Moheshkhali Floating Liquefied Natural Gas (LNG) Import Terminal Development, Bangladesh

Environmental and Social Impact Assessment

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Environmental and Social Impact Assessment for Moheshkhali Floating Liquefied Natural Gas (LNG) Import Terminal Development, Bangladesh

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List of Acronyms

Acronym	Term
ADB	Asian Development Bank
AGA	American Gas Association
AIP	Access to Information Policy
ANSI	American National Standard Institute
API	American Petroleum Institute
APSCL	Ashuganj Power Station Company Ltd
AQMP	Air Quality Management Project
ASEAN	Association of Southeast Asian Nations
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BCCT	Bangladesh Climate Change Trust
BDL	Below Detected Limit
BEISP	Bangladesh Environmental Institutional Strengthening Project
BERC	Bangladesh Energy Regulatory Commission
BFICD	Bangladesh Forest Industries Development Corporation
BFRI	Bangladesh Forest Research Institute
BMP	Biodiversity Management Plan
BNH	Bangladesh National Herbarium
BOD	Biochemical Oxygen Demand
BOG	Boil-off Gas
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
BS	British Standards
BSCP	Bangladesh Spoon-billed Sandpiper Conservation Project
BSTI	Bangladesh Standard and Testing Institutes
CEI	Chief Electric Inspector
CH4	Methane
CHARM	Chemical Hazard and Risk Management
CMS	Conservation of Migratory Species
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand

COLREG	Convention on the International Regulations for Preventing Collisions at Sea
CPA	Chittagong Port Authority
CPGCBL	Coal Power Generation Company Bangladesh Limited
CR	Critically Endangered
CTMS	Custody Transfer and Monitoring Station
DC	Direction General
DESCO	Dhaka Electric Supply Company Limited
DLRS	Directorate of Land Records and Surveys
DoE	Department of Environment
DoF	Department of Forest
DPDC	Dhaka Power Distribution Company Limited
EA	Electric Advisor
ECA	Environmental Conservation Act
ECA	Ecologically Critical Area
ECA	Ecologically Critical Area
ECC	Environmental Clearance Certificate
ECR	Environmental Conservation Rules
ECR	Environment Conservation Rules
EDGE	Evolutionarily Distinct and Globally
EGCB	Electricity Generation Company of Bangladesh Ltd
EHS	Environmental, Health and Safety Guidelines
EIA	Environmental Impact Assessment
EN	Endangered
EPC	Engineering, Procurement, and Construction
ERL	Eastern Refinery Limited
ERP	Emergency Response Plan
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
FAO	Food and Agriculture Organization
FSRU	Floating Storage and Regasification Units
GHG	Greenhouse Gas
GIIP	Good International Industry Practice
GRI	Gas Technology Institute (formerly Gas Research Institute)
GTCL	Gas Transmission Company Limited
GWP	Global Warming Potential
HSP	Health and Safety Plan
ICIMOD	International Centre for Integrated Mountain Development
IFC	International Finance Corporation
IMO	International maritime Organization
IOGP	International Oil and Gas Producers
IPIECA	Petroleum Industry Environmental Conservation Association
IPP	Independent Power Producers

IUCN	International Union for Conservation of Nature
LEL	Lower Explosive Limit
LGED	Local Government Engineering Department
LNG	Liquefied Natural Gas
LRB	Land Reform Board
MARPOL	International Convention for the Prevention of Pollution from Ships
MCT	Main Central Thrust
MEDEVAC	Medical Evacuation Plan
MEG	Monoethylene Glycol
MGPS	Marine Growth Preventative System
MMSCFD	Million Standard Cubic Feet per Day
MoEF	Ministry of Environment and Forest
MOST	Ministry of Science and Technology
MoU	Memoranda of Understanding
MSS	Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.
NACE	National Association of Corrosion Engineers International
NBR	National Board of Revenue
NEMAP	National Environmental Management Action Plan
NFPA	National Fire Protection Association
NIO	National Institute of Oceanography
NOAA	US National Oceanographic and Atmospheric Administration
NOx	Nitrogen Oxides
NTCB	National Technical Committee on Biodiversity
NWZPGC	North-West Power Generation Company
O&M	Operations and Maintenance
O_3	Ozone
OGP	Oil and Gas Producers
OSRP	Oil Spill Response Plan
OVMSA	Offshore Vessel Management and Self-Assessment
Pb	Lead
PGCB	Power Grid Company of Bangladesh Ltd
PLEM	Pipeline End Manifold
PM_{10}	Particulate matter with a diameter of not more than 10 microns;
PM_{25}	Particulate matter with a diameter of not more than 2.5 microns
POP	Persistent Organic Pollutants
PPI	Plastic Pipe Institute
PPM	Parts Per Million
PPT	Parts Per Thousands
PSMP	Power Sector Master Plan
RAPSS	Remote Area Power Supply
REB	Rural Electrification Board
ROV	Remote Operated Vehicle

