance staffs of BPDB during decommissioning, construction, and erection and operation and maintenance phases.

9.10 Budget for EMP

678. The cost of implementing the EMP including monitoring is USD 26.8 million. Details of EMP and associated costs are given in Table 9-5.

Table 9-5: Estimated cost of EMP

SI	Items	Unit	Quantity	Unit Rate (USD)	Amount (USD)
1	**EPC Contract**				
	Boiler Decommissioning	No	1	4,000,000	4,000,000
	Continuous Stack Emission Monitoring System	No	1	250,000	250,000
	Continuous Effluent Quality Monitoring Instrument	No	1	150,000	150,000
	Central Water and Effluent Treatment Plant		(Included in Cooling Tower System)		
	Continuous Ambient Air Quality Monitoring Stations	No	2	250,000	500,000
	Noise attenuation measures	LS	1	15,000	15,000
	Micro Weather Station	No	1	40,000	40,000
	Environmental Laboratory	No	1	400,000	400,000
	New Closed-cycle Cooling Tower System	No	1	16,000,000	16,000,000
	EHS Staffs of Contractor (3)	MM	78	5,000	390,000
	Contractor's HIV/AIDS Management	LS			59,000
2	**Environmental Management Plan**				
	Plantation Program				2,828
	Emergency Response Plan				2,010,000
3	**Environmental Monitoring**				
	Boiler Decommissioning (6 months)				40,440
	Pre-Construction and Construction (3 years)				475,540
	Independent Monitoring (3 years of Operation)				134,563
4	**Institutional Arrangements**				
	EHS Consultant of Owner's Engineer				942,000
	EHS Staffs of EHSU Circle (6 years)[1]				445,112
	Capacity Building and Training				131,725
	Independent Monitor (Fees)				813,780
				Total	**26,799,988**

Notes:

[1] 3 years during construction and 3 years during operation

10. Risk Assessment and Management

10.1 Introduction

679. This Chapter contains the risk assessment and management strategy concerning Ghorashal Power Plant (GPS) of the Bangladesh Power Development Board. This risk assessment and management strategy has been developed as part of the repowering of Unit 4 of GPS from a Steam Turbine to Combined Cycle Power Unit. This strategy is applicable to decommissioning (currently boiler decommissioning for both Units 3 and 4), construction/ erection of plant equipment, and operation and maintenance stages of the entire GPS.

10.2 Decommissioning Stage

10.2.1 Risk/Hazard Identification

680. The main requirement during decommissioning is the implementation of safety measures and the receipt of the necessary permits. The potential hazard points during decommissioning are listed in Table 10-1.

Table 10-1: Hazard identification during the decommissioning stage

Hazard category	Hazard points
Mechanical	• Falling debris or machineries • Fall from heights • Cuts, burns and bruises from handling machineries and equipment, slips and falls
Toxic chemical exposure	• Inhalation of asbestos dust, glass wool dust, metal rusts and other small dust particles
Failure mode hazard	• Non-functional equipment • Non-functional safety straps • Non-functional construction pulleys and cranes • Non-functional personal protective equipment (PPEs)
Roads and Highway hazard	• Road accidents • Rollover of vehicles and machineries • Demolition of properties and structures

10.2.2 Risk/Hazard Management

Onsite

681. The potential on-site hazards and their risk management during decommissioning are presented in Table 10-2.

Table 10-2: Potential hazard, their consequences and suggested mitigation measures during decommissioning process

Event	Causes/comment	Possible Consequences	Prevention/ Protection
• Lifting of machineries and equipment's from tall heights • Use of generators for powering up machineries and equipment • Use of jackhammers, electric drills and welders for dismantling of structures	• Improper safety procedures and use of PPEs while dismantling heavy machineries • Mechanical failure of lorries/cranes/ pulleys • Use of improper safety harness/cranes/pulleys in bringing down machineries • Negligence while working. • Faulty structures/equipment/machineries • Unconsciousness of workers.	• Injury • Loss of lives • Damage to properties/landscapes.	• Regular inspection and maintenance • Dismantling of heavy machineries/structures into smaller portions • Use of PPEs
Asbestos, glass wool dust, metal rust and other small dust particles in insulation materials	• Improper safety procedures while dismantling heavy machineries containing hazardous material (especially asbestos containing material) • Improper handling of liquid waste containing asbestos and other hazardous materials • Lack of awareness among the workers • Negligence while working.	• Impact on environment (e.g., in-terms of airborne asbestos particles, liquid waste) and nearby ecosystem • Injury to workers due to inhalation of toxic dust particles • Skin and eye irritation of the workers due to contact with dust particles.	• Regular inspection and maintenance. • Spraying of water using low-pressure sprayer to minimize dust (e.g., airborne asbestos particles) cloud formation. • Collection of liquid waste containing asbestos in a lined collection lagoon and final disposal to on-site hazardous waste disposal site. • Maintaining safety procedures, such as, putting appropriate asbestos warning signs in equipments and areas involved in asbestos removal work.

Event	Causes/comment	Possible Consequences	Prevention/ Protection
			• Proper training to workers in handling and safe removal of asbestos. • Sealing of asbestos waste in a tightly sealed bag (labeled with appropriate asbestos hazard label) and transport and dispose them in on-site hazardous waste disposal site. • Use of respiratory protective equipments, safety goggles, gloves, footwear and other necessary PPEs during asbestos removal work.
Cutting and welding	• Electric failure • Equipment failure • Lack of training • Exposure to workers and passerby	• Burn injuries • Electric shocks • Injuries to eyes	• Proper training on health and safety measures • Proper training on handling equipments for dismantling boilers. • Adoption of welding standard practice • Wearing PPEs during welding activities • Putting up warning signal/danger signs for passerby
Working at heights	• Faulty safety harness • Negligence towards safety measures • Unconsciousness of workers	• Injuries • Loss of lives	• Proper training and implementation of health and safety measures • Proper inspection of safety harness before starting work • Use of PPE
Motor vehicle	• Mechanical failure • Negligence of road and safety guidelines • Driving in a bad health condition	• Injuries • Loss of lives	• Maintaining traffic safety measures • Regular inspection of

Event	Causes/comment	Possible Consequences	Prevention/ Protection
			vehicles/lories/cranes; servicing and maintenance of vehicles • Awareness of warning and hazardous signs. • Inspecting the physical/mental status of drivers.

Off-site

682. The potential off-site hazards and their risk management during decommissioning process are shown in Table 10-3.

Table 10-3: Potential hazard, their consequences and suggested risk management during decommissioning process

Event	Cause/comment	Possible Consequences	Prevention/Protection
• Lifting of machineries and equipments from tall heights • Use of generators for powering up machineries and equipment • Use of jackhammers, electric drills and welders for dismantling of structures	• Improper safety procedures and use of PPEs while dismantling heavy machineries • Mechanical failure of lorries/cranes/ pulleys • Use of improper safety harness/cranes/pulleys in bringing down machineries • Negligence while working. • Faulty structures/equipment/machineries • Unconsciousness of workers.	• Injury • Loss of lives • Damage to properties/landscapes.	• Regular inspection and maintenance • Dismantling of heavy machineries into smaller portions. • Covering the boiler area and its peripheral areas with boundaries made of cloth. • Blocking off at least 360 m radial area around the boiler decommissioning zone and putting up warning signal/danger signs to warn passerby • Enlisting security officials to restrict the movement of passerby and residential members during decommissioning stage.
Asbestos and other	• Improper safety procedures while transporting	• Impact on environment and	• Regular inspection and

Event	Cause/comment	Possible Consequences	Prevention/Protection
dust particles	and final disposal • Lack of awareness among the workers • Negligence while working.	nearby ecosystem • Passerby and power plant residential members would get exposed to various health problems due to inhalation of toxic dust particles • Irritation to the eyes of the passerby and power plant residential members due to contact with dust particles.	maintenance. • Spraying of water using low-pressure sprayer to minimize dust cloud formation. • Maintaining safety procedures, such as, putting appropriate asbestos warning signs in equipments and areas involved in asbestos removal work; so that worker's and others are warned. • Prior announcement of decommissioning work to the residents of the neighboring towns and power plant residential area. •
Noise from heavy equipment and vehicles	• Noise from plant equipment and vehicle engines and horns • Mechanical failure • Not following traffic rules	• Injuries • Loss of lives • Demolition of public properties and structures	• Maintaining traffic safety measures • Regular inspection of vehicles/ lories/cranes; servicing and maintenance of vehicles • Development of a greenbelt to attenuate noise generated from decommissioning activities. • Limit decommissioning work during 8AM to 7PM. •

10.3 Construction/Erection Stage

10.3.1 Introduction

683. Leakage of flammable natural gas is a potential hazard associated with the proposed site. This could cause injury or damage resulting from a fire or explosion incident. The possible factors involved in such incident are:

- When the pipelines, vessel or equipment fail in a particular mode causing a release. There are several possible causes of failure, the main ones being corrosion and damage by external agents;

- If the released material come into contact with a source of ignition. In some cases this may be heat or sparks generated by mechanical damage while in others, the possible ignition source could include non-flame proof equipment, vehicles, or flames at some distance from the release;

- Depending on the release conditions, including the mass of flammable material involved and how rapidly it got ignited, the results may be a localized fire (for example a jet fire), a flash fire or an explosion of the vapor cloud formed through the release;

- Finally, human dimension of such hazards and degree of risk would be dependent if there is presence of people within the harmful range (consequence distance) of the fire or explosion. Degree of close proximity of people will determine the nature and extent of any injuries or fatalities due to such incidence. Environmental damage from gas fire incidents are generally associated with a failure to control fire water used.

684. Natural gas is a buoyant, flammable gas which is lighter than air (density of air is 1.225 kg/m^3 and natural gas is 0.712 kg/m^3). On release into the open space the non-ignited gas tends to disperse rapidly at high altitude. Ignition at the point of release is possible, in which case the gas would burn as a jet (or torch) flame. On release in an enclosed area (for example within the gas turbine housing) an explosion or a flash fire is possible.

685. The gas is non-toxic, posing only an asphyxiation hazard. Due to its buoyancy, any release of credible proportions from operations of this scale, in the open, would not present an asphyxiation hazard. With standard confined space entry procedures and appropriate security arrangements to prevent unauthorized access to any of the facilities, the risk associated with asphyxiation from natural gas should be minimal.

686. Locally, the pressure of the compressed gas may be hazardous in case of an uncontrolled release. These hazards, would adversely affect people working at the site, but do not have implications beyond the immediate location of the release unless the released gas is ignited. Therefore, the risk associated with non-ignited compressed gas does not form part of the scope of the present risk assessment.

687. This potential risk would however need to be closely managed through job safety analysis (JSA) and/or other risk assessment practices used by management and operators of the facility.

688. Other potential hazards are associated with the handling and use of combustible liquids (i.e., the lubricants used for pumps, compressors, turbines etc.).

689. Minor quantities of flammable acetone (used for cleaning) will also pose a potential fire hazard.

10.3.2 On-Site Risk Mitigation Measures

690. The Hazard Identification and management program, included in Table 10-4, provides a summary of the hazardous incidents identified for the GPS and their associated mitigating features. Each potential location of the Power Station and associated pipelines was assessed to determine the potentially hazardous scenarios relevant to that location. The potential locations studied were:

- Section 1 -Natural gas lateral supply pipeline to the Power Station boundary
- Section 2-Gas receiving station (Regulating Metering Station) and on-site gas transport at the Power Station;
- Section 3-Turbine enclosure construction/installation
- Section 4- Carbon dioxide (or other asphyxiant fire quenching gas) storage;
- Section-5: Whole site (including supply pipeline).

691. Table 10-4 provides an overview of the preventative and protective features proposed and recommended for the site.

Table 10-4: Location-wise hazard identification and management

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
SECTION 1: Natural Gas Lateral Supply Pipeline (from Gas Pipeline to the Site Boundary)			
1. Mechanical impact causes release of flammable gas.	3rd party involvement digging or trenching, or other earth work.	Massive release of natural gas (NG). If ignition, then possibility of flash or jet fire.	- Gas supply pipeline runs for its entirety within Ghorashal pipeline easement. - Pipe is buried (minimum 750mm or 450mm in rock) - Signage along pipe route, including Dial Before You Dig information. Drawings available to Dial Before You Dig. - Resistance of pipelines to penetration through use of pipe thickness and low design factor. - Rapid shut down from low pressure trips if massive leak at pipelines prevents backflow from Plant and uncontrolled flow from Gas pipeline. - Manual shut down (by isolating manually at the Gas pipeline off-take point and/or at gas receiving station. - NG disperses readily upwards, minimizing chances of ignition. Explosion not credible in unconfined situation. **The risk associated with this scenario is evaluated quantitatively.**

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
2. Corrosion causes release of flammable gas.	Damage of pipeline coating due to excavation inspection damage leads to corrosion	If ignition, a jet fire is possible.	- Cathodic protection for external corrosion with regular inspections and testing as per AS2885. - Internal corrosion virtually absent with clean hydrocarbon. - Coating on external surfaces of pipelines. - Regular patrolling of pipelines. Vegetation browning off around ground leak (lack of oxygen) aid detection. Further, a small hole will be sonic – possible detection through high pitched sound. - NG disperses readily upwards, minimizing chances of ignition. **The risk associated with this scenario will be evaluated quantitatively.**
3. Valve gland nut of flange leak causes release of flammable gas.	Maintenance failure at valves. Wear and tear. Impact.	Release of natural gas. If ignition, then possibility of fire.	- Periodic surveillance of pipe and valve points. - Valves will be exercised periodically. - Gas detectors at valve stations. - Icing up at leak point improves detection. - Valve stations contained on site. - Minimum number of flanges. Welded connections wherever possible. **The risk associated with this**

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
			scenario will be evaluated quantitatively.
4. Terrorism / vandalism damages pipe or valve causing release of flammable gas.	Terrorism / vandalism	Massive release of natural gas. If ignited, then possibility of flash or jet fire.	- Terrorism and severe vandalism is highly improbable in Bangladesh. - Buried pipelines and no valve points at public areas. - Valve station fenced. - Regular and periodic surveillance. - Intruder detection. **This scenario does not require further action for this site.**
5. Explosion at neighboring natural gas (Gas) Trunk line causes damage to gas supply pipeline.	Failure of maintenance of Trunk line. Hot tapping by error.	Massive release of natural gas (NG). If ignited, then possibility of flash or jet fire.	- Internal risk management procedures / systems by pipeline operators. - Pipeline integrity plan (incl. protection, pigging etc. to monitor integrity of pipeline and coating inspection). - 24 hour monitoring of natural gas and ethane pipelines. - NG disperses readily upwards, minimizing chances of ignition. Explosion not credible in unconfined situation. - Buried natural gas Trunk line. - Thickness and grade of pipelines. - Hot tapping is a specialist field

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
			with highly trained personnel. **This scenario does not require further action for this site.**
6. Pressure excursion leading to failure of the pipeline.	Operational error up or downstream of gas supply pipeline.	Release of natural gas. If ignited, then possibility of fire.	- The pipelines are to be hydro tested at a minimum of 1.4 times the MAOP (maximum allowable operating pressure). - The pipelines can operate against closed head (i.e. the main valve at the entrance to the site may be closed). - 24 hour monitoring of Trunk line and lateral supply gas pipeline. - Continuous monitoring of pressure of the pipelines supplying natural gas to the power plant. - High and low pressures of the natural gas supply will be monitored and if required (as defined in detailed HAZOP), associated with an automatic trip / shut down, see Recommendation. **The risk associated with this scenario will be evaluated quantitatively.**

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
7. Spontaneous loss of integrity of pipe.	Construction defect or operational error (repeated)	Massive release of natural gas. If ignited, then possibility of flash or jet fire.	- All welds are x-rayed (100%). - Thickness of pipe material and temperature cycling make this scenario highly unlikely. - Cathodic protection. - Design for pipelines to prevent crack propagation. **This scenario does not require further action for this site.**
8. Land subsiding causes damage to pipe and release of flammable gas.	Mining activities in area or earthquake	Release of natural gas. If ignition, then possibility of flash or jet fire.	- See Event number 17 and 18 below (for the whole site)
SECTION -2 : Gas Conditioning Station and On-Site Natural Gas Transport at the Power Station			
9. Leak of natural gas to atmosphere from gas pipes on-site (outside the turbine housings).	Mechanical impact, weld failure, operational error corrosion, sabotage etc.	Release of odorized natural gas. If ignition source available (or if ignited at source), then flash fire or jet fire possible.	- Use of fully welded pipework wherever possible. Minimize pipe-runs (pipe lengths). Pipes of robust design. - Detectors positioned strategically at high risk leak areas. - The use of fusible tubing around high risk leak piping to be investigated, see Recommendation. - Overpressure protection. - Communication systems. - Actuated isolation valve at receiving station inlet. - Fire protection system to be installed, incl. fixed sprinkler or water/hose system.

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
			The risk associated with this scenario will be evaluated quantitatively.
10. Venting of gas from process.	Maintenance work, shutdown, flaring.	Release of flammable gas or heat to process area. Fire hazard.	- Releases to be piped to safe area (flare). Vents to elevated point. **Standard design practices to be applied.**
11. An explosion within piping or inside a vessel.	Failure of maintenance activities creates ingress of air into natural gas piping and vessels and subsequent start-up without adequate purging.	Possible explosion. Due to the limited quantities of gas involved the effects of the explosion would however not be expected to pose a threat to nearby land uses.	- This scenario is only theoretically possible during start-up, shut-down and maintenance operations; - Piping normally operated at a positive pressure, preventing ingress of air; - Prevention of ingress of air will be considered throughout the design and operation of the facility (for example in the preparation of start-up, shut-down and maintenance procedures). **This scenario does not require further action for this site.**
SECTION-3 : Turbine Enclosure Construction/Installation			
12. Leak of natural gas to inside of turbine housing due to failure of pipe.	Mechanical impact, weld failure, operational error corrosion, sabotage etc.	Release of odorized natural gas (NG). If ignition source available (or if ignited at source), then flash fire or jet fire possible. If confinement sufficient then an explosion is possible with	- The detailed design of the turbine housing and associated equipments need to demonstrate that explosive situations do not arise and need to clearly outline

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
		overpressure effects and projectiles. Due to the limited quantities of gas involved and the size of the site, the effects of the explosion would however not be expected to pose a threat to nearby land uses.	the basis of safety used to this end - Training of operators and maintenance workers. - System put in place to ensure removal of safety critical functions is subject to careful scrutiny (see Recommendation). - Permit to Work procedures, including for entry into Confined Space. - Emergency procedures and drills. **The risk associated with this scenario will be evaluated quantitatively.**

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
13. Leak of natural gas to inside of turbine housing due to projectile.	Violent mechanical failure of rotating machine (compressor, turbine) creates projectile.	Projectile would be ejected with high energy. Personnel hazard if in the vicinity. If a gas pipe is hit by the projectile or associated equipment / instrumentation then it may fail, causing gas release and fire / explosion if ignition source.	- Preventative maintenance of rotating machines. - Vibration monitoring. - Shut down of machine and repair if out of alignment. - Rotating machines to be designed such that risk associated with projectile is minimized (gas pipelines protected or not in probable line of projectile, people protected substation and electricity facility not in direct line of projectile or protected etc.). - Buried pipeline is not at risk from such projectiles. **The risk associated with this scenario will be evaluated quantitatively**
SECTION-4: Carbon dioxide (or other asphyxiant fire quenching gas) Storage			
14. Release of carbon dioxide (or of other fire quenching material to be used for fire protection) into turbine housing.	Leaking cylinders, flanges, pipes into enclosed area.	Potential asphyxiation of person inside the enclosed area if concentrations reach hazardous levels.	- Small quantities, impact localized to enclosed area. - Permit to Work requirements. - Alarm (visual and audible) inside enclosed area allowing personnel escape prior to offloading carbon dioxide / other fire quenching material. **The consequences of this scenario are local only to the immediate vicinity of the**

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
			release. No off-site consequences expected.
SECTION-5: Whole Site (including supply pipeline)			
16. Flooding results in process upsets.	Uncontrolled flooding of site	Potential for damage to process / storage facilities resulting in release of hazardous material (particularly natural gas)	- Topography prevents flooding from any rivers or streams
17. Land subsidence due to mining activity.	Land subsiding due to mining activities in area creates failure of pipes / pipeline resulting in potential for rupture or massive leak.	Release of natural gas. If ignited, then possibility of flash or jet fire.	- Thick walled pipe and pipe grade can withstand considerable plastic deformation. - Subsidence issue to be taken into account during detailed design, including requirements for thrust blocks on pipelines to be over-sized and prevented from separating from the pipe. - Pipelines located above ground where possible. **The risk associated with this scenario will need to be addressed through design (i.e. inherent safety to be incorporated into the detailed design)**
18. Earthquake results in process upsets, potential damage to process / storage facilities resulting in hazardous releases.	Earthquake	Potential damage to process / storage facilities resulting in hazardous releases, fire / explosion.	- Structures and plant are designed to withstand earthquake effects using well-established procedures in accordance with relevant national or international standards.

10.3.3 On-Site Emergency Response Plan

692. Possible emergency events during construction phase could be immediate medical evacuation due to personnel injury, traffic accidents (road), leakage of hazardous materials (airborne asbestos particles), civil disturbance/riot, structure collapse, terrorist events/threats and gas leakage/explosion.

693. An Emergency Response Plan (ERP) is to provide a systematic approach to the protection of employees, assets and the environment from the impact of serious incidents. It can be defined as a plan that encompasses organizing, coordinating and implementing a range of procedures to prevent, mitigate, respond to and recover from the consequences of an emergency event. The concept is designed to be applied to all incidents, regardless of nature, severity, or location. Although it is flexible in nature, acceptance and application of the concept should be viewed as a critical factor in our ability to organize and manage incident response

694. A well-constructed ERP will prevent a minor incident from becoming a disaster, save lives, prevent injuries and minimize damage to property and the environment. It facilitates a rapid and effective emergency response and recovery; provides assistance to emergency and security services; implements an effective evacuation plan if required and communicates vital information to all relevant persons involved in the emergency (both internal personnel and external agencies) with a minimum of delay. It outlines the necessary resources, personnel, and logistics, which allow for a prompt, coordinated, and rational approach to an accident. The plan will contain sufficient detail to enable those involved in the response to effectively carry out their duties.

695. The goals of the ERP are to:

- Provide for clear lines of authority and communication during incident and crisis events;
- Provide a means by which trained people and resources are available to those managing the incident or crisis event.

696. The emergency management strategy and organization structure is defined and included in Vol. 5: Emergency Response Plan of this EIA report.

10.4 Operation Stage

10.4.1 Consequence Analysis-Onsite and Offsite

Leakage from Gas Pipe Line:

697. Natural gas is a flammable chemical which is enlisted as explosive under the Explosive Act of 1884 of Bangladesh. The natural gas to be used for the proposed plant consists of mostly Methane (96% by volume) and ethane, propane, butane and other alkanes. Though methane is highly flammable gas, its explosion limit is low, 5% - 15%. Leakage of gas from pipeline and other associated facilities may cause series of hazards. In the following section potential hazards and consequences are discussed.

698. Presently, gas is supplied from a Titas Gas Transmission & Distribution System located outside the GPS, nearly at 750 away from the power plant. Gas is supplied by a 16 inch diameter pipeline and a Regulating and Metering Station (RMS) situated at north east corner of the GPS complex. For the proposed Unit 4, a new RMS with 16 inch dia pipeline

will be installed at the western side of the proposed repowering plant. Leakage from these Gas supply facilities may lead to series of hazards that may ultimately results in damage of the property and loss of human life. Table 10-5 lists all identified major potential hazards and hazard sourcing points related to natural gas during plant operation.

Table 10-5: Potential Hazard Points and Possible Hazards

Hazard Points	Possible Hazards	Consequences
Regulatory and Metering Station	Gas Leak leads to: • Toxic Vapor Cloud Formation • Vapor Cloud Explosion • Jet Fire • Limited Space Explosion • Over Pressure Explosion	• Fire • Poisoning • Suffocation • Damage to Structure • Health Loss
16” Gas Pipeline, valves		

699. Leakage from pipeline or RMS may lead a sequential hazard. A pipeline of 1,320m long, 16 inch diameter will supply gas to the power plant. The gas pipeline may experience leakage due to any fracture or failure of the pipeline. ALOHA (Areal Locations of Hazardous Atmospheres) software has been used to simulate the consequence of gas leakage. ALOHA is a modeling program to estimate threat zones associated with hazardous chemical releases, including toxic gas clouds, fires, and explosions. The simulation considers that it is possible to close off the gas supply connection through valve installed at RMS. ALOHA has been applied to simulate the following sequential hazards

- Toxic Area of Vapor Cloud Formation
- Flammable Area of Vapor Cloud Formation
- Blast Area of Vapor Cloud Formation

700. The basic assumptions on climatic condition, site condition and release conditions are provided in Figure 10-1. One of the key assumptions is wind direction, which has been considered as ‘South East’ on the basis of the analysis of the wind rose diagrams provided in Figure 6-17 in Chapter 6. The windrose indicates that most of the time in a year wind flows from South East. Wind speed has been considered as 3 m/s. Most of the time in a year wind speed remains in between 3– 5 m/s (see Figure 6-17) at 10m height. The pipeline area is surrounded by main plant structure and vegetation that obstruct free flow of wind at 3m height. Considering this fact, the lower limit of the frequent wind speed range (3 – 5 m/s) has been considered.

701. Both ends of the gas pipe between plant and RMS is regulated by valves. Both of the valves are operated by DCS. In ALOHA, it is assumed that the release duration would be 1 minute considering DCS operated valves, pipe length, and possible amount of gas in the pipe. As the valves are operated by DCS, therefore, 1 minute is enough to shut down the valve.

702. *Simulation of Toxic Area of Vapor Cloud Formation*- ALOHA estimates that toxicity may spread up to 288 m. Death threatening toxicity may spread up to 69 m towards windward. Figure 10-1 presents the threat zone area of toxic vapor cloud formation. In addition, Table 10-6 presents a brief summary of the toxicity.

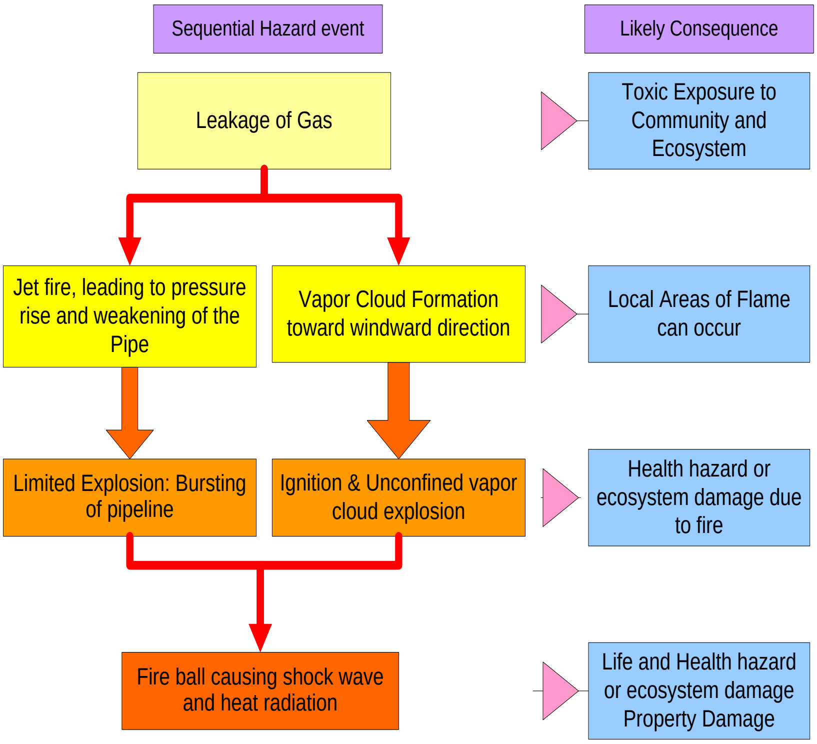


Figure 10-1: Sequential Hazard Event from a Gas Leakage

Table 10-6: Threat Zone of Vapor Cloud Formation

Items	Red Threat Zone (meter)	Orange Threat Zone (meter)	Yellow Threat Zone (meter)
Definition	PEC 3: Concentration <17000 PPM More than one hour exposure to this concentration threats adverse health effect or death	PEC 2: concentration < 2900 PPM, More than one hour exposure to this concentration threats irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape	< 1000 PPM, exposure to this concentration threats discomfort, irritation, or certain asymptomatic, non-sensory effects
Toxic Area	69 m	167 m	288 m

Note: PAC: Protective Action Criteria

10.4.2 Simulation of Flammable Area of Vapor Cloud Formation

703. The vapor cloud formed from a leakage of a gas pipeline has flammability. ALOHA has been applied to estimate the possible flammable area of the vapor cloud. The explosion limit of methane is low, only 5% (LEL) - 15% (UEL). The local area of flame can occur even though the concentration is below the lowest explosion limit (LEL). ALOHA considers 60% of the LEL to cause a flame.

704. 60% of the LEL level i.e., 30,000 ppm concentration has been considered as high threat zone (red) of occurring flame. 30% of LEL i.e., 15,000 ppm concentration has been considered as moderate threat zone (orange) and 10% of LEL i.e., 5,000 ppm is considered

low threat zone (yellow) of occurring flame. The model estimated the high threat zone might spread up to 72m. The details of the simulation results are shown in Figure 10-3 and Table 10-7.

Table 10-7: Threat Zone of Flammable Vapor Cloud Formation

	Red Threat Zone (meter)	**Orange Threat Zone (meter)**	**Yellow Threat Zone (meter)**
Definition	LOC: > 30,000 PPM Which is 60% of the Lowest Explosion Limit (LEL) of Methane. LEL of Methane if 50,000ppm	LOC: > 15,000 PPM Which is 30% of the Lowest Explosion Limit (LEL) of Methane. LEL of Methane if 50,000ppm	LOC: > 5000 PPM Which is 10% of the Lowest Explosion Limit (LEL) of Methane. LEL of Methane if 50,000ppm
Toxic Area	72 m	103 m	179 m

Note: LOC: Level of Concern

10.4.3 Simulation of Blast Area of Vapor Cloud Formation:

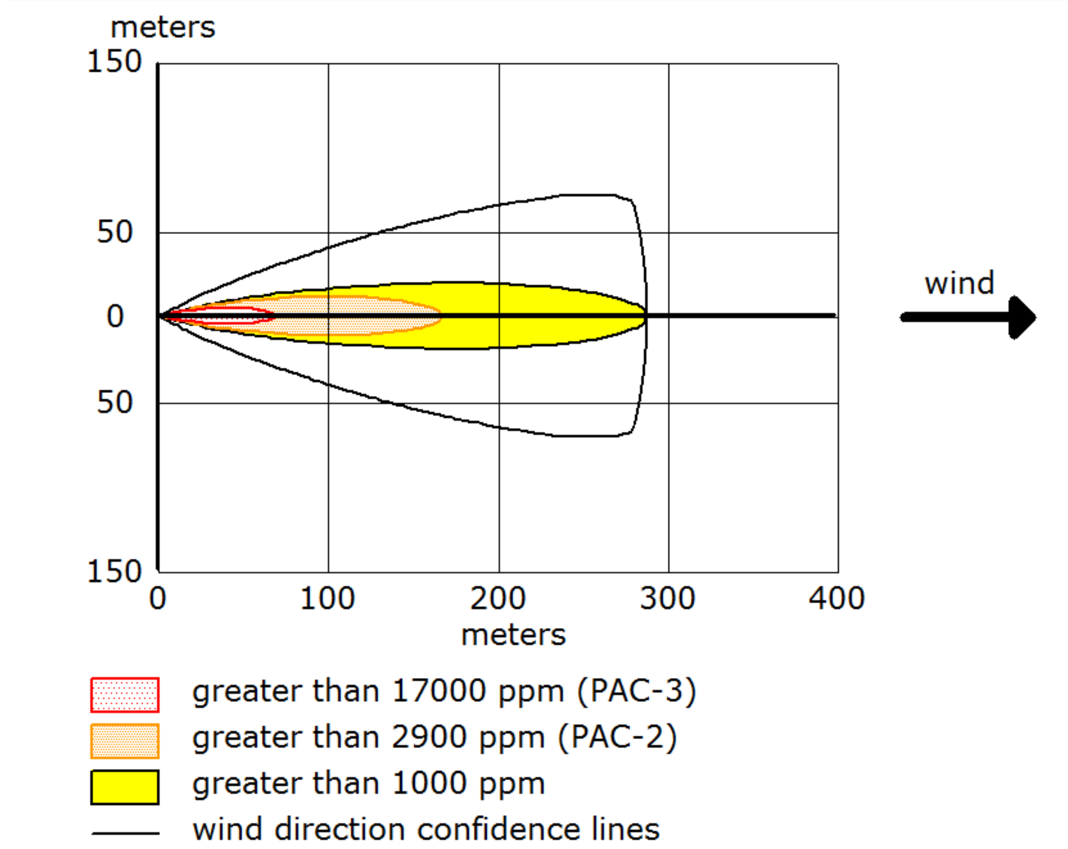
705. ALOHA defines three Level of concern for classifying threat zones on the basis of overpressure formed by the shock wave created from blast:

- High Threat Zone, 8 psi pressure which is destructive for buildings
- Moderate Threat Zone, 3.5 psi pressure serious injury
- Low Threat Zone, 1.0 psi pressure that is enough to shatter window glass

706. The model predicts that, the possible blast of the flammable vapor cloud would not be strong enough to create any pressure above 1 psi to shatter even a window glass.

10.4.4 Simulation of Jet Fire:

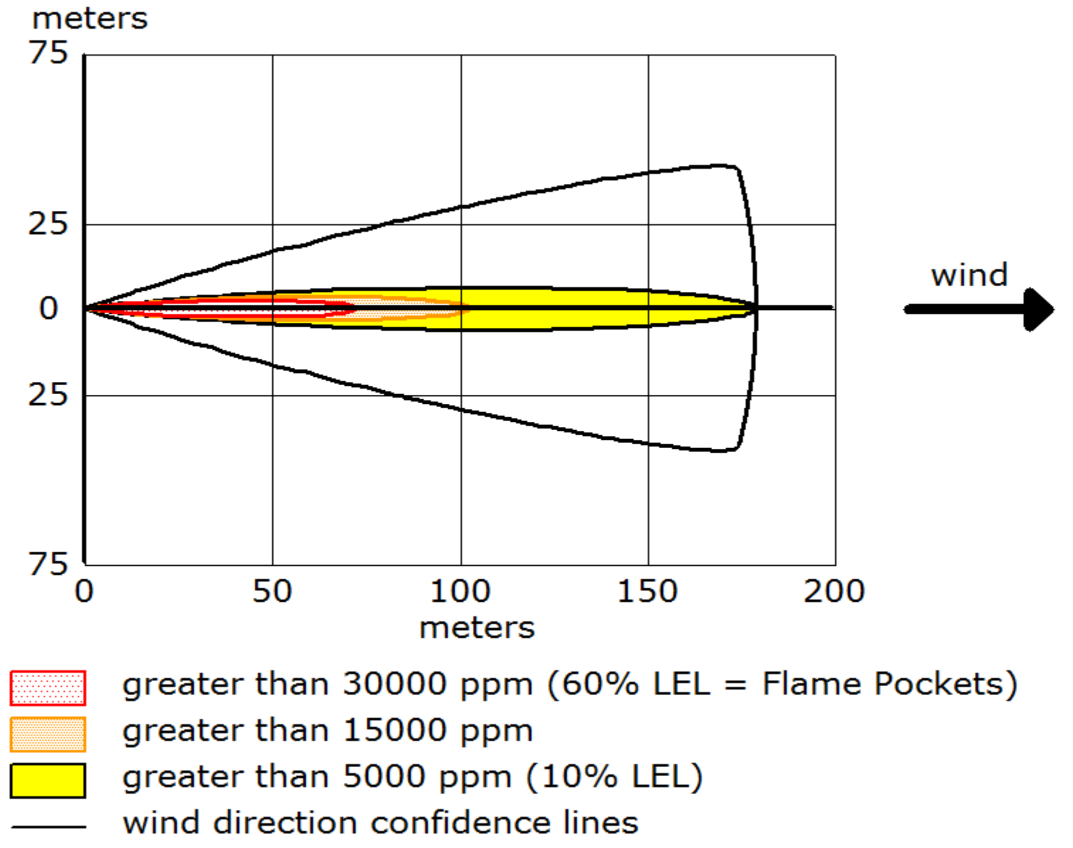
707. Methane gas leakage from a pipeline may cause a jet fire if it ignites with fire, come close proximity to thermal radiation, heat and toxic byproducts. ALOHA software has been applied for estimating the threat zone of thermal radiation of the possible jet fire. The Figure 10-2 shows the predicted areas of different threat zone and Table 10-8 gives a narrative summary of the prediction.



a)

Note: Assumptions: Wind Direction SE, Temperature: 39^{0}C, Wind Speed 3m/s,

Figure 10-2: Threat Zone of Toxic Vapor Cloud resulted from a Gas Pipeline Leakage

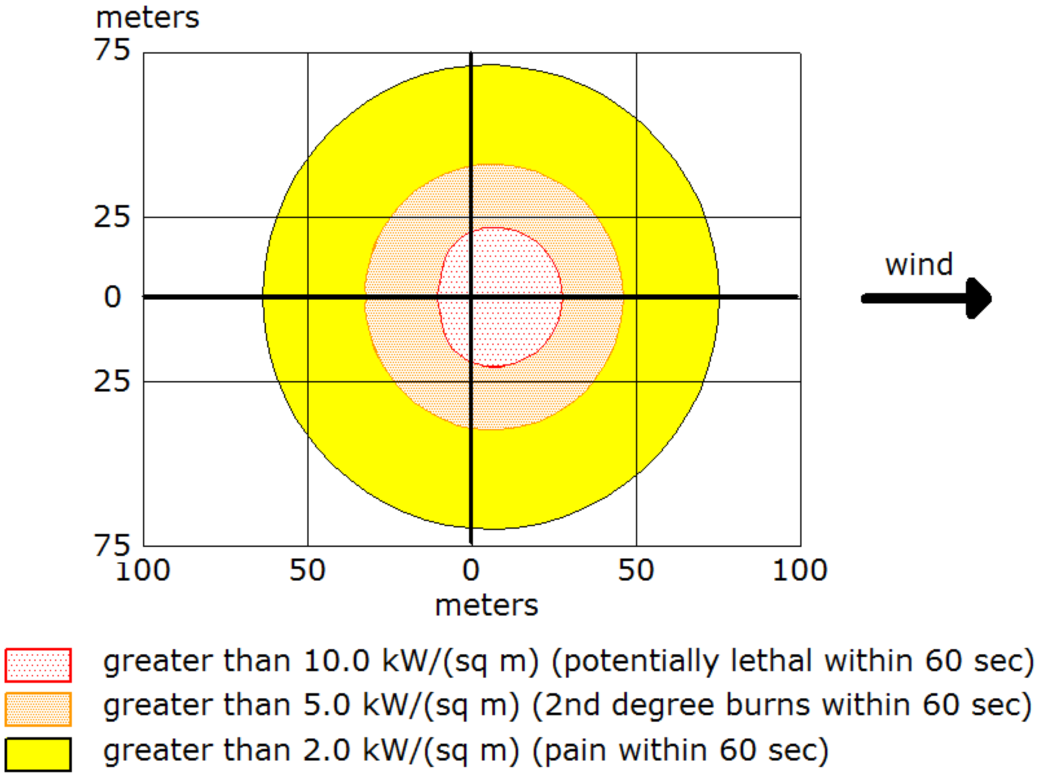


a)

b)

Note: Assumptions: Wind Direction SE, Temperature: 39^{0}C, Wind Speed 3m/s,

Figure 10-3: Threat Zone of Flammable Vapor Cloud resulted from a Gas Pipeline Leakage



a)

b)

Note: Assumptions: Wind Direction SE, Temperature: 39^0C, Wind Speed 3m/s,

Figure 10-4: Threat Zone of Thermal Heat Radiation of a Jet Fire from gas leak

Table 10-8: Threat Zone of Thermal Heat Radiation of a Jet Fire from gas leak

	Red Threat Zone (meter)	**Orange Threat Zone (meter)**	**Yellow Threat Zone (meter)**
Definition	LOC: 10 kw/m^2 Potentially lethal within 60 sec exposure	LOC: 5 /m^2 2nd degree burn within 60 sec exposure	LOC: 2 kw/m^2 Pain within 60 sec exposure
Toxic Area	28 m	47 m	76 m

Note: LOC: Level of Concern

708. The simulation of the threat zone (Figure 10-4, b) shows that, the moderate risk zone (orange threat zone, Table 10-8) of the area of flammable vapor cloud reaches to HFO storage tank (in case of a gas leak when the wind direction is SE and wind speed is 3 m/s). However, based on a discussion with GPS officials, it was learnt that HFO tanks are not operational for long period of time and these will be dismantled by the BPDB. Therefore, no further risk of explosion of HFO tanks is involved. This dismantling or relocation of the HFO will mitigate potential risk of explosion.

Model set up for simulating Toxic Area of Vapor Cloud Formation

SITE DATA:

Location: GHORASHAL POWER STATION, BANGLADESH

Building Air Exchanges per Hour: 0.44 (sheltered double storied)

Time: May 11, 2015 1632 hours ST (user specified)

CHEMICAL DATA:

Chemical Name: METHANE Molecular Weight: 16.04 g/mol

PAC-1: 2900 ppm PAC-2: 2900 ppm PAC-3: 17000 ppm

LEL: 50000 ppm UEL: 150000 ppm

Ambient Boiling Point: -161.5° C

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 3 m/s from SE at 3 m height (refer Figure 6-18) Ground Roughness: urban or forest Cloud Cover: 3 tenths

Air Temperature: 39° C Stability Class: D

No Inversion Height Relative Humidity: 75%

SOURCE STRENGTH:

Flammable gas escaping from pipe (not burning)

Pipe Diameter: 16 inches Pipe Length: 132 meters

Unbroken end of the pipe is closed off

Pipe Roughness: smooth Hole Area: 201 sq in

Pipe Press: 30 atmospheres Pipe Temperature: 39° C

Release Duration: 1 minute

Max Average Sustained Release Rate: 5.18 kilograms/sec

(Averaged over a minute or more)

Total Amount Released: 311 kilograms

THREAT ZONE:

Model Run: Gaussian

Red : 69 meters --- (17000 ppm = PAC-3)

Orange: 167 meters --- (2900 ppm = PAC-2)

Yellow: 288 meters --- (1000 ppm)

THREAT AT POINT:

Concentration Estimates at the point:

Downwind: 272 meters Off Centerline: 161 meters

Note: Concentration not drawn because there is no significant concentration at the point selected.

Mode Setup for simulating Flammable Area of Vapor Cloud Explosion

SITE DATA:

Location: GHORASHAL POWER STATION, BANGLADESH

Building Air Exchanges per Hour: 0.44 (sheltered double storied)

Time: May 11, 2015 1632 hours ST (user specified)

CHEMICAL DATA:

Chemical Name: METHANE Molecular Weight: 16.04 g/mol

PAC-1: 2900 ppm PAC-2: 2900 ppm PAC-3: 17000 ppm

LEL: 50000 ppm UEL: 150000 ppm

Ambient Boiling Point: -161.5° C

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 3 m/s from SE at 3 m height

Ground Roughness: urban or forest Cloud Cover: 3 tenths

Air Temperature: 39° C Stability Class: D

No Inversion Height Relative Humidity: 75%

SOURCE STRENGTH:

Flammable gas escaping from pipe (not burning)

Pipe Diameter: 16 inches Pipe Length: 132 meters

Unbroken end of the pipe is closed off

Pipe Roughness: smooth Hole Area: 201 sq in

Pipe Press: 30 atmospheres Pipe Temperature: 39° C

Release Duration: 1 minute

Max Average Sustained Release Rate: 5.18 kilograms/sec

(Averaged over a minute or more)

Total Amount Released: 311 kilograms

THREAT ZONE:

Threat Modeled: Flammable Area of Vapor Cloud

Model Run: Gaussian

Red : 72 meters --- (30000 ppm = 60% LEL = Flame Pockets)

Orange: 103 meters --- (15000 ppm)

Yellow: 179 meters --- (5000 ppm = 10% LEL)

Mo
Ther

SITE DATA

Location:
BANGLADE

Building
double stori

Time: May

CHEMICAL

Chemical
Weight: 16.0

PAC-1: 29
17000 ppm

LEL: 5000

Ambient B

Vapor Pre
1 atm

Ambient S
100.0%

ATMOSPH

Wind: 3 m

Ground R
tenths

Air Tempe

No Invers
75%

SOURCE S

Flammabl

Pipe Diam
meters

Unbroken

Pipe Roug
in

Pipe Pres
Temperature

Flame Len
seconds

Burn Rate

Total Amo

THREAT Z

Threat Mo

Red : 2
lethal within

Orange: 4
burns within

Yellow: 76
sec)

Figure 10-5: The basic assumptions on climatic condition, site condition and release conditions

10.4.5 Emergency Response Plan- Onsite and Offsite

709. Possible emergency events during operational phase could be immediate medical evacuation due to personnel injury, kidnap and/or extortion, bomb threat, pandemic, significant business loss, pollution incident, fire and explosion, gas leak and structure collapse.

Emergency Management Strategy

710. This ERP during operation is intended to provide information, strategies and procedures relating to all aspects of emergency management which comprise:

a. Prevention of emergencies,

b. Preparation for emergencies.

c. Response to an emergency. and

d. Recovery following an emergency.

Emergency Management Organization

The Incident Response Team (IRT)

711. The Incident Response Team (IRT), based at Ghorashal plant location, is trained and responsible for dealing with all envisaged incidents and emergency situations which may occur at the location. Where additional support in the way of resources and advice may be required by the IRT at a remote location this will be requested through and provided by the Emergency Response Group (ERG) of Dhaka Office. On all occasions when an IRT is mobilized due to an incident or emergency situation the ERG Manager must be notified immediately.

712. The IRT is chaired by the Plant Manager and includes senior staff from the Human Resources (HR), Health Safety Environment (HSE) and Logistics department within the plant.

713. The IRT is responsible for monitoring the safety of the repowering of existing plant and coordinating and responding to all emergency events during the decommissioning and construction of combine unit and directly report to the ERG Manager.

The Emergency Response Group (ERG)

714. The Emergency Response Group (ERG) is based in the BPDB Head Office in Dhaka, and is responsible for providing tactical response, support, assistance and advice to all incident and emergency situations at site/location and for providing operational response to any emergency situation which may occur. This plan describes how the ERG should handle both the "technical" crises e.g. fire, explosion, oil spill, and "social" crises e.g. illness, injury, kidnap, civil unrest. On all occasions that the ERG is mobilized due to an incident or emergency situation the Incident Response Chair must be notified immediately.

715. The function of the ERG is to coordinate and oversee arrangements to ensure that the IRT meets its emergency management obligations. The Chief Engineer of Power Station Construction of BPDB will be the Chair of the ERG and will nominate an Emergency Response Coordinator to coordinate with representatives from various agencies and also senior staff from HR, Finance, HSE, Logistic, Security, IT, and public affairs department within the BPDB.

The Incident Management Team (IMT)

716. The Incident Management Team (IMT) is the corporate body located in the BPDB headquarters in Dhaka, with the responsibility to define and control strategy for major incidents. A strategic response is defined as a situation arising from a single or multiple incidents or emergencies that escalate to a point beyond which significant damage to the Company’s business could result, including commercial and reputation damage, significant financial loss, shareholders’ loss of confidence and damages resulting from litigation. When a potential strategic situation appears the IMT will be mobilized to manage issues pertaining to the reputation and the continued commercial wellbeing of the Company. The IMT may however also be called upon to address some of the tactical roles that would normally be the responsibility of the ERG, for example, if the Dhaka Office were out of action or in the event of an evacuation from a country, which may equally limit the ERG’s capability.

717. The IMT is chaired by the Member-Generation of BPDB and includes high level representation from the Ministry of Power, Energy and Mineral Resources, Army, Police Department, Fire Department, District Commissioner’s Office and the Disaster Management Bureau (DMB) of the Bangladesh Government.

718. The detailed Emergency Response Plan is prepared separately and included in Vol. 5 of this EIA.

11. Environmental Monitoring Plan

11.1 Monitoring Plan

719. A three tier monitoring program has been proposed comprising compliance monitoring, impact monitoring, and external or independent monitoring, as the key elements of the EIA. The main purpose of this monitoring program is to ensure that the various tasks detailed in the environmental management plan, particularly the mitigation measures are implemented in an effective manner, and also to evaluate project's impacts on the key environment and social parameters. Various types of monitoring are presented in the following sections and the locations of monitoring are presented in Figure 11-1.

11.1.1 Compliance Monitoring

720. Compliance monitoring is a very important aspect of environmental management to safeguard the protection of environment. The compliance monitoring plan is presented in Table 11-1. The monitoring will comprise surveillance to check whether the contractor is meeting the provisions of the contract during construction and operation of the Project including the responsible agencies for implementation and supervision.

721. For monitoring of physico-chemical parameters, any location near the baseline sampling points is suggested. Actual monitoring time and location will be decided by OE and BPDB. The Contractor will be responsible for carrying out, or contracting to an approved third party, the monitoring of all the parameters as required frequency as shown in the table by his own cost during the construction phase. The measurement values are to be compared with the WBG's General EHS Guidelines, where relevant standards are specified, or the national standards (Environmental Conservation Rules, 1997 and amended in 2005), where WBG's General EHS guidelines do not provide a specific parameter or value, for compliance.

11.1.2 Impacts Monitoring during Construction

722. The purpose of the impacts monitoring is to ensure that the contractor implements the mitigation measures given in the EMP effectively and implements timely. This monitoring will generally be carried out by the Owners Engineer (OE) with the help of checklists prepared on the basis of the impact monitoring Plan (Table 11-2).

11.1.3 Independent/External Monitoring

723. The BPDB will engage an independent organization to monitoring of the EMP implementation. The main purpose of the Independent monitoring will be to ensure that all key entities including EHSU, Owner's Engineer, and contractors are effectively and adequately fulfilling their designated role for EMP implementation, and that all the EMP requirements are being implemented in a timely and effective manner. The ToR of the Independent monitor is presented in Annex 11-1.

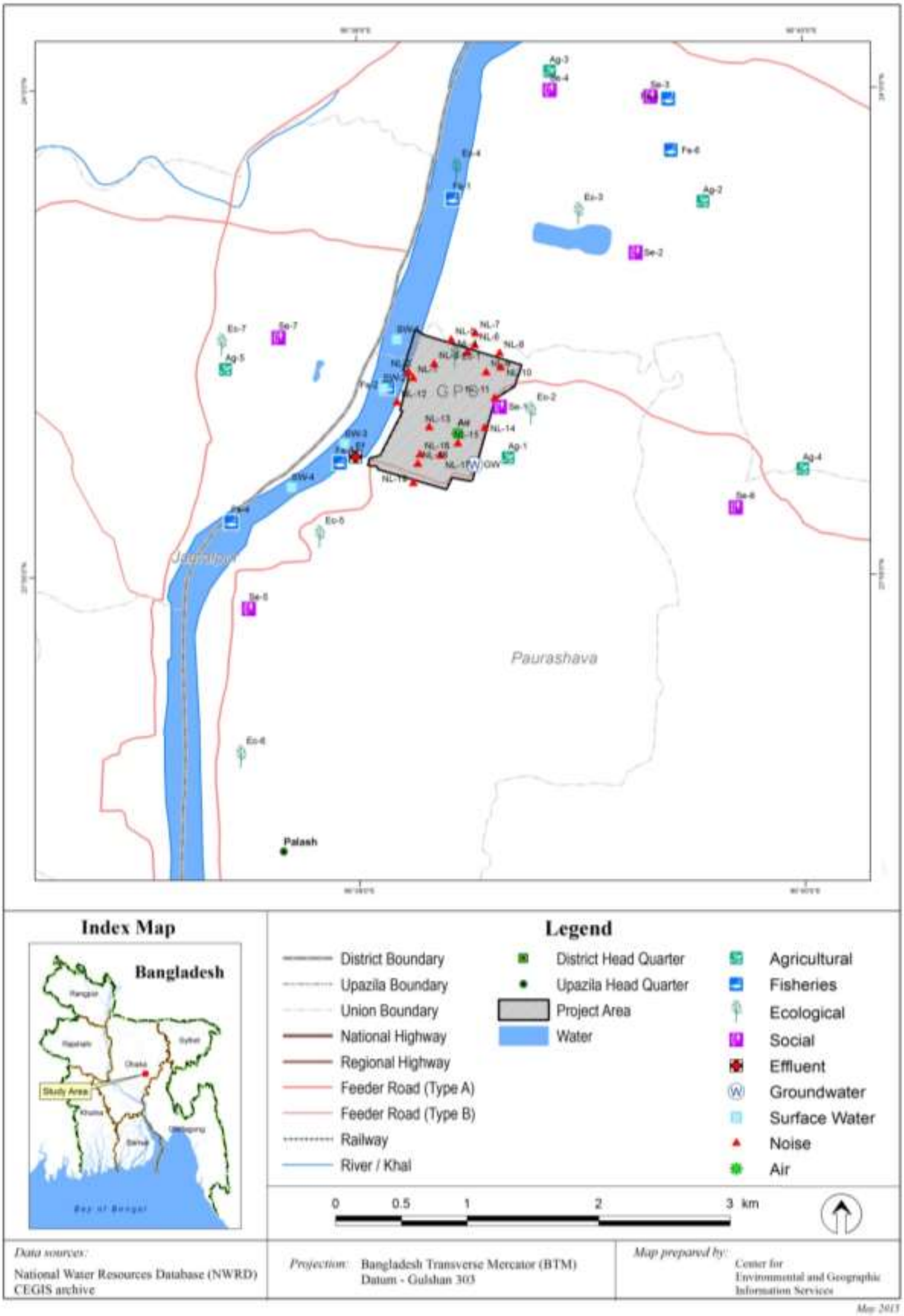


Figure 11-1: Locations of monitoring

Table 11-1: Environmental Compliance Monitoring Plan

Sl no	Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Implemented by	
						Monitoring	Supervision
1.	**Boiler Decommissioning**						
1.1.	Air Quality	Asbestos Dust, Fiber	Two Samples: 100 m downwind and upwind of the Confined area for Boiler Decommissioning	Weekly	24hr	Contractor	OE, BPDB
1.2.	Soil Quality	Pb, Cd, Cr, Cu, Zn, Mn, As, Se Hg, and oil/grease	Soil surrounding of boiler area, asbestos disposal area	Bi-annual	Composite Sampling	Contractor	OE, BPDB
1.3.	Water Quality	Oil and Grease, Total Residual Cl, alkalinity, Ammonium Nitrogen, Free Ammonia, Total Cr, Fe, Ca, Zn, Cu, etc.	Water bodies and nearby Tube well (if any)	Bi-annual	Grab Sampling	Contractor	OE, BPDB
1.4.	Noise	LAeq, L10, L90	7 locations in and around GPS as mentioned in Figure 11- 1	Twice Weekly	Three Sample during day time and one sample during night, 15 min sampling each time.	Contractor	OE, BPDB
1.5.	Occupational health and Safety	Noise (LAeq)	Two Location: Construction site Labor Shed	Weekly	Three Sample during day time and one sample during night, 15 min sampling each time.	Contractor	OE, BPDB
		Use of PPEs and practice of Safety Procedure	Employers involved in Boiler Decommissioning activities	Daily	Purposive Sampling from Employers involved in Boiler Decommissioning	Contractor	OE, BPDB

Sl no	Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Implemented by	
						Monitoring	**Supervision**
					activities		
		Health Checkup		Monthly		Contractor	OE, BPDB
2.	**Environmental Monitoring during Pre-construction and Construction Phase**						
2.1.	Ambient Air Quality	NOx, SOx, SPM, PM_{10}, $PM_{2.5}$, CO, O_3	a. 1.5km North-westward of the Plant b. 1.5 km South-eastward of the plant	Twice Weekly	24 hour	Contractor	OE, BPDB
2.2.	Ambient Noise	Day time (6:00 – 21:00) and Night time (21:00 – 6:00) L10, L90	7 locations in and around GPS as mentioned in Figure 11-1	Twice Weekly	Three Sample during day time and one sample during night, 15 min sampling each time.	Contractor	OE, BPDB
2.3.	Water Quality	pH, TSS, TDS, Oil and Grease, Total Residual Cl, Total Cr, Fe, Ca, Zn, Pb, Cd, Hg, As, total alkalinity, Ammonium Nitrogen, Free Ammonia, BOD_5, COD, EC Temperature outside the mixing zone, etc.	a. At the point of effluent discharge b. 500m u/s of the discharge point c. 500m d/s of the discharge point	Bi-monthly	Grab Sampling	Contractor	OE, BPDB
2.4.	Ecosystem and Biodiversity	Plant Growth, Canopy Coverage, Disease, etc.	Green belt area within GPS Complex	Yearly	Plot Survey	Contractor	OE, BPDB
		Tree felling	Construction Site, Stack Yards	Monthly	Direct Counting	Contractor	OE, BPDB
2.5.	Fish Diversity and	Diversity Index,	River reach 1: Three	Quarterly	Fish Catch	Contractor	OE

Sl no	Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Implemented by	
						Monitoring	Supervision
	Composition	Richness, Composition, Habitat Suitability Index, etc.	(3) km reach u/s of the intake point River reach 2: Three (3) km reach d/s of the discharge point		Assessment, Fishers' interview		
2.6.	Agricultural Production	Crop Production Loss	Five locations: Two locations at Khanpur; One at Jamalpur, one at ChhotaTaragaon, and one at Palash.	Six monthly following cropping patterns	Agricultural Survey	Contractor	OE
2.7.	Occupational Noise	LAeq	Two locations: Construction site, Labor shed	Twice weekly	Three Sample during day time and one sample during night, for noise 15 min sampling each time. by using: ANSI Type II Noise Meter, and vibration meter	Contractor	OE
2.8.	Exposure to Electro-magnetic Field[43]	Electrical Field, Magnetic Field	Outside the safety fence of Substation, Power evacuation bay, along HV line	Quarterly	One time sampling using EMF meter	Contractor	OE
2.9.	Health and Sanitation	Availability of Potable Water, Drinking water quality, Availability of Hygienic Toilet	Power Plant Complex	Monthly	Inspection and interview of labor, project personnel	Contractor	OE
2.10.	Community Health, Safety and Security	Implementation of EMP	As specified in the EMP	Quarterly	Inspection and interview of labor,	Contractor	OE

[43] See Annex 11-2 for the standards related to electro-magnetic field.

Sl no	Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Implemented by	
						Monitoring	Supervision
					project personnel followed by a checklist		
3.	**Environmental Monitoring During Operation**						
3.1.	Physical Environment						
	Stack Emission	NOx	Stack	Continuous	Continuous	ESHSU /GPS	Independent Monitor/ BPDB
	Ambient Air Quality	NOx, SOx, SPM, PM_{10}, $PM_{2.5}$, CO, O_3	1. 1.5km North-westward of the Plant 2. 1.5 km South-eastward of the plant	Continuous	24 hour	ESHSU/ GPS	Independent Monitor/ BPDB
	Ambient Noise	Day time (6:00 – 21:00) and Night time (21:00 – 6:00) LAeq, L10, L90	1. Housing colony 2. Township Area 3. Fertilizer Factory (Outside Boundary) 4. Nearest Community	Monthly	Three Sample during day time and one sample during night, 15 min sampling each time.	ESHSU/GPS	Independent Monitor/ BPDB
	Gas flow measurement	(a) The water dew point, and (b) The HC dew point	Regulating and metering station	Monthly	Gas chromatographic analysis	ESHSU	Independent Monitor/ BPDB
	Leak detection	Along corridors to locate secondary indicators and walking the corridor with a “sniffer”	RMS and pipeline corridor	Every 3-5 years	Visual Observation for stressed vegetation and with a “sniffer”	ESHSU	Independent Monitor/ BPDB
	Meteorology	Temperature, Rainfall, Humidity, Evaporation, Sun shine hour, wind	Plant Area	Continuous	Continuous	GPS	Independent Monitor/ BPDB

Sl no	Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Implemented by	
						Monitoring	Supervision
		speed, wind direction					
	Effluent (Waste Water)	pH, TSS, TDS, Temperature, EC	Effluent Discharge Channel	Continuous	Continuous	GPS	Independent Monitor/ BPDB
		Oil and grease, Total Residual Cl, Cu, Fe, Zn, Pb, Cd, Hg, As, COD, BOD	Effluent Discharge Channel	Weekly	Grab Sampling	GPS	Independent Monitor/ BPDB
	Storm Water	As above	Combined Discharge Channel	Monthly	Grab Sampling	GPS	Independent Monitor/ BPDB
	Water Quality: Surface Water	pH, TSS, TDS, Oil and Grease, Total Residual Cl, Total Cr, Fe, Ca, Zn, Pb, Cd, Hg, As, total alkalinity, Ammonium Nitrogen, Free Ammonia, BOD_5, COD, EC , Temperature outside the mixing zone, etc.[44]	1. At the point of effluent discharge 2. 500m u/s of the discharge point 3. 500m d/s of the discharge point	Monthly	Grab Sampling	GPS	Independent Monitor/ BPDB
	Water Quality: Ground Water	pH, Total Hardness, Color, Cl, Total Coliform,	Plant Area	Monthly	Grab Sampling	GPS	Independent Monitor/ BPDB

[44] These monitoring parameters will be revised after monitoring the effluent water quality from the discharge channel. Some parameters might become redundant if the effluent water does not contain them.

Sl no	Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Implemented by	
						Monitoring	Supervision
		F, Fe, Mn, As, PO_4, SO_4, etc.					
3.2.	Waste Generation and Management						
	Generation of Non Hazardous Solid Waste (Domestic waste, Office Waste,)	Types and Quantity, Characteristics	Waste Disposal Point	Quarterly	Visual Inspection, waste classification	IM	GPS/ BPDB
	Generation of Hazardous Solid Waste	Types and Quantity, Characteristics	Waste Disposal Point, Waste Generation Sources	Quarterly	Visual Inspection, waste classification	IM	GPS/ BPDB
	Generation of Hazardous Liquid Waste, Sludge (return from Water Treatment Plant, Sludge from clarifier, neutralization pond)	Quality of Water in effluent pit e.g., corrosivity, reactivity.	Hazardous Liquid Waste and Sludge Disposal site (i.e. effluent pit)	Quarterly	Visual Inspection, waste classification	IM	GPS/ BPDB
	Waste Management	Condition of waste bins, waste transportation vans,	N/A	Quarterly	Visual inspection and document checking	IM	GPS/ BPDB
		Capacity of Waste Disposal Site	Waste Disposal Point	Quarterly	Visual inspection and document checking	IM	GPS/ BPDB
		leaks, drips or other indications of waste spill during handling and transporting	From Waste generation to disposal site	Quarterly	Visual inspection, and document checking	IM	GPS/ BPDB
	Hazardous Waste Management	Labeling of Hazardous Materials, hazardous waste,	Chemical Storage, Hazardous Material Storage area, Hazardous Waste	Quarterly	Visual inspection, and document checking	IM	GPS/ BPDB

Sl no	Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Implemented by	
						Monitoring	Supervision
		documentation of hazardous chemical use, etc.	Disposal Area.				
3.3.	**Ecosystem and Biodiversity**						
3.3.1.	Plant Health	Plant Growth, Canopy Coverage, Disease, etc.	1. Proposed Green belt area near neutralization Pond 2. Proposed Greenbelt area near Asbestos Disposal Site 3. Other Greenbelt area in GPS Complex	Yearly	Proposed Greenbelt area around the Neutralization pond and asbestos disposal site: Whole area Survey Other Vegetative area in GSP: Four Plots of 25m X 25m (one plot at each corner of GSP Complex) Plot Survey	IM	GPS/ BPDB
3.3.2.	Occurrence of Wildlife	Species Composition and Status	Same as above	Six monthly	Same as above	IM	GPS/ BPDB
3.3.3.	Fish Diversity and Composition	Diversity Index, Richness, Composition, Habitat Suitability Index, etc.	River reach 1: Three (3) km reach u/s of the intake point River reach 2: Three (3) km reach d/s of the discharge point	Quarterly	GPS	IM	GPS/ BPDB
3.4.	**Land and Agricultural Resources**						
3.4.1.	Land use and Land Cover change	Land cover and Land use	5km buffer area of the plant	Once in three years	Satellite Image (5km buffer area of GPS) Analysis	IM	GPS/ BPDB
3.4.2.	Agricultural Production	Crop Production Loss	Agricultural land around the GPS complex	Yearly	Farmers' Interview, Secondary Data from DAE	IM	GPS/ BPDB

Sl no	Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Implemented by	
						Monitoring	Supervision
3.5.	**Occupational Health and Safety**						
3.5.1.	Occupational Noise and vibration	LAeq, L10, L90, Noise Exposure	a. Inside Plant Area (Turbine hall, RMS, etc.) b. Control room c. Administrative building	Quarterly	Three Samples during day time and one sample during night, for noise 15 min sampling each time. by using: ANSI Type II Noise Meter Inspection of record of shifting hour, workers' roster	GPS	Independent Monitor/ BPDB
3.5.2.	Exposure to Electro-magnetic Field	Electrical Field, Magnetic Field	Outside the safety fence of Substation, Power evacuation bay, other EHV area	Quarterly	Measurement by EMF Meter Inspection of workers' roster shifting hours etc.	GPS	Independent Monitor/BPDB
3.5.3.	Worker Health	General Health Condition, Hearing health, skin disease, etc.	Workers involved in the Plant operation and maintenance	Quarterly	Health Check up	IM	GPS/ BPDB
3.6.	Labor and Working Condition						
3.6.1.	Health and Sanitation	Availability of Potable Water	Power Plant Complex	Monthly	Visual Inspection and Record Checking	IM	GPS/ BPDB
		Drinking water quality (pH, TS, EC, F, Cl, As, Mn, Fe, Total Hardness, Total Coliform, PO4, SO4)	Water Supply System	Monthly	Three samples from Drinking water supply system	IM	GPS/ BPDB
		Availability of Hygienic Toilet	Office Building, Township Area,	Monthly	Visual Inspection	IM	GPS/ BPDB

Sl no	Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Implemented by	
						Monitoring	Supervision
			Common Places, etc.				
3.7.	Community Health, Safety and Security						
3.7.1.	Community Health	Status of Communicable Diseases	Township Area, Nearest Community	Two times in a year	Inspection of Disease Profile/Records in Health Camps/Clinic in GPS, nearby area Hospital	IM	GPS/ BPDB
		Status of Vector Borne Diseases				IM	GPS/ BPDB
3.7.2.	Safety and Security	Emergency Preparedness and Response of GPS	N/A	Two times in a year	Visual Inspection and Record Checking	IM	GPS/ BPDB
		Community Relation Program/ Community Awareness Program, Training	N/A	Two times in a year		IM	GPS/ BPDB
3.8.	**Measures beyond compliance**						
3.8.1.	Social Development Program	Number of benefited person/family	Nearest Community	Two times in a year	Inspection of Documents, records	IM	GPS/ BPDB
3.8.2.	Sustenance of irrigation network	Number of additional hacterage of farmland	Nearest Community	Two times in a year	Visual Inspection and record checking	IM	GPS/ BPDB
3.8.3.	HealthCare/Development Program	Number of benefited person/family	Nearest Community	Two times in a year	Inspection of Documents, records	IM	GPS/ BPDB
3.8.4.	Other Aid to Community	Number of benefited person/family	Nearest Community	Two times in a year	Inspection of Documents, records	IM	GPS/ BPDB

Table 11-2: Impact Monitoring Plan

Parameter / Activity	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implemented By	Supervised By
Boiler Decommissioning					
Removal of insulation materials containing asbestos	Boiler, steam pipes and its surrounding area	Visual inspection to see whether the polythene sheet cladding are used to arrest stray asbestos dust	Twice Weekly	Contractor	OE/Independent Monitor
		Visual inspection to ensure that the concrete water proofed bund are installed and they are working effectively	Twice Weekly	Contractor	OE/Independent Monitor
		Visual inspection to ensure that barricaded GI sheets are installed to physically isolate the boiler and gated with security staff so that unauthorized entry is restricted	Twice Weekly	Contractor	OE/Independent Monitor
		Visual inspection to ensure that asbestos fibers appear in the air are removed by manually operated water spray to minimize spreading of asbestos fibers in atmosphere.	Twice Weekly	Contractor	OE/Independent Monitor
		Visual inspection to ensure that asbestos fibers appear in the air are removed by manually operated water spray to minimize spreading of asbestos fibers in atmosphere.	Weekly	Contractor	OE/Independent Monitor
During Construction					
Hydrocarbon and chemical	Construction camps	Visual Inspection of storage facilities	Monthly	Contractor	OE/Independent Monitor

Parameter / Activity	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implemented By	Supervised By
storage					
Damage to local roads	Approach Roads to the construction sites	Visual inspection to ensure local roads are not damaged	Monthly	Contractor	OE/Independent Monitor
Traffic Safety	Haul Roads	Visual inspection to see whether proper traffic signs are placed and flag-men for traffic management are engaged	Monthly	Contractor	OE/Independent Monitor
Air Quality (dust, -smoke)	Construction sites	Visual inspection to ensure good standard equipment is in use and dust suppression measures (e.g., spraying of waters) are in place.	Daily	Contractor	OE/Independent Monitor
	Batch mixing Plant	Visual inspection to ensure batch plant is located >500 m from residential areas	Monthly	Contractor	OE/Independent Monitor
	Material storage sites	Visual inspection to ensure dust suppression work plan is being implemented	Monthly	Contractor	OE/Independent Monitor
Noise	Construction sites	Physical inspection to ensure good standard equipment are in use;	Twice Weekly	Contractor	OE/Independent Monitor
	Construction sites	Visual inspection to ensure ear plugs are in use by the construction workers	Twice Weekly	Contractor	OE/Independent Monitor
		Ensure work restriction between 20:00-06:00 close to the sensitive locations	Twice Weekly	Contractor	OE/Independent Monitor
Plantation	Designated sites	Visual inspection to observe growth of saplings around neutralization pond and asbestos	Monthly	Contractor	OE/Independent Monitor

Parameter / Activity	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implemented By	Supervised By
		disposal site			
Waste Management	Construction camps	Visual inspection that solid waste is disposed at designated site Solid Wastes are managed in efficient way	Monthly	Contractor	OE/Independent Monitor
Hazardous Waste Handling	Hazardous Material Storage Area Hazardous Waste Disposal Area	Visual Inspection of safe handling and storage of hazardous waste and hazardous materials	Monthly	Contractor	OE/Independent Monitor
Drinking water and sanitation	Camps, offices	Ensure the construction workers are provided with potable water and sanitation facilities in the site	Weekly	Contractor	OE/Independent Monitor
Cultural and archeological Sites	At all work sties	Visual observation for chance finds	Daily	Contractor	OE,Independent Monitor, BPDB
Restoration of Work Sites	All Work Sites	Visual Inspection	After completion of all works	Contractor	OE, Independent Monitor, BPDB
Safety of workers Monitoring and reporting accidents	At work sites	Usage of Personal Protective equipment, Safety Sign, Safety Documentation, safety training, etc.	Monthly	Contractor	OE, Independent Monitor, BPDB
Emergency Response Plan	At work sites	Inspection of Emergency Preparedness and Response mechanism	Monthly	Contractor	OE, Independent Monitor, BPDB
Grievance Mechanism	At work site	Visual inspection and enquiry to know the Grievance Mechanism.	Monthly	Contractor	OE, Independent Monitor, BPDB
During Operation and Maintenance					
Monitoring of Environmental Quality	As specified inTable11.1	Inspection and Record checking of Monitoring activities	Quarterly	Independent Monitor	BPDB

Parameter / Activity	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implemented By	Supervised By
(Ambient Air, Noise, Water, effluent, Soil, etc.)		carried out by EHSU circle of GPS			
Environmental Laboratory	GPS Complex	Inspection of laboratory Condition, accreditation and certification (from GOB) status	Six-monthly	PIU	Independent Monitor, BPDB
Meteorological Condition	GPS	Checking and compiling climatic data collected and recorded by micro weather station installed in GPS	Quarterly	Independent Monitor	BPDB
Ambient Noise Level	Township area, Administrative area and nearby community	Noise nuisance/ disturbance perceived by power plant personnel and nearby community to be surveyed by interview and FGD	Six-monthly	Independent Monitor	BPDB
Fisheries	Shitalakhya River around the water intake point, effluent discharge point	Visual inspection of fish mortality Interviewing local fishermen	Six-monthly	Independent Monitor	BPDB
Plant Health	Blooming of flowers and fruits in plants within the GPS, number of tree felling	Visual inspection	Six-monthly	Independent Monitor	BPDB
Land use and land cover	50km buffer area of the plant	Satellite image analysis of land use and land cover	yearly	Independent Monitor	BPDB
Hazardous Waste and Hazardous Material Handling	Hazardous Material Storage Area and Use Area Hazardous Waste Disposal Area At monitoring well location	Visual Inspection of safe handling and storage hazardous waste and hazardous materials	Quarterly	EHS Circle	Independent Monitor, BPDB
Grievance Mechanism	GPS complex and nearby	Interview of local population to check	Quarterly	EHSU Circle	Independent Monitor,

Parameter / Activity	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implemented By	Supervised By
	community	whether grievance mechanism is working or not. Checking records of complaints and redresses			BPDB
Emergency Response Plan	At work sites	Inspection of Emergency Preparedness and Response mechanism	Quarterly	EHSU Circle	Independent Monitor, BPDB
Health and Safety Preparedness	GPS Complex	Inspection of training list, safety meetings records, means of awareness growing	Quarterly	EHSU Circle	Independent Monitor, BPDB
Community Relation	GPS Complex, Nearby Community	Inspection of community relation maintaining procedures, relation building activities, FGD with community	Quarterly	EHSU Circle	Independent Monitor, BPDB
CSR Program	GPS Complex, Nearby Community	Inspection of record completed and planned CSR programs and activities	Six-monthly	Independent Monitor	BPDB

11.2 Implementation of Environmental Monitoring Plan

11.2.1 Responsible Agency

724. The Chief Engineer, Power Station Construction (PSC) is the responsible authority for administrating and implementing the Project and the Project Director GPS Unit 4 Repowering will implement environmental monitoring program during construction and the Chief Engineer Operation will implement monitoring plan during operation stage. During construction stage, the Environmental Compliance Monitoring will be conducted by the Contractor(s) supervised by the Owner’s Engineer (OE) and Environmental Impact Monitoring will be carried out by the by the Owner’s Engineer (OE) in support from the Contractor(s). In addition, an independent Monitor will also be retained by PIU during three years of construction and by GPS during three years of post-construction (operation stage). The EHSU Circle of GPS will implement the monitoring program during operation stage.

11.3 Action during Emergent Operation

725. The plant can have an Emergent operation if there is a major failure of control system, plant component, grid failure, etc. Normally the modern distributed control system (DCS) is good enough to handle all such emergencies. Otherwise, the plant operator/shift in-charge can change the plant control to manual mode and adjust the process variables and

finally change the plant back to auto mode. The proposed project will have DCS control system with modern sensors and a proper interface with the existing old sensors/system.

726. The plant will be operated ensuring all pollution control devices are in order. In case of any event of malfunction of a pollution control device, immediate action of resolving the problem will be taken. If any emergent situation arises during operation, the shift in-charge will be immediately notified to take corrective measures and action.

11.4 Performance Indicators

727. For evaluating the performance of the environmental management and monitoring plan, performance indicators are identified to, for efficient and timely implementation of measures/actions proposed in EMP. The indicators are defined both for construction and operation phases. OE will be responsible for compiling the information on these indicators and report to BPDB.

728. Separate performance indicators for each environmental issue have been specified in Table 11-1 and Table 11-2. To measure the overall environmental performance of the project, an additional list of performance indicators is provided below:

- Number of inspections carried out by OE per month
- Number of non-compliances observed by OE or EHSU.
- Continuous period of non-compliance
- Number of grievances received.
- Number of grievances resolved.
- Number of construction and occupational related accidents.
- Timely reporting of documents (as defined in EMP and monitoring plan)
- Availability of environmental and H&S specialists in EHSU.
- Availability of environmental and H&S specialists in OE.
- Availability of environmental specialists and H&S with contractors.
- Number of trainings imparted to stakeholders/other capacity building initiatives

11.5 Reporting and Feedback Mechanism

729. The monitoring activities will require proper documentation. In case of Independent monitor, the monitoring results and relevant document should be properly reported to the project implementation authority. The project authority would submit the report to the Department of Environment and to the Financer (World Bank in this case).

730. During construction stage, the environmental specialist of OE will be engaged in monthly discussion meeting with the project implementation unit and the Contractor(s) for giving necessary feedback. The project implementation unit may arrange a discussion meeting quarterly with the financer regarding environmental compliance.

731. During the operation phase, the EHSU Circle will carry out the monitoring activities and keep all the records and results of monitoring with proper documentation and will produce quarterly reports on Environmental Monitoring. Besides, the third party Independent Monitor would prepare and submit environmental compliance monitoring report annually to the power plant authority. All the reports should be submitted to DoE which is a condition of

renewing the Environmental Clearance Certificate from DoE and to the World Bank for post-completion monitoring and evaluation of the project.

732. During operation, the EHSU Circle will give necessary feedback instantly to the person in concern. The EHSU Circle will arrange a monthly meeting to disclose the results of environmental monitoring to the personnel.

11.6 Budgets for Monitoring

733. Summary costs of monitoring including investments costs are presented in Table 11-3, Table 11-4, and Table 11-5. The detailed breakdown is presented in Annex 11-3.

Table 11-3: Environmental Compliance Monitoring Cost

Sl no	Activities	Estimated Cost (USD)
During pre-construction and Construction (borne by EPC Contractor)		
1	Environmental quality (air, water, noise, soil) monitoring	393,120
2	Occupational health, safety, and sanitation	78,060
3	Ecosystem, Biodiversity, Fisheries Resources and Agricultural Resources Monitoring	44,800
	Subtotal	*515,980*
During 3 years of operation (to be included in O/M cost)		
1	Environmental quality (air, water, effluent, noise, soil) monitoring	76,500
2	Waste Generation and Management	6,300
3	Ecosystem and biodiversity	12,000
4	Land and agriculture resources	6,500
5	Health, safety, and sanitation	14,130
6	Monitoring beyond compliance	6,900
	Subtotal	*122,330*
	Total Monitoring	**638,310**

Table 11-4: Investment Cost of Environmental Monitoring

Sl no	Activities	Estimated Cost (USD)
1	Continuous Stack Emission Monitoring System	250,000
2	Continuous Ambient Air Quality Monitoring Stations (2)	500,000
3	Continuous Effluent Quality Monitoring Instrument	150,000
4	Micro Weather Station	40,000
5	Environmental Laboratory	400,000
	Estimated Total Cost	**1,340,000**

Table 11-5: Cost of Independent Monitor

Sl no	Activities	Estimated Cost (USD)
1	Independent Monitor for a six (6) years period including 3 years of operation (only fees and cost)	**813,780**

12. Indirect Project Benefits and Measures Proposed Beyond Compliance

12.1 Preamble

734. The re-powering Project is designed as environmentally sound in comparison to the existing operation regime of Unit 4 as described in Chapter 4. Even then, the Project might have sensitivity to environment and thus measures to go beyond regulatory requirements are introduced in the EIA and EMP. Aspects such as GHG emission reduction, corporate social responsibility, extending support to use of condenser cooling water for irrigation, and measures such as, green belting of asbestos pit and neutralization pond are therefore proposed.