RPCL	Rural Power Company Limited
SO_2	Sulfur Dioxide
SOPEP	Ship Oil Pollution Emergency Plan
SO_x	Sulfur Oxides
SREDA	Sustainable & Renewable Energy Development Authority
SSFATE	Suspended Sediment FATE
STCW	Standards of Training, Certification and Watchkeeping
STL	Submerged Turret Loading
SZPGC	South Zone Power Distribution Company Ltd
TDS	Total Dissolved Solids
ToR	Term of Reference
TS	Total Solids
TSP	Particulate Matter with a diameter of no more t
TSS	Total Suspended Solids
TUA	Terminal Use Agreement
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
WARPO	Water Resources Planning Organization
WHO	World Health Organization
WMP	Waste Management Plan
WZPCD	West Zone Power Distribution Company Limited

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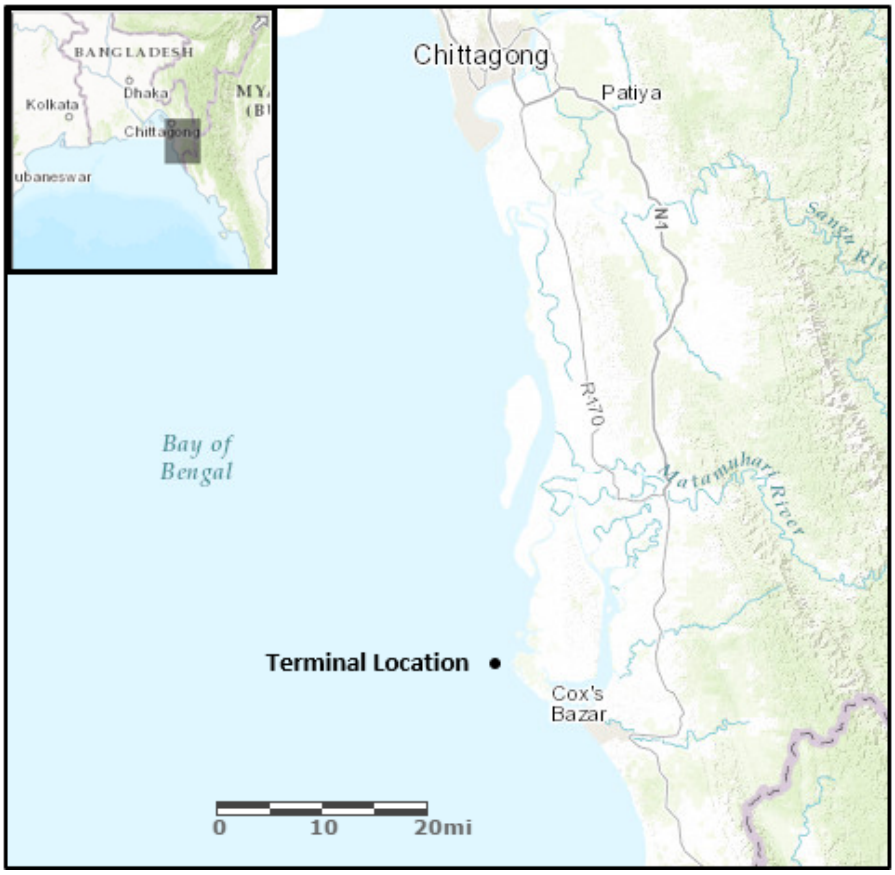
Executive Summary

Project Overview

On July 18, 2016, Excelerate Energy Bangladesh, Ltd. (Excelerate), Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), and the Government of Bangladesh executed a Terminal Use Agreement and Implementation Agreement for the construction and operation of Bangladesh's first liquefied natural gas (LNG) import terminal – Moheshkhali Floating LNG (the "project" or the "terminal"). Moheshkhali Floating LNG will be located approximately 2.4 km offshore Sonadia Island (a distinct feature of the Island of Moheshkhali), approximately 20 km northwest of Cox's Bazar in Bangladesh (Figure ES-1).

Figure ES-1: Project Location



The terminal would include the provision of one of Excelerate's existing floating storage and regasification units (FSRU), the *Excellence*, and the installation of a turret loading buoy anchored offshore, flexible riser, pipeline end manifold (PLEM), and 7.5 km subsea pipeline with final tie-in connection at the Delivery Point (the battery limit with the existing onshore pipeline). Excelerate will also utilize a temporary construction area onshore, rent office and port space, during construction and operation, employ various support vessels during construction, and employ port service vessels (i.e., tugs and crew boat) during operation. Office and port activities are likely be based in Chittagong, although potential activities out of Cox's Bazar may be required.