12.2 GHG Emission Reduction – An Indirect Project Benefit

735. Since, the repowering will improve efficiency from 33.9% to 54.1% there will be a net benefit in greenhouse gas (GHG) emissions. The implementation of combined cycle would further reduce the emission of greenhouse gases as the flue gas emitted from the gas turbine is used again in the Heat Recovery Steam Generator. Such power generation process combined with the implementation of energy efficiency programs in power sectors and in other infrastructures would not only make the production cost-effective but also reduces greenhouse gas emissions. Natural gas-fired, primarily combined-cycle fleet consumes significantly less fuel to generate power than conventional boiler/steam turbine power plants and emits fewer GHG emissions per MWh of power produced as compared to coal-fired or oil fired power plants. The proposed project thus demonstrates a case of voluntary GHG emission reduction. These reductions may qualify Clean Development Mechanism (CDM).

736. The clean development mechanism was designed to meet a dual objective: (a) to help developed countries fulfill their commitments to reduce emissions, and (b) to assist developing countries in achieving sustainable development. CDM projects earn tradable, saleable certified emission reduction (CER) credits that can be used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. Benefits of CDM projects include investment in climate change mitigation projects in developing countries, transfer or diffusion of technology in the host countries, as well as improvement in the livelihood of communities through the creation of employment or increased economic activity.

737. Table 12-1 summarizes approximate annual GHG emissions from the natural gas-fired, combined-cycle power plant (repowering) in comparison to the gas based steam-cycle generation (baseline). It is estimated that 1,439,264 ton/y of CO_2 emission generates from the baseline scenario (steam cycle) and 901,868 ton/y of CO_2 emission produced from the repowering case for the equal amount of power (412 MW), respectively. The net CO_2 emission benefit is estimated as 537,396 ton/y and a total of 13,434,904 ton in the entire project life (25 years).

Table 12-1: GHG emissions in baseline and repowering conditions

Parameter	Baseline (Steam Turbine)	Re-powering (Combined Cycle)	GHG Benefits
Efficiency	33.90%	54.10%	-
CO_2 (tons/y	1,439,264	901,868	537,396
CH_4 (tons/y)	26	16	10
N_2O (tons/y)	31	6	25
CO_2 - equivalent (tons/y)	1,449,286	903,934	545,352

Notes:
1) Output and emissions calculations based on 412 MW (gross) generation and 80% load factor.
2) CO_2 and CH_4 emission factors from 2006 IPCC Guidelines for National Greenhouse Gas Inventories
3) N_2O emission factor from EPA AP 42, Fifth Edition,and Volume I.
4) GWP of 1, 21, and 310 used for CO_2, CH_4 and N_2O, respectively.

738. It is recommended that BPDB keeps track of GHG emission reductions on an annual basis and includes the actual figures realized in the form of a GHG Register.

12.3 Measures under corporate social responsibility

739. Corporate Social Responsibility (CSR) has become an important part of corporate obligations reflecting non-financial aspects of an organization's performance like BPDB. These non-financial aspects have significant implications for a company's internal and external stakeholders, including nearby communities, civil society organizations, regulators, international financial organizations, and news media. Local people have the concern about corporate accountability and the impact of corporate strategies and operations on the physical, economic, and socio-political environments. Financial analysts often view adverse public opinion on corporate social performance as a measure of long-term reputational risk to a company's market value. Thus, CSR have become a competitive tool in promoting an organization's practices and values when compared with those of its peers and competitors. CSR activities for the proponent to repower Unit 4 of Ghorashal Power Plant are therefore proposed as follows:

- The health facility presently available in the GPS is in good shape and is not overloaded with patients. So, this facility can be available for the poor people around the GPS. Appropriate security measures may be taken;
- Providing sanitation facilities, such as setting up of public toilets at different hot spots of the Ghorashal municipality area following the guidelines for public toilet[45] and with the coordination of Ghorashal Municipality Administration. Management of those toilets may be based on lease system, so that it remains usable over a long run to a large number of people;
- Training of local youth so that they can, in turn, be employed during project construction and GPS operation. Bangladesh is one of the major manpower supplying countries of the world. But it supplies non-skilled to semi-skilled

[45] WaterAid Bangladesh, 2006. Step by Step Implementation Guidelines for Public Toilet

manpower particularly in the Middle East and South East Asian countries and earns low foreign currency compared to the countries which provide skilled manpower. There is a huge demand of power related technicians. So, there is a scope of developing manpower in power sector in technician category and as such they can earn more foreign currency. In this connection, this Project can facilitate capacity development of the local youths through relevant training programs using knowledge hub of the Ghorashal Power Station.

- Develop socio-cultural facilities such as mosques, playgrounds and community centers for the community.

Table 12-2: Estimated budget for CSR

Sl	Items	Quantity	Amount (US$)
1	Public toilets	3	10,500
2	Training of local youths	200	15,000
3	Socio-cultural facilities	3	30,000

12.4 Use of cooling water discharge for irrigation – extending support for three years

740. The existing units of the Ghorashal Power Station are being operated by the once-through condenser cooling system and use a large quantity of Shitalakhya River water. This large quantity of water maintains the same quality of river water except the water temperature. Currently, GPS is diverting about 7.79 m^3/s of water from the effluent discharge canal to an irrigation network for the benefits of local farmers. About 4,000 acres (1,619 ha) of farmland is cultivated using this water. At present, 6,152 ton of boro rice is produced per season using the condenser cooling water discharge. During the public consultation local farmers expressed their gratitude to GPS and requested to continue this services and if possible to increase the quantity of water for irrigating additional land. Before the existence of this canalized irrigation system, using condenser cooling water discharge, this area had been hugely suffering from shortage of water to irrigate cropland despite having deep tube wells. The tube-wells were also producing insufficient volume of water which was just meeting the domestic demand for water, i.e., for cleaning of utensils and drinking purposes. In the given circumstances, the local inhabitants could not grow crops in all of their croplands and the yield was relatively low. Taking the opportunity of the availability and considering the usefulness of cooling water discharge, the Bangladesh Agricultural Development Corporation (BADC) facilitated development of canalized surface water irrigation to the farmlands of the Palash Upazila, and during 1992-93 this service delivery system was formalized between BPDB and BADC. To make the irrigation system effective, the BADC developed different structures, such as culverts, canals, footbridges and sluice gates, which were considered relevant and necessary to ensure supply of water to the remote agriculture lands.

741. The cooling water discharge has a temperature of 7° - 9°C higher than the ambient temperature in the river water. However, when this cooling water passes through a long distance through the irrigation network to reach the agricultural lands, the water loses its temperature and returns near to its ambient temperature. However, the near-field croplands experience higher temperature at the intake point of irrigation network.

742. The irrigation cost per hectare of land is about Taka 6,500.00 if the water is directly withdrawn from the Shitalakhya River. But the use of condenser cooling water discharge in irrigation cost the farmers only Taka 800 per hectare. Overall the cost benefits of the desired implementation measures on irrigation outweigh the cost of farmers in using other irrigation methods.

743. Notwithstanding the above benefits, use of cooling water discharge for irrigation in some instances become detrimental to some croplands those are located in low lying lands due to accumulation of warm stagnant water. This particularly the case, where the water passes through the earthen canals and do not lose sufficient temperature.

744. In the repowering proposal of Unit 4, close cycle cooling is recommended. In addition, all future repowering projects may follow the same recommendation, which would mean that condenser cooling water supply for irrigation may not be made available. This is detrimental to the current irrigation practices in the project impact area. Under the close cycle cooling the water demand from Shitalakhya River will be significantly reduced and some of the pumps may become redundant. Considering, the severance of the issue and the significant benefits to the communities, it is recommended that one pump can be dedicated for the irrigation water for at least three years of project operation. GPS should coordinate with BADC to handover the pumps and watermain for irrigation services. The operation and maintenance costs after three years should be borne by BADC. Current annual operation and maintenance costs of one pump is about BDT 10 million, however, for irrigation purpose much less operation cost will be required.

12.5 Greenbelt Development

745. There will be about 25 trees of mahogany species, shrubs, and grasses require clearing for the project footprint, which requires compensation by 3-5 times per tree felt to comply with DoE requirements. In addition, wildlife habitat especially bird species will be affected. To compensate the trees and wildlife habitat loss, a plantation program under the project is considered in terms of green belt development beyond compliance within the project boundary. The greenbelt will minimize the ambient noise generated from the power plant. As well as help attenuate the dust. Indigenous tree species that are pollution resistant and with thick foliage will be selected for green belt development. Table 12-3 presents the distribution and number of each species for the plantation program. It is proposed that saplings should be planted in rows around the existing sludge disposal site (Figure 12-1), proposed hazardous waste disposal site (Figure 12-2), and close to the new gas turbine and HRSG plant. The saplings will be planted and maintained by GPS authority. Table 12-4 presents the budget for greenbelt development program.

Table 12-3: Species distribution and numbers for greenbelt program

Local Name	Scientific Name	Number
Chambol	*Albizia richardiana*	18
Mahagoni	*Swietenia Mahagoni*	8
Weeping Debdaru	*Polyalthia sp.*	152
Neem	*Azadirachta indica*	46
Dumur	*Ficus hispida*	176
	Total	**400**

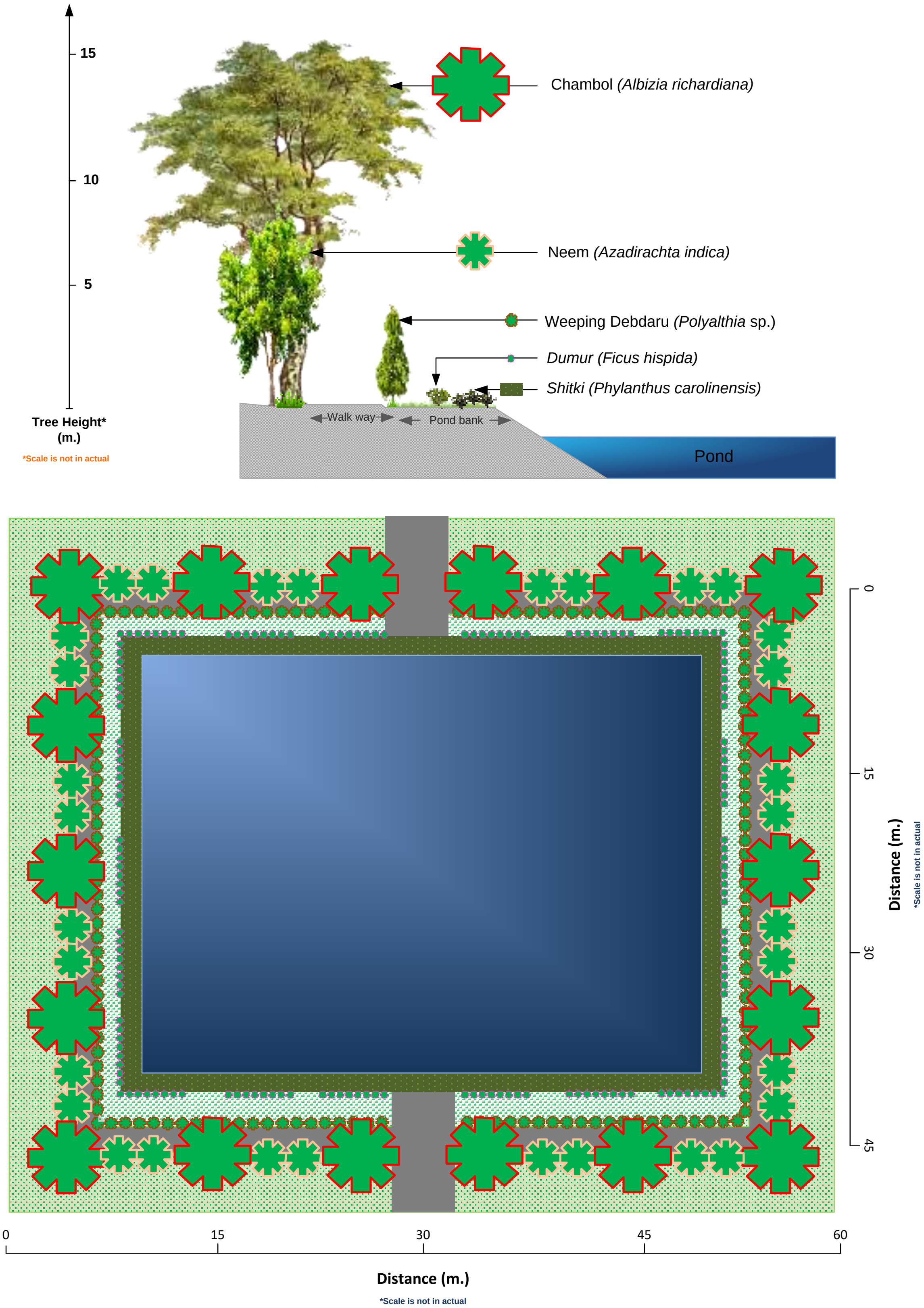
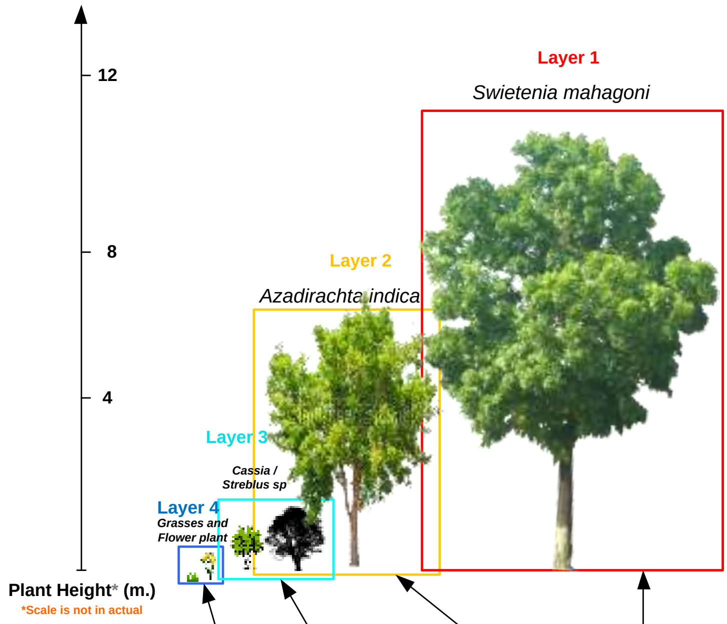


Figure 12-1: Schematic diagram showing plantation around the sludge disposal site

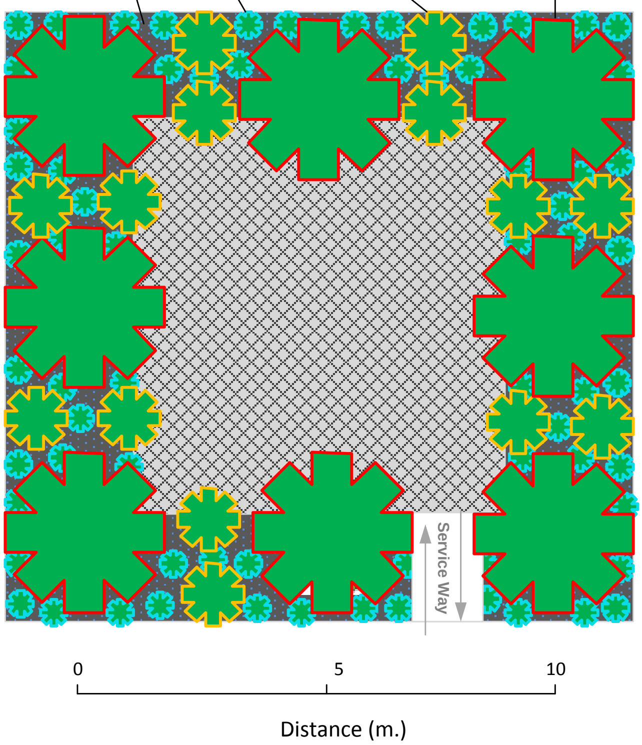


Plant Legend

Mahagoni *(Swietenia mahagoni)*

Neem *(Azadirachta indica)*

Grasses and Flower Plants



Required Number of Sapling for Plantation

Mahagoni *(Swietenia mahagoni)* = 8
Neem *(Azadirachta indica)* = 14
Shewra/Kolkasunda *(Cassia/Streblus* spp.*)* = 71
Grasses and Flower Plants = as per required

Figure 12-2: Schematic diagram showing plantation around the proposed hazardous waste disposal site

Table 12-4: Budget for plantation program

Items	Amount (USD)
Saplings	1,242.95
Labor cost for planting	358.97
Others	1,000.00
Total	**2,601.92**

12.6 Closing

746. The re-powering Project is designed as environmentally sound project and an environmental management plan has been devised to take care of the environmental issues. With the apprehension that the Project might still have sensitivity to the environment, measures discussed above are considered to enhance environmental and social conditions of the project area. These measures are essentially beyond compliance requirements and can provide inspiration to other companies and corporations in Bangladesh to follow.

13. Institutional Arrangements and Capacity Building

13.1 Profile of key government institutions

13.1.1 Bangladesh Power Development Board

747. The Bangladesh Power Development Board (BPDB) was created as a statutory public sector organization through the Presidential Order No. 59 in 1972. The aim was to increase the power generation capacity to meet the demand of independent Bangladesh. The BPDB is responsible for planning and development of country's power generation and distribution infrastructures as well as operation of many of nation's power generation facilities. At present, the BPDB is main agency responsible for generation and distribution of electricity mainly in urban areas of the country. The BPDB falls under the auspices of the Power Division, Ministry of Power, Energy and Mineral Resources, Government of Bangladesh. The organogram of the BPDB is presented in Figure 13-1.

748. Since the mid-seventies, the Government recognized the need and importance of providing electricity to rural households, particularly to achieve desirable social improvement and stimulate rural industries in the country. To this end a different approach was adopted, and in October 1977, the government established the Rural Electrification Board (REB). Subsequently, in 1991 Dhaka Electric Supply Authority (DESA), now renamed as Dhaka Power Distribution Company (DPDC) was created. The latter was created basically to operate and develop distribution system in and around Dhaka (including the metropolitan city), collect revenues and provide better customer services. The DPDC was also entrusted with these responsibilities to lessen administrative burden of BPDB.

749. In all these efforts, public investments and State ownership have been the case and the power sector remained under government control.

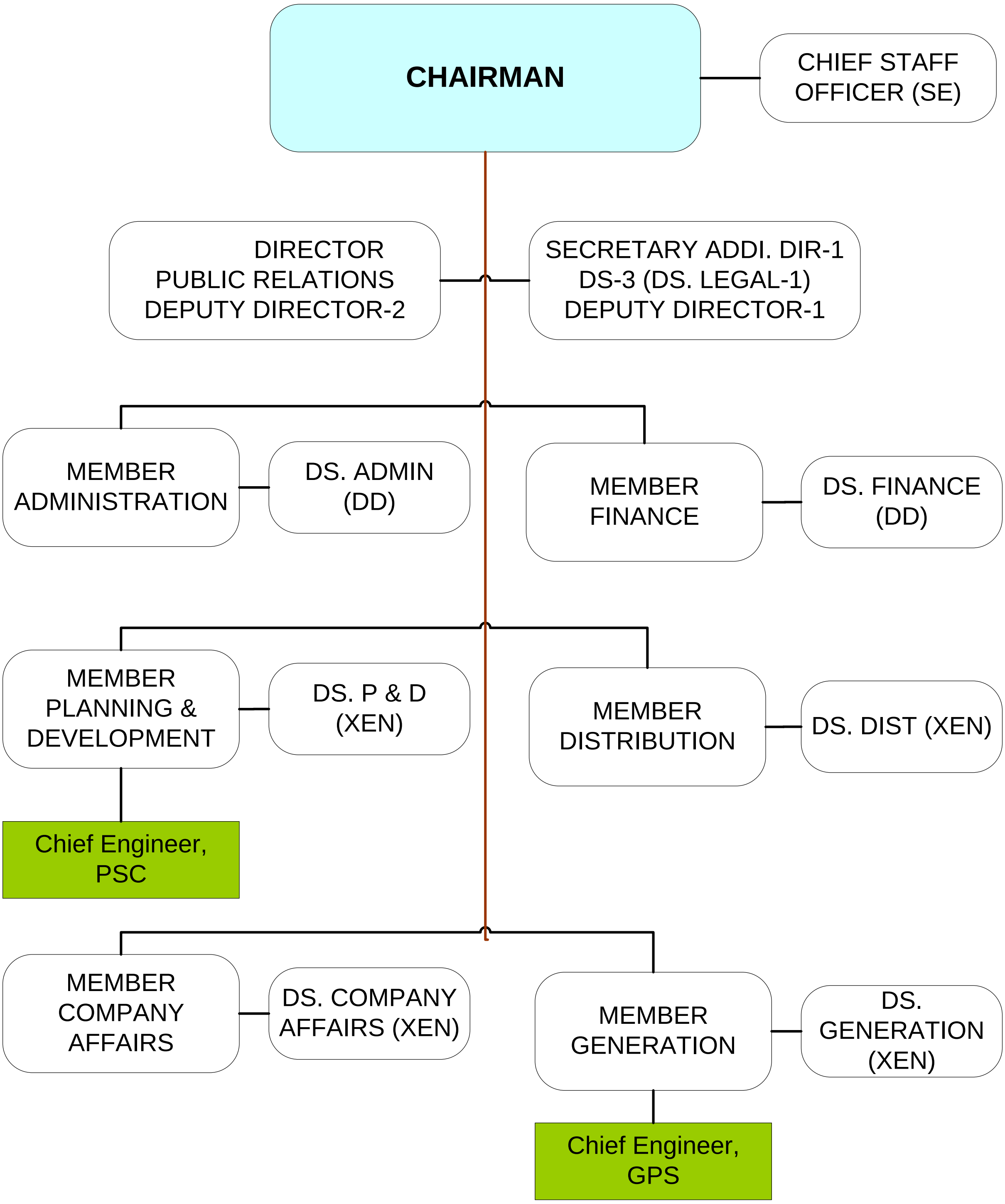


Figure 13-1: Organogram of BPDB

13.1.2 Project Implementation Unit

750. For the operation of Ghorashal Unit-4 Power Plant, the BPDB has created a project implementation unit (PIU), under the office of the Chief Engineer, Power Station Construction (PSC). The PIU consists of one Project Director (PD), one Executive Engineer, and an Assistant Director-cum- Accountant.

751. To strengthen the PIU additional resources are needed. A Development Project Proforma (DPP) with a provision of additional man power of 22 engineers and an assistant

director (accounts) has been submitted to the Government for approval. This DPP has been prepared and submitted to implement the project within the approved time and budget. Detailed qualification, required number of people in each post and responsibility of each position is depicted in Table 13-1.

Table 13-1: Qualification and Responsibilities of the PIU Staffs

Sl no.	Name of the post	Quantity	Qualification	Responsibility
1	Project Director (Chief Engineer)	1	B.Sc. Engineering or as per BPDB's Service Rule	Responsible to implement the project on time and furnishing both financial and physical progress report of the project for deliberation on the progress in the monthly Pre-steering and Steering meetings.
	Deputy Project Director (Superintending Engineer)	1	B.Sc. Engineering or as per BPDB's Service Rule	To assist the Project Director in all respect. In the absence of the PD, responsible for implementing the project
2	Superintending Engineer (S E)	2	B.Sc. Engineering or as per BPDB's Service Rule	Supervision of contractor's work during the construction of the proposed power plant as per the design and scope of works outlined in the contract document. Report on work progress from time to time to the CE/PD. Monitor all issues related to environment, health and safety (EHS). One of the two Superintending Engineers should be fully assigned to cover EHS issues.
3	Executive Engineer	2	B.Sc. Engineering or as per BPDB's Service Rule	To provide all supports to the SE in the execution of the EPC contractor's works engaged for the construction of the proposed power plant project.
	Executive Engineer (EHS)	1	B.Sc. Engineering (environment) or as per BPDB's Service Rule	To provide all supports to the SE in the execution of the EPC contractor's works engaged for EHS issues of the construction of the proposed repowering project. One Executive Engineer will be dedicated to EHS issues.
4	Sub-Divisional Engineer	2	B.Sc. Engineering or as per BPDB's Service Rule	Providing all support to the Executive Engineer in the supervision of file works of proposed power plant project.
	Sub-Divisional Engineer (EHS)	1	B.Sc. Engineering (environment) or as per BPDB's Service Rule	Providing all support to the Executive Engineer (EHS) in the supervision of file works related to EHS issues of proposed repowering project. One sub-divisional engineer will be dedicated to EHS issues.
5	Assistant Engineers	4	B.Sc. Engineering or as per BPDB's	Providing all support to the Executive Engineer in the supervision of file

Sl no.	Name of the post	Quantity	Qualification	Responsibility
			Service Rule	works of proposed power plant project.
	Assistant Engineers (EHS)	2	B.Sc. Engineering (environment) or as per BPDB's Service Rule	Providing all support to the Executive Engineer in the supervision of file works of proposed repowering project. These assistant engineers will be dedicated to EHS issues. One must have previous experience in environmental management and one in occupational health, and safety issues.
6	Assistant Director (Accounts)	1	Masters/Graduate	Maintaining general ledger book, processing of contractor's bill for payment, preparation of monthly accounts statement for the project related financial transaction. Also responsible for all personnel and administrative matters as per delegation of authority.
7	Sub-Assistant Engineer	6	Diploma Engineering	Providing all support to the Executive Engineer/ /SDE/AE in supervision of field works of proposed power plant project.

13.1.3 Ghorashal Power Station (GPS)

752. Ghorashal Power Station is the largest power station in Bangladesh. The station started its operation in 1974. The station is headed by a Chief Engineer and four operation and maintenance managers. Table 13-2 gives a summary of actual approved posts, posts currently having personnel and posts that are vacant. The revised organogram as proposed by BPDB is presented in Figure 13-2.

Table 13-2: Levels and ist and number of positions in Ghorashal Power Station and their current status in terms of incumbency

Designation	Allocation	Posted	Vacant
Chief Engineer	1	1	-
Manager (Superintending Engineer)	4	3	1
Executive Engineer	31	27	4
Sub-Divisional Engineer	39	9	30
Assistant Engineer	45	27	18
Sub-Assistant Engineer	74	80	-
Non-Technical Officers	30	25	5
3rd & 4th Class Staff (Technical)	729	697	32
3rd & 4th Class Staff (Non-Technical)	289	167	122
Total	**1,242**	**1,036**	**212**

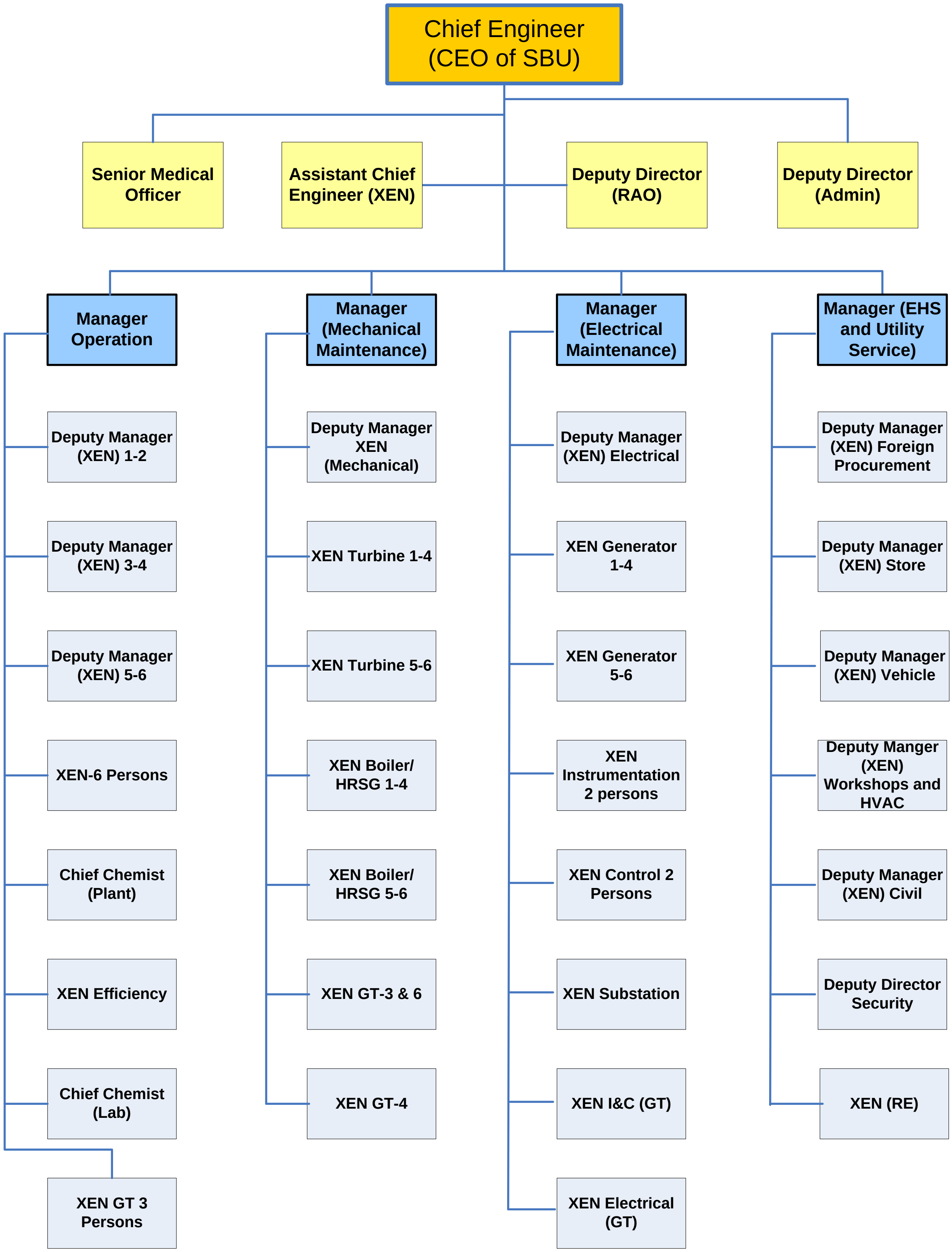


Figure 13-2: Revised Organogram of GPS

13.1.4 Other Relevant Organizations

753. Other relevant organizations involved in the implementation of EMP are: (a) Department of Environment (DOE) oversee implementation of all development projects in the country verifying that the environmental requirements are fulfilled, government guidelines and procedures followed and environmental quality standards are maintained properly. DOE will be consulted in case of complicated issues and if it requires any further environmental clearance certificates (ECC), (b) Department of Fisheries (DoF) is responsible for fisheries resources, (c) Department of Public Health Engineering (DPHE) is responsible for maintaining the quality of drinking water and addressing sanitation issues, and (d) District administration and municipality are responsible for traffic management, law and order and resolving the social disputes that may arise during construction activities.

13.1.5 Owner's Engineer

754. PIU will recruit an Owner's Engineer for supervision of implementation of boiler decommissioning, EPC contractor involving in civil works, erection of turbine and HRSG, including supervision and implementation of EMP. The Owner's Engineer will consist of an environmental unit with 2 international and 3 national environmental experts. The proposed positions and man month requirements of environmental specialists of the Owner's Engineer are given in Table 13-3. The terms of reference for the environmental consultants of Owner's Engineer are given in Annex 13-1. Environmental specialists of Owner's Engineer, in coordination with EU staff, will ensure the implementation of environmental management practices at each stage of the project activities. The Owner's Engineer will also be responsible for updating EMP, if required.

Table 13-3: Proposed EHS Consultant of Owner's Engineer

Sl. No	Expertise	Input (PM)
A	**International Consultants**	
1	Intl. Environmental Specialist	18
	Subtotal (A)	*18*
B	**National Consultants**	
1	Environmental Specialist	36
2	Occupational, Health, and Safety Specialist	36
3	Field Surveyor	36
	Subtotal (B)	*108*
	Total (A+B)	**126**

13.1.6 Independent Monitor

755. Besides internal monitoring and evaluation by the PIU/BPDB for environmental management and monitoring, independent/external monitors will be retained by BPDB, to undertake monitoring of all compliance and effects monitoring components. These external monitors will carry out monitoring implementation of the different components and submit an independent monitoring and appraisal report to the PIU, BPDB and to the World Bank.

13.1.7 Contractors

756. Each Contractor procured under this Project (especially boiler decommissioning Contractor and EPC Contractor) will be recommended to be a compliant of ISO 14001

Environmental Management System (EMS) certification. Further conditions of compliancy for OHSAH 18000 (2007) related Occupational Health and Safety (OHS) and SA 8000 (Social Accountability) could also be imposed on the Contractors. Each contractor will be recommended to have one Environmental Specialist and one Occupational, Health and Safety Specialist, who will be working in close coordination with the environmental staff of Owner's Engineer and PIU.

13.1.8 Need for Institutional Strengthening

757. Presently, the GPS has four circles which are Operation, Mechanical Maintenance, Electrical Maintenance and Civil. However, currently there is no dedicated Environment, Health, and Safety (EHS) Circle to address environmental management and occupational health and safety issues. A proposal has been made to create an EHS and Utility Services Circle headed by a manager and two deputy managers, one for environment and one for health and safety. One EHS consultant is also proposed under the manager of this circle to advise the circle on environmental, health, and safety issues. The circle is currently responsible for plant security and utility services (electricity and water distribution to offices and staff colonies). The staffs are deputed from other wings/circles of the GPS or from other departments in BPDB. After completion of development projects, the staffs return to their parent circle from where they were deputed. Currently GPS has no staff with previous experience in implementing environmental management and monitoring plan.

758. Generally, GPS/PIU outsource key services to consulting firm or relevant academic institutions well-suited to the environmental, socio-political and socio-economic conditions in Bangladesh. Furthermore, the manager and Deputy Managers for EHS are appointed on deputation from other circles of GPS having relevant experience, are often not dedicated to do their jobs. These deputed workers do not consider the EHSU Circle as their own work place. This gets further complicated by the fact the deputed/seconded staff gets transferred within 2-3 years.

759. In order to implement the environmental management plan (EMP) as proposed in this EIA, an effective PIU with dedicated staff will be of crucial significance. Without qualified full time staff it would be nearly impossible to minimize and/or eliminate the effects of environmental hazards and risks and ensuring a safe working environment for the workers, staffs and staff family members, who are residing in the project compound.

13.2 Proposed Institutional Strengthening of GPS

13.2.1 PIU Dedicated EHS Staff Requirements

760. Under the proposed DPP there is a request for additional 20 staff to strengthen the PIU. However, in the DPP no provisions have been made for dedicated staff to ensure compliance to EHS issues. For effective and meaningful implementation of the EMP, it is recommended that one Executive Engineer, with requisite training and practical experiences in implementing and/or monitoring environmental, health and safety issues pertaining to power sector are recruited. The executive engineer (EHS) will be supported by one Sub-Divisional Engineer (EHS), and two Assistant Engineers (one experienced in environmental management, and other in Occupational Health and Safety). Table 13-1 presents some of the key required qualifications of these staffs.

761.

13.2.2 Strengthening of the Proposed Environmental, Health and Safety Circle

762. In order to comply with the EMP requirements that has been proposed in this EIA, an effective EHSU Circle with experienced and dedicated staffs are essential. After a careful review of the proposed organogram of GPS, the Consultant made a proposal to strengthen the proposed organization structure, which is presented in Figure 13-3. The key highlights of the strengthening are presented below:

- Two deputy managers one for environment and one for occupational health and safety.
- Two Sub-Division Engineers or Assistant Engineers with Environment background under deputy manager environment
- Two Occupational health and safety officers under deputy manager occupational health and safety
- Two chemists under deputy manager environment.
- Environment engineers and occupational health and safety officers must have qualifications in their relevant areas of expertise.
- Since, it will be difficult to get staffs within BPDB who has experience in environmental, health and safety background, it is recommended that EHSU should be supported by an EHS Consultant in environmental, health, and safety aspects of the project implementation.

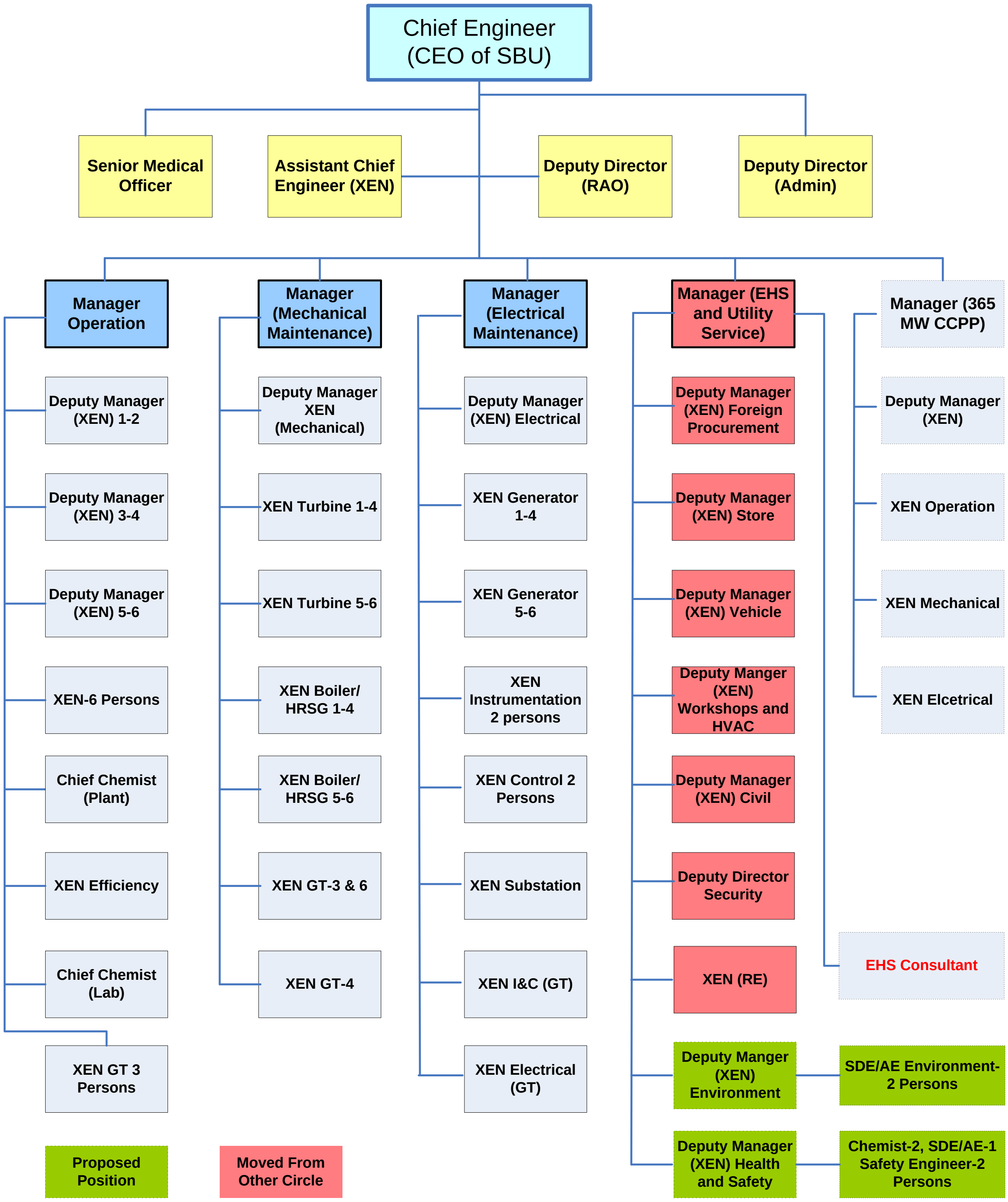


Figure 13-3: Organogram of GPS Proposed by the Consultant

763. The budget of the EHS staffs of EHSU Circle during three years of construction and three years of operation is presented in Table 13-4. The job descriptions of the key EHS staffs of EHSU Circle with preferred responsibilities and qualifications are presented in Table 13-5.

Table 13-4: Budget for EHS Staffs of EHSU Circle

Sl	Items	Amount (USD)
1	Staff Budget (8 staffs x 6 years)	209,612
2	EHS Consultant	180,000
2	Library	5,000
3	Furniture, Computers, Printer	15,500
4	Filming/Media/Publicity of Project Activities	10,000
5	Surveys, Analysis and Reports	25,000
	Total	**445,112**

Table 13-5: Job descriptions and responsibility with qualifications of key EHS staffs

Positions	No. of positions	Job Responsibilities	Qualifications
Manager EHS and Utility Services	1	• Supervise environmental management plan during construction and operation stages including compliance and effects monitoring • Ensure the occupational health and safety and security of all employees and supervise contractors' compliance of EMP obligations. • Maintain the EHS management system and ensure all electricity generation related work in compliance with all the requirements of health and safety programs. Maintenance of all documentation. • Initiate actions for improvement of all environmental and health & safety programs based on periodical audits of the EHS management system. • Working closely with deputy managers of EHS and Chief Chemist to ensure all works are done in compliance with ISO 14000 and ISO 31000 standards. • Monitor the progress of boiler decommissioning and safe disposal of Hazardous Wastes. • Ensure compliance with all	• At least a Master's Degree in Environmental Engineering or Environmental Science with experience in Occupational Health and Safety or related field. • At least 15 years of experience in power sector and a minimum of 5 years working experience in development Bank financed Projects preferably in power sector. • Must have adept knowledge of national policies, such as the Labour Act, 2006, The Factories Act, 1965, Environmental Conservation Rules, 1997 as well as International OHSA standards such as ISO 14001, ISO 31000 and other related OHSA guidelines.

Positions	No. of positions	Job Responsibilities	Qualifications
		BPDB policies and administrative rules, including the Health and Safety policy and other environmental requirements. • Practice safe work habits in accordance with Occupational Safety & Health Administration (OSHA) guidelines, Factories Act, 1965 and Environmental Conservation Rules, 1997.	
Deputy Manager (Environment)	1	• Manage and supervise environmental management and monitoring activities of the plant. • Monitor environmental mitigation and compensation measures carried out by the contractors along with the consultants as outlined in the project's EMP. • Conduct periodic consultations with various stakeholders, focus group discussions, and community consultation to monitor the progress of the EMP implementation. • Participate in grievance redress committee and resolve issues related to environmental concerns raised by the communities. • Assists in the preparation, implementation, monitoring and controlling of annual budget for the Circle. • Review quarterly and annual environmental monitoring reports and submit them to GPS, BPDB, and development partners. • Play a lead role in acquiring environmental permits, licenses, and approvals from regulatory agencies (e.g., DoE) in support of boiler decommissioning and	• Master's degree from a reputed institution on Environmental Engineering or Science or any related field • Must have good knowledge on various environmental policies and standards, both national and international. • Minimum 10 years of working experience on power sector projects or any environmental related projects that are funded by development Banks

Positions	No. of positions	Job Responsibilities	Qualifications
		new boiler erection projects. • Perform any other relevant and lawful duties as assigned by the Manager of EHSU from time to time. • The Environmental Specialist should adhere to the rules and regulations of Bangladesh and of development partners such as World Bank, ADB, etc.	
Deputy Manager (Occupational Health and Safety)	1	• Advise GPS management of areas not in compliance with Environmental Conservation Rules, 1997; Factory Act, 1965; Bangladesh Labour Act, 2006 and OSHA guidelines. • Train workers on how to recognize hazards; environmental and OSHA regulations; how to properly use personal protective equipments (PPEs); fire safety drills etc. • Evaluate the probability and severity of accidents. Supervise the preparation of accident reports and continually update these reports and inform them to the EHSU Manager. • Review existing safety procedures and risk assessments for work activities conducted by employees, contractors and others to ensure adherence with internal standards and project's EMP and to promote worker/contractor safety; identifies non-compliant, incomplete or substandard procedures, revises existing procedures or develops new procedures for activities involving employees and contractors where sound practical knowledge of occupational safety is required. • Ensure a safe and healthy	• At least a Master's degree in Occupational Health and Safety from an international accredited institution and a minimum 10 years of working experience or a diploma in OHS from a reputed institution (e.g. NEBOSH or anything similar) and at least 15 years of working experience. • Must have adept knowledge of national policies, such the Labour Act, 2006, the Factories Act, 1965, Environmental Conservation Rules, 1997 as well as International OHSA standards such as ISO 14001, ISO 31000 and other related OHSA guidelines.

Positions	No. of positions	Job Responsibilities	Qualifications
		working environment and systems of work through sensitizing employees on occupation health and safety. • Screen all new projects under preparation to determine whether an HIV/AIDS, STI, Malaria prevention component is mainstreamed into the project design. • Keep the provision of seed money to each project's EMP budget for HIV prevention, this involves contacting the relevant Ministry during project preparation and implementation. • Make periodic visits to all project sites especially construction camp and yards to monitor health and safety standards and hygiene conditions. • Provide personal protective equipment (PPE) to operation sections where necessary and monitor the adequacy of contractor's PPE at construction site. • Disseminate information about HIV/AIDS and STI prevention. Awareness campaigns should deliver appropriate information by targeting champions within each vulnerable group. Information on HIV/AIDS and STI should be more specific and less ambiguous regarding the modes of transmission and the methods of protection. • Conform to changing attitudes and practices among high risk groups. This includes targeting truck and equipment drivers at construction sites, migrant laborers, and sex workers.	

Positions	No. of positions	Job Responsibilities	Qualifications
		• Prepare monthly and quarterly reports on occupational health and safety and providing updates on health and safety issues. • Perform any other relevant and lawful duties as may be reasonably assigned.	
SDE/AE Environment	2	• Conduct environmental screening and scoping and assist in environmental impact assessments of all GPS and donor funded projects. • Monitor environmental mitigation and compensation measures carried out by the contractors along with the consultants as outlined in the project's EMP. • Conduct periodic consultations with various stakeholders, focus group discussions, and community consultation to monitor the progress of the EMP implementation. • Participate in grievance redress committee and resolve issues related to environmental concerns raised by the communities. • Prepare the implementation of a range of environmental compliance documents required for project approval and implementation, such as IEE, EIA, EMPs, etc. • Perform any other relevant and lawful duties as assigned by the Manager of EHSU from time to time.	• Bachelor of Science degree in Civil Engineering with major in Environmental Engineering from a reputed institution • Must have good knowledge on various environmental policies and standards, both national and international. • Working experience in power sector projects or any environmental related projects are preferred.
Occupational health and safety officer	2	• Monitor all health and safety activities carried out by the contractors along with the consultants as outlined in the project's EMP. • Conduct, arrange and report periodic inspections of all	• Bachelor of Science degree in occupational Health and safety or public health or related field from an international accredited institution and a minimum 2 years of working experience

Positions	No. of positions	Job Responsibilities	Qualifications
		installations/ laboratories/ workshops to identify risks and safeguard of all persons from death or injury. • Provide personal protective equipment (PPE) to operation sections where necessary and monitor the adequacy of contractor's PPE at construction site. • Conduct fire safety audits on all GPS buildings to ensure that facilities are compliant with safety rules and ensure that appropriate procedures to minimize risks are in place. • Disseminate information about HIV/AIDS and STI prevention. Awareness campaigns should deliver appropriate information by targeting champions within each vulnerable group. Information on HIV/AIDS and STI should be more specific and less ambiguous regarding the modes of transmission and the methods of protection. • Prepare monthly and quarterly reports on occupational health and safety and providing updates on health and safety issues. • Perform any other relevant and lawful duties as may be reasonably assigned.	or a diploma in OHS from a reputed institution. • Must have adept knowledge of national policies, such the Labour Act, 2006, The Factories Act, 1965, Environmental Conservation Rules, 1997 as well as International OSHA standards such as ISO 14001, ISO 31000 and other related OSHA guidelines.
Chemists	2	• Preparing test solutions, compounds, and reagents for conducting test. • Assisting chief chemist in analyzing organic and inorganic compounds to determine chemical and physical properties, composition, structure, relationships, and reactions, utilizing chromatography, spectroscopy, and spectrophotometry	• At least a Master's degree in Chemistry, or Applied Chemistry or analytical chemistry from a reputed national or international institution • Must have good experience in laboratory analysis and techniques (e.g., HPLC, Gas Chromatography, Mass Spectrometry etc.) • Must be organized in maintaining good logbook

Positions	No. of positions	Job Responsibilities	Qualifications
		techniques. • Developing, improving, and customizing products, equipment, formulas, processes, and analytical methods. • Direct, coordinate, and advise lab assistants in test procedures for analyzing components and physical properties of materials. • Helping Deputy Manager (Environment) in preparing written reports on analysis, maintaining computer database and meeting deadlines for report submission.	practices • At least 5 years of working experience in sampling and analytical laboratories.

13.2.3 Capacity Building Programs

764. The environmental and social trainings will help to ensure that the requirements of the EMP are clearly understood and followed by all project personnel. The primary responsibility of providing these trainings to all project personnel will be that of the contractor, Owner's Engineer, and a designated training consultant. The trainings will be provided to different professional groups separately such as managers, skilled personnel, unskilled labors, and camp staff. Capacity building will be aimed at strengthening the PIU and EHSU Circle of GPS staffs in the field of environmental management and occupational health and safety. Members of the EHSU Circle and PIU staffs responsible for supervision of environmental mitigation measures would be trained in environmental management, environmental quality control, ecology, environmental awareness, participatory approach and occupational health and safety. The contractor will also be required to provide environmental and health and safety trainings to its staff, to ensure effective implementation of the EMP. A budget of USD 0.13 million has been earmarked for capacity building of PIU and GPS staffs and the scope of work is included in Annex 13-2. The contractors' training plan shall include a program for the delivery of intermittent training, to cover the subjects included in Table 13-6. Training should be carried out initially at induction of staff and repeated throughout the project.

Table 13-6: Training Subjects for Inclusion in Contractors Training Plan

Training Subject	Target Audience
Handling, use & disposal of hazardous material	Construction workers with authorized access to hazardous material storage areas and required to use hazardous material during their works
Waste Management	All staff (construction and camp staff)
Efficient & safe driving practices, including road & vehicle restrictions	Drivers & mobile plant operators
Actions to be taken in the event of major or	All construction staff

Training Subject	Target Audience
minor pollution event on land	
Use of flexible booms and surface skimmers in event of pollution event in water	All construction staff working on the jetty renovation (if required)
Pollution prevention: Best practice	All staff
Refuelling of water borne plant – pollution prevention	Operators of water borne plant & vehicles
Health & Safety: Safe way to work & hazard awareness	All construction staff
Health & Safety: Safe use of plant & equipment	Operators of plant & equipment
Health & Safety: Working at height	Boiler decommissioning, turbine hall, HRSG and cooling tower refurbishment construction staff
Health & Safety: Working near/on water	All staff working on jetty strengthening and unloading heavy equipment from ship
Health & Safety: Use of PPE	All construction staff
Emergency procedures and evacuation	All staff
Fire fighting	All staff
Site inductions, including requirements under the Environmental Management Plan & details of environmentally sensitive areas of the site	All staff
Culturally sensitive awareness rising on HIV/AIDS and the spread of sexually transmitted diseases. Awareness raising on risks, prevention and available treatment of vector-borne diseases	All staff
Cultural sensitivities of the local population	On induction of all non-local staff

13.2.4 Formation of a Grievance Redress Committee

765. Two grievance redress committees (GRCs) will be formed: local grievance redress committee (LGRC); and project grievance redress committee (PGRC). Most of the grievances would be resolved at LGRC within 7 days of receipt of compliant, while a few might be forwarded to PGRC, which will take two weeks to resolve the complaint. More detailed information is presented in Chapter 14. Institutional Framework for Implementing EMP

766. Proposed Institutional Framework for Implementation of EMP is shown in Figure 13-4.

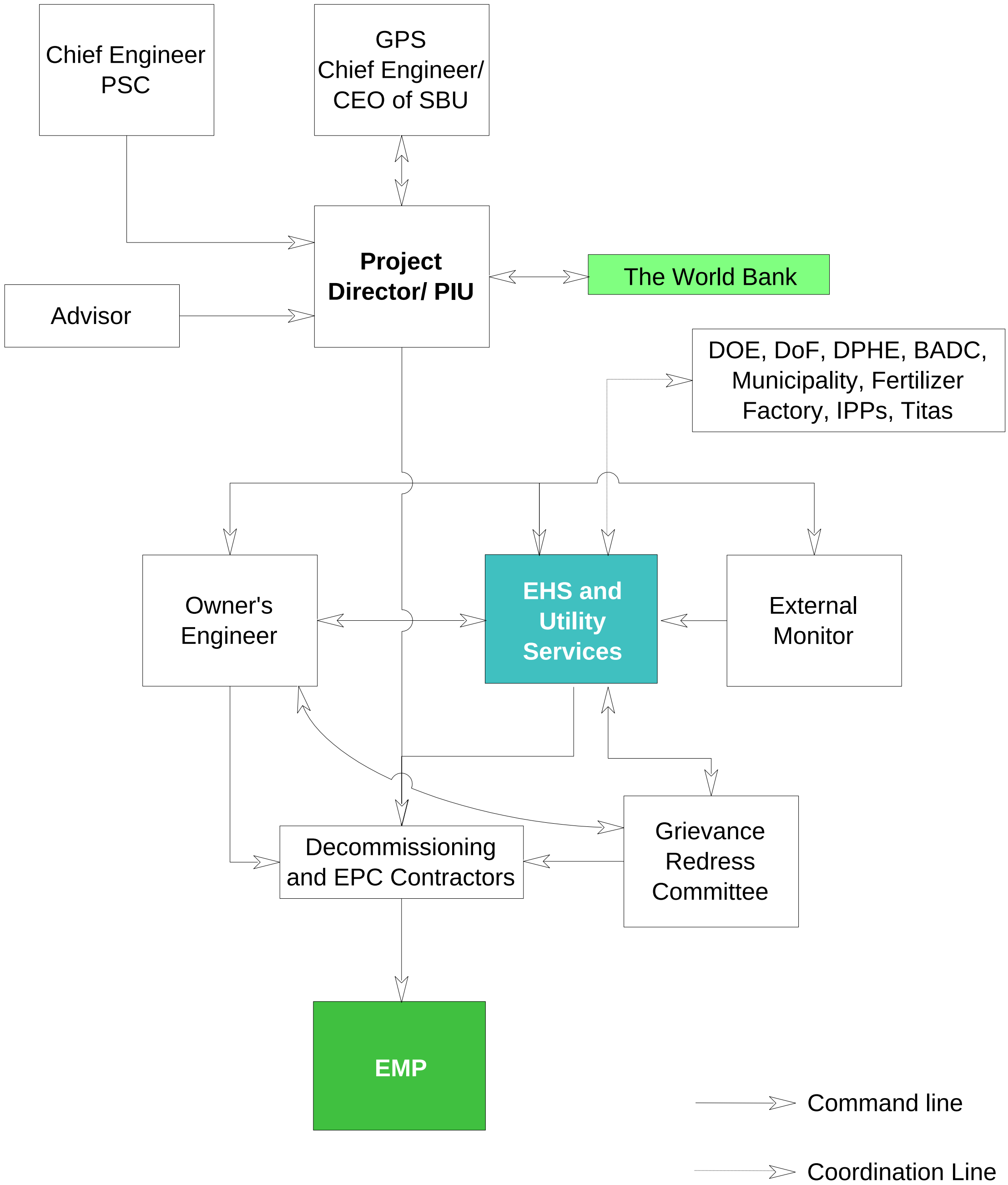


Figure 13-4: Proposed Institutional Framework for EMP Implementation

13.2.5 Cost Estimates for Institutional Strengthening

767. The cost estimates for all the institutional strengthening measures proposed in this chapter are given in the Table 13-7.

Table 13-7: Proposed Budget for Institutional Strengthening and Capacity Building

Sl.	Strengthening/Capacity Building Measure	Amount, USD
1	Strengthening of EHSU Circle (Table 13-4)	445,112
2	EHS Consultants of Owner's Engineer (Annex 13-1)	942,000
3	Capacity Building and Training (Annex 13-2)	131,675
	Total	**1,518,787**

14. Public Consultation and Information Disclosure

14.1 Introduction and definitions

768. The Environmental Impact Assessment (EIA) process included public participation and consultation to assist BPDB and MoPEMR to achieve public acceptance of the Project. Public consultation is a regulatory process by which the public's input on matters affecting the community is involved and their suggestions solicited.

769. Public consultation is preferred for the EIA study of any development Project according to the DoE Guidelines of Environmental Assessments, 1997. The World Bank Operation Policy require that public consultations to be included in the EIA process.

14.2 Regulatory Requirements

14.2.1 Bangladesh Guidelines

770. The EIA guideline formulated by DoE in 1997 (Chapter 4, Section 4.11) stated that since the general public is the ultimate recipient of the economic benefit and environmental damages, an EIA study should involve the public as part of decision making process development. To achieve effective public participation, it is necessary to communication with as many people as possible, as early as possible and through as many different ways as possible. This requires pre-planning, resources, identification of target groups and several of techniques for effective communication.

14.2.2 World Bank Group Requirements

771. *Consultation:* The World Bank recognizes and endorses the fundamental importance of transparency and accountability to the development process. Bank's policy is to be open about its activities and to welcome and seek out opportunities to explain its work to the widest possible audience. According to 'OP 4.01: Environmental Assessment' for a Category A projects the borrower should consult the project-affected groups and local nongovernmental organizations (NGOs) about the project's environmental aspects and takes their views into account. Consultations should be conducted twice: (a) shortly after environmental screening and before the terms of reference for the EIA are finalized; and (b) once a draft EIA report is prepared. In addition, the borrower should consult with such groups throughout project implementation as necessary to address EIA-related issues that affect them.

772. *Disclosure:* For a Category A project, the borrower should provide relevant information on project interventions in a timely manner prior to consultation and in a form and language that are understandable and accessible to the groups being consulted. The borrower should provide a summary of the proposed project's objectives, description, and potential impacts for the initial consultation. For consultation after the draft EIA report is prepared, the borrower should provide a summary of the EIA's conclusions. In addition, for a Category A project, the borrower makes the draft EIA report available at a public place accessible to project-affected groups and local NGOs. The borrower also ensures that EIA reports for Category A project are made available in a public place accessible to affected groups and local NGOs. The document needs to be translated into Bengali. Public

availability of the EIA report for Category A project in the borrowing country and official receipt by the Bank are prerequisites to Bank appraisal of these projects.

14.2.2.1 Grievance Redress

773. The borrower will respond to concerns of the project-affected communities related to the project in a timely manner. For this purpose, the borrower will provide a grievance mechanism, process or procedure to receive and facilitate resolution of stakeholders' concerns and grievance regarding the Borrower's environmental and social performance. The grievance mechanism will be scaled to the risks and potential adverse impacts of the project. Where possible, such grievance mechanism will utilize existing formal or informal grievance mechanisms suitable for project purpose, supplemented as needed with project-specific arrangements.

a) The grievance mechanism, process or procedure is expected to address concerns promptly and effectively, in a transparent manner that is culturally appropriate and readily accessible to all segments of the project-affected communities, at no cost and without retribution. The Borrower will inform the project-affected communities about the grievance process in the course of its course of its community engagement activities, and will make publicly available a record documenting the responses to all grievances received; and

b) Handling of grievances will be done in a culturally appropriate manner and be discreet, objective, sensitive and responsive to the needs and concerns of the project-affected communities. Where there is threat of reprisal, the mechanism will also allow for anonymous complaints to be raised and addressed.

14.3 Consultation Methodology

774. *Consultation Approach:* Participatory approach was followed for identifying the stakeholders for conducting consultations (Figure 14-1). The study team consulted the project proponent (BPDB) for understanding the project brief and identifying the potential stakeholders. Therefore, the key stakeholders include occupational groups, such as farmers, fishermen, traders, elite persons, etc. whose activities are likely to be impacted due to the implementation of the proposed project. Furthermore, local population, interested groups, and BPDB officials were considered as the potential stakeholders and were also consulted at this EIA stage.

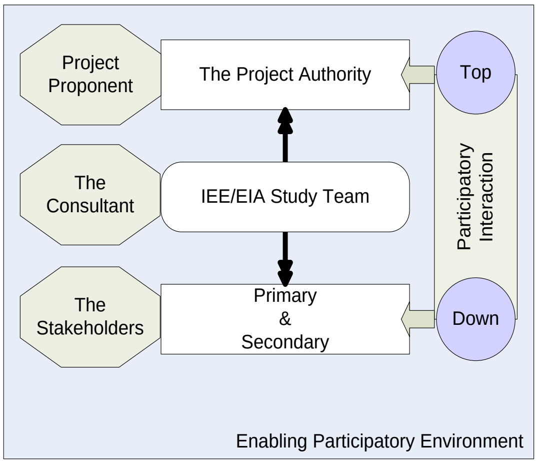


Figure 14-1: Overall consultation approach

775. An expert multidisciplinary team made a number of visits to the study area for conducting informal consultations with the predefined stakeholders. Furthermore, a formal public consultation meeting was held at Ghorashal Paurashava informing the stakeholders through paper advertisement and also communicating formally by invitation letters. A comment sheet was prepared, covering all potential environmental and social issues of the project and distributed to the participants. This comment sheet was used in the meeting to unveil peoples' perception and opinion on the proposed project along with suggestions (comment sheet is attached in Annex 14-2).

The team also informed the stakeholder about the project activities and potential impacts that may surface during implementation and eventually during operation of the Plant. The team sought stakeholders' views on various aspects of the Project, and recorded all findings for analysis and eventual incorporation in the report.

776. *Stakeholder identification:* Stakeholders include all those who affect and are being affected by policies, decisions or actions within a particular system. Stakeholders can be groups of people, organizations, institutions and sometimes even individuals. Stakeholders can be divided into primary and secondary stakeholder categories.

777. Primary stakeholders are people who would be directly benefited or impacted by the proposed project. In this context, people who have/had land within the project boundary were considered as the primary stakeholders.

778. The second category of stakeholders (secondary stakeholders) pertains to those who may not be directly affected but have interests that could contribute to the study, play a role in implementation at some stage, or affect decision making on Project aspects. In this project local elite persons, people who are living at the close vicinity, occupational groups, government departments and line agencies fall under this category.

14.4 Details of Consultation Meetings

779. The details of consultation meetings are presented below:-

780. *Informal consultation:* A number of occupational groups and other relevant stakeholders were consulted informally. These consultations were made on spot when the team was visited in the project area. This was done to create awareness and clear any misunderstanding about the project and eventually obtain support from the local communities to conduct baseline environmental, ecological, fisheries, and socio-economic surveys. No formal questionnaire was used rather peoples were consulted by the individual team member in terms of sectors (i.e. agriculture, fishery, socio-economic, etc.) to which he/she is assigned.

781. *Expert/Institution Consultation:* Experts were consulted through individual and group meetings, during early stage of the study, selected individuals and organizations with professional knowledge of EIA processes. The meetings were conducted at a very early stage (Scoping Stage) of the EA with the objective to identify people to be consulted, to brief stakeholders about the project components, and to discuss potential environmental and social impacts of the Project. The outcomes of those consultations were used to identify valued environmental components, stakeholders for public consultation and institutional strengthening of BPDB to implement the EMP.

782. *Focus Group Discussion:* FGDs were held on 19th April, 2015 with agriculture and fisheries groups to obtain feedback on the proposed repowering of Unit 4. FGD with agriculture group was conducted at Ghorashal municipality and FGD for fisheries group was conducted at Danga village. The purpose of the FGDs were to harness knowledge on issues, such as, how noise and air pollution are affecting the nearby communities (e.g., hearing difficulties, respiratory ailments and problems related with pregnancies), whether the discharge of hot water and effluents affecting the fishermen and farmers and whether the proposed project will aid in any socio-economic development or not; availability of construction materials close to the project site; availability of local labors; site safety and security; community involvement, and sustainable environmental management. The outcomes of these discussions were used to prioritize impacts and risks, and to structure the

EMP. *Public Consultation:* A formal public consultation meeting was held at 10:00 am on 11th April, 2015 (Saturday) at Conference Room of Ghorashal Paurashava. Affected people were invited through advertisement in locally published newspaper called *Dainik Grameen Dorpan*. Additionally, they were communicated through the local representatives and leaders for ensuring their presence. Saturday being a public holiday in Bangladesh, was chosen for conducting the public consultation meeting as it will allow for the participation of various local resident officers and people of different occupational levels. The day was sunny and was a fine day for holding the meeting. The target number of participants crossed well over the expected number of participants (50). A total of 61 participants had attended (Table 14-1), which comprised of local government representatives, occupation groups, NGO representative, businessmen, etc. A list of participants is presented in Annex 14-1.

Table 14-1: Participants in the Public Consultation Meetings


14.5 Consultation Outcome

14.5.1 Stakeholder Consultations

783. Table 14-2 presents the comments, suggestions, and concerns obtained and action points taken to address them during FGDs, informal discussions and formal public consultations.

Table 14-2: Outcome of stakeholder consultations

Groups/ Sectors	Comments/Suggestions/ Concerns	Action Points
Socio-economic	784. The participants stated that they have no objection on Ghorashal power plant project. Rather they thought it will expedite local, regional and national development as power is the main driving force of development. 785. They also believe that the successful operation of the proposed project will yield considerable employment opportunities for local people. 786. The proposed plant would have a positive impact in curbing load-shedding, socio-economic development and continuous supply of electricity to residential and other commercial and industrial sectors, according to the opinion of the participants. 787. They stated that noise is a serious problem in this area that is produced from other rental power plants. If this repowering project produces noise as such it will exacerbate this problem. 788. Respiratory disease is alarming in the study area that is brought out by the fertilizer company due to ammonia absorbent. The participants urged that the produced power should not encourage such type of chemical based industries in the area. 789. Child labor is also found notable in the study area. The participants stated that if produced power eventually encourages industrial expansion the current rate of child labor may be increased.	790. Possible mitigation measures suggested includes soundproofing turbines or structures that emit loud noise, plantation around the plant area which will act as noise barriers, noise dampening wall etc. BPDB will take up ammonia release issue from fertilizer factories to relevant government agencies. 791. Child labor will be prohibited in the construction work of the proposed GPS repowering project. **EMP has covered mitigation and enhancement measures for the impacts of air pollution and risk of hazardous materials.**
Water Resource	792. Ghorashal power plant complex is directly dependent on the water system of the Shitalakhya River.	795. Refurbishment of cooling water with enhancements will reduce thermal plume significantly

Groups/ Sectors	Comments/Suggestions/ Concerns	Action Points
	When the entire power plant runs with full capacity, two pump houses with maximum flow rate of 40.25 m^3/s water are abstracted from the Shitalakhya River. Around 90% of the intake water returns to the same river with the temperature of around 37^0C to the downstream discharge point. A significant amount of heated water diverts to the agricultural fields for irrigation. Discharge of thermal plume in the Shitalakhya River is one of the major causes of reducing the fish population close to the discharge point. Local population living at the bank of the Shitalakhya River near the discharge point expressed their concern about this warm water discharge. They also reckon about the deterioration of river water quality due to the effluent discharge from other industries such as, oily substances, chemicals and other pollutants. They believe that discharged of such effluents might affect the water quality of the Shitalakhya River. 793. Measures should be taken, such setting up an effluent treatment plant so that pollutants are treated/removed before they are discharged into the river and setting up of cooling tower for cooling purposes instead of using river water. 794. Local people reported that periodically the river water becomes highly polluted with bad odor. This is because of periodical release of ammonia gas from the fertilizer factory, wastes from Pran Agro Industry, release of temperature borne effluent from power plant, etc. Sometimes water becomes unusable. Groundwater has been depleting due to over exploitation. Local people gave emphasis on not to use ground water for the proposed plant.	Shitalakhya River. 796. The design has considered the treatment of effluent by construction of an ETP plant. 797. Effluent treatment complying with national and international standards before discharge is recommended. 798. Power plant authority should be abstained from using underground water instead they can conserve water through the use of water efficient technology. 799. Local communities were advised to raise their concern through local administration about the release of ammonia from fertilizer factory.

Groups/ Sectors	Comments/Suggestions/ Concerns	Action Points
Fisheries	800. According to the opinion of the participants, before the emergence of various industries, once the area had lots of open water bodies that were habitats for various fisheries including seasonal floodplains, beels and interconnected canals that connected Shitalakhya River. 801. Decades ago there were lots of fishermen fishing in those water bodies. However, their numbers are greatly reduced. 802. The main reasons being the unavailability/decreased availability of fishes in and around the Shitalakhya River. 803. One of the major reasons for this decreased availability of fishes in those habitats is because of the lowering of the water level of the Shitalakhya river due to the unavailability of water from old Brahmaputra River during the dry season. 804. According to the participants the development of various industries has caused the people to expand the land areas towards the river through encroachment, which means narrowing down the river conveyance area. This narrowing down of the river causes increased river erosion which leads up to the accumulation of silt, decreasing the river area and depth, as a result aquatic habitats has been depleted. 805. Overfishing, by fine mesh nets, also lead to the death of many fingerlings and fish species. 806. The development of various industries close to the river bank discharge untreated effluent causing severe water pollution. They believe the fertilizer factory near the bank of	812. Effluent treatment complying with national and international standards before discharge is recommended. 813. BPDB will take up ammonia release issue from fertilizer factories to relevant government agencies. 814. Design has considered the renovation of cooling water system which will discharge relatively cool water.

Groups/ Sectors	Comments/Suggestions/ Concerns	Action Points
	the Shitalakhya River, in particular, released untreated-toxic gas into the river that has been killing many fish. Periodically the river reach along the Ghorashal Fertilizer factory and its surrounding reach become void of fish. 807. Water pollution of the Shitalakhya River from different point and non-point sources creates havoc for fisheries. 808. The participants also stated that the warm water discharge from the current Ghorashal Power Station contributes higher temperature of river water killing many small and soft fish and fingerlings or causing them to migrate away from the Shitalakhya River. 809. The lack of availability of fish caused many fishermen to look for alternative sources of income. 810. Participants also stated that fish was one of the major sources of protein and due to the depletion of fish species in Shitalakhya River, people are deprived of the source of protein and are now suffering from various protein-deficient diseases. 811. They suggested appropriate measures, such as, cooling the discharged water before dumping them into the river water and arrange proper advocacy measures so that the fertilizer factory could stop the release of untreated toxic gas into the river by setting up appropriate treatment plants.	
Agriculture	815. Before the development of the Power Plant Ghorashal had very little ground water reserve for agriculture. Deep tube wells were used for irrigation, which was costly and as a result crop productivity was less in Palash Upazila.	826. Adoption of close cycle cooling technology with refurbishment of existing cooling system and construction of new cooling tower to meet the capacity of Unit-4 repowering will reduce the condenser cooling water in the

Groups/ Sectors	Comments/Suggestions/ Concerns	Action Points
	816. Previously agricultural activities were only reserved to areas close to the river bank. Farmers used to collect river water via low lift pumps. However, this method of drawing water was costly (Tk. 6,500 per hectare). 817. According to the opinion of the participants, the majority of them expects the proposed project will not affect their irrigation practices. 818. The development of Ghorashal Power Plant, on the contrary, has helped agricultural productivity significantly. Farmers are now able to use the condenser cooling water discharge for irrigation. With the help of Bangladesh Agricultural Development Corporation (BADC), condenser cooling water discharge is distributed through an irrigation network cultivating twelve thousand bighas (1,667 hectare) of land. The process is also relatively cheap (Tk. 800 per hectare) compared to abstracting water from the groundwater via LLPs. 819. The availability of water would ensure appropriate soil moisture content. Since the discharge water is full of nutrients it would facilitate the growth of trees, particularly the various fruit-bearing ones. This would increase the growth and development of seasonal fruits for local people to consume while the extra amount could be sold for profit. 820. Overall the use of discharge water would benefit the agricultural industry in the Ghorashal region. This would, in the long run, would elevate the socio-economic standards for the people in the region. 821. Since the benefits of discharged water in agricultural sector	discharge channel. With reduction of discharges from the Unit 4, the remaining operating units will be sufficient for existing irrigation facilities. 827. Water allocation for irrigation can be continued as usual by arranging one of the intake pumps dedicated for irrigation facilities. It is possible as the pumps dedicated for Unit 4 will have the limited use after adopting the close cycle cooling system. BADC can go for an agreement with the GPS in this regard. 828. BPDB will take up ammonia release issue from fertilizer factories to relevant government agencies. 829. Effluent treatment complying with national and international standards before discharge is recommended.

Groups/ Sectors	Comments/Suggestions/ Concerns	Action Points
	are huge, the participants suggested that such facilities remain uninterrupted in the coming days and should increase the allocation to cover additional farming land. 822. Despite the positive outlook of condenser cooling water on irrigation, experts, however, think that there might be possible adverse effects on agriculture because of the hot water/oily water discharge from the plant. 823. Since, the people are dependent on the Shitalakhhya River for cultivation, the experts fear that the chemicals and oily substances discharged into the river from the proposed plant might hamper their agricultural productivity. It might also affect the growth of nearby plants and trees. 824. Precautionary and preventive measures are thus suggested so that the temperature of the water is kept as close to ambient temperature as possible and be removed of any pollutants before being discharged into the river. 825. Steps should also be taken to prevent water-logging as it is one of the major concerns of agricultural loss.	
Ecology	830. Aquatic ecosystem is under serious threat and being destroyed by the untreated gaseous emission from fertilizer factory, power plant etc.; untreated or improperly treated effluent of different industries and dumping of wastes into the nearby Shitalakhya River 831. The discharged hot water and chemicals/oily substances released into the river might kill off various zooplankton, phytoplankton, fish roes and fish larvae.	834. Treatment of effluent is being considered in the design prior to discharge to Shitalakhya River. 835. BPDB will take up ammonia release issue from fertilizer factories to relevant government agencies 836. Design has considered the renovation of cooling water system which will significantly lessen warm water in the discharge channel. Consequently,

Groups/ Sectors	Comments/Suggestions/ Concerns	Action Points
	832. The lack of fish species, algae, zooplankton and phytoplankton might drive other higher species of plants and animals into extinction such as lizards, iguanas etc. 833. Measures should be taken to curb these adverse impacts.	the reduction in warm water discharge, due to closed cycle cooling system, to the discharge channel would contribute to less warm being discharged into the river as a whole. River water would be less warm and would facilitate the dispersion of these warm waters via tidal current. This phenomenon would facilitate aquatic habitat restoration.

14.5.2 Expert/Institution Consultation

837. Table 14-3 presents list of experts and institutions consulted and their opinion on different aspects of the proposed GPS repowering project.

Table 14-3: List of experts/institutions consulted and their opinion

Name	Organization & Position	Expert Opinion	Action points
Mr. Syed Javed Hossain (Upazila Chairman) Mr. Md. Alam Mollah (Vice Chairman) Their associates.	Palash Upazila	• No environmental concern is being observed from the GPS except the quick rental and peaking power plants. • Canalized irrigation which is facilitated by BADC based on the condenser cooling water discharge of the GPS is the blessings for the farmers. It should be continued and more agricultural areas should be brought into the irrigation network. • Excessive warm water is harmful for the aquatic organisms at around the effluent discharge point in Shitalakhya River. • Ammonia gas that releases from the fertilizer factory may cause respiratory problem. • Livelihood will be facilitated after the operation of the proposed power plant. • Skilled manpower particularly the technician has been developed due to	• Upazila chairman should consult with GPS and BADC for more use of cooling water discharge and expand the irrigation network • Adoption of close cycle cooling technology with refurbishment and modernization of existing cooling tower; or construction of new cooling tower for Unit-4 will significantly lessen warm water in the discharge channel. Even after the withdrawal of discharges from the Unit-4, the remaining water from other plants will be sufficient for existing irrigation facilities.

Name	Organization & Position	Expert Opinion	Action points
		power station; this manpower is supplied to different countries particularly to the Middle East countries.	• Consequently the reduction in warm water discharge, due to closed cycle cooling system, to the discharge channel would contribute to less warm being discharged into the river as a whole. River water would be less warm and would facilitate the dispersion of these warm waters via tidal current. This phenomenon would facilitate aquatic habitat restoration. Close cycle cooling will reduce warm water discharge, which will reduce thermal plume in the river. This will facilitate aquatic habitat restoration. • BPDB will take up ammonia release issue from fertilizer factories to relevant government agencies.
Mr. Md. Amirul Islam (Upazila Agriculture Officer)	Department of Agriculture Extension, Palash	Gas released from the Palash Fertilizer Factory is responsible for the yellowish color of the paddy which is less productive. Radiation of heat may adversely affect the biodiversity close by. Reduction of birds of this area has been affecting negatively the integrated pest management (IPM) i.e. perching pest control of the crop fields. Noise and heat radiation may cause sterile to useful insects. This may affect the pollination of the fruiting	• BPDB will take up ammonia release issue from fertilizer factories to relevant government agencies. • The repowering project through combined cycle power generation will release less thermal pollution in the atmosphere. • EMP has considered plantation program in the project area,

Name	Organization & Position	Expert Opinion	Action points
		trees as well as paddy. During winter season irrigation is highly required which is currently supported by the plant cooling water. Adoption of new technology with low water requirement may affect the present irrigation water demand.	which may provide bird habitats in the future.
Mr. Sajjad Hossain (Tubewell Mechanic)	DPHE, Palash	Due to aquifer loss less water is coming out through shallow tube well during dry season. Ground water of this area is with less arsenic contamination. Ground water withdrawal for the power plant if done may decline the ground water availability.	Abstraction of groundwater is limited to only potable water (colony and office use)
Mr. Mosarraf Hossain (Sub Assistant Engineer)	BADC, Palash	Depending on the operation of the units of the GPS water availability differs. Water availability is reduced when units are tripped. Irrigation facilities linked with GPS covers following unions fully or partially, such as Danga, Jinardi, Char Sindur and Gazaria.	Design has considered the renovation of cooling water system which will discharge relatively cool water and eventually improve current warm water discharge for crop production.
Mr. Mohammad Azibur Rahman (Upazila Fisheries Officer)	Department of Fisheries, Palash	Risen temperature in the effluent of condenser cooling that has been discharging into the Shitalakhya River is detrimental for soft fish species like Small Indigenous Species (SIS) including Bele, Mola, and Katchki particularly in the dry season. Warm water spreads over up to Kauadi close by Desh Bandhu Sugra Mill is not only detrimental to aquatic organisms but also to the microbes essential for fish feed and biodegradation. Periodical gas released from the fertilizer factory, wastes	Design has considered the renovation of cooling water system which will reduce thermal plume in Shitalakhya River. BPDB will take up ammonia release issue from fertilizer factories to relevant government agencies. The contractors will be encouraged to employ local people in the construction work.

Name	Organization & Position	Expert Opinion	Action points
		from the Pran Factory, polluted water from dying factories all are harmful for the aquatic organisms as well as for the consumers. Numbers of fishermen are reduced to around 400 which were about 1,260 in a decade ago in Palash Upazila.	
Lakshmi Saha (Office Assistant)	Social Welfare Department	Social safety net is the major function of the department. Observance of the corporate social responsibility (CSR) by the BPDB parallel to Social welfare department may reduce the stress on the social safety net program.	BPDB will liaison with Social Welfare Department for CSR program under the proposed repowering project
Mr. Khabir Uddin (Junior Statistical Assistant) Ms. Tania Akter (Junior Statistical Assistant)	Statistical Department	In-migration of laborers and other service holders from other areas had the down trend due to laying-off of jute mills one after another. Accordingly, economical activities were declining. But construction of the proposed Project may cause the in-migration of different professional people and retrieve the economic activities. [After the shut-down of Fuji Jute Mill a sum of about 500HHs has been shifted to other areas from the Palash Upazila]. Though there will be a population pressure but the local people will be benefitted from getting more house rent. Periodical gas released from the fertilizer factory has been causing death to aquatic organisms including fishes. Crop land is reducing over the years; in that case the proposed site is appreciable. There is no defined kitchen waste dumping area.	The contractors will be encouraged to employ local people in the construction work.

Name	Organization & Position	Expert Opinion	Action points
		Increased human pressure may cause more stress on waste dumping areas. Wastes from the Pran Factory have been polluting river water which is harmful for the aquatic organisms. Female contribution in family level income mainly based on labor selling is increasing in this area.	
Mr. Borhan Ahmed	Titas Gas Transmission and Distribution Co. Ltd. (TGTDCL), Palash	Gas pipeline connected to GPS from TGTDCL is 100 psig while gas inlet from NSD-TGTDCL for GPS in the range of 350-800 psig. The diameter of the pipeline from NSD=GPS is 16˝. The length of the pipeline is about 21 km from Narsingdi to Palash .	These information will be used by EPC Contractor while conducting the gas related work.

14.6 Disclosure

838. The EIA, documenting the mitigation measures and consultation process, will be made available for public review in both English and Bengali. The Executive Summary of the EIA will be published on the BPDB, DOE, and the World Bank's websites, and the full EIA will be made available upon request from the World Bank and will also be accessible in BPDB website. During the consultations, the affected people and the local communities expressed support for the Project as they clearly saw the benefit to the community as well as in country. Consultations and public disclosure of information will continue during project implementation through:

(i) The preparation and dissemination of a brochure in Bengali, explaining the affected peoples' entitlements and the procedures for obtaining compensation for the loss of trees, crops, and land and the procedure for recording grievances; and

(ii) Setting up of two grievance redress committees (GRCs): local grievance redress committee (LGRC); and project grievance redress committee (PGRC) with a representation from GPS, Ward Councilor, Member, women representative, representative of Civil Society, Owner's Engineer, and the Contractor in the project area to ensure participatory process and to allow voices of the affected communities in the grievance procedures.

839. The draft EIA will be shared with the stakeholders during a second public consultation in the project area and in a national workshop in Dhaka. Once finalized, the EIA will be submitted to the DoE for their review and clearance.

14.7 Grievance Redress Mechanism

840. Grievances are actual or perceived problems that might give grounds for complaints. As a general policy, Project Implementation Unit (PIU) in association with EHSU Circle will

work proactively towards preventing grievances through the implementation of impact mitigation measures and community liaison activities that anticipate and address potential issues before they become grievances. Minor issues will be resolved by the Contractor in consultation with Owner’s Engineer.

841. The project will establish a grievance redress mechanism (GRM) for addressing grievances and complaints received from the project-affected persons. The claims and complaints will need to be brought to the attention of the Ward Councilor. They will then forward grievances to the higher levels of authorities as desired. The Grievance Redress Mechanism is shown in Figure 14-2. The fundamental objective of GRM will be to resolve any project-related grievances locally in consultation with the aggrieved party to facilitate smooth implementation of the environmental management plans. Another important objective is to democratize the development process at the local level and to establish accountability to the affected people. The procedures will however not a person’s right to go to the courts of law. It needs to be highlighted that other units of GPS do not have a GRM. However, with the introduction of GRM in Unit 4, other units may adopt a similar GRM, as well.

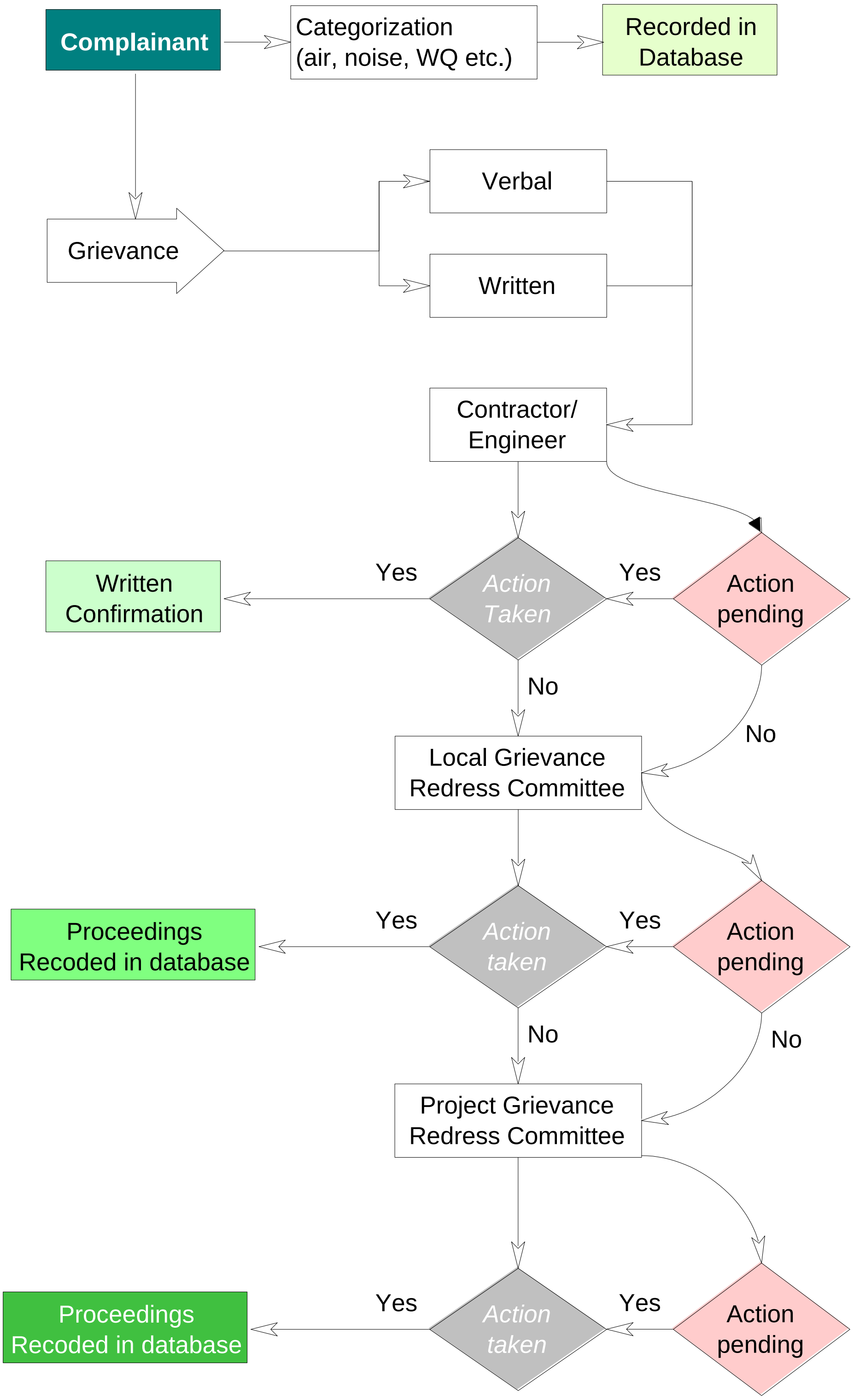


Figure 14-2: Grievance Redress Mechanism

842. Under the GRM, two grievance redress committees (GRCs) will be formed: local grievance redress committee (LGRC); and project grievance redress committee (PGRC). Most of the grievances would be resolved at LGRC within 7 days of receipt of compliant, while a few might be forwarded to PGRC, which will take two weeks to resolve the complaint. These GRCs are described below.

14.7.1 Local Grievance Redress Committee

843. The following LGRC composition has been proposed for the project:

- Deputy Manager/Executive Engineer (Environment)– EHSU Circle, GPS: Convener
- Ward Councilor: Member Secretary
- Environmental Specialist, Owner's Engineer: Member
- Community Representative(s)[46]: Members
- Representative of Women affected persons (APs): Member
- Contractors Representative: Member

844. LGRC meetings will be held in the convener's office in the project impact area or other location(s) as agreed by the Committee members. If needed, LGRC members may undertake field visits to verify and review the issues, including mistakes related to temporary disturbance due to construction works, unauthorized disposal of solid and hazardous wastes, noise and vibration due to the use of heavy equipment, access restrictions, etc.

14.7.2 Project Grievance Redress Committee

845. The grievances that are not resolved at the LGRC will be forwarded to the PGRC. The PGRC will be empowered to take a decision, which would be binding on BPDB but it will require approval of the Project Director for implementation of the decision. The Project Director will head the PGRC. The composition of the PGRC will be as follows:

- Project Director: Chair Person
- Manager EHSU Circle, GPS: Member Secretary (Environmental Specialist of Owner's Engineer will assist the Member Secretary in grievance redress mechanism).
- Representative of Civil Society: Member (nominated by Project Director with the help of Owner's Engineer).

846. The Secretary of PGRC with the help of Environmental Specialist of Owner's Engineer will provide necessary knowledge and information regarding relevant project policies and agreements with development partner. The provision of PGRC will further establish fairness and transparency in the resolution of grievances of the project-affected persons. In case of technical nature of environmental issues, or any legal matters, Environmental Specialist of Owner's Engineer will advise the PGRC. In specific cases, external legal and or technical advice may also be sought, if required.

[46] This may be, for example, any community member representing project affected persons and one woman.

15. Discussions and Conclusion

847. The project is indispensable to meet the objectives of the nation's power plan and in view of the serious shortage of natural gas, the primary energy produced in the country. Through repowering, the plant's energy efficiency will increase form 31% to 54%; thus augmenting power generation with less fuel consumption. As a repowering plant, the location of the plant is fixed and only alternative analysis in respect of technology was undertaken and best available technologies have been chosen for the plant and its subsystems. The plant is going to be one of most cost effective investment in the power sector delivering power at near lowest price in the country. The knock on economic benefits will be substantial in industry, business, employment generation, tax revenue and other sectors. Because of increased energy efficiency of the plant, there will be considerable emission reduction of CO_2 which is a greenhouse gas on per MW basis.

848. This ESIA process was designed to ensure that all potentially significant environmental impacts are identified and assessed. The ESIA for the plant includes assessment of the topic areas: air quality, water quality and quantity, the aquatic environment, terrestrial ecology, ground conditions and flood risk, noise, transport, cultural heritage, landscape and visual impacts and socio-economic impacts. The ESIA process included a wide ranging consultation program to inform the local communities and other stakeholders of the proposed development. The feedback and comments received have been taken into account during the drafting of the ESIA document where appropriate. The assessment of environmental impacts have been done using mostly secondary data available in view of the time constraint. However, the essential conclusions from current assessment are unlikely to be impacted when more data are available.

849. It will be the obligation of the EPC contractor to submit their Environmental Management Action Plan (EMAP) before commencement of work since they will be responsible for the implementation of the EMP during boiler decommissioning, plant construction and operation. The EMP implementation during the project implementation is included in the bidding document and its cost will be included the project cost. The EMP will take care of all the EHS issues in compliance with WBG guidelines and advisory. A document on existing boiler decommissioning plan has been prepared as part of ESIA. Implementation of decommissioning plan is included in the EPC contract.

850. The plant is located in an Airshed degraded in respect of particulate matter i.e., both PM10 and PM2.5. The Airshed is compliant in NAAQS (National Ambient Air Quality Standards) in respect of other criteria pollutants NO_2, SO_2, CO and O_3. However, because of the use of sulfur free natural gas and advance combustion technology, the emission levels of the plant are low for all pollutants including PM. Cumulative impact assessment shows that the contribution of the plant to PM emission in the Airshed is almost negligible. With the implementation of this project there is a significant reduction in emissions from the baseline to repowering case for the Ghorashal power station. Thus, with the implementation of this project the air quality in the airshed will be brought closer to compliance with national ambient air quality standards and WHO Guidelines. Continuous ambient air quality monitoring stations will be installed at the maximum ground level concentration location during operation phase to keep tract of air quality change with time.

851. The new plant like the old one, will withdraw water from river Shitalakhya. So, the quantity and quality of water that may be available have been carefully evaluated over a 30 years' time horizon; the expected life of the plant. Based on these assessment and also the thermal plume dispersion analysis, the cooling system has been changed to closed cycle cooling system from the present once through cooling system. This will reduce the water requirement for the plant by more than 90% and will ensure that the operation of the plant will not contribute to the thermal effluent stream of the rest of the units of GPS. The essential water quality data will be generated during the operation phase as part of the environment monitoring plan to monitor river water quality. The cooling tower is included in the bid document and a financial allocation of $16 million has been made for this in the EMP budget.

852. The demolition of the existing boiler will produce considerable amount of asbestos containing material. Asbestos being a hazardous material with be handled and disposed as per WBG's Good Practice note on Asbestos (2009) and other international best practice documents as required to ensure health and safety of both worker and general public. An on-site concrete lined secured asbestos facility will be constructed within the GPS premises to dispose and isolate the debris. One of the chemicals, i.e., Hydrazine used in the water treatment system is a hazardous substance and a carcinogen. Hydrazine will be replaced with a less hazardous material.

853. Noise level has been identified as a significant potential impact of the proposed power plant during both the construction and operation phases as RMS, gas pipes, and gas turbine which are the major components of the plant generate significant noise. However, noise would not impact major receptors such as schools, residential areas because of the distance. The EMP has suggested measures to minimize this impact of noise during construction and operation phases of the plant.

854. An emergency response plan (ERP) for the plant has been prepared for effective response to deal effectively and efficiently with any emergency, major accident or natural disaster.

855. A management structure for EMP implementation has been proposed in the EIA document. During the construction period overall responsibility for implementation of EHS provision will be the responsibility of EPC Contractor as specified in the contract document. The EPC contractor will be supervised by owner's engineer and the environment team of the PIU. During operation EMP implementation will be the responsibility of the BPDB, i.e., project management. Technical Assistance for capacity building for EMP implementation is included in the project.

856. Overall, it is expected that by repowering, Unit 4 will be more environmentally friendly compared to the current condition as discussed above. In addition, the unit will substantially reduce greenhouse gas emissions during its entire lifetime.

16. References

1. Alam, M. A., Badruzzaman, A. B. M, and Ali, M. A (2012). Spatiotemporal Assessment of Water Quality of the Shitalakhya River, Bangladesh. International *Journal of Engineering and Technology, 2* (6), pp. 953-962.
2. Asbestos Essentials Task Manual (2001); www.hse.gov.uk/asbestos/essentials/index.htm
3. Bangladesh Power Development Board (2015). Power Sector Emergency Information, *System Planning Department*
4. Bari, M F and Marchand, M. (2006). Management of Rivers for Instream Requirement and Ecological Protection: Introducing Environmental Flow Assessment in Bangladesh: Multidisciplinary Collaborative Research. BUET-DUT Linkage Project, Phase III*. Capacity Building in the Field of Water Resources Engineering and Management.* 12 pages.
5. Billah, M., Chatani, S., and Sudo, K. (2009). *Application of WRF-CMAQ Modeling System to Study of Urban and Regional Air Pollution in Bangladesh.* Retrieved from https://www.cmascenter.org/conference/2009/abstracts/billah_application_wrf-cmaq_2009.pdf
6. Ghorashal Thermal Power Plant, 2nd Phase, Unit4. *Working Project of Heat Insulation*. Code: 087-04-11-TN; Book I Explanatory Note - Volumes of Work and materials .
7. Government of Bangladesh Planning Commission (2015). Background Paper for the 7th Five Year Plan. *Environment, Forestry and Biodiversity Conservation*. Retrieved from http://www.plancomm.gov.bd/7th-five-year-plan/
8. Government of the People's Republic of Bangladesh (2012). *Perspective Plan Of Bangladesh 2010-2021: Making Vision 2021 A Reality*. Retrieved from http://www.plancomm.gov.bd/wp-content/uploads/2013/09/Perspective-Plan-of-Bangladesh.pdf
9. Government of the People's Republic of Bangladesh - Ministry Of Power, Energy And Mineral Resources (2004). *National Energy Policy.* Retrieved from http://www.petrobangla.org.bd/NEP_2004_fulldoc.pdf
10. Gumbel, E. J. (1958). Statistics of Extremes, pp 375. *Columbia University Press, New York*.
11. Hanrahan, P.L. (1999). The Plume Volume Molar Ratio Method for Determining NO_2/NO_x Ratios in Modeling—Part I: Methodology. *Journal of the Air & Waste Management Association, 49*(11), pp 1324-1331.
12. International Finance Corporation (2007). *Environmental, Health, and Safety General Guidelines*. Retrieved from http://www.gcgf.org/wps/wcm/connect/554e8d80488658e4b76af76a6515bb18/Final%2B-%2BGeneral%2BEHS%2BGuidelines.pdf?MOD=AJPERES
13. Ontario Ministry of the Environment and Climate Change (2004). *Air Dispersion Modelling Guideline for Ontario*. Ministry of the Environment, Canada.
14. Sarraz A., Ali M. K., Das D. C. (2015). Seismic Vulnerability Assessment of Existing Buildings Stocks at Chandgaon in Chittagong city, Bangladesh. *American Journal of*

Civil Engineering, *3*(1), pp 1-8. Retrieved from http://www.sciencepublishinggroup.com/j/ajce

15. Spath, P. and Mann, M. (2000). *Life Cycle Assessment of Natural Gas Combined Cycle Power Generation System*. Retrieved from http://library.umac.mo/ebooks/b28020261.pdf.
16. Sarraz A., Ali M. K., Das D. C., 2015; Seismic Vulnerability Assessment of Existing Buildings Stocks at Chandgaon in Chittagong city, Bangladesh, American Journal of Civil Engineering 2015; 3(1): 1-8, retrieved from http://www.sciencepublishinggroup.com/j/ajce
17. TEPCO (2010). Power System Master Plan, Power Division. *Ministry of Power, Energy and Mineral Resources*, *Government of the Peoples Republic of Bangladesh*. Retrieved from http://www.powerdivision.gov.bd/user/brec/112/58.
18. The Dow Chemical Company (n.d.). Retrieved on 16th May, 2015 from http://www.dowwaterandprocess.com/en/Industries%20and%20Applications/Industrial_Water/Boiler_Feed_and_Process_Water/Demineralization/Reverse_Osmosis
19. The Environment Conservation Rules (1997). Retrieved from https://www.elaw.org/system/files/Bangladesh+--+Environmental+Conservation+Rules,+1997.pdf.
20. The Environmental Conservation Act (1995). Retrieved from http://faolex.fao.org/docs/pdf/bgd42272.pdf.
21. The World Bank (1999). *OP 4.11 - Cultural Property.* Retrieved from http://siteresources.worldbank.org/INTFORESTS/Resources/OP411.pdf.
22. The World Bank (2012). *OP 7.50 – Projects on International Waterways*. Retrieved from https://www.se.gob.ar/contenidos/archivos/permer/PoliticaAguasInternacionales2001.pdf
23. The World Bank (2013a). *OP 4.01 - Environmental Assessment*. Retrieved on 7th April, 2015 from http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTPOLICIES/EXTOPMANUAL/0,,contentMDK:20064724~menuPK:4564185~pagePK:64709096~piPK:64709108~theSitePK:502184,00.html
24. The World Bank (2013b). *OP 4.10 - Indigenous Peoples*. Retrieved from http://www.bicusa.org/wp-content/uploads/2013/10/FINAL-BANK-IP-SAFEGUARD.pdf.
25. The World Bank (2013c). *OP 4.12 - Involuntary Resettlement*. Retrieved from http://www.bicusa.org/wp-content/uploads/2013/10/FINAL-BANK-IR-SAFEGUARD.pdf.
26. Trivedi, A.K., Ahmad, I., Musthapa, M.S., Ansari, F.A. and Rahman, Q. (2004). Environmental contamination of chrysotile asbestos and its toxic effects on growth and physiological and biochemical parameters of Lemna gibba. *Archives of Environmental Contamination and Toxicity, 47*(3)*,* pp 281-289.
27. U.S. Environmental Protection Agency (2009). USEPA AP 42 Compilation of Air Pollutant Emission Factors, *5th ed., vol. 1: Stationary Point and Area Sources*. Retrieved from http://www.epa.gov/ttn/chief/ap42/index.html.
28. U.S. Environmental Protection Agency (2010). *Applicability of Appendix W Modeling Guidance for the 1-hour N02 National Ambient Air Quality Standard.* Retrieved from

http://www.epa.gov/scram001/guidance/clarification/ClarificationMemo_AppendixW_Hourly-NO2-NAAQS_FINAL_06-28-2010.pdf

29. U.S. Environmental Protection Agency (2014). *Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard*. Retrieved from http://www.epa.gov/scram001/guidance/clarification/NO2_Clarification_Memo-20140930.pdf
30. Water Aid Bangladesh (2006). *Step by Step Implementation Guidelines for Public Toilet.* Retrieved from file:///C:/Users/Redwan/Downloads/public%20toilet%20guidelines%20rural.pdf
31. *WBG's General EHS Guidelines: Environmental, Wastewater and Ambient Water Quality, 2007*
32. *WBG Environmental, Health, and Safety Guidelines for Thermal Power Plants, 2008*
33. *WBG's Good Practice Note: Asbestos, 2009*
34. *WHO Air Quality Guidelines for Asbestos in Europe, 2000*
35. *WHO Air Quality Guidelines, 2005*
36. *WHO Guidelines for Drinking-water Quality, 2010*

ANNEXES

Annex 1.1: Terms-of-Reference of the EIA Study

ENVRONMENTAL ASSESSMENTFOR REPOWERING OF UNIT-4 GHORASHAL POWER STATION

A.Background

1. Ghorashal is a major power generation center of BPDB located on the eastern bank of river Shitalakhya in the Palash Upazilla of Narsingdi District. Currently, it has six generating units with a nominal generating capacity of 950MW (2x55MW and 4x210 MW) based on gas fired conventional steam turbine technology. The average efficiency of the plants at Ghorashal is around 31% which is quite poor compared to the efficiency of around 55% for the modern combined cycle power plants. Studies have shown that repowering of Ghorashal plants is technically feasible and highly beneficial economically. BPDP is already in the process of repowering three of the four 210 MW units and there is no reason why other units will also not be upgraded given the benefits. Thus, eventually the capacity of Ghorashal will probably be around 2000MWor more. Such capacity increase will call for upgrading of infrastructure of the Ghorashal complex both physical and environmental. As the plants are expected to have lifetime of 30 years or more, the environmental infrastructures such as water supply have to be planned for all the units (i.e., based on strategic overview) as piecemeal changes may not be efficient or cost effective. The same is true for land use planning.

2. The purpose of the current project is to repower unit-4 (nominal capacity of 210 MW) of the Ghorashal power plant. The World Bank has agreed to finance the project. The project involves the replacement of the current steam plant with a more efficient combined cycle plant. As part of new plant, a gas turbine will be installed and the present boiler will be replaced by a HRSG (Heat Recovery Steam Generator). The steam turbine may or may not be retained depending on the assessment of its residual life. This means that the current boiler has to be decommissioned. Environmental issues remain the biggest and most costly items to address as part of decommissioning. The boiler for the unit-4 power plant is quite a massive installation. It consists mainly of steel structures containing sheet metals, beams, bars and carbon-steel pipes. The steam carrying pipes are insulated with asbestos and fiber glass according to information available. The total weight of the boiler installation is expected to be several thousand tons with asbestos containing material probably more than 50 tons. Asbestos is considered as a hazardous material (CAS# 1332-21-4) and its use is banned in many countries especially in developed ones. Thus, Asbestos abatement must occur before any demolition. The guidelines on hazardous materials have to be followed in addition to general EHS [47] (Environmental Health and Safety) guidelines during decommissioning of the boiler installation.

3. With the proposed repowering, the needed quantity and quality of water will also change. A comprehensive assessment of water requirement for next 30 years in terms of quality, quantity, treatment technology, cooling water options, heat plume dispersion etc. have to be carried out. It is to be noted that HRSGs require high-purity water because of the use of the IP drum steam for turbine injection (i.e., for reducing NOx emission). Dissolved solids must be kept to a bare minimum in these units. Hydrazine(CAS# 302-01-2), which is currently being used as de-oxygenator for boiler feed water, is considered as a highly hazardous material and a carcinogen. As per WBG's guideline hydrazine can no longer be used as less toxic alternative is available (i.e.,Carbohydrazide). In addition to being less toxic, carbohydrazide is also an extremely effective metal passivator.

[47] WBG Environmental, Health, and Safety Guidelines for Thermal Power Plants, 2008

4. Water from primary treatment appears to contain rather high TDS (i.e.,reportedly 250mg/l). Use of high TDS feed water for the deionization plant require regeneration of resin columns at short intervals (i.e., reportedly every three minutes or so). For frequent resin regeneration, more acid and alkali are required and this also reduces the life of the resin. It appears essential to reduce the TDS level of feed water to the demineralization plant by using technologies like RO (Reverse Osmosis).

5. It may be noted that not more than 10% of water flow can be intercepted from the river as per WBG's guidelines. The Shitalakhya River is a distributary of the old Bhramaputra River. The water flow in the old Bhramaputra River has decreased considerably in recent times (i.e., last 30 years). So, it is not unlikely that in next 30 years the flow may decrease even further which may lead to drastic decrease of water flow in Shitalakhya River (i.e., currently reported to be 74 m^3/s) especially during the dry season (i.e., Nov – May). Thus, it may be necessary to move away from once through cooling currently in use, to closed cycle cooling. Such a change if decided will add additional cost for the project for cooling towers.

6. In the repowering process, the best available technologies will be used that will also minimize environmental pollution levels. In addition to the repowering, the proposed project includes new gas pipeline with Regulating & Metering Station (RMS) in the Ghorashal Power Plant Complex.With the purpose of obtaining Site Clearance and Environmental Clearance Certificates from Department of Environment of Bangladesh it is required to carry out Initial Environmental examination (IEE) and Environmental Impact Assessment (EIA) studies. For financing by the World Bank, the EIA document has to compatible with Bank's operational policies and guidelines.

7. The Bangladesh Power Development Board (BPDB) is to hire a consulting firm (the Consultant) to carry out an Environmental Assessment (EA) of the proposed project i.e., repowering and new gas pipeline with RMS

B. Objective of the Assignment

8. The objective of the assignment is to prepare the Environment Assessment (EA) report of the repowering of the Unit-4 and associated infrastructure (gas pipeline within Ghorashal Power Plant Complex) to meet the compliance requirement of the Government of Bangladesh (GoB)[48] and the World Bank.

9. The specific objectives are:

i. Conduct Initial Environmental Examination to identify possible environmental and socio-economic impacts with possible mitigation measures and a tentative Environmental Management Plan; and

ii. Conduct Environmental Impact Assessment with detail environmental baseline survey, prediction and evaluation of possible environmental and socio-economic impacts, and detail Environmental Management Plan.

10. The consultant will assess as appropriate, the impacts of a range of reasonable and technically feasible alternatives as well as the proposed project. The alternatives to the project must include a "no action" alternative, indicating what would happen in the absence of the proposed project as well as consideration of best practices that may not otherwise have been incorporated in the proposed project. Other alternatives should be developed as needed to address significant issues with the proposal.

[48] The GoB requires 2 stages environmental assessment as per ECA'95 and ECR'97: (i) initial environmental examination and site clearance; and (ii) environmental impact assessment and environmental clearance.

11. The assessment will consider all relevant plans related to the proposed project, for example, engineering and site preparation plans, operations and decommissioning/closure, environmental management, and mitigation in whatever form these may take.

12. The consultant will prepare a water balance for the different uses of water from the Shitalakhya River for the next 30 years and assess whether any rehabilitation of river would be required to sufficient water for the power plant needs and other consumers of the water. If the upgrade of the river front structures would be required, the impact of the upgrade as well as mitigation and monitoring measures will be covered under this assignment.

13. In addition to the impacts of the proposed project activities, the EA will also investigate possible cumulative impacts through the combination of project impacts and background concentrations and impacts from other economic activities (‘domino’ impacts).

14. The consultant will consider uncertainty and how that uncertainty will be addressed through monitoring and contingency plans as may be needed to reduce risk of adverse impacts in the future.

15. The EA report will provide specific plans on the responsibility as to how the environmental actions, monitoring, reporting and auditing will be done.

16. The consultant will make presentations on EIA report to the client, World Bank and DoE at the draft and final stage.

17. The consultant will respond to DOE’s and the World Bank clarifications and queries in respect of application submitted for DOE’s environmental clearance certificate and the World Bank’s clearance on EIA report.

18. The Erection, Procurement and Construction (EPC) Contractor will be selected after the EA report has been prepared. As a consequence, the EA report will not capture the details on design or technology choices, but it will be based on the assessment of available information and standards to be met. Based on the EA report, the EPC contractor will prepare the detailed environmental action plan with the implementation schedule considering the detailed design and technology options.

C. EA Requirement

19. The Government’s Environment Conservation Act (amended 2010) is currently the main legislation relating to environment protection in Bangladesh. This Act is promulgated for environment conservation, environmental standards development and environment pollution control and abatement. Environment Conservation Rules (ECR), 1997 and Amendments provide categorization of industries and projects and identify types of environmental assessment required against respective categories of industries or projects. The proposed project is ‘Red’ category project as the ECR’97. In addition, the Consultant will also need to identify any other government laws, regulations and guidelines applicable for the project.

20. The Bank requires environmental assessment (EA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable, and thus decision making. EA will take into account the natural environment (air, water, and land), human health and safety, social aspects (involuntary resettlement, indigenous people, and physical cultural resources), transboundary and global environmental aspects. The borrower is responsible for carrying out the EA.

21. The proposed project will fall under ‘Category A’ as per the World Bank policies and BPDB requires an Independent Environmental Assessment Firm (not affiliated with the project) to carry out the environmental assessment (EA). According the policy, the EA is closely integrated with project’s economic, financial, institutional, social and technical analyses to ensure that environmental considerations are given adequate weight in project selection, siting and design decisions.

22. Again, when one or more members of the World Bank Group are involved in a project, the Environmental, Health, and Safety (EHS) Guidelines are applied as required by their respective

policies and standards. These EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). There are General EHS and Industry/Sector specific EHS Guidelines. 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.

D. Scope of Initial Environmental Examination (IEE)[49]

23. The scope of works includes mainly preparation of IEE reports and activities essential for the preparation of the reports. The scope of the services is detailed below:

- Selection of the proposed site which involves minimum agricultural land, minimum habitats to be displaced, minimum/avoiding hilly area, use maximum Government land (if available) and develop suitable layouts.
- Land acquisition plan from the office of the Deputy Commissioner's office (if required).
- Land use/ Land cover including ecologically critical area, national parks, forest, orchard, cultural heritage site etc., if any, in the site selected for the power plant.
- Topographical survey of the selected project site.
- Meteorological data collection of the site from Bangladesh Meteorological Department (BMD).
- Hydrological and morphological data collection from BWDB and BIWTA.
- Agro-ecological zones data collection from AEZ report.
- Agricultural data collection from BBS and DAE.
- Water resources and soil salinity data collection from BWDB and SRDI.
- Collection of data on access to site
- Soil investigation of the selected site.
- Seismicity analysis.
- Sources of water during construction and operation.
- Effluent disposal point(s).
- Data on water quality, air quality and noise level.
- Transportation of raw material and fuel.
- Collection of Preliminary planning, design and drawing of power plants.
- Specific statutory requirements applicable in Bangladesh.
- Establishment of the environmental and social baseline condition in respect of water resources, air quality, noise level, land resources including land use/land cover, agriculture, fisheries, ecosystems and socio-economic condition.
- Public consultation and disclosure
- Identification of Important Environmental and Social Components (IESC).
- Assessment of impacts of the proposed power plant on the environmental and social components.
- Preliminary Environmental Management Plan (EMP).
- Risk and hazard analysis.
- Terms of Reference (TOR) for the Environmental Impact Assessment (EIA) study for approval by DOE.
- Produce an IEE report, which shall form the basis of obtaining location/ site clearance from the DOE.

E. Scope of Environmental Impact Assessment (EIA)

24. The scope of works includes carrying out environmental impact assessment of the proposed project that will satisfy the applicable environmental requirements, including the laws, bylaws and

[49] This is requirement of ECR'97. The World Bank Policy does not require IEE report.

rules of Bangladesh and World Bank Group's operational policies, guidelines including health and safety guidelines. The scope of the services is detailed below:

Task 1. Describe the proposed project

25. Elaborate project description including location of all project-related development sites, including offsite investments, general layout of facilities at project-related development sites, drawings of facilities, size, capacity, flow through of unit operations, including pollution control technology, pre-construction activities including decomissioning of exstig boiler, construction activities and schedule, commissioning, operation and maintenance activities, staffing and support for different phases, facilities and services,life expectancy for major components.

Task 2. Description of the Environment(baseline conditions)

26. Assemble and evaluate baseline data on the physical, biological and socioeconomic characteristics of the project area and area of influence. The environemntal parameters have to be collected, measured and presented in ways which are consistent with applicable environmental standards, norms, and requirements of both national (i.e., ECR'97 and its latter amendents) and international (i.e., WB operational policies and guidelines). Include information on any changes anticipated before the project commences.

(a) **Physical Environment:** geology (e.g., stratigraphy and seismic history of project areas), topography (e.g., drainage patterns around construction areas),climate and meteorology (e.g., prevailing wind patterns around stacks and other sources of emissions, precipitation patterns at residue disposal sites),noise level, ambient air quality (e.g., ability to assimilate emissions and maintain air quality standards), input from other major pollutant generators in the area (if any), surface water hydrology including flood hazard potential, water resources (e.g., adequacy of water supplies), receiving water quality (e.g., ability to assimilate effluent discharges and maintain water quality standards for desired uses, input from major pollutant generators in the area, if any); significant pollutant sources in the area and prospect for their mitigation.

(b) **Biological environment:** flora (e.g., types and diversity), fauna (e.g., resident and migratory), rare or endangered species within or in areas adjacent to project, sensitive habitats, including wetlands, parks or reserves, significant natural habitats within or in areas downstream/down gradient of project area, species of commercial importance in areas affected by the project.

(c) **Socio-cultural environment:** (both present and projected in the sourrounded area of the Glorashal power plant): e.g., population, land use (i.e., year-round and seasonal), community structure, employment and labor market, distribution of income, goods and services, recreation, public health; education; cultural properties (e.g., archaeological and historically significant sites), indigenous peoples and traditional tribal lands; customs, aspirations and attitudes.

Task 3. Legislative and Regulatory Considerations

27. Review the pertinent policies, laws, regulations and standards governing environmental quality, health and safety (please refer to section C of this ToR) and explain the possible implication of the policies, laws, regulations and standards on the proposed project.

Task 4. Determination of the Potential Impacts of the Proposed Project

28. The consultant will predict and assess all significant impacts that the project is likely to generate, in quantitative terms as far as possible. These may include, but not be limited to, changes in the following: wastewater effluents and atmospheric emissions and solid wastes (empahsis on waste characteristics of decomissioned unit and repowered plants and means to reduce pollution emissions

and effluents as part of the production process), land use, infrastructure, exposure to disease, noise, and traffic, socio-cultural behavior). Assess the impacts from changes brought about by the project on baseline environmental conditions as described under Task 2.

29. In this analysis, the consultant will distinguish between significant positive and negative impacts, direct, indirect and cumulative impacts, and immediate and long-term impacts. Include indirect impacts from the increased power supply (e.g., industrial expansion and increased urbanization). Identify impacts that may occur due to accidental events (e.g., leakage from a gas pipeline).Identify impacts that are unavoidable or irreversible. Wherever possible, describe impacts quantitatively, in terms of environmental costs and benefits. Assign economic values when feasible.The impact analysis will be divided into decommissioning of boiler impacts, other pre-construction impacts, construction impacts and operations impacts. The followings are some key specific scopes under Task 4.

(a) Carry out in-depth impact assessment of decomssionig of the boiler and other assoicated equipment. Special attention will be provided on asbestos of steam carrying pipes and hydrazine used as de-oxygenerator for bioler feed water. The risk and hazard assessment will extensively cover how the hazardous materials will be collected, handled and managed.

(b) Assess the overall potential impacts and risks associated with collection and disposal of liquid waste and solid waste from decommisioning, other pre-construction activities, construction and operation operation facility.

(c) Assess impact of project decomissinoning, storage, construction and operation on the gorund water from potential leaching and/or percolation of toxic or harmful substance.

(d) Assess impact of the project decomissioning, construction and operation on the biological environment with particular focus on endangared, threatended and protected species.

(e) Carry out a comprehensive water need assessment including hydrological investigations.A comprehensive assessment of water requirement for next 30 years in terms of quality, quantity, treatment technology, cooling water options, heat plume dispersion etc. will be carried out. It is to be noted that HRSGs require high-purity water because of the use of the IP drum steam for turbine injection (i.e., for reducing NOx emission). Assessment will include the option to move away from once through cooling currently in use, to closed cycle cooling.

(f) Identify plant's impacts on air quality especially due to $PM_{2.5}$, PM_{10} and NO_x on the local environment using dispersion modelling. Identify exhaust stack requirements (as per DOE rules) applicable to the plant so that concentration of NO_x and particulate matter in the surrounding area is within standards.

(g) Assess impact of the project with respect to generation of noise and vibrations (with focus on workers, neighboring communities and business, and sensitive natural receptors) on account of construction equipment and construction activities.

(h) Conduct thermal plume modelling to evaluate hot water discharge into Shitalakhya River so that it complies with the WB guidelines (i.e., $<3^oC$), considering the proposed power plant and planned changes for other units.

(i) Assess the occupational health and safety risk of the proposed project at different phases. Evaluate the issues related to comply with all health and safety and environmental laws of Bangladesh and the requirements of the World Bank Group. Identify any restriction that will reasonably be imposed on the developers of the power generation projects to ensure that expansion projects can be designed, constructed and operated in compliance with all such laws, regulations and requirements and also international obligations.

Task 5. Analysis of Alternatives to the Proposed Project

30. The EA will include a systematic analysis of feasible alternatives to meet the ultimate project

objectives. This analysis may suggest designs that are sounder from an environmental perspective than the originally proposed project. Include the "no action" alternative (no major development work) to demonstrate environmental conditions without it. Alternatives will also include the following: the alternative of upgrading (repowering) existing facilities, alternative means of meeting the energy requirements, complete replacement of existing power plant, alternative design, and alternative methods of construction, including costs and reliability.

31. The consultant will make an comparison of altenatives in terms of: potential environmental impacts, feasibility of mitigating impacts, capital and operating costs, suitability under local conditions (e.g., skill requirements, public cooperation, availability of parts, level of technology), and institutional, training, and monitoring requirements. When describing the impacts of alternatives, the consultant will indicate which impacts would be irreversible or unavoidable and which may be mitigated.

32. To the extent possible, the consultant will quantify the costs and benefits of each alternative, incorporating the estimated costs of any associated mitigating measures. Describe the reasons for selecting the proposed project over the other alternatives on environemntal prespective.

Task 6. Cummulative Impact Assessment

33. The consultant will carry out the cumulative impact assessment to identify cumulative impacts on Valued Environmental Components (VECs) like as water bodies or watercourses, community health, atmospheric environment (air quality), acoustic environment (noise) etc. due to the cumulative effects of existing and future activities in the influence area (within and beyond the Ghorashal power plant) from the power plants and other economic activities. The scopes of the cummulative impact assessment are:

(a) Identify the VECs associated with the proposed project in consultation with stakeholders, communities, local NGOs and define the assessment goals.

(b) Establish the geographic scope for the analysis.

(c) Establish the timeframe for the analysis.

(d) Identify the other actions affecting the VECs (including resources, ecosystem and communities).

(e) Characterize the VECs in terms of their responses to change and capacity to withstand stresses.

(f) Characterize the stresses affecting VECs.

(g) Review the baseline defined under Task-2 and if required, uodate the baseline to include selected VECs.

(h) Identify the important cause-and-effect relationship between human activities and VECs.

(i) Determine the magnitude and significance of cummulative effects.

(j) Modify or add alternatives to avoid, minimize or mitigate significant cummulative effects.

Task 7. Development of an Environmental Management Plan (EMP)

34. The consultant will recommend feasible and cost-effective measures to prevent or reduce significant negative impacts to acceptable levels. This will include measures to address emergency response requirements for accidental events and occupational health & safety.

35. The consultant will estimate the impacts and costs of those measures, and of the institutional

and training requirements to implement them. Prepare a management plan including proposed work programs, budget estimates, schedules, staffing and training requirements, and other necessary support services to implement the mitigating measures. Provide environmental protection clauses for application by EPC contractor and consultant.

36. The consultant will prepare a detailed plan to monitor the implementation of mitigating measures and the impacts of the project of other inputs (such as training and institutional strengthening) needed to conduct it during construction and operation. This will include an estimation of capital and operating costs and a description of other inputs (such as training and institutional strengthening) needed to implement the plan.

37. The detailed scope for EMP includes:

(a) Prepare a set of mitigation and management measures to be taken during decommissioning, other pre-constructions, construction and operation period to avoid, reduce, mitigate, or compensate for adverse environmental impacts.

(b) Prepare separate plan for (i) boiler decomissioning, (ii) occupational health & Safety and (iii) emergency response & disaster management.

(c) Describe each mitigation measure with technical details, including the type of impact to which it relates and the conditions under which it is required (for instance, continuously or in the event of contingencies), together with designs, equipment descriptions, and operating procedures, as appropriate.

(d) Quantify and assign financial and economic values to mitigating methods and also quantify associated costs.

(e) Delineate the desired outcomes of each item of the management plan as measurable events to the extent possible, such as performance indicators, targets or acceptance criteria that can be tracked over defined time periods.

(f) Prepare environmental monitoring program, which should ensure that the mitigation plans are respected including the technical aspects of monitoring, measurement methodologies, data analysis, and reporting schedules, and detailed budget & procurement schedules of environment related equipment and materials.

(g) Describe mitigation, monitoring and reporting procedures and responsibilities to ensure early detection of conditions that necessitate particular mitigation measures and document the progress and results of mitigation.

(h) Describe the desired outcomes as measurable events to the extent possible, such as performance indicators, targets, or acceptance criteria that can be tracked over defined time periods.

(i) Describe institutional or organizational arrangements, such as, who is responsible for carrying out the mitigation and monitoring measures including capital and recurring cost and describes the sources of fund.

(j) Prepare plan to strengthen environmental, and occupational health & safety management capability: technical assistance programs, training programs, procurement of equipment and supplies related to environmental management and monitoring, and organizational changes.

<u>Task 8.Consultation, Disclosure and Grievance Redress</u>

38. The Consultant will assist BPDB in coordinating the EA with relevant stakeholders and to facilitate consultation with communities, local NGOs and other stakeholders on the environmental aspects of the proposed project. These groups will be consulted at least twice: in meetings held during scoping of the study and when a draft EA is available (a summary of the EA in local language will be available prior to the meeting). The draft EA should also be available in a public place accessible to

affected groups and local NGOs. The scope of the Task 8 includes:

(a) Carryout a stakeholder analysis to categorize the most important actors for preparation, design, implementation and monitoring of the proposed project.

(b) Inform, consult, and be engaged in dialogue with stakeholders regarding proposed project design alternatives, likely impacts of the interventions (both positive and negative), environmental enhancement measures and possible measures for environmental mitigation/compensation, implementation and monitoring of mitigation/compensation measures.

(c) Develop a procedure to answer project-related queries and address complaints, disputes, and grievances about any aspect of the project, including disagreements regarding the assessment and mitigation of environmental impacts.

(d) Translate the Executive Summary of the report and EMP in Bangla.

(e) Assist BPDB for the disclosure requirement of environmental documents so that the stakeholder consultation, full information on the designs and environmental mitigation measures will be disclosed and made accessible to common people.

F. Reports and Deliverables

39. The following reports are to be delivered by the consultants to BPDB for separately each proposed power project. All report shall be submitted to BPBD in (five) hard copies and soft copy on CD.

- An Inception Report
- The Draft Final Initial Environment Examination (IEE) Report
- The Final IEE Report
- The Decommissioning Plan for Boiler
- The Draft Final Environment Impact Assessment (EIA) Report;
- The Final EIA Report
- The Executive Summary and EMP in Bangla

40. The consultant will provide an EIA report which is concise and limited to significant environmental issues. The main text should focus on findings, conclusions and recommended actions, supported by summaries of the data collected and citations for any references used in interpreting those data. Detailed or uninterrupted data are not appropriate in the main text and will be presented in annex or a separate volume. Unpublished documents used in the assessment may not be readily available and should also be assembled in an annex. The following are the broad outline to organize the environmental assessment report. The Annex of the ToR provides additional details of some chapters/sections as guidence.

- Executive Summary
- Policy, Legal and Administrative Framework
- Description of the Proposed Project
- Description of the Environment
- Significant Environmental Impacts
- Analysis of Alternatives
- Cumulative Impact Assessment
- Environmental Management Plan, incl. mitigation, monitoring, capacity development and training and implementation schedule and costs; include environmental clauses for incorporation in contract agreements (EMP chapter includes plan for (i) boiler decomissioning, (ii) occupational health & Safety and (iii) emergency response & disaster management)
- Consultation, Disclosure and Grievance Redress
- List of References.
- Annexes:

- List of Environmental Assessment Preparers
- Records of Communications and consultation
- Data and Unpublished Reference Documents

G. Responsibilities of Consultants

41. The consultant shall carry out the services as detailed in "Scope of Works" in the best interest of the BPDB with the reasonable care, skill and diligence with sound engineering administrative and financial practices and shall be responsible to the executive agency (BPDB) for discharge of responsibilities. In addition, the consultant will address the comments of the BPDB, DoE, World Bank and any other independent reviewer appointed by the government or the World Bank. The consultant will provide clarification and revise the report accordingly.

H. Responsibility of the Clients

42. The client, Bangladesh Power Development Board will provide all necessary information on project design, process and data as per requirement of Department of Environment. In addition, the client will facilitate the study with necessary support and references in collecting data from different Government Departments.

I. Resources Requirement/Qualification of Professionals

43. The EA requires interdisciplinary analysis. The general skills required of an EA team are: Environment Assessment Specialist, Power System Engineer, Environmental Management Planner, Air Quality Modeling Specialist, Water Resources Specialist, Water Quality Specialist, Hazardous Waste Management Specialist, Institutional Specialist, Ecologist and Occupational Health & Safety Specialist particular esperience in desommissioning. The consulting team must be able to demonstrate appropriate skill mix and depth of experience to cover all areas of the proposed analysis, including incorporation of other specialized skill sets where required. The consulting team shall be led by a Team Leader with at least 10 years of experience leading EIA studies, including prior international experience on similar types of power projects, and prior experience as either team leader or deputy team leader on major infrastructure EAs for World Bank/ADB funded projects.

44. Following is an indicative allocation of manpower for the study. The Consultant is free to employ resources i.e. support staff as they see fit to carry out the assignment within stipulated time and meet the requirement of this service.

Annex- Reports

The IEE report has to be completed following the DoE's guideline. The EIA report should be prepared following the Format provided in section E. The following are additional and detailed points of some chapters/sections. The consultant is also required to include the points given below. However, these do not represent the table of contents of the EIA report. The broad EIA report content has been presented in the section E of the ToR. The followings are additional guidance which the consultants have to follow based on their judgment for best presentation of the report.

I. Acronyms and abbreviations

All acronyms and abbreviations used in the document should be defined, so that the reader will not have to look for their first occurrence.

II. Executive Summary

The ES should mirror the main report both in form and content. It should be about 10% of the report in length.

III. Introduction

III.1. Background

III.2. Purpose of the Study

III.3. Need of the Project

III.4. Importance of the Project

III.5. Scope of EIA Study

III.6. EIA Team

IV. Legal and Legislative Framework, Regulations and Policy Considerations (including inter alia National Policies, Laws and rules on relevant issues such as Environment , Energy , Industry, Water , , Land use, , Fisheries , Natural gas policy, etc.; Relevant WB operational policies and Guidelines, Relevant international Treaties and obligations)

V. Project Data Sheet

V.1. Project Proponent

V.2. Project location and area

V.3. Nature and Size of the Project

V.4. Project Concept

V.5. Project Components

V.6. Project Activities

V.7. Project schedule

V.8. Resources and utilities demand

V.9. Sources of NG and Quality

V.10. Pipelines for NG

VI. Project Description

VI.1. Project Site

VI.2. Project Layout including site drainage

VI.3. Land Requirement

VI.4. Fuel Requirement

VI.5. Water Requirement and Hydrology of Shitalakhya

VI.6. Technology Selection and Process Description

VI.7. Description of Major Sub-Systems

VI.7.1 Power station facilities (CC, HRSG, Steam Generator)

VI.7.2 Plant Control System

VI.7.3 Cooling Water system

VI.7.4 Water Supply and Treatment System

V1.7.5 Wastewater Treatment System

V1.7.6 Sludge Treatment

VI. 7.7 Boiler Blowdown

V1.7.8 Cooling Tower (if any)

VI. 7.9 Cooling water discharge

VI. 7.10 Gas pipeline with RMS construction

VI. 7.11 Material Storage and Handling

VI. 7.12 Fire Fighting and emergency management

VI.8. Material Balance

VI.9 Construction

VI.9.1 Site Preparation

VI.9.2 Existing Boiler Decommissioning (A separate decommissioning plan should be produced and only a summary may be included here)

VI.9.3 Access Roads

VI.9.4 Natural Gas pipeline relocation including RMS

VI.10 Operation and Maintenance

VI.11 Pollution Mitigation Measures (Units & Devices especially for NOx reduction)

VI.12 Dispatch of Power

VI.13 Life Cycle Overview (including decommissioning)

VII. **Analysis of Suitability for Different Alternatives** (this analysis shall be performed, among other approaches, in a GIS based Spatial Decision Support System (SDSS) presenting the suitability of different options for both the interventions)

VIII. **Detail description of the land cover/land use** (with all the existing resource classes along with area coverage shall be shown in the respective maps derived from updated image of proper spatial and spectral resolution. Basic information (name of satellite, date and time of acquisition with atmospheric condition, spatial resolution, color composite etc.) of the image data to be used for making land use/land cover maps shall be mentioned; Should also include land use plan map for Ghorashal power complex showing all current and planned activities within the compound.)

VIII. **Description of Baseline Environment**

VIII.1 Study Area (10 Km. radius), Period, Component and methodology (Seasonal Variation should be covered)

VIII.2 Topography

VIII.3 Seismicity

VIII.4 Hydrogeology

VIII.5 Meteorology

VIII.6 Ambient Air Quality

VIII.7 Ambient Noise Quality

VIII.8 Surface & Ground Water Quality

VIII.9 Aquatic Monitoring

VIII.10 Soil Quality

VIII.11 Ecology

VIII.12.1 Forests

VIII.12.2 Flora

VIII.12.3 Fauna

VIII.12 Demography Profile and Occupational Pattern

VIII.13 Land use and Cropping Pattern

VIII.14 Socio-economic and cultural Scenarios

VIII.15 Distance to urban and rural communities (proximity to sensitive receptors)

VIII.16 Transmission capacity/options for linking to grid

VIII.17 Distance to existing infrastructure such as roads, etc.

VIII.18 Current and surrounding land use and associated communities

IX. Environmental Impacts

IX.1 Identification of Impact

IX.2 Sustainability of Quality of Gas and Continuity of Supply

IX.3 Construction Stage Impact

IX.3.1 Impact on Landform

IX.3.2 Impact on Natural Resources

IX.3.3 Impact on Eco-systems

IX.3.4 Impact on Ambient Air

IX.3.5 Impact on Ambient Noise

IX.3.6 Impact on Water Bodies

IX.3.7 Impact on Soil

IX.3.8 Impact on Workers Health, Sanitation and Safety

IX.3.9 Impact on Key Point Installations & others

IX.3.10 Solid Waste Disposal

IX.3.11 Social Impact due to industrial set up and harnessing of coal and other resources locally (if any)

IX.3.12 Impact due to transportation of raw materials

IX.4 Operation Stage Impact

IX.4.1 Impact on Natural Resource

IX.4.2 Impact on eco-systems

IX.4.3 Impact due to collection of Resources from Local Sources within the Country (if any)

IX.4.4 Impact on Ambient Air (including dispersion modelling)

IX.4.4.1 Cumulative Effect on Ambient Air quality

IX.4.4.2 Greenhouse Gas Emission

IX.4.5 Impact on Ambient Noise (including modelling for noise profile)

IX.4.6 Impact on Water Bodies (both surface & ground)

IX.4.7 Solid Waste Disposal

IX.4.8 Soil and Agriculture

IX.4.9 Impact on Ground Water

IX.4.10 Impact of Cooling water discharge including heat plume modelling

IX.4.11 Ecology (Flora and Fauna)

IX.4.12 Impact on Occupational Health

IX.4.13 Impact on Public Health and Safety

IX.4.14 Impact on Traffic Movement

IX.4.15 Social Impact

IX.4.16 Impact on Tourism

IX.4.16 Impact due to transportation of primary fuels

X. Evaluation of Impacts

The impacts should be evaluated in terms of their local, regional and national importance. The impact should be assessed in terms of the magnitude, significance, frequency of the occurrence, duration and probability. The confidence level in the prediction must be stated. The judgment of significance of impacts can be based on one or more of the following, depending on the environmental factor being evaluated. These are:

i. comparison with laws, regulation or accepted national or international standards
ii. reference to pre-set criteria such as conservation or protected status of a site, feature or species
iii. consistency with pre-set policy objectives
iv. consultation and acceptability with the relevant decision makers, civil society, local community or the general public.

XI. Mitigation of Impacts

Mitigation measures which may be of the following categories and coverage:

i. changing project layout, transport routes, disposal routes or locations, timing or engineering design
ii. introducing pollution controls, waste treatment, phased implementation and construction, engineering measures, monitoring, landscaping, social services or public education;
iii. rehabilitation, compensation to restore, relocate or provision of concession for damage

XII. Environmental Management Plan

XII.1 EMP during Construction Phase

XII.1.1 Site Preparation including boiler decommissioning plan

XII.1.2 Infrastructure Services

XII.1.3 Construction Equipment

XII.1.4 Safety Measures

XII.2 EMP during Operation Phase

XII.2.1 Air Pollution Management

XII.2.1.1 Transportation and handling of raw materials

XII.2.1.2 Operation Stage

XII.2.2 Waste Water Management

XII.2.3 Used Lubricant Management

XII.2.4 Noise Management

XII.2.5 Solid Waste Management

XII.2.6 House Keeping

XII.2.7 Safety and Occupational Health

XII.3 Greenbelt Development

XII.4 Rain Water Harvesting Plan

XII.5 Rehabilitation and Resettlement Plan

XII.6 Thermal pollution management

XII.7 CDM Intent

XII.8 Budget for EMP

XII.9 Contingency Plans

The project authority shall:

a) Provide a conceptual contingency plan that considers environmental effects associated with operational upset conditions such as serious malfunctions or accidents;

b) Describe the flexibility built into the plant design and layout to accommodate future modifications required by any change in emission standards, limits and guidelines.

XIII. Risk Assessment

XIII.1 Consequence Analysis

XIII.2 Emergency Response Plan

XIII.3 Risk Mitigation Measures

XIV. Environment Monitoring Plan

XIV.1 Monitoring Plan

XIV.1.1 Stack Emission

XIV.1.2 Ambient Air

XIV.1.3 Meteorological

XIV.1.4 Ambient Noise

XIV.1.5 Surface Water & Waste Water

XIV.1.5.1 River Morphology

XIV.1.5.2 Ambient River Temperature

XIV.1.5.3 Cooling water

XIV.1.5 Ground Water XIV.1.6 Solid & Hazardous Waste including used lubricant XIV.1.7 Flora and Fauna

XIV.1.8 Workers Health and Safety XIV.1.9 Community Health XIV.1.10 EMP Implementation

XIV.1.11 Monitoring and CSR

XIV.2 Action during Abnormal Operating conditions

XIV.3 Budgets for Monitoring

XIV.4 Reporting

XV. Public Consultation and Information Disclosure

XV,1 Introduction and definitions

Annex 2. 1: Harmonization between Environment Safeguard of GOB, the WBG Safeguard Policies to draft Operational Framework for GPS Unit 4 Repowering Project

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
Environmental Policy and Regulations	• Environment Conservation Act (1995) • Environment Conservation Rules (1997) and amendment on 2005 • EIA guidelines on Industrial projects, 1997 • National Water Policy - 1999	• Policy on Disclosure of Information, May 2002 • Operational Policy 4.01 Environmental Assessment and associated BP 4.01	• General Environment, Health and Safety Guidelines, 2007 • Environmental, Health, and Safety Guidelines for Thermal Power Plants, 2008	
Screening and Categorisation	• The ECA (1995) and ECR (1997) has set out screening criteria to categorize projects into Green, Orange A, Orange B and Red. • These screening criteria are generally based on project type only irrespective of its scale and location. In some cases, order of investment is indicated to reflect on the magnitude of the impact. • Categorization determines the level of EIA or environmental examination a project requires.	• The Bank undertakes environmental screening of each proposed project to determine the appropriate extent and type of EA • Categorization into Category A, B, C, FI • Categorization takes into account the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impact • The categorization defines the level of EIA that has to be conducted		• Screen each proposed project as early as possible to define the scope of Environmental Assessment (EA) covering all project components. • Categorization should take into account the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impactAccording to GoB rules as outlined in the ECA 1995 and ECR 1997 the proposed project fall in category Red and hence a detailed EIA is mandatory.

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
Scoping	• The impacts assessed in the GOB's EIA system include components such as Air, Noise, Land, Water, Biological and Socio-Economic aspects. • Scoping is a step in the EIA process as per EIA guidelines. s • EIA Guidelines consider IEE as the milestone where scoping is to be carried out.	• EA evaluates - project's potential environmental risks and impacts in its area of influence; - examines project alternatives; - identifies ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts; - includes the process of mitigating and managing adverse environmental impacts throughout project implementation • EA takes into account natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, physical cultural resources; transboundary and global environmental aspects • It also takes into account variations in project and country conditions; findings of country environmental studies; national environmental action plans; the country's overall policy		• Conduct the Environmental Assessment taking into account the national laws and policies as well as relevant directives/policies of the donors to ensure that the assessment takes an integrated approach in identifying and valuating all the potential environmental (including labor, health, and safety) risks and impacts of the project. • EA must take into account natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, physical cultural resources; trans-boundary and global environmental aspects • EA should also address potential impact of the climate change on the project design, alternatives and operations, as well as project's potential contribution to climate change • Ensure that the project is designed and carried out in compliance with environmental laws and regulations of the country where the operation is being implemented, including national obligations established under ratified Multilateral Environmental Agreements (MEAs).

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
		framework, national legislation, and institutional capabilities related to the environment and social aspects • obligations of the country, pertaining to project activities, under relevant international environmental treaties and agreements		
Exclusions and Sensitivities	The ECA (1995) and ECR (1997) have clear stipulation what can be done where and to what extent.	• Avoid or mitigate adverse impacts on physical cultural resources from development projects that it finances (OP 4.11). • The impacts on physical cultural resources resulting from project activities, including mitigating measures, should not contravene either the borrower's national legislation, or its obligations under relevant international environmental treaties and agreements.		• Given the fact under the GoB rules intervention in legally protected area is prohibited, it is advisable to avoid such areas • Proceed only if there are no technically and financially feasible alternatives, and overall benefits from the project substantially outweigh the environmental costs, but with adequate provision of all possible mitigation measures. • Do not implement project activities that involve or are likely to result directly or indirectly in the significant conversion or degradation of critical habitats. • If a project is located within a legally protected area, implement additional programs to promote and enhance the conservation aims of the protected area • Use a precautionary approach to the use, development and management of renewable natural resources • Conserve physical cultural resources (PCR) and avoid their destruction or damage by using field based surveys

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
				with qualified and experienced expert(s) during environmental assessment
Alternatives	ECA (1995) and ECR (1997) do not explicitly ask for identification and assessment of alternatives. EIA Guidelines however include identification and assessment of alternatives under IEE (page 12 of EIA Guidelines for Industrial Projects). In the preparation of EIA, alternatives (site/routes/process/raw materials) are looked at as part of the mitigation measures (page 28 of EIA Guidelines for Industrial Projects)	• EA is initiated as early as possible in project processing and is integrated closely with the economic, financial, institutional, social, and technical analyses of a proposed project • The EA may recommend alternative emission levels and approaches to pollution prevention and abatement for the project taking into account borrower country legislation and local conditions • The EA report must provide full and detailed justification for the levels and approaches chosen for the particular project or site		• Examination of financially and technically feasible alternatives to the project location, design, technology and components, their potential environmental and social impacts • Documentation of the rationale for selecting a particular alternative(s) proposed, where relevant • For the project, alternatives should be examined for repowering option, technology selection, cooling water system, and plant layout alternative
Standards/ Guideline values	GOB has issued emission as well as ambient standards under ECR 1997. These standards are in general at par with the international standards and in some cases even stricter. The workspace or occupational standards are directed under the Factories Act.	• The Pollution Prevention and Abatement Handbook describes pollution prevention and abatement measures and emission levels	• General Environment, Health and Safety Guidelines, provides guidelines for effluent discharge quality, occupational health and safety, hazardous materials management	Achieve environmental standards that are stricter (either GOB's or international), and justify deviations in the EA report when alternatives to the standards for the project or site are selected. For the Project, agreeing on ambient air quality standards for the NOx/NO_2 will be important.

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
	DOE has updated their air quality (only ambient air quality) standards and set some new standards for motor vehicles emission on July 2005 by a GOB Gazette notification.			
EMP	DOE requires Environmental Management Plan (EMP) as an outcome of EIA. Under the guidelines, DOE prescribes conduct of special studies as relevant. These studies include aspects such as Risk analyses (when there is storage and handling of hazardous and toxic substances), Resettlement and Rehabilitation (when more than 1000 people are displaced), Compensatory Afforestation (when deforestation involves more than 5 ha area), Severance etc. Prevention and recycling are to be followed as the first options (Pages 29 and 30 of EIA Guidelines for Industrial Projects). In addition to this EMP must be supplied with the work plan, budget/cost estimate; implementation schedule and	• EMP consists of the set of mitigation, monitoring, and institutional measures to be taken during implementation and operation to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels • Preparation of Management Plan includes - identification of responses to potentially adverse impacts; - determining requirements for ensuring that those responses are made effectively and in a timely manner; - describing the means for meeting those requirements • EMP includes the following components - Mitigation - Monitoring - Capacity Development and Training • implementation Schedule and Cost Estimates		• EMP consists of the set of mitigation, measures to be taken during implementation and operation to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels • Monitoring includes compliance, impact and independent external monitoring • Institutional arrangements of the EMP implementation include strengthening of project implementation and supervising offices, capacity building and training, and grievance management • Preparation of Management Plan includes - identification of responses to potentially adverse impacts; - determining requirements for ensuring that those responses are made effectively and in a timely manner; - describing the means for meeting those requirements • EMP includes the following components - Mitigation

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
	monitoring requirements (Page 31 of EIA Guidelines for Industries) monitoring plan and project scheduling.			- Monitoring - Capacity Development and Training • implementation Schedule and Cost Estimates • EMP also provide for workers - safe and healthy working conditions, and prevent accidents, injury, and disease • Establish preventive and emergency preparedness and response measures to avoid, minimize the adverse impacts and risks to the health and safety of the local communities • For the Project, EMP should be presented for pre-construction, construction and operational phases. It should include construction safety and emergency preparedness plan to address gas leaks/explosion and risk/ hazard management during boiler decommissioning and erection. • EMP should not just address mitigative measures but enhancement measures well e.g. green belt development plan, irrigation use of cooling water discharge etc. • EMP should also address other major source contribution and policy issues considering cumulative impacts of the other facilities (especially Ghorashal and Palash fertilizer factories, Aggreko, Max power etc.) that are not in the scope of the present project. EMP should interface with boiler decommissioning of Unit 3, new 365 MW

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
				CCPP, and BADC for irrigation water distribution.
Consultation	The EIA Guidelines of DOE states that a Summary, not too technical, should be prepared for the purpose of communication to public (Page 32 of EIA Guidelines for Industries). Section 4.11 of the Guidelines encourages Public Participation in EIA. However as per ECA (1995) or ECR (1997), public consultation and participation is not mandatory. No time-frames are however fixed for prior disclosure of EIA to the public. No Grievance mechanism facility is mentioned in the regulations The DOE makes the minutes of the meetings on Environmental Clearance available at its website (http://www.doe-bd.org/minutes.php)	• For all Category A and B projects proposed for IBRD or IDA financing, during the EA process, the borrower consults project-affected groups and local nongovernmental organizations (NGOs) about the project's environmental aspects and takes their views into account • The borrower initiates such consultations as early as possible • For Category A projects, the borrower consults these groups at least twice: a) shortly after environmental screening and before the terms of reference for the EA are finalized (b) once a draft EA report is prepared • In addition, the borrower consults with such groups throughout project implementation as necessary to address EA-related issues that affect them • The borrower provides relevant material in a timely manner prior to consultation and in a form and language that are understandable and accessible		• Free, prior and informed consultation with stakeholders to solicit feedback and ensure their participation as early as possible and throughout the project implementation. • Disclosure in local language with understandable content during public consultation. • Ensure community engagement free of external manipulation, interference, or coercion, and intimidation, and conducted on the basis of timely, relevant, understandable and accessible information. • Establish a grievance mechanism to receive and facilitate resolution of the affected communities' concerns and grievances about the borrower's environmental performance. • For the Project, expert/ institution consultation, focus group discussion and two stage formal public consultations have adopted.

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
		to the groups being consulted • For the initial consultation a summary of the proposed project's objectives, description, and potential impacts is provided by the borrower • For consultation after the draft EA report is prepared, the borrower provides a summary of the EA's conclusions • In addition, the borrower makes the draft EA report available at a public place accessible to project-affected groups and local NGOs		
Independent Review	Preparation and submission of EIA report is the responsibility of the project proponent, in accordance to the TOR approved by the DOE. DOE has the liberty to send any EIA report for external review by an independent institute of person. DOE applies its judgement on the merits of such feedback and if needed send the report back for further revision.	• The borrower is responsible for carrying out the EA • For Category A projects, the borrower retains independent EA experts not affiliated with the project to carry out the EA. • For Category A projects that are highly risky or contentious or that involve serious and multidimensional environmental concerns, the borrower should normally also engage an advisory panel of independent, internationally recognized environmental specialists to advise on all aspects of the project relevant to the EA		• For the Project, BPDB should use inputs from Independent Environment Advisor for independent review. • For the project TOR for EIA was approved by the DOE. • The EIA report is prepared based on the approved TOR. DOE may wishes to send the EIA report for external review, if DOE is not convinced of the conclusions and the EMP proposed.
Monitoring and Disclosure	EIA Guidelines for Industrial Projects recommend	• The borrower reports on - compliance with measures agreed with the Bank on the		• Compliance with measures agreed with the DOE and the Bank on the basis of the findings and results of the

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
	preparation of a Post-Project Monitoring Program. This program is to be included in the EIA report and on review gets reflected as a condition in granting ECC. There is a process of renewable of ECC that requires monitoring and assessment. DOE has the responsibility of follow up and monitoring of ECC conditions. DOE makes the proponent compliance reports available on its website to the public There are no formal provisions to obtain independent assessment of EIA report if found necessary. There is also no formal mechanism or a program at DOE that conducts independent audit of approved projects. Third party monitoring is recommended through approved laboratories. GOB passed The Environment Court Act, 2000 (Act No. 11 of 2000) to allow making of	basis of the findings and results of the EA, including implementation of any EMP, as set out in the project documents; - status of mitigation measures; and findings of monitoring programs		EIA, including implementation of the EMP proposed. • DOE may ask for periodic reports on the status of mitigation measures; and findings of monitoring programs, which could be the basis for extending the EC and/or suspension of the same. • Monitoring the effectiveness of EMP implementation • Documentation of monitoring results, including development and implementation of corrective actions • Disclosure of periodic progress reports

Aspect of Operational Framework	GOB	World Bank	IFC	Harmonized Operational Framework
	appeals from public on non-compliance with the ECA (1995) and ECR (1977).			
Climate Change	Compliance with the GOB's climate change strategy and national action plan			• Follow GOB's climate change strategy and action plan

Annex 7-1: Gas Supply Confirmation

Revision of tender doc's based on technical and proc. comments (4)

People
Braam, Ad Dear Mr. Hossain, Herewith we submit a revision of a part of the tender documents based on the technical and procurement comments (received at 15-2-2015 via an email from Mr Anis). For questions and
Apr 3 at 7:30 PM
Mohammad Anis Mr. Nawaz Please ensure that the relevant team at BPDB reviews the documents and make comments if any URGENTLY. Also, please provide the relevant documents requested. Regards Anis -----Original Messag
Apr 7 at 11:07 AM
Dear Mr. Bikash

Either Power Cell or PD should have forwarded these attachments to you.

Following up on the meeting yesterday at BPDB Board, please review (amongst your team first)and then let us sit at our office for a half day or full (with lunch) this week to go over these and finalize the tender documents. **May be on this Thursday?**

As I mentioned earlier, in addition to reviewing these documents, we need to finalize the i) qualification requirements ii) evaluation criteria iii) guarantee conditions in the bidding documents;

We have already agreed with the Power Secretary and BPDB Chairman that there would be no restriction on gas requirement for the project and supplemental firing. We would rely on the market to provide the best economic solution.

Regards
Anis

Annex 9-1: Environmental Code of Practices

Introduction

The objective of the Environmental Code of Practices (ECPs) is to address all potential and general construction related impacts during Repowering of Ghorashal Unit 4. The ECPs will provide guidelines for best operating practices and environmental management guidelines to be followed by the contractors for sustainable management of all environmental issues. These ECPs shall be annexed to the general conditions of all the contracts, including subcontracts, carried out under the Project.

The list of ECPs prepared for the Project is given below.

ECP 1: Waste Management
ECP 2: Fuels and Hazardous Goods Management
ECP 3: Water Resources Management
ECP 4: Drainage Management
ECP 5: Soil Quality Management
ECP 6: Erosion and Sediment Control
ECP 7: Top Soil Management
ECP 8: Topography and Landscaping
ECP 9: Quarry Areas Development and Operation
ECP 10: Air Quality Management
ECP 11: Noise and Vibration Management
ECP 12: Protection of Flora
ECP 13: Protection of Fauna
ECP 14: Protection of Fish
ECP 15: Road Transport and Road Traffic Management
ECP 16: Construction Camp Management
ECP 17: Cultural and Religious Issues
ECP 18: Worker Health and Safety
ECP 19: Construction and Operation Phase Security

Contractors will prepare site specific management plans, namely Construction Environmental Management Plan (CEMP), in compliance with the World Bank and Environmental Conservation Rules o 1997 of Bangladesh and based on the guidance given in the ECPs. The CEMP will form the part of the contract documents and will be used as monitoring tool for compliance. It is mandatory for the main contractors procured directly by the project to include these ECPs in their subcontracts. Violation of this requirements will be treated as non-compliance leading to the corrections or otherwise imposing penalty on the contractors.

ECP 1: Waste Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
General Waste	Soil and water pollution from the improper management of wastes and excess materials from the construction sites.	The Contractor shall • Develop site specific waste management plan for various waste streams (e.g., reusable waste, flammable waste, construction debris, food waste etc.) prior to commencing of construction and submit to supervision consultant for approval. • Organize disposal of all wastes generated during construction in the designated disposal sites approved by the Project authority. • Minimize the production of waste materials by 3R (Reduce, Recycle and Reuse) approach. • Segregate all wastes, wherever practical. • Vehicles transporting solid waste shall be totally confined within an enclosed vehicle or is fully covered with a tarp to prevent spilling waste along the route. • Tarp must be undamaged (not torn or frayed) properly secured to the body of the vehicle or trailer with ropes, chains, straps, or cords so that no waste is exposed. The edges of the tarps shall extend 12 inches over the permanent sides and back of the open top vehicle or trailer and must be secured to the permanent vehicle. All loads must be tarped from the point of origin of the waste to the tipping area of the final disposal/landfill. • Train and instruct all personnel in waste management practices and procedures as a component of the environmental induction process. • Provide refuse containers at each worksite. • Request suppliers to minimize packaging where practicable. • Place a high emphasis on good housekeeping practices. • Maintain all construction sites clean, tidy and safe and provide and maintain appropriate facilities as temporary storage of all wastes before transporting to final disposal. • Potable water should be supplied in bulk containers to reduce the quantity of plastic waste (plastic bins). Plastic bag use should be avoided.
Hazardous Waste	Health hazards and environmental impacts due to improper waste management practices	The Contractor shall • Collect chemical wastes in 200 liter drums (or similar sealed container), appropriately labeled for safe transport to an approved chemical waste depot.

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		• Store, transport and handle all chemicals avoiding potential environmental pollution. • Store all hazardous wastes appropriately in bunded areas away from water courses. • Make available all Material Safety Data Sheets (MSDS) for hazardous materials on-site during construction. • Collect hydrocarbon wastes, including lube oils, for safer transport off-site to reuse, recycle, treatment or disposal at approved locations. • Construct concrete or other impermeable hard-stand to prevent seepage in case of spills. • Keep sufficient stock of absorbents for generally used chemicals or for petrochemicals (e.g., dirt, sawdust, etc.) within the storage area to contain accidental spills.

ECP 2: Fuels and Hazardous Goods Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Fuels and hazardous goods.	Materials used in construction have a potential to be a source of contamination. Improper storage and handling of fuels, lubricants, chemicals, hazardous goods/materials on-site, wash down of plant and equipment, and potential spills may harm the environment or health of construction workers.	The Contractor shall • Prepare spill control procedures and submit them for supervision consultant for approval. • Train the relevant construction personnel in handling of fuels and spill control procedures. • Refueling shall occur only within bunded areas. • Store dangerous goods in bunded areas on top of a sealed plastic sheet away from watercourses. Store all liquid fuels in fully bunded storage containers, with appropriate volumes, a roof, a collection point and appropriate filling/decanting point. • Store and use fuels in accordance with material safety data sheets (MSDS). Make available MSDS for chemicals and dangerous goods on-site. • Store hazardous materials at above flood level,determined for construction. • Make sure all containers, drums, and tanks that are used for storage are in good condition and are labeled with expiry date. Any container, drum, or tank that is dented, cracked, or rusted might eventually leak. Check for leakage regularly to identify potential problems before they occur. • Sit containers and drums in temporary storages in clearly marked areas, where they will not be run-over by vehicles or heavy machinery. The

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		area shall preferably drain to a safe collection area in the event of a spill. • Take all precautionary measures when handling and storing fuels and lubricants, avoiding environmental pollution. • All machinery is to be stored and away from any water body, drainage inlets or natural drainage area, where practical. Environmental control measures such as appropriate barriers (i.e. bunding, sediment fence, etc.) will be considered and/or implemented to control runoff away from the machinery and prevent any washout in to adjacent water body, drainage inlets or natural drainage area. • Transport waste of dangerous goods, which cannot be recycled, to an approved waste disposal facility. Safe transport of fuel or other hazardous liquids to and from the storage container will be facilitated through the provision detailed within the Material Safety Data Sheets (MSDS). • Wash down of plant and equipment and vehicle servicing will be performed only in isolated impervious areas away from drainage inlets, connecting the drainage with an oil interceptor. Pits/bunds located away from waterways will be provided for concrete wash near construction areas. The contractor's environmental officer with assistance from supervisors is to ensure that pits/bunds are available, maintained at capacity and drivers instructed regarding the location and required procedures. • Keep stock of absorbent and containment material (e.g., absorbent matting, dirt, sawdust, etc.) where hazardous material are used and stored; and ensure staffs are trained in their correct use. • Oil and chemical spills and washouts shall be cleaned up and collected immediately, where safety permits. Disposal of remediated / cleanup/ washout materials shall be to an approved waste disposal facility. Materials shall be transported by an approved / licensed transporter. Contaminated Material to be removed from site as soon as reasonably practical after the incident. • Provide appropriate personal protective equipment (protective clothing, safety boots, helmets, masks, gloves, goggles, etc.) to the construction personnel, depending on the materials handled. • Avoid the use of material with greater potential for contamination by substituting them with more

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		environmentally friendly materials.

ECP 3: Water Resources Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Hazardous material and Waste	Water pollution from the storage, handling and disposal of hazardous materials and general construction waste, and accidental spillage	The Contractor shall • Follow the management guidelines proposed in ECP 1and ECP 2: Fuels and Hazardous Goods Management.. • Minimize the generation of spoils, oil and grease, excess nutrients, organic matter, litter, debris and any form of waste (particularly petroleum and chemical wastes). These substances must not enter waterways or storm water systems.
Discharge from construction sites	Construction activities, sewerages from construction sites and work camps may affect the surface water quality. The construction works will modify groundcover and topography, changing the surface water drainage patterns of the area. These changes in hydrological regime lead to increased rate of runoff, increase in sediment and contaminant loading, increased flooding, and effect habitat of fish and other aquatic biology.	The Contractor shall • Install temporary drainage works (channels and check dams) in areas required for sediment and erosion control and around storage areas for construction materials. • Install temporary sediment lagoons, where appropriate, to capture sediment-laden run-off from work site. • Divert runoff from undisturbed areas around the construction site. • Stockpile materials away from drainage lines. • Prevent all solid and liquid wastes entering waterways by collecting spoils, oils, chemicals, bitumen spray waste and wastewaters from brick, concrete and asphalt cutting where possible and transport to an approved waste disposal site or recycling depot. • Wash out ready-mix concrete agitators and concrete handling equipment at washing facilities off site or into approved bunded areas on site. Ensure that tires of construction vehicles are cleaned in the washing bay (constructed at the entrance of the construction site) to remove the mud from the wheels. This should be done in every exit of each construction vehicle to ensure the local roads are kept clean.
Soil erosion and siltation	Soil erosion and dust from the material stockpiles will increase the sediment and contaminant loading of surface water bodies.	The Contractor shall • Stabilize the cleared areas not used for construction activities with vegetation or appropriate surface water treatments as soon as practicable following earthwork to minimize

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		erosion. • Ensure that roads used by construction vehicles are swept regularly to remove dust and sediment. • Water the loose material stockpiles, access roads and bare soils on an as needed basis to minimize dust. Increase the watering frequency during periods of high risk (e.g. high winds).
Construction activities in water bodies	Dredging/ excavation activities associated with construction of pipelines, bulkheads and river training works, and buildings for a facility can cause turbidity and sedimentation in nearby waters, degraded water quality, and substrate alterations.	The Contractor Shall • Dewater sites by pumping water to a sediment basin prior to release off site – do not pump directly off site. • Monitor the water quality in the runoff from the site or areas affected by dredge/excavation plumes, and improve work practices as necessary. • Protect water bodies from sediment loads by silt screen or other barriers. • Minimize the generation of sediment, oil and grease, excess nutrients, organic matter, litter, debris and any form of waste (particularly petroleum and chemical wastes). These substances must not enter waterways or storm water systems. • Do not discharge cement and water curing used for cement concrete directly into water courses and drainage inlets.
	Highly motile adult and juvenile life stages of most fishes could flee when construction is ongoing, however, egg and larval stages as well as non-motile benthic organisms will likely not be able to avoid impacts. As a general rule, the severity of adverse effects tends to be greatest for early life stages and for adults of some highly sensitive species.	The Contractor shall • Avoid dredged material disposal activities in areas containing sensitive or unique benthic habitats (e.g., spawning and feeding sites). • Restrict construction during December-February when appropriate to avoid temporary impacts to habitat during critical life history stages (e.g., spawning, egg and embryo development, and juvenile growth).
Drinking water	Untreated surface water is not suitable for drinking purposes due to presence of suspended solids and Ecoli.	The Contractor Shall • Provide drinking water that meets National and WHO Drinking Water standards. Drinking water to be chlorinated at source, and ensure presence of residual chlorine 0.1 ~ 0.25 ppm as minimum after 30 minutes of chlorine contact

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		time.

ECP 4: Drainage Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Excavation and earth works, and construction yards	Lack of proper drainage for rainwater/liquid waste or wastewater owing to the construction activities harms environment in terms of water and soil contamination, and mosquito growth.	The Contractor shall • Prepare drainage management procedures and submit them for supervision consultant for approval. • Prepare a program to prevent/avoid standing waters, which supervision consultant will verify in advance and confirm during implementation. • Provide alternative drainage for rainwater if the construction works/earth-fillings cut the established drainage line. • Establish local drainage line with appropriate silt collector and silt screen for rainwater or wastewater connecting to the existing established drainage lines already there. • Rehabilitate road drainage structures immediately if damaged by contractors' road transports. • Build new drainage lines as appropriate and required for wastewater from construction yards connecting to the available nearby recipient water bodies. Ensure wastewater quality conforms to National Standards, before it is being discharged into the recipient water bodies. • Ensure that there will be no water stagnation at the construction sites and camps. • Provide appropriate silt collector and silt screen at the inlet and manholes and periodically clean the drainage system to avoid drainage congestion. • Protect natural slopes of drainage channels to ensure adequate storm water drains. • Regularly inspect and maintain all drainage channels to assess and alleviate any drainage congestion problem.
Ponding of water	Health hazards due to mosquito breeding	• Do not allow ponding of water especially near the waste storage areas and construction camps. • Discard all the storage containers that are capable of storing of water, after use or store them in inverted position.

ECP 5:Soil Quality Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Storage of hazardous and toxic chemicals	Spillage of hazardous and toxic chemicals will contaminate the soils	The Contractor shall • Strictly manage the wastes management plans proposed in ECP 1and storage of materials and ECP 2: Fuels and Hazardous Goods Management.. • Construct appropriate spill containment facilities for all fuel storage areas. • Establish and maintain a hazardous material register detailing the location and quantities of hazardous substances including the storage, and their disposals. • Train personnel and implement safe work practices for minimizing the risk of spillage. • Identify the cause of contamination, if it is reported, and contain the area of contamination. The impact may be contained by isolating the source or implementing controls around the affected site. • Remediate the contaminated land using the most appropriate available method.
Construction material stock piles	Erosion from construction material stockpiles may contaminate the soils	The Contractor shall • Protect the toe of all stockpiles, where erosion is likely to occur, with silt fences, straw bales or bunds.

ECP 6: Erosion and Sediment Control

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Clearing of construction sites	Cleared areas and slopes are susceptible for erosion of top soils, which affects the growth of vegetation and causes ecological imbalance.	The Contractor shall • Prepare site specific erosion and sediment control measures and submit them for supervision consultant for approval. • Reinstate and protect cleared areas as soon as possible. • Cover unused area of disturbed or exposed surfaces immediately with mulch/grass turf/tree plantations.
Construction activities and material stockpiles	The impact of soil erosion are (i) Increased run off and sedimentation causing a greater flood hazard to the downstream and silt accumulation and (ii) destruction of aquatic	The Contractor shall • Locate stockpiles away from drainage lines. • Protect the toe of all stockpiles, where erosion is likely to occur, with silt fences, straw bales or bunds. • Remove debris from drainage paths and sediment control structures.

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
	environment by erosion and/or deposition of sediment damaging the spawning grounds of fish	• Cover the loose sediments of construction material and water them if required. • Divert natural runoff around construction areas prior to any site disturbance. • Install protective measures on site prior to construction, for example, sediment traps. • Install 'cut off drains' on large cut/fill batter slopes to control water runoff speed and hence erosion. • Observe the performance of drainage structures and erosion controls during rain and modify as required. • Restrict construction during December-February July when appropriate to avoid temporary impacts to habitat during critical life history stages (e.g., spawning, egg and embryo development, and juvenile growth).
Soil erosion and siltation	Soil erosion and dust from the material stockpiles will increase the sediment and contaminant loading of surface water bodies.	The Contractor shall • Stabilize the cleared areas not used for construction activities with vegetation or appropriate surface water treatments as soon as practicable following earthwork to minimize erosion. • Ensure that roads used by construction vehicles are swept regularly to remove sediment. • Water the material stockpiles, access roads and bare soils on an as required basis to minimize dust. Increase the watering frequency during periods of high risk (e.g. high winds).

ECP 7: Top Soil Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Land clearing and earth works	Earthworks will impact the fertile top soils that are enriched with nutrients required for plant growth or agricultural development.	The Contractor shall • Strip the top soil to a depth of 35 cm and store in stock piles of height not exceeding 2m. • Remove unwanted materials from top soil like grass, roots of trees and others. • The stockpiles will be done in slopes of 2:1 to reduce surface runoff and enhance percolation through the mass of stored soil. • Locate topsoil stockpiles in areas outside drainage lines and protect from erosion. • Construct diversion channels and silt fences around the topsoil stockpiles to prevent erosion and loss of topsoil.

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		• Spread the topsoil to maintain the physico-chemical and biological activity of the soil. The stored top soil will be utilized for covering all disturbed area and along the proposed plantation sites. • Prior to the re-spreading of topsoil, the ground surface will be ripped to assist the bunding of the soil layers, water penetration and revegetation
Transport	Vehicular movement outside ROW or temporary access roads will affect the soil fertility of the agricultural lands	• Limit equipment and vehicular movements to within the approved construction zone. • Plan construction access to make use, if possible, of the final road alignment.

ECP 8: Topography and Landscaping

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Land clearing and earth works	Construction activities especially earthworks will change topography and disturb the natural rainwater/flood water drainage as well as change the local landscape.	The Contractor shall • Prepare landscaping and plantation plan and submit the plan to supervision consultant for approval. • Ensure the topography of the final surface of all raised lands (construction yards, approach roads and rails, access roads, etc.) are conducive to enhance natural draining of rainwater/flood water. • Keep the final or finished surface of all the raised lands free from any kind of depression that causes water logging. • Undertake mitigation measures for erosion control/prevention by grass-turfing and tree plantation, where there is a possibility of rain-cut that will change the shape of topography. • Cover immediately the uncovered open surface that has no use of construction activities with grass-cover and tree plantation to prevent soil erosion and better landscaping. • Reinstate the natural landscape of the ancillary construction sites after completion of works.

ECP 9: Quarry Areas Development and Operation

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Development and	Borrow areas will have	The Contractor shall

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
operation of borrow areas	impacts on local topography, landscaping and natural drainage.	• Prepare borrow/quarry area management plan and submit the plan for supervision consultant approval. • Use only approved quarry and borrow sites. • Identify new borrow and quarry areas in consultation with the client, if required. • Reuse excavated or disposed material available in the project to the maximum extent possible. • Store top soil for reinstatement and landscaping. • Develop surface water collection and drainage systems, anti-erosion measures (berms, revegetation etc.) and retaining walls and gabions where required. Implement mitigation measures in • ECP 3: Water Resources Management, ECP 6: Erosion and Sediment Control • The use of explosive should be used as low as possible to reduce noise, vibration, and dust. • Control dust and air pollution by application of watering and implementing mitigation measures proposed in ECP 10: Air Quality Management • Noise and vibration control by ECP 11: Noise and Vibration Management.

ECP 10: Air Quality Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Construction vehicular traffic	Air quality can be adversely affected by vehicle exhaust emissions and combustion of fuels.	The Contractor shall • Prepare air quality management plan (under the Pollution Prevention Plan) and submit the plan for supervision consultant approval. • Fit vehicles with appropriate exhaust systems and emission control devices. Maintain these devices in good working condition. • Operate the vehicles in a fuel efficient manner. • Cover hauling vehicles carrying dusty materials moving outside the construction site. • Impose speed limits on all vehicle movement at the worksite to reduce dust emissions. • Control the movement of construction traffic. • Water construction materials prior to loading and transport. • Service all vehicles regularly to minimize

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		emissions. • Limit the idling time of vehicles not more than 2 minutes.
Construction machinery	Air quality can be adversely affected by emissions from machinery and combustion of fuels.	The Contractor shall • Fit machinery with appropriate exhaust systems and emission control devices. Maintain these devices in good working condition in accordance with the specifications defined by their manufacturers to maximize combustion efficiency and minimize the contaminant emissions. Proof of maintenance register shall be required by the equipment suppliers and contractors/subcontractors. • Pay special attention to control emissions from fuel generators. • Machinery causing excessive pollution (e.g., visible smoke) will be banned from construction sites. • Service all equipment regularly to minimize emissions. • Provide filtering systems, dust collectors or humidification or other techniques (as applicable) to the concrete batching and mixing plant to control the particle emissions in all stages, including unloading, collection, aggregate handling, cement application, circulation of trucks and machinery inside the installations.
Construction activities	Dust generation from construction sites, material stockpiles and access roads is a nuisance in the environment and can be a health hazard, and also can affect the local crops	The Contractor shall • Water the material stockpiles, access roads and bare soils on an as needed basis to minimize the potential for environmental nuisance due to dust. Increase the watering frequency during periods of high risk (e.g. high winds). Stored materials such as gravel and sand shall be covered and confined to avoid their being wind-drifted. • Minimize the extent and period of exposure of the bare surfaces. • Restore disturbed areas as soon as practicable by vegetation/grass-turfing. • Store the cement in silos and minimize the emissions from silos by equipping them with filters. • Establish adequate locations for storage, mixing and loading of construction materials, in a way that dust generation is minimized during such operations. • Not use water as dust suppression on potentially contaminated areas, to prevent generation of liquid waste stream. • Crushing of rock and aggregate materials shall be

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		wet-crushed, or performed with particle emission control systems. • Not permit the burning of solid waste.

ECP 11: Noise and Vibration Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Construction vehicular traffic	Noise quality will be deteriorated due to vehicular traffic	The Contractor shall • Prepare a noise and vibration management plan (under the Pollution Prevention Plan) and submit the plan for supervision consultant approval. • Maintain all vehicles in order to keep it in good working condition in accordance with manufactures maintenance procedures. • Make sure all drivers will comply with the traffic codes concerning maximum speed limit, driving hours, etc. • Perform the loading and unloading of trucks, and handling operations minimizing construction noise on the work site.
Construction machinery	Noise and vibration may have an impact on people, property, fauna, livestock and the natural environment.	The Contractor shall • Appropriately organize all noise generating activities to avoid noise pollution to local residents. • Use the quietest available plant and equipment in construction work. • Maintain all equipment in order to keep them in good working order in accordance with manufactures maintenance procedures. Equipment suppliers and contractors shall present proof of maintenance register of their equipment. • Install acoustic enclosures around generators to reduce noise levels. • Fit high efficiency mufflers to appropriate construction equipment. • Avoid unnecessary use of alarms, horns and sirens.
Construction activity	Noise and vibration may have an impact on people, property, fauna, livestock and the natural environment.	The Contractor shall • Notify adjacent landholders prior to typical noise events outside of daylight hours. • Educate the operators of construction equipment on potential noise problems and the techniques to minimize noise emissions. • Employ best available work practices on-site to

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		minimize occupational noise levels. • Install temporary noise control barriers where appropriate. • Notify affected people if major noisy activities will be undertaken, e.g. blasting. • Plan activities on site and deliveries to and from site to minimize impact. • Monitor and analyze noise and vibration results and adjust construction practices as required. • Avoid undertaking the noisiest activities, where possible, when working at night near the residential areas.

ECP 12: Protection of Flora

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Vegetation clearance	Local flora are important habitats for birds, provide fruit harvest, timber/fire wood, protect soil from erosion and overall keep the natural balance for human-living. As such damage to flora has wide range of adverse environmental impacts.	The Contractor shall • Prepare a plan to protect flora and submit the plan for supervision consultant approval. • Minimize disturbance to surrounding vegetation. • Use appropriate type and minimum size of machine to avoid disturbance to adjacent vegetation. • Get approval from supervision consultant for clearance of vegetation. • Make selective and careful pruning of trees where possible to reduce need of tree removal. • Control noxious weeds by disposing of at designated dump site or burn on site. • Clear only the vegetation that needs to be cleared in accordance with the engineering plans and designs. These measures are applicable to both the construction areas as well as to any associated activities such as sites for stockpiles, disposal of fill, etc. • Not burn off cleared vegetation – where feasible, chip or mulch and reuse it for the rehabilitation of affected areas, temporary watermain and valve access or landscaping. Mulch provides a seed source, can limit embankment erosion, retains soil moisture and nutrients, and encourages re-growth and protection from weeds. • Return topsoil and mulched vegetation (in areas of native vegetation) to approximately

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		the same location from where it came from. • Avoid work within the drip-line of trees to prevent damage to the tree roots and compacting the soil. • Minimize the length of time the ground is exposed or excavation left open by clearing and re-vegetate the area at the earliest practically possible. • Ensure excavation works occur progressively and re-vegetation done at the earliest. • Provide adequate knowledge to the workers regarding nature protection and the need of avoid felling trees during construction • Supply appropriate fuel in the work camps to prevent fuel wood collection.

ECP 13: Protection of Fauna

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Construction activities	The location of construction activities can result in the loss of wild life habitat and habitat quality,	The Contractor shall • Prepare a plan for protection of fauna and submit the plan for supervision consultant approval. • Limit the construction works within the designated sites allocated to the contractors. • Check the site (especially trenches) for trapped animals, and rescue them by the help of a qualified person. • Provide temporary access to the animals to cross the trenches.
	Impact on local and migratory birds, their habitats and active nests	The Contractor shall • Not be permitted to destruct active nests or eggs of birds. • Minimize the tree removal during the bird breeding season. If works must be continued during the bird breeding season, a nest survey will be conducted by a qualified biologist prior to commence of works to identify and locate active nests. • If bird nests are located/ detected within the right-of-way and roadside embankments then those areas should be avoided. • Petroleum products should not come in contact with the natural and sensitive ecosystems. Contractor must minimize the release of oil, oil wastes or any other substances harmful to migratory birds'

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		habitats, to any waters, wetlands or any areas frequented by migratory birds.
Vegetation clearance	Clearance of vegetation may impact shelter, feeding and/or breeding and/or physical destruction and severing of habitat areas	The Contractor shall • Restrict the tree removal to the minimum numbers required. • Relocate hollows, where appropriate. • Fell the hollow bearing trees in a manner which reduces the potential for fauna mortality. Felled trees will be inspected after felling for fauna and if identified and readily accessible will be removed and relocated or rendered assistance if injured. After felling, hollow bearing trees will remain unmoved overnight to allow animals to move of their own volition. Care should be taken to make sure bird habitats are not destroyed. If there is no option available, rehabilitate them in other neighboring trees. Also protect and rehabilitate injured or orphaned birds.
Night time lighting	Lighting from construction sites and construction camps may affect the visibility of night time migratory birds that use the moon and stars for navigation during their migrations.	The Contractor shall • Use lower wattage flat lens fixtures that direct light down and reduce glare, thus reducing light pollution, • Avoid flood lights unless they are absolutely required. • Use motion sensitive lighting to minimize unneeded lighting. • Use, if possible, green lights that are considered as bird's friendly lighting instead of white or red colored lights. • Install light shades or plan the direction of lights to reduce light spilling outside the construction area.
Construction camps	Illegal poaching	The Contractor shall • Provide adequate knowledge to the workers regarding protection of flora and fauna, and relevant government regulations and punishments for illegal poaching. • Ensure that staff and Subcontractors are trained and empowered to identify, address and report potential environmental problems. • Provide sufficient food allowance to the workers so that they don't engage in illegal poaching or hunting.

ECP 14: Protection of Fish

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Construction activities in River	The main potential impacts to fisheries are dredging, hydrocarbon spills and leaks from riverine transport, and disposal of wastes into the river.	The Contractor shall • Prepare procedures for protection of fish and submit them for supervision consultant approval. • Restrict dredging and piling in the intake area during fish breeding and spawning season to avoid hindrance or blockage of fish breeding and spawning. • Ensure the construction equipment used in the river are well maintained and do not have oil leakage to contaminate river water. • Contain oil immediately on river in case of accidental spillage from equipment; make an emergency oil spill containment plan (under the Fuels and Hazardous Substances Management Plan) to be supported with enough equipment, materials and human resources. • Do not dump wastes, be it hazardous or non-hazardous into the nearby water bodies or in the river.
Construction activities on the land	The main potential impacts on river are increased suspended solids from earthworks erosion, sanitary discharge from work camps, and hydrocarbon spills	The Contractor shall • follow mitigation measures proposed • ECP **3: Water Resources** Management and ECP 4**: Drainage Management**.

ECP 15: Road Transport and Road Traffic Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Construction vehicular traffic	Increased traffic use of road by construction vehicles will affect the movement of normal road traffics and the safety of the road-users.	The Contractor shall • Prepare a traffic management plan and submit the plan for supervision consultant approval. • Strictly follow the Project's 'Traffic Management Plan' and work with close coordination with the Traffic Management Unit. • Prepare and submit additional traffic plan, if any of his traffic routes are not covered in the Project's Traffic Management Plan, and

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		requires traffic diversion and management. • Include in the traffic plan to ensure uninterrupted traffic movement during construction: detailed drawings of traffic arrangements showing all detours, temporary road, temporary bridges, temporary diversions, necessary barricades, warning signs / lights, road signs, construction schedule etc. • Provide signs at strategic locations of the roads complying with the schedules of signs contained in the National Traffic Regulations.
	Accidents and spillage of fuels and chemicals	The Contractor shall • Restrict truck deliveries, where practicable, to day time working hours. • Restrict the transport of oversize loads. • Operate vehicles, if possible, to non-peak periods to minimize traffic disruptions. • Enforce on-site speed limit, especially close to the sensitive receptors, schools, health centers, etc.

ECP 16: Construction Camp Management

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Siting and Location of construction camps	Campsites for construction workers are the important locations that have significant impacts such as health and safety hazards on local resources and infrastructure of nearby communities.	The Contractor shall • Prepare a construction camp management plan and submit the plan to supervision consultant for approval. • Locate the construction camps within the designated sites or at areas which are acceptable from environmental, cultural or social point of view and approved by the supervision consultant or the Client. • Conduct consultation with communities including local government institutes bodies (Village Head and Group Village Head, Local member of Union Parishad) prior to set-up the camp. • Consider the location of construction camps away from communities in order to avoid social conflict in using the natural resources such as water or to avoid the possible adverse impacts of the construction camps on the surrounding communities. • Submit to the supervision consultant for

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		approval a detailed layout plan for the development of the construction camp showing the relative locations of all temporary buildings and facilities that are to be constructed together with the location of access roads, fuel storage areas (for use in power supply generators), solid waste management and dumping locations, and drainage facilities, prior to the development of the camps. • Local authorities responsible for health, religious and security shall be duly informed on the set up of camp facilities so as to maintain effective surveillance over public health, social, and security matters.
Construction Camp Facilities	Lack of proper infrastructure facilities, such as housing, water supply, and sanitation facilities will increase pressure on the local services and generate substandard living standards and health hazards.	Contractor shall provide the following facilities in the campsites • Adequate housing for all workers. • Safe and reliable water supply, which should meet national/WHO standards. Drinking water to be chlorinated at source, and ensure presence of residual chlorine 0.1 ~ 0.25 ppm as minimum after 30 minutes of chlorine contact time (WHO guideline). • Hygienic sanitary facilities and sewerage system. The toilets and domestic waste water will be collected through a common sewerage. Provide separate latrines and bathing places for males and females with total isolation by location. The minimum number of toilet facilities required is one toilet for every ten persons. • Treatment facilities for sewerage of toilet and domestic wastes. • Storm water drainage facilities. • Paved internal roads. • Provide child crèches for women working at construction site. The crèche should have facilities for dormitory, kitchen, indoor and outdoor play area. Schools should be attached to these crèches so that children are not deprived of education whose mothers are construction workers. • Provide in-house community/common entertainment facilities. Dependence of local entertainment outlets by the construction camps to be discouraged/prohibited to the extent possible.

Project Activity/ Impact Source	**Environmental Impacts**	**Mitigation Measures/ Management Guidelines**
Disposal of waste	Management of wastes is crucial to minimize impacts on the environment	The Contractor shall • Ensure proper collection and disposal of solid wastes within the construction camps. • Insist waste separation by source; organic wastes in one container and inorganic wastes in another container at household level. • Store inorganic wastes in a safe place within the household and clear organic wastes on daily basis to waste collector. Establish waste collection, transportation and disposal systems with the manpower and equipment/vehicles needed. • Do not establish site specific landfill sites. All solid waste will be collected and removed from the work camps and disposed in approved waste disposal sites.
Fuel supplies for cooking purposes	Illegal sourcing of fuel wood by construction workers will impact the natural flora and fauna	The Contractor shall • Provide fuel to the construction camps for their domestic purpose, in order to discourage them to use fuel wood or other biomass. • Made available alternative fuels like natural gas or kerosene on ration to the workforce to prevent them using biomass for cooking. • Conduct awareness campaigns to educate workers on preserving the protection of biodiversity and wildlife of the project area, and relevant government regulations and punishments on wildlife protection.
Health and Hygiene	There will be a potential for diseases to be transmitted including malaria, exacerbated by inadequate health and safety practices. There will be an increased risk of work crews spreading sexually transmitted infections and HIV/AIDS.	The Contractor shall • Provide adequate health care facilities within construction sites. • Provide first aid facility round the clock. Maintain stock of medicines in the facility and appoint fulltime designated first aider or nurse. • Provide ambulance facility for the laborers during emergency to be transported to nearest hospitals. • Initial health screening of the laborers coming from outside areas. • Train all construction workers in basic sanitation and health care issues and safety matters, and on the specific hazards of their work. • Provide HIV awareness programming, including STI (sexually transmitted infections)

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		and HIV information, education and communication for all workers on regular basis. • Provide adequate drainage facilities throughout the camps to ensure that disease vectors such as stagnant water bodies and puddles do not form. Regular mosquito repellant sprays during rainy season in offices and construction camps and yards. • Not dispose food waste openly as that will attract rats and stray dogs. • Carryout short training sessions on best hygiene practices to be mandatorily participated by all workers. Place display boards at strategic locations within the camps containing messages on best hygiene practices.
Security and Safety	Inadequate security and safety provision in construction camps may create security and safety problems of workforces and assets and fire hazards	The Contractor shall • Provide appropriate security personnel (police or private security guards) and enclosures to prevent unauthorized entry in to the camp area. • Maintain register to keep a track on a head count of persons present in the camp at any given time. • Encourage use of flameproof material for the construction of labor housing / site office. Also, ensure that these houses/rooms are of sound construction and capable of withstanding wind storms/cyclones. • Provide appropriate type of firefighting equipment suitable for the construction camps. • All construction material storage should be sit a visible location secured with fence or solid walls with locks to avoid theft and vandalism. • Display emergency contact numbers clearly and prominently at strategic places in camps. • Communicate the roles and responsibilities of laborers in case of emergency in the monthly meetings with contractors.
Site Restoration	Restoration of the construction camps to original condition requires demolition of construction camps.	The Contractor shall • Dismantle and remove from the site all facilities established within the construction camp including the perimeter fence and lockable gates at the completion of the construction work. • Dismantle camps in phases and as the work gets decreased and not wait for the entire work to be completed.

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		• Give prior notice to the laborers before demolishing their camps/units. • Maintain the noise levels within the national standards during demolition activities. • Different contractors should be hired to demolish different structures to promote recycling or reuse of demolished material. • Reuse the demolition debris to a maximum extent. Dispose remaining debris at the designated waste disposal site. • Handover the construction camps with all built facilities as it is if agreement between both parties (contactor and land-owner) has been made so. • Restore the site to its condition prior to commencement of the works or to an agreed condition with the landowner.

ECP 17: Cultural and Religious Issues

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Construction activities near religious and cultural sites	Disturbance from construction works to the cultural and religious sites, and contractors lack of knowledge on cultural issues cause social disturbances.	The Contractor shall • Communicate to the public through community consultation regarding the scope and schedule of construction, as well as certain construction activities causing disruptions or access restriction. • Not block access to cultural and religious sites, wherever possible. • Restrict all construction activities within the foot prints of the construction sites. • Stop construction works that produce noise (particularly during prayer time) should there be any church/mosque/religious/educational institutions and health center close to the construction sites and users make objections. • Take special care and use appropriate equipment when working next to a cultural/religious center. • Stop work immediately and notify the site manager, if during construction, an archaeological or burial site is discovered. It is an offence to recommence work in the vicinity of the site until 'approval to continue' is obtained by the archaeological authority. • Provide independent prayer facilities to the construction workers.

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		• Show appropriate behavior with all construction workers especially women and elderly people. • Allow the workers to participate in praying during construction time, if there is a request. • Resolve cultural issues in consultation with local leaders and supervision consultants. • Establish a mechanism that allows local people to raise grievances arising from the construction process. • Inform the local authorities responsible for health, religious and security duly informed before commencement of civil works so as to maintain effective surveillance over public health, social, and security matters.

ECP 18: Worker Health and Safety

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
Best practices	Construction works may pose health and safety risks to the construction workers and site visitors leading to severe injuries and deaths. The population in the proximity of the construction site and the construction workers will be exposed to a number of (i) biophysical health risk factors, (e.g., noise, dust, chemicals, construction material, solid waste, waste water, vector transmitted diseases, etc.), (ii) risk factors resulting from human behavior (e.g., STD, HIV/AIDS, etc.) and (iii) road accidents from construction traffic.	The Contractor shall • Prepare an Occupational Health and Safety plan and submit the plan for supervision consultant's approval. • Implement suitable safety standards for all workers and site visitors, with sufficient provisions to comply with international standards (e.g. International Labor Office guideline on 'Safety and Health in Construction; World Bank Group's 'Environmental Health and Safety Guidelines') and contractor's own safety standards, in addition to complying with national standards. • Provide the workers with a safe and healthy work environment, taking into account inherent risks in its particular construction activity and specific classes of hazards in the work areas. • Provide personal protective equipment (PPE) for workers, such as safety boots, helmets, masks, gloves, protective clothing, goggles, full-face eye shields, and ear protection. Maintain the PPE properly by cleaning dirty ones and replacing the damaged ones. • Safety procedures include provision of information, training and protective clothing to workers involved in hazardous operations and proper performance of their job. • Appoint an environment, health and safety manager to look after the health and safety of the workers.

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		• Inform the local authorities responsible for health, religious and security duly informed before commencement of civil works and establishment of construction camps so as to maintain effective surveillance over public health, social and security matters.
	Child and pregnant labor	The Contractor shall • not hire children of less than 14 years of age and pregnant women or women who delivered a child within 8 preceding weeks.
Accidents	Lack of first aid facilities and health care facilities in the immediate vicinity will aggravate the health conditions of the victims	The Contractor shall • Ensure health care facilities and first aid facilities are readily available. Appropriately equipped first-aid stations should be easily accessible throughout the place of work. • Document and report occupational accidents, diseases, and incidents. • Prevent accidents, injury, and disease arising from, associated with, or occurring in the course of work by minimizing, so far as reasonably practicable, the causes of hazards, in a manner consistent with good international industry practice. • Identify potential hazards to workers, particularly those that may be life-threatening and provide necessary preventive and protective measures. • Provide awareness to the construction drivers to strictly follow the driving rules. • Provide adequate lighting in the construction area, inside the tunnels, inside the powerhouse cavern and along the roads.
Construction Camps	Lack of proper infrastructure facilities, such as housing, water supply and sanitation facilities will increase pressure on the local services and generate substandard living standards and health hazards.	The Contractor shall provide the following facilities in the campsites to improve health and hygienic conditions as mentioned in ECP 16**: Construction Camp Management**: • Adequate ventilation facilities • Safe and reliable water supply. • Hygienic sanitary facilities and sewerage system. • Treatment facilities for sewerage of toilet and domestic wastes • Storm water drainage facilities. • Recreational and social facilities • Safe storage facilities for petroleum and other chemicals in accordance with ECP 2 • Solid waste collection and disposal system in accordance with ECP1.

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		• Arrangement for trainings • Paved internal roads. • Security fence at least 2 m height and security guards at entrances and every corner of the facility. • Sick bay and first aid facilities
Water and sanitation facilities at the construction sites	Lack of Water sanitation facilities at construction sites cause inconvenience to the construction workers and affect their personal hygiene.	The contractor shall • Provide portable toilets at the construction sites with workforce size 25 people or more, work the whole day for a month. Location of portable facilities should be at least 6 m away from storm drain system and surface waters. These portable toilets should be cleaned once a day and all the sewerage should be pumped from the collection tank once a day and should be brought to the common septic tank for further treatment. • Provide safe drinking water facilities to the construction workers at all the construction sites.
Other ECPs	Potential risks on health and hygiene of construction workers and general public	The Contractor shall follow the following ECPs to reduce health risks to the construction workers and nearby community • ECP 2: **Fuels and Hazardous Goods Management** • ECP 4: **Drainage Management** • ECP 10: **Air Quality Management** • ECP 11: **Noise and Vibration Management** • ECP 15: **Road Transport and Road Traffic Management**
Trainings	Lack of awareness and basic knowledge in health care among the construction workforce, make them susceptible to potential diseases.	The Contractor shall • Train all construction workers in basic sanitation and health care issues (e.g., how to avoid malaria, transmission of sexually transmitted infections (STI), and HIV/AIDS. • Train all construction workers in general health and safety matters, and on the specific hazards of their work. Training should consist of basic hazard awareness, site specific hazards, safe work practices, and emergency procedures for fire, evacuation, and natural disaster, as appropriate. • Implement malaria, HIV/AIDS and STI education campaign targeting all workers hired, international and national, female and male, skilled, semi- and unskilled workforces, at the time of recruitment and thereafter pursued throughout the construction phase on ongoing and regular basis. This should be

Project Activity/ Impact Source	Environmental Impacts	Mitigation Measures/ Management Guidelines
		complemented by easy access to condoms at the workplace as well as to voluntary counseling and testing.

ECP 19: Construction and Operation Phase Security

Project Activity/ Impact Source	Impacts /Concerns	Mitigation Measures/ Management Guidelines
Construction Phase	Inadequate construction site security poses a significant risk to assets, construction materials and property. Theft/vandalism of assets, materials and property would increase construction costs and cause delays in project completion.	The Contractor shall: • Provide appropriate security personnel (i.e. security guards) to prevent unauthorized entry into the camp area. • Employ night watchman for periods of significant on-site storage or when the area necessitates. • Ensure all assets (i.e., tools, equipment, etc.) and construction materials at construction site are identified, inventoried and tracked as closely as possible. All assets should be clearly labeled and marked. Keep records of tool serial numbers and check inventory on a regular basis. • All tools and equipment should have a check out/in system, if not in use should be secured and stored in a proper place to prevent theft or loss. Provide storage sheds for the secure storage of equipment and tools when not in use. • Ensure there is proper fencing around construction site perimeter. Fencing should be chain-link at least 2.4 m high and secured with a steel chain and lock. If possible the entire site should be fenced; if this is not possible, make sure construction trailer and any equipment storage areas are fenced. • Ensure construction site has controlled access points (one or two entry points at most), allowing for close monitoring of comings and goings from the site. • Workers should be easily identified and have credentials that indicate site access. • No trespassing signs should be posted in conspicuous areas throughout the job site. • List of employees who have after hour access to the property should be available to the BWB PMU and local authorities. • Ensure job site is properly lighted at night. Well-lit areas should include any office trailers and equipment storage trailers. Floodlights operated by sensors should also be installed where appropriate. • Pre-employment screening investigations should be used to verify the applicants relating to their

		employment, education and criminal history background.
	Improper security measures may pose security risk for construction workers and especially foreign staff on construction sites.	The Contractor shall: • Prepare site specific security plan. • Maintain register to keep track of number of persons present in the camp at any given time. • Provide appropriate security personnel at job sites as mentioned above. • Ensure proper fencing as mentioned above. • Ensure controlled access points to job site as mentioned above. • Ensure works have easily identified credentials as mentioned above. • Ensure job sites are properly lighted at night, as mentioned above.
Operation Phase	Vandalism/damage (including use of explosives) of water transmission mains, transfer stations Plant, Gas Pipelines, RMS, control stations and storage reservoirs. Theft of infrastructure (i.e. metals and etc.) is also of concern.	• Patrol Men and Pipeline Community Policing Forum shall routinely conduct patrols and inspections of transmission mains Plant area and facilities. • They shall monitor suspicious activity and notify local authorities and BWB GPS along with VH/GVH/TA's in event of any such occurrence/incident. • Ensure strategic infrastructure sites such as reservoirs RMS, Gas Pipelines, and main Plant transfer stations are secure and fenced with controlled access points. Fencing should be chain-link at least 2.4 m high and secured with a steel chain and lock.

Annex 11-1: Terms of reference of the Independent Monitor

A. Background

857. Ghorashal is a major power generation center of BPDB located on the eastern bank of river Shitalakhya in the Palash Upazilla of Narsingdi District. Currently, it has six generating units with a nominal generating capacity of 950MW (2x55MW and 4x210 MW) based on gas fired conventional steam turbine technology. The average efficiency of the plants at Ghorashal is around 31% which is quite poor compared to the efficiency of around 55% for the modern combined cycle power plants. Government has decided to repower the unit-4 (nominal capacity is 210 MW) of the Ghorashal Power Plants. Accordingly the feasibility study and EIA has been conducted. The World Bank is financing the project. The project involves the replacement of the current steam plant with a more efficient combined cycle plant. As part of new plant, a gas turbine will be installed and the present boiler will be replaced by a HRSG (Heat Recovery Steam Generator).

858. The ECR 1997 of MoEF and EHS guideline of World Bank require detail environmental monitoring during pre-construction, construction and operation of the plant. The monitoring includes environmental compliance monitoring, impact monitoring and monitoring of environmental quality.

B. Objectives

859. A detailed EMP has been prepared as part of the present EIA study. As one of the key elements of the EMP, a three-tier monitoring program has been proposed comprising compliance monitoring, impact monitoring, and Independent monitoring. The main purpose of the monitoring program is to ensure that the various tasks detailed in the EMP particularly the mitigation measures are implemented in an effective manner, and also to evaluate project’s impacts on the key environment and social parameters.

860. The main purpose of the Independent monitoring – the third tier of the monitoring program - will be to ensure that all the key entities including EHSU Circle, OE, and contractors are effectively and adequately fulfilling their designated role for EMP implementation, and that all the EMP requirements are being implemented in a timely and effective manner. The primary objective for engaging an independent monitor is to review the efficacy of EMP implementation as well as internal monitoring, and conduct periodic third party monitoring and provide feedback to BPDB and WB on policy improvement and enhancement of implementation process. The Independent Monitoring Consultants (IMC) will review implementation process as per set procedures and tasks given in the EMP and assess the achievement of overall environmental management objectives.

861. The Independent Monitoring Consultant should have good experience in carrying out Environmental Monitoring including Environmental Compliance Monitoring of Power Plant. The Consulting Institute/Firm should have well equipped and certified laboratory for necessary analysis or should have arrangement with other laboratories which are certified by the relevant statutory body of the country.

C. Scope of Work

862. The scope of work of the IMC will include the following specific tasks:

- To develop specific monitoring indicators, checklists, and questionnaires to undertake external monitoring (a preliminary list of monitoring indicators has been given in the EMP) in consultation with BPDB and WB.

- To review and verify the implementation progress of various EMP elements, particularly, mitigation plan, compliance and impact monitoring, environmental trainings, documentation, and grievance redress mechanism.
- To review and verify the functioning of the key entities – EHSU circle, OE, and contractors - for environmental management.
- Identify the strengths and weaknesses of the design of EMP and its implementation, and also the entities tasked to undertake various tasks detailed in the EMP.
- Evaluate and assess the institutional arrangements established for the environmental management of the project. Evaluate and assess the effectiveness and appropriateness of the key personnel of EHSU Circle, OE, and contractors tasked to implement various aspects of the EMP.
- Evaluate and assess the adequacy of the mitigation measures proposed in the Mitigation Plan in addressing the potentially negative impacts of the project activities and propose changes as appropriate.
- Review results of internal monitoring (compliance and impact monitoring) and verify its effectiveness through community consultations, spot checks, and field observations.
- Review the process and outcome of environmental trainings conducted by different project entities in line with the training program given in the EMP.
- Review the process and outcome of the documentation and reporting being carried out by various project entities in line with the EMP requirements.
- Identify, quantify, and qualify the types of EMP-related conflicts and grievances reported and resolved and the consultation and participation procedures.
- Provide a summary of whether EMP is being effectively implemented
- Describe any outstanding actions that are required to bring EMP implementation in line with the GoB and WB requirements as stated in the EIA. Describe further mitigation measures and or corrective actions needed to ensure that the project remains environmentally and socially acceptable. Provide a timetable and define budget requirements for these supplementary mitigation measures / corrective actions.
- Describe any lessons learned that might be useful for environmental assessment and management of future projects.

D. Approach and Methodology

863. The general approach will include monitoring of EMP implementation activities and to identify any environmental impacts actually caused by the project. The IMC will conduct quarterly field visits for external monitoring. During the field visits, the IMC will carry out meetings with the key project entities including PMU, EHSU Circle, OE, and contractors; review reports and record of IMP implementation; conduct consultation meetings with key stakeholders particularly communities and local government officials; carry out field investigations including spot checks and visual observations, and identify need of any sampling and laboratory analysis.

864. The IMC will prepare checklists and questionnaires for the field investigations, comprising both qualitative and quantitative parameters. After each field visit, the IMC will

prepare external monitoring report comprising field observations and findings, assessment of EMP implementation, key gaps identified, conclusions, and recommendations for addressing the gaps.

865. E. Responsibility of BPDB

866. The BPDB through its PIU will ensure timely supply of background references, data and project options to the IMC. It will ensure uninterrupted access to work sites, relevant offices of the GOB and BPDB in particular. The IMC will participate in quarterly coordination meetings with the BPDB in presence of the OE.

867. Recommendation based on the result of the external monitoring will be provided to BPDB to cover up the deficiencies identified by the IMC. BPDB will accept the recommendations of the IMC if they are within the scope of work and there is nothing incorrect in the report.

F. Responsibility of Owner's Engineer

868. The OE will provide appropriate protocol at site or at its Project Office for the field visit of the IMC. It will on behalf of BPDB ensure free access to work sites, impact areas and the database on EMP implementation. The OE will ensure timely intimation of its works planning as and when made or updated during the construction period and keep the IMC informed.

G. Team Composition of the IMC

869. The tasks of the key members of the IMC are given below:

Position/expertise	Qualification and experience
1. Team Leader/ EMP Implementation Specialist	B.Sc. in environment engineering or environmental science, with M. Sc.in relevant field with 15 years (including 5 years of development bank funded project) experience in planning, implementation and monitoring of environmental management for large infrastructure projects. Experience in institutional capacity analysis, preparation and implementation of EMPs, monitoring reports, and knowledge of latest environmental safeguard policies of the international financial institutions are required.
2. Environment Specialist(s)	B.Sc. in environment engineering or environmental science with 10 years working experience in environmental impact assessment including field surveys, stakeholder consultations, and analyzing environmental impacts to identify mitigation measures in compliance with environmental safeguard policies of the international financing institutions and national legislations. Experience of preparing and implementing EMP for externally financed projects is essential.
3. Ecology and Fisheries Specialist	Masters in biological sciences with 10 years working experience in relevant fields. Thorough knowledge of ecological issues (natural vegetation, terrestrial as well as aquatic fauna, fish, and birds) and their implications for development projects; research and work experience relating to ecological issues; and knowledge of techniques for data collection and analysis.
4. Occupational Health	Masters in Occupational health and safety or relevant fields with

Position/expertise	Qualification and experience
and Safety Specialist	10 years of experience in IEE, EIA, EMP planning, environment monitoring, and occupational health and safety Issues.
5. Data Base Specialist	Graduate in relevant field with working experience and knowledge of software, those are commonly used in Bangladesh; demonstrated ability to design and implement automated MIS(s) for monitoring progress, comparing targets with achieved progress and the procedural steps.
6. Junior Environmental Monitoring Specialist (s)	B.Sc. in environment engineering or environmental science with minimum three (3) years of experience in Environmental monitoring, data collection and analysis, environmental analysis, or relevant environmental field.

H. Time Frame and Reporting

870. The IMC will be employed over a period of five years with intermittent inputs from the professional team to continue one year after completion of the Power Plant Commissioning.

871. Quarterly and annual monitoring reports should be submitted to the BPDB with copies to the WB. An evaluation report at the end of the Project should be submitted to the BPDB and WB with critical analysis of the achievement of the programs and the environmental performance of Ghorashal unit-4.

872. The IMC will provide monitoring and evaluation report covering the following aspects:

- Field observations, results of any field investigations and or laboratory analysis
- Assessment of whether the EMP is being implemented as planned and budgeted
- Assessment of the extent to which the specific EMP objectives and the expected outcomes/results have been achieved and the factors affecting their achievement or non achievement
- Major areas of improvement and key risk factors
- Major lessons learnt and
- Recommendations.

873. Formats for collection and presentation of monitoring data will be designed in consultation with BPDB.

E. Budget and Logistics

The budget should include all expenses such as staff salary, office accommodation, training, computer/software, transport, field expenses and other logistics necessary for field activities, data collection, processing and analysis for monitoring and evaluation work. Additional expense claims whatsoever outside the proposed and negotiated budget will not be entertained. VAT, Income Tax and other charges admissible will be deducted at source as per GOB laws.

Sl..	Item	Unit	Qty	Rate, USD	Amount, USD
Remuneration					
1	Team Leader/EMP Implementation Specialist	man-month	24	6,000	144,000
2	Environmental Specialist	man-month	36	4,000	144,000
3	Ecology and Fisheries Specialist	man-month	24	4,000	96,000
4	Occupational Health and Safety Specialist	man-month	24	4,000	96,000
5	Data Base Specialist	man-month	36	3,000	108,000
6	Junior Environmental Monitoring Specialist (s)	man-month	72	1,500	108,000
	Subtotal				*696,000*
Reimbursable Cost					
1	Vehicle Rental	Months	36	800	28,800
2	Vehicle Fuel	LS			5,000
3	Logistics	LS			10,000
4	Monitoring Costs (3 years of operation)				122,330
	Subtotal				*166,130*
	Contingency (10%)				*86,213*
	Total				**948,343**

Annex 11-2: Guidelines for electricity and electro-magnetic fields for work zones

According to the WBG's General Health and Safety Guidelines, 2007 following standards presented in Table A11-2 (a) should be maintained for ensuring work place safety related to high voltage power lines.

Table A11-2(a): No Approach Zones for High Voltage Power Lines

Nominal Phase to phase voltage rating	Minimum distance (m)
750 or more volts, but no more than 150,000 volts	3
More than 150,000 volts, but no more than 250,000 volts	4.5
More than 250,000 volts	6

In addition, WBG Guidelines on Thermal Power Plants (2008) recommended additional indicators specifically applicable to electric power sector activities, which include the ICNIRP exposure limits for occupational exposure to electric and magnetic fields listed in Table A11-2 (b).

Table A11-2 (b): ICNIRP Exposure limits for occupational exposure to electric and magnetic fields

Frequency	Electric Field (V/m)	Magnetic Field (µT)
50 Hz	10,000	500
60 Hz	8300	415
Source: INCIRP (1998): 'Guideline for limiting exposure to time varying electric, magnetic, and electromagnetic fields (up to 300 GHz) in WBG (2008): EHS Guidelines for Thermal Power Plants		

Annex 11-3: Detailed environmental monitoring costs

Sl	Components of EHS Monitoring	Monitoring Indicators	Nos of sample	Frequency (yearly)	Total NOS of Samples	Cost Estimate (USD)	
						Rate	Total
1.	**Boiler Decommissioning (six month)**						
1.1.	Air Quality	Asbestos Fiber	2	96	48	500	24,000.00
1.2.	Soil Quality	Asbestos, Pb, Cd, Cr, Cu, Zn, Mn, As, Se Hg, and oil/grease	3	2	3	750	2,250.00
1.3.	Water Quality	Asbestos, Oil and Grease, Total Residual Cl, alkalinity, Ammonium Nitrogen, Free Ammonia, Total Cr, Fe, Ca, Zn, Cu, etc.	3	2	3	250	750
1.4.	Ambient Noise	LAeq, L10, L90 (day time only)	1	96	48	15	720
1.5.	Occupational health and Safety	Noise (LAeq)	2	48	48	15	720
		Use of PPEs and practice of Safety Procedure	LS				6,000.00
		Health Checkup	LS				6,000.00
						Subtotal	*40,440*
2.	**Environmental Monitoring during Pre-construction and Construction Phase (3 years)**						
2.1.	Ambient Air Quality	NOx, SOx, SPM, PM_{10}, $PM_{2.5}$, CO, O_3	2	96	576	500	288,000.00
2.2.	Ambient Noise	LAeq, L10, L90 (day and Night time)	7	96	2016	25	50,400.00
2.3.	Water Quality	pH, TSS, TDS, Oil and Grease, Total Residual Cl, Total Cr, Fe, Ca, Zn, Pb, Cd, Hg, As, total alkalinity, Ammonium Nitrogen, Free Ammonia, BOD_5, COD, EC Temperature outside the mixing zone, etc	3	12	108	250	27,000.00
2.4.	Ecosystem and Biodiversity	Plant Growth, Canopy Coverage, Disease	1	1	3	7,000.00	21,000.00
		Tree felling				LS	10,000.00
2.5.	Fish Diversity and Composition	Diversity Index, Richness, Composition, Habitat Suitability Index, etc.	2	4	24	450	10,800.00
2.6.	Agricultural Production	Crop Production Loss	5	2	30	100	3,000.00
2.7.	Occupational Noise (Day and Night time)	LAeq, vibration	2	96	576	25	14,400.00

Sl	Components of EHS Monitoring	Monitoring Indicators	Nos of sample	Frequency (yearly)	Total NOS of Samples	Cost Estimate (USD)	
						Rate	Total
2.8.	Exposure to Electro-magnetic Field	Electrical Field, Magnetic Field	3	4	36	15	540
2.9.	Health and Sanitation	Inspection of Availability of Potable Water, Drinking water quality, Availability of Hygienic Toilet	1	12	36	700	25,200.00
2.10.	Community Health, Safety and Security	Implementation of EMP	1	12	36	700	25,200.00
						Subtotal	*475,540*
Total							**515,980**

Sl	Components of EHS Monitoring	Monitoring Indicators	Location No	Frequency	Total Sample in 3 year	Cost Estimate (USD)	
						Rate	Total
3	**Environmental Monitoring During 3 years of Operation**						
3.1	*Physical Environment*						
3.1.1	Ambient Noise	LAeq, L10, L90 (day and Night time)	5	Monthly	180	25	4,500.00
3.1.2	Effluent (Waste Water)	Oil and grease, Total Residual Cl, Cu, Fe, Zn, Pb, Cd, Hg, As, COD, BOD	1	Weekly	144	250	36,000.00
3.1.3	Water Quality: Surface Water	pH, TSS, TDS, Oil and Grease, Total Residual Cl, Total Cr, Fe, Ca, Zn, Pb, Cd, Hg, As, total alkalinity, Ammonium Nitrogen, Free Ammonia, BOD5, COD, EC , ACM, Temperature outside the mixing zone, etc. [1]	3	Monthly	108	250	27,000.00
3.1.4	Ambient Water Quality: Ground Water	pH, Total Hardness, DO, CL, Total Coliform, F, Fe, Mn, As, PO_4, SO_4, ACM, etc	1	Monthly	36	250	9,000.00
3.2	*Waste Generation and Management*						
3.2.1	Generation of Non Hazardous Solid Waste (Domestic waste, Office Waste,)	Types and Quantity, Characteristics		Quarterly		LS	900
3.2.2	Generation of Hazardous Solid	Types and Quantity, Characteristics		Quarterly		LS	900

Sl	Components of EHS Monitoring	Monitoring Indicators	Location No	Frequency	Total Sample in 3 year	Cost Estimate (USD)	
						Rate	Total
	Waste						
3.2.3	Generation of Hazardous Liquid Waste, Sludge (return from Water Treatment Plant, Sludge from clarifier, neutralization pond)	Quality of Water in Neutralization Pond (e.g., corrosivity, reactivity), Presence of carcinogenic chemicals (e.g., hydrazine)		Quarterly		LS	900
3.2.4	Non Hazardous Waste Management	Condition of waste bins, waste transportation vans,		Quarterly		LS	900
		Capacity of Waste Disposal Site		Quarterly		LS	900
		Leaks, drips or other indications of waste spill during handling and transporting	-	Quarterly		LS	900
3.2.5	Hazardous Waste Management	Labeling of Hazardous Materials, hazardous waste, documentation of hazardous chemical use, etc.	-	Quarterly		LS	900
3.3	*Ecosystem and Biodiversity*						
3.3.1	Plant Health	Plant Growth, Canopy Coverage, Disease, etc.	3	Yearly		LS	4,500.00
3.3.2	Occurrence of Wildlife	Species Composition and Status	3	Yearly		LS	1,500.00
3.3.3.	Fish Diversity and Composition	Diversity Index, Richness, Composition, Habitat Suitability Index, etc.	3	Quarterly		LS	6,000.00
3.4	*Land and Agricultural Resources*						
3.4.1	Land use and Land Cover change	Land cover and Land use	-	Once in three years		1/3 of the total LS cost	5,000.00
3.4.2	Agricultural Production	Crop Production Loss	1	Yearly	3	500	1,500.00
3.5	*Occupational Health and Safety*						
3.5.1	Occupational Noise	LAeq, L10, L90, Noise Exposure (Day and Night time)	3	Quarterly	36	25	900
3.5.2	Exposure to Electro-magnetic Field	Electrical Field, Magnetic Field	3	Quarterly	36	15	540
3.5.3	Worker Health	General Health Condition, Hearing test, skin disease, etc.	1	Quarterly	9	50	450
3.5	*Labor and Working Condition*						
3.5.1	Health and Sanitation	Availability of Potable Water	2	Monthly	72	10	720

Sl	Components of EHS Monitoring	Monitoring Indicators	Location No	Frequency	Total Sample in 3 year	Cost Estimate (USD)	
						Rate	Total
		Drinking water quality (Ph, TS, EC, F, Cl, As, Mn, Fe,Total Hardness, Total Coliform, PO4, SO4)	1	Monthly	36	200	7,200.00
		Availability of Hygienic Toilet	2	Monthly	72	10	720
3.6	*Community Health, Safety and Security*						
3.6.1	Community Health	Status of Communicable Diseases	2	Half yearly	6	250	1,500.00
3.6.2	Safety and Security	Emergency Preparedness and Response of GPS	1	Half yearly	6	250	1,500.00
		Community Relation Program/ Community Awareness Program, Training	1	Half yearly	6	100	600
3.7	*Measures beyond compliance*						
3.7.1	Public Toilets and socio-cultural facilities	Condition of toilets and socio-cultural facilities, number of benefited person/family	3	Half yearly	18	50	900
3.7.3	Training of youths	Number of youths trained, quality of training, and perception of youth about the training	1	Half yearly	6	500	3,000.00
3.7.4	Free healthcare service to poor	Number of patients served and perception of population about the service	1	Half yearly	6	500	3,000.00
Total							*122,330*

Annex 13-1: Terms of Reference of EHS Consultants of Owner's Engineer

A. Objective

The primary objectives of the consulting services of supervising environmental and health and safety management during decommissioning and construction are to:

- ensure that the construction methods as proposed by the contractor for carrying out the works are satisfactory, with particular references to the technical requirements of sound environmental standards on the basis of safeguard requirements (proposed in the EIA, this includes Government and the World Bank environmental guidelines), inspection of contractors' construction equipment, review contractor's health and safety standards, inspect construction yards and work camps, interview contractors' personnel and general public;
- Prepare checklist of monitoring factoring WBG's EHS Guidelines on occupational health and safety procedure and practice, sanitation condition, implementation of EMP, and waste management practices and efficiency.
- Supervise contractor in implementing EMP, environmental monitoring plan, and ensuring environmental social safeguarding during construction activities.
- Ensure that the recommendations of the environmental management plan (EMP), environmental monitoring plan and environmental code of practices (ECPs) are strictly followed by the contractors;
- prepare quarterly environmental and health and safety monitoring and annual reports of implementing these plans as part of project implementation report, and carry out environmental management seminars for contractors and BPDB staffs; and
- monitor the implementation of the health and safety program at work site including the information and education campaign on sexually-transmitted diseases and HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) as required by the civil works contracts

B. Resources

The consulting services will require the following input:

Sl. No	Expertise	Input (PM)
A	**International Consultants**	
1	Intl. Environmental Specialist	15
2	Asbestos Management Specialist	3
	Subtotal (A)	*18*
B	**National Consultants**	
3	Environmental Specialist	36
4	Occupational Health and Safety Specialist	36
5	Social Specialist	12
6	Field Surveyors	36
	Subtotal (B)	*120*
	Total (A+B)	**138**

C. International Consultants

1. International Environmental Specialist

The duties of the Consultant shall include, but not limited to:

- Update the EMP provided in the EIA which will be a part of the Tender Documents of EPC Contractor
- Prepare checklist of monitoring on occupational safety procedure and practice, health and sanitation condition, implementation of EMP, and waste management practices and efficiency
- Ensure that the construction methods as proposed by the contractor for carrying out the works are satisfactory, with particular references to the technical requirements of sound environmental and social safeguard standards on the basis of the EIA
- Carry out environmental and social management seminars for contractors and BPDB staffs
- Prepare quarterly environmental and social monitoring and annual reports of implementing the EMP as part of project implementation report

2. Asbestos Management Specialist

The Owner's Engineer will engage an Asbestos Management Specialist to manage removal and disposal of asbestos during decommissioning of boiler. The specialist shall have relevant training and three years of experience in managing removal and disposal of asbestos. Specific responsibilities include:

a. Undertake assessment of the facility to determine the presence of asbestos, estimate their volume, and assess their condition (intact, degraded, friable, etc.)

b. Assist International Environmental Specialist in preparing the checklist for the monitoring work

c. Plan removal and disposal work including volume of asbestos to be removed

d. Train the removal workers in removal of asbestos

e. Ensure that required PPE is available before start of the work

f. Supervise removal and disposal work

g. Prepare regular progress reports

D. National Consultants

1. Environmental Specialist

The duties of the national environmental specialist shall include, but not limited to:

- Assist international environmental specialist in updating the EMP provided in the EIA
- Based on the checklist conduct monitoring on implementation of EMP, sanitation condition, and waste management practices and efficiency
- Supervise the construction methods as proposed by the contractor for carrying out the works are satisfactory, with particular references to the technical requirements of sound environmental and social safeguard standards on the basis of the EIA
- Assist the international environmental specialist in conducting environmental and

social management seminars for contractors and BPDB staffs
- Assist in the preparation of quarterly environmental monitoring and annual reports of implementing the EMP as part of project implementation report

2. Occupational Health, and Safety Specialist

The duties of the Consultant shall include, but not limited to:
- Assist international environmental specialist in ensuring that that the construction methods as proposed by the contractor for carrying out the works are satisfactory, with particular references to the technical requirements of sound environmental standards on the basis of EMP
- Based on the checklist conduct monitoring on occupational safety procedure and practice
- Assist international environmental specialists in preparing quarterly environmental monitoring and annual report of implementing this plan as part of project implementation report, and carry out environmental management seminars for contractors and BPDB staff
- Assist in plantation and community forest development work along the Rawwater transmission main corridor, community woodlots, and other project site as proposed in the EMP
- Ensure worksite health and safety aspects of the contractors' work as per EMP and ECPs
- Ensure that the contractors do not damage the existing plantations

3. Social Specialist

The social specialist will be responsible for the following:
- Reviewing the EMP including mitigation and monitoring plan, enhancement plan pertaining to social aspects;
- Inspect working and labor condition
- Ensure priorities are giving to the local labor during recruitment of construction labor
- Ensure that gender aspects are adequately covered as per the EMP
- monitor the implementation of the information and education campaign on sexually-transmitted diseases and HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) as required by the civil works contracts
- Monitor grievance redress mechanism
- provide inputs to the quarterly and annual reports

4. Field Surveyors (2)

The Field Surveyors will be responsible for:
- Work under the guidance of the team to collect data and monitor ecological resources, HIV/AIDS program, plantation program in bi-monthly basis as recommended in the ESIA through various defined methodologies such as technical sampling, planting activities, etc.
- Inspect the construction activities to ensure activities are carrying out in line with the EMP under the guidance of the team
- Exclusively engaged in the project site and influence area and responsible for collecting secondary data from the concerned agencies.
- Exclusively engaged to work in close association with the local government institutions, NGOs and maintaining all sorts of liaisons with different institutions and officials.

E. Budget

Sl.	Item	Unit	Qty	Unit Cost (USD)	Amount, USD
International Consultants					
1	Intl Environmental Specialist	MM	15	25,000	375,000
2	Asbestos Management Specialist	MM	3	25000	75,000
National Consultants					
3	Environmental Specialist	MM	36	5,000	180,000
4	Occupational Health and Safety Specialist	MM	36	5,000	180,000
5	Social Development Specialist	MM	12	5,000	60,000
6	Field Surveyors	MM	36	1,000	36,000
4	International Travel - Airfare	RT	9	4,000	36,000
	Total				**942,000**

Annex 13-2: Scope of Work for Capacity Building and Training Consultant

A. Background

A capacity building program in environmental impact assessment, environmental management and occupational health and safety has been proposed fir PIU and GPS staffs. The program will (a) prepare training plan in environmental, health and safety, and (b) conduct training programs to improve the capability of 'implementation staff' in monitoring the implementation of environmental management and monitoring plan (EMMP) of the Project including hazardous waste management and occupational health and safety. This will be done through a program of technical assistance and training over a period of 3 months.

B. Objectives of the Services

The objectives of the services are: (a) to make PIU and EHSU Circle staffs familiar with environmental issues and impacts related to the project and to improve their skills in management and evaluation of the EMP (b) to develop and deliver training on hazardous waste management, (c) to develop and deliver training programs on occupational health and safety, and (d) to develop and deliver training on environmental monitoring, evaluation, and reporting.

C. Scope of Work

Task 1: Preparation of Training Modules on Environmental Management and Monitoring:

The purpose of this task is to develop training modules on (i) environmental issues and impacts related to the project, (ii) hazardous waste management in the project, (iii) occupational health and safety in the project, and (iv) environmental monitoring, evaluation, and reporting.

Training in Module 1 on environmental issues and impacts will broadly include:

- Fundamentals of Environmental Impact Assessment and the EIA Process at DoE and at the World Bank
- Typical Environmental Issues in thermal power projects
- Analyses of Alternatives and Identification of Preferred Option
- Case studies on Scoping of Issues and Assessment of Alternatives for thermal generation Projects
- Identification and Prioritization of Issues
- Conducting Baseline Environmental and Socio-economic Information
- Case studies on Collection of Baseline Information in EIA of thermal generation Projects
- Prediction and Assessment of Impacts – Tools and Case studies
- Conducting cumulative impacts and climate change assessments
- Building an Environmental Management Plan
- How to Review an EIA Report?
- Public Consultation and Information Disclosure – The process with case studies

Training in Module 2 on hazardous waste management will broadly include:

- Overview of hazardous waste regulations (US DOT, USEPA, OSHA, WBG etc.)
- What is hazardous waste?

- What are the hazardous waste in thermal power stations?
- What to do with hazardous waste? Segregation, transportation and disposal to permanent site.
- Emergency response

Training in Module 3 on occupational health and safety in the project will broadly include:

- Overview of Labor Act, Factory Act, and international Acts (e.g., the Occupational Safety and Health Act)
- General construction related standards, such as, scaffolding, fall protection, excavations, ladders, head protection, etc.
- Walking-Working Surfaces, Means of Egress, Powered Platforms, Man lifts, and Vehicle-Mounted Work Platforms
- Occupational Health and Environmental Control
- Use of Personal Protective Equipment
- Access to Medical and First Aid
- HIV/AIDS and other STD management
- Fire Protection Procedure
- Handling and working with Compressed Gas and Compressed Air Equipment
- Machinery and Machine Guarding, especially extremely heated environment
- Use of Hand and Portable Powered Tools and Other Hand-Held Equipment, precautions in Welding, Cutting, and Brazing
- Working with live electrical equipment
- Commercial Diving Operations
- Toxic and Hazardous Substances

Training in Module 4 on monitoring, evaluation, and reporting will broadly include:

- Monitoring techniques and methods for various components of EMP
- Environmental Monitoring Plan and Institutional Arrangements
- Identify parameters to be monitored
- Collection and analysis of environmental quality data, and Interpretation of monitoring parameters
- Internal and external monitoring needs during construction and operation
- Organizational responsibilities and implementation schedules
- Reporting requirements of monitoring

Task 2: Deliver Training on Environmental Management and Monitoring:

The purpose of this task is to deliver a series of training programs for all the activities proposed in Task 1 to all the implementing agencies of the Project (BPDB, PIU, and GPS).

Based on the above scope of works, the consultant will carry out the following activities:

- Undertake training need assessment for stakeholders including the implementation / construction personnel.
- Devise training programs based on EIA report and site visits to the Project area
- Prepare a staff training plan and associated materials (modules).
- Evaluate the trainings.
- Modify the training modules as necessary.
- Hand over the final training modules to the BPDB/GPS for use in future training.
- Prepare training reports.

D. Organization and Staffing

The services are expected to be provided over a 3 months period by a team comprising one environmental specialist/team leader and one occupational health and safety specialist. Details of proposed professionals and their required input are shown below.

Table 16-1: Details of Proposed Consultants

Items	Input (Man Months)
Key Professional Staff	
1. Int'l Environmental Specialist/Team Leader	3
2. Nat'l Occupational health and safety (including HIV/AIDS)	3

E. Supervision

The team will work in association with the PIU, reporting to the project director on a day-to-day basis. Overall supervision will be done by the EHSU Circle of GPS.

F. Outputs

The team's outputs will include: (i) an inception report after one week of mobilization, (iii) a draft final report at the end of 8th week, containing a description of achievements, details of the training services provided, including all materials, an assessment of their effectiveness in meeting objectives and recommendations for further training assistance, (iii) and a final report at the end of assignment. All reports will be submitted in English

In addition, the team will prepare training materials for both training programs. Each training program will consist of about 4 modules including some case studies and worked out examples. The draft training modules should be submitted to the PIU and GPS before conducting training programs for evaluation and final training modules will be presented at the end of assignment.

G. Budget

Following Table presents the estimated budget for the capacity building and training program.

Item	Unit	Unit Cost, US$	Quantity	Total Cost, US$
A. Remuneration and Per Diems				
i. Key Professional Staff				
Intl. Team Leader and Environmental Specialist	man-month	25,000	3	75,000
Natl Occupational health and safety Specialist (including HIV/AIDS)	man-month	5,000	3	15,000
Sub Total A				*90,000*
B. Airfare and Transport				
i. Local Transport	Day	100	60	6,000
ii. Airfare	RT	5,000	2	10,000
Sub Total B				*16,000*
C. Training Module Preparation and Production	No	2,500	1	*2,500*
D. Trainee Allowance	days	75	150	*11,250*
E. Contingency (10% of subtotal, A+B+C)	LS	1		**11,975**
Grand Total (A+B+C+D+E)				**131,675**

Annex 14-1: Advertisement for Public Consultation Meeting

বিজ্ঞপ্তি

বিশ্বব্যাংকের সম্ভাব্য অর্থায়নে, গণপ্রজাতন্ত্রী বাংলাদেশ সরকার, বাংলাদেশ বিদ্যুৎ উন্নয়ন বোর্ড (বিউবো)-এর মাধ্যমে ঘোড়াশাল ৪র্থ ইউনিট বিদ্যুৎ কেন্দ্র পুণর্গঠন ও উৎপাদন ক্ষমতা বৃদ্ধিকরণ প্রকল্পটি হাতে নিয়েছে। উক্ত প্রকল্পের মূল উদ্দেশ্য হচ্ছে পুরনো, অনির্ভরযোগ্য ও ক্রমহ্রাসমান বিদ্যুৎ উৎপাদন ক্ষমতা (নির্মাণকালীন ক্ষমতা ২১০ মে.ও. থেকে ১৮০ মে.ও.-এ নেমে আসা) ৪০৩.৫ মে.ও. এ উন্নীত করা যা জাতীয় বিদ্যুৎ গ্রীডকে সংহত করার মাধ্যমে নিরবিচ্ছিন্ন বিদ্যুৎ সরবরাহ ঘাটতি মেটাতে বাংলাদেশ সরকারের পরিকল্পনায় সহায়ক ভূমিকা পালন করবে। উক্ত প্রকল্প বাস্তবায়নের ফলে উদ্ভূত পরিবেশগত ও আর্থ-সামাজিক সম্ভাব্য প্রভাব সমীক্ষা নিরূপণের জন্য পানি সম্পদ মন্ত্রনালয় অধীনস্থ সরকারী ট্রাস্ট, CEGIS (সেন্টার ফর এনভায়রনমেন্টাল এন্ড জিওগ্রাফিক ইনফরমেশন সার্ভিসেস) -কে দায়িত্ব দেয়া হয়েছে। উক্ত সমীক্ষার মূল লক্ষ্য হচ্ছে, পরিবেশগত ও আর্থ-সামাজিক বিভিন্ন বিষয়াদিকে বিবেচনায় রেখে প্রকল্প বাস্তবায়ন করা। এরই অংশ হিসেবে প্রকল্প ও সন্নিহিত এলাকার জনগণের সুচিন্তিত মতামত ও পরামর্শ গ্রহণের লক্ষ্যে আগামী ১১ই এপ্রিল, ২০১৫খ্রিঃ (শনিবার) সকাল ১০ ঘটিকায়, ঘোড়াশাল পৌরসভার সম্মেলন কক্ষে একটি মতবিনিময় সভার আয়োজন করা হয়েছে। উক্ত মতবিনিময় সভায় উপস্থিত থেকে উপরোক্ত বিষয়ে আপনাদের সুচিন্তিত মতামত প্রদান করার জন্য সাদরে আমন্ত্রণ জানানো যাচ্ছে। ধন্যবাদ।

যোগাযোগ: cegis@cegisbd.com

Annex 14-2: List of Participants in the Public Consultation Meeting

List of Participants
Public Consultation Meeting
on
Environmental Study for Ghorashal Unit-4 Repowering Project

Venue: Ghorashal Pourashava, Palash, Narsingdi — Date: 11 April, 2015

Sl. No.	Name	Designation/Organization	Cell Phone & E-mail	Signature
1	MD MONWAR HOSS.	ADBo. PDBF.		[illegible]
2	Md. Fazlul [illegible]	agriculture	0196109824[illegible]	[illegible]
3	MONIRUL HAQUE ROMEL	AEO, Palash, Narsingdi	romelbscag@yahoo.com.	[illegible]
4	[illegible]	[illegible]		[illegible]
5	[illegible]	AFO, পলাশ, নরসিংদী	[illegible]@gmail.com	[illegible]
6	মো: [illegible] ইসলাম	[illegible]	01710687872	[illegible]
7	[illegible]	[illegible]	01710-69[illegible], 019261979[illegible]	[illegible]
8	[illegible]	[illegible]	01937805462	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]
10	মো: [illegible]	[illegible]	01716591497	[illegible]
11	রুনা আক্তার	[illegible]	0183456390	Runa
12	Md. Mofiz Rah.	Business.	0176-[illegible]	[illegible]
13	মো: [illegible] ইসলাম	চাকুরী	01711-510347	[illegible]
14	মো: [illegible] ইসলাম	চাকুরী		[illegible]
15	মো: [illegible] রহমান	SAE [illegible]	0171976[illegible]	[illegible]
16	মো: [illegible] ইসলাম	[illegible]	01727511241	[illegible]
17	[illegible]	[illegible]	01724170007	[illegible]
18	[illegible]	গৃহিনী		[illegible]
19	[illegible]	গৃহিনী		[illegible]
20	[illegible]	গৃহিনী		[illegible]
21	[illegible]	[illegible]	01715410468	[illegible]
22	[illegible]			
23	[illegible]	[illegible]	01765249981	[illegible]
24	[illegible]	কৃষি		
25	মো: [illegible]	[illegible]		[illegible]

Center for Environmental and Geographic Information Services
House 6, Road 23/C, Gulshan-1, Dhaka-1212, Bangladesh. Tel: 8817648-52, Fax: 880-2-8855935

List of Participants
Public Consultation Meeting
on
Environmental Study for Ghorashal Unit-4 Repowering Project

Venue: Ghorashal Pourashava, Palash, Narsingdi

Date: 11 April, 2015

Sl. No.	Name	Designation/Organization	Cell Phone & E-mail	Signature
1	মো: [illegible]	[illegible]		[illegible]
2	[illegible]	চাকুরী		[illegible]
3	মো: [illegible]	চাকুরী		[illegible]
4	মো: [illegible]	চাকুরী		[illegible]
5	[illegible]	চাকুরী		[illegible]
6	[illegible]	ব্যবসা		[illegible]
7	রনি দত্ত	ছাত্র		Rony Datta.
8	সুজন দাস	ব্যবসা		[illegible]
9	জয়ন্ত সাহা	ব্যবসা		[illegible]
10	রাসেল	ব্যবসা		Rasel
11	[illegible]	ছাত্র		[illegible]
12	শাহআলম	ছাত্র		Shalam
13	[illegible]	[illegible]		[illegible]
14	[illegible]	[illegible]		[illegible]
15	মো: [illegible]	কৃষি		[illegible]
16	মো: [illegible]	[illegible]		[illegible]
17	[illegible]	ঠিকাদার		[illegible]
18	[illegible]	কৃষক		[illegible]
19	[illegible]	ছাত্র		[illegible]
20	মো: রফিকুল ইসলাম	ছাত্র		রফিকুল
21	[illegible]	কৃষক		
22	মো: আব্দুল মান্নান	কৃষক / ব্যবসায়ী		[illegible]
23	মো: [illegible]	[illegible]		[illegible]
24	রবি	গৃহিনী		[illegible]
25	[illegible]	[illegible]		[illegible]
26	[illegible]	[illegible]		[illegible]

CEGIS Center for Environmental and Geographic Information Services
House 6, Road 23/C, Gulshan-1, Dhaka-1212, Bangladesh, Tel: 8817648-52, Fax: 880-2-8855935

List of Participants
Public Consultation Meeting
on
Environmental Study for Ghorashal Unit-4 Repowering Project

Venue: Ghorashal Pourashava, Palash, Narsingdi | Date: 11 April, 2015

Sl. No.	Name	Designation/Organization	Cell Phone & E-mail	Signature
1	Shahin Sultana	UCO. Palash.	01716985240	[illegible]
2	মো: [illegible]	উপজেলা প্রকৌশলী	01711576563	[illegible]
3	মো: [illegible]	[illegible]	01712906275	[illegible]
4	[illegible]	[illegible]	01710687872	[illegible]
5	মো: [illegible]	উপজেলা কৃষি অফিসার	01715366775	[illegible]
6	Dilruba Yeasmin	AUEO. Palash	01716901592	[illegible]
7	মো: [illegible]	SAE Palash	01719960716	[illegible]
8	[illegible]	[illegible]	0171337934	[illegible]
9	Dr. Khondker [illegible]	UA&PPO UAO, Palash	01712083656	[illegible]
10	Md. Maniruzzaman	PO (Edu) BRAC, palash.	01717230995	[illegible]
11	[illegible]	[illegible]	01914080910	[illegible]
12	AZHARul Islam	BASS	01729 7494	[illegible]
13				
14				
15				
16				

C≋GIS

Annex 14-3: Comment Sheet used during Public Consultation

Questionnaire

পরিবেশ ও আর্থ-সামাজিক প্রভাব নিরূপণে সংশ্লিষ্ট জনগোষ্ঠীর মতামত

ঘোড়াশাল ইউনিট-৪ রি-পাওয়ারিং প্রকল্প, বিউবো, পলাশ, নরসিংদী

[কনফারেন্স হল, ঘোড়াশাল পৌরসভা]

তারিখঃ ১১ ই এপ্রিল, ২০১৫; সময়ঃ সকাল ১০ ঘটিকা

সঞ্চালনায়ঃ সিইজিআইএস (পানি সম্পদ মন্ত্রণালয়াধীন সরকারী ট্রাস্ট), গুলশান, ঢাকা-১২১২।

১. অনুগ্রহ করে এই প্রকল্প সম্পর্কে আপনার আগ্রহ ব্যক্ত করুন (নিম্নলিখিত তালিকায় আপনার অবস্থান চিহ্নিত করুন)

ক. প্রকল্প দ্বারা সম্ভাব্য প্রভাবিত জনগোষ্ঠী
খ. ঘোড়াশাল বিদ্যুৎ কেন্দ্রের বাসিন্দা
গ. পলাশ উপজেলাধীন সরকারী কর্মকর্তা
ঘ. স্থানীয় সংসদ সদস্য
ঙ. উপজেলা চেয়ারম্যান
চ. উপজেলা ভাইস চেয়ারম্যান
ছ. পৌরসভা মেয়র
জ. ইউনিয়ন পরিষদ চেয়ারম্যান
ঝ. ঘোড়াশাল বিদ্যুৎ কেন্দ্র কর্মকর্তা
ঞ. এনজিও কর্মকর্তা
ট. অন্যান্য (অনুগ্রহ করে আপনার পেশা লিখুন)

২. প্রস্তাবিত প্রকল্পটি নিম্নলিখিত সামাজিক ও সাংস্কৃতিক অবকাঠামোসমূহে কি ধরণের সম্ভাব্য প্রভাব ফেলতে পারে বলে আপনি মনে করেন?
ক. মসজিদ খ. মন্দির গ. কবরস্থান ঘ. শ্মশান ঘাট ঙ. স্কুল/কলেজ চ. মাদ্রাসা ছ. কমিউনিটি সেন্টার জ. বাজার ঝ. অন্যান্য

৩. ঘোড়াশাল পাওয়ার স্টেশন থেকে সেচ ক্যানেলের মাধ্যমে সরবরাহকৃত পানি কৃষিকাজের ব্যবহারে মাধ্যমে আপনাদের ফসলের কোনো ক্ষয়ক্ষতি হয়ে থাকলে তা বলুন।

৪. ঘাড়াশাল পাওয়ার স্টেশন থেকে নির্গত ধোঁয়ার কারনে বায়বীয় পরিবেশ দূষিত ও সহনীয় শব্দের মাত্রায় প্রভাবের কারনে শ্রবণ/মহিলা সংক্রান্ত কোনো ক্ষয়ক্ষতি হয়ে থাকলে তা বলুন।

৫. প্রস্তাবিত প্রকল্প থেকে নিঃসরিত তরল বর্জ্য পরিবেশে কি ধরনের সম্ভাব্য প্রভাব ফেলতে পারে বলে আপনি মনে করেন?

৬. প্রস্তাবিত প্রকল্প দ্বারা বায়বীয় পরিবেশ ও সহনীয় শব্দের মাত্রায় সম্ভাব্য কী প্রভাব হতে পারে বলে মনে করেন?

৭. নিম্নলিখিত বিষয়ের উপর প্রস্তাবিত প্রকল্পটি বিশেষ কী প্রভাব/ভূমিকা রাখতে পারে বলে আপনার ধারণা?
ক. পার্শ্ববর্তী শিল্পকারখানা ও অন্যান্য স্থাপনা
খ. কৃষি জমি ও ফসল
গ. মৎস্য
ঘ. অন্যান্য জলজ প্রাণী
ঙ. নৌ-চলাচল
চ. গাছপালা ও পশুপাখি
ছ. অন্যান্য (গৃহস্থালীর পানির ব্যবহার, গবাদি পশু, ইত্যাদি)

৮. নিম্নলিখিত বিষয়ের উপর প্রস্তাবিত প্রকল্পের গুরুত্ব সম্পর্কে আপনার কোনো মতামত থাকলে উল্লেখ করুন।
ক. আর্থ-সামাজিক উন্নয়ন
খ. লোড শেডিং নিরসন
গ. আবাসিক ও অবকাঠামোগত স্থাপনা সমূহে নিরবিচ্ছিন্ন বিদ্যুৎ সরবরাহ

Center for Environmental and Geographic Information Services
House 6, Road 23/C, Gulshan-1, Dhaka-1212, Bangladesh. Tel: 8817648-52, Fax: 880-2-8855935

Questionnaire

৯. নিম্নলিখিত বিষয়ের উপর গ্যাস জ্বালানী চালিত বিদ্যুৎ কেন্দ্রের প্রভাব সম্পর্কে আপনার ধারণা ব্যক্ত করুন।

প্রভাবিত খাত সমূহ	নেতিবাচক প্রভাব	প্রভাব প্রশমনের উপায়	ইতিবাচক প্রভাব	প্রভাব বৃদ্ধির উপায়
পেশা				
স্বাস্থ্য				
শিক্ষা ও অবকাঠামো				
শিল্পাঞ্চল সম্প্রসারণ				
শ্রমবাজার				
শিশু শ্রম				
মহিলাদের কর্মসংস্থান				
অভিবাসন				
সামাজিক সম্পর্ক				

১০. প্রস্তাবিত প্রকল্পের নকশা ও নির্মাণ পরিকল্পনায় সম্ভাব্য শব্দ মাত্রা প্রশমণে, জীবনযাত্রার মানোন্নয়নে, স্থানীয় সম্পদের ব্যবহারে, স্থানীয় লোকের অগ্রাধিকারের ভিত্তিতে চাকুরীতে নিয়োগের ব্যাপারে আপনার মতামত তুলে ধরুন।

১১. আপনি কী প্রস্তাবিত প্রকল্পটির বাস্তবায়ন সমর্থন করেন? হাঁ/না; কেন?

১২. আপনি কী মতবিনিময় সভার প্রয়োজনীয়তা আছে বলে মনে করেন? [ ] হ্যাঁ [ ] না ; মন্তব্য করুন।

১৩. আপনি কী নির্মাণ শ্রমিক, স্থানীয় কন্ট্রাক্টর বা অন্য কোন ভাবে প্রকল্পটির বাস্তবায়নে যুক্ত থাকতে চান?

১৪. সাধারণ মন্তব্য (উল্লেখিত মতামত ছাড়া অন্য কোনো মতামত থাকলে তা উল্লেখ করুন)।

নাম: ঠিকানা:

টেলিফোন/মোবাইল: পেশা:

আমরা প্রকল্পের পরিবেশগত ও আর্থ-সামাজিক বিষয়ের উপর আপনার সুচিন্তিত মতামত/মন্তব্য গ্রহণ করবো যা প্রতিবেদনে লিপিবদ্ধ করা হবে। প্রশ্নপত্রটি পূরণে আপনাদের মূল্যবান সময় দেয়ার জন্য আপনাদেরকে আন্তরিক ধন্যবাদ জ্ঞাপন করছি। এছাড়াও অন্যান্য কোনো প্রাসঙ্গিক তথ্য দিয়ে সহযোগিতা করতে চাইলে নিম্নলিখিত ঠিকানায় যোগাযোগ করার জন্য অনুরোধ জানানো যাচ্ছে।

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