The FSRU will have 138,000 cubic meters of LNG storage capacity and a base regasification capacity of 500 million standard cubic feet (MMSCFD) per day. LNG carriers will deliver LNG to the terminal approximately every 5 days at rated sendout of 500 MMSCFD. LNG will be vaporized using open-loop shell-and-tube vaporizers.

Construction of the terminal is expected to begin in Q4 2017 and last approximately four months, and the terminal is expected to be in operation in 2018.

Construction of the terminal will require approximately 280 personnel, a majority of which will be housed onboard the vessels on hire to support terminal construction at all time.

Inherent Sector Risk

The oil and gas 'value chain' is complex and involves many market segments (i.e. exploration and production, transportation, refining, distribution, and marketing), each with a distinct set of risks and potential impacts. Moheshkhali Floating LNG includes transportation, storage and regasification of LNG. These activities have a much lower risk profile than most oil and gas activities.

The physical and chemical properties of LNG render it safer than other hydrocarbons. LNG is a refined product composed almost entirely of methane. If LNG is spilled (on land or water), it vaporizes and leaves essentially no residue behind, unlike crude oil or other liquid hydrocarbons that can cause long-lasting impacts. Further, LNG facilities and vessels feature natural gas, fire, and smoke detection systems that identify hazardous situations and engage automatic shutdown systems that halt operations.

A 2014 report by the Society of International Gas Tanker and Terminal Operators (SIGTTO) estimates more than 77,000 commercial LNG cargoes have been safely delivered in the last 50 years with only 40 m^3 of LNG spills and "during this period there has been no loss of cargo tank containment and no fatalities directly attributable to the cargo." [1] Incidents that have occurred mainly involve problems with machinery (e.g. loss of propulsion and blackouts) and cargo handling systems (e.g. connection and disconnection of the marine loading arms). Of the four grounding events, none have resulted in loss of cargo.[2]

Regulatory Compliance

In accordance with the procedures defined in the Environment Conservation Rules, 1997 (as amended in 2002, 2003 and 2010), the project was classified by the Department of Environment (DoE) as a Red category project, requiring Site Clearance and Environmental Clearance, based on a full Environmental Impact Assessment (EIA).

DoE issued the Terms of Reference (ToR) for the project EIA November 13, 2011, and an EIA was submitted in 2012. DoE approved the EIA and provided Site Clearance and Environmental Clearance January 1, 2016, With Site Clearance and Environmental Clearance, the project has obtained key Bangladesh approvals to proceed. Environmental Clearance was valid for one year and Excelerate, via Petrobangla, has submitted an application for a new/extended Environmental Clearance Certificate.

[1] Society of International Gas Tanker and Terminal Operators. 2014. LNG Shipping at 50.
[2] Woodward J.L. and R.M. Pitblado. 2010. LNG Risk Based Safety: Modeling and Consequence Analysis. Hoboken, New Jersey: John Wiley & Sons, Inc.

Excelerate intends to receive financing from International Finance Corporation (IFC), a member of the World Bank Group. Prior to financing, a scoping study was conducted to:

- Evaluate status of project compliance with Bangladesh regulatory requirements
- Identify and define the potentially significant impacts associated with the Project and its alternatives, and review the original EIA to identify potential gaps
- Assess alignment with lender requirements, e.g., IFC Performance Standards on Environmental and Social Sustainability (Performance Standards) and World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines).

A scoping workshop was held to discuss findings of the scoping study on September 12 and the Scoping Report was finalized September 19, 2016. As the original EIA was largely completed in 2011/2012, prior to availability of many project details, 2016 scoping identified a number of gaps. Based on Scoping, it was determined that a new Environmental and Social Impact Assessment (ESIA) should be developed.

This ESIA builds off the original EIA to the extent feasible, and integrates a number of supplemental studies to support impact evaluation, namely:

- Air emissions inventory
- Air emissions dispersion modeling
- LNG leak simulation modeling
- Thermal plume dispersion modeling
- Sediment dispersion modeling
- Navigability and water suitability assessment
- Critical Habitat Assessment
- Pipeline 'windscreen' survey
- Geotechnical and environmental baseline survey

Stakeholder Engagement

There are no legal requirements in Bangladesh for public consultation or information disclosure during the permitting process. However, sector specific guidelines suggest public participation as a part of impact assessment study and recognize the need to consider socio-cultural, physical, and biological impacts. Project stakeholders include representatives of the government—public agencies responsible for regulatory oversight—as well as interested members of civil society and the general public for whom project development may present potential impacts.

The original impact assessment consultation was undertaken between 2012 and 2015. As part of the update to the impact assessment, scoping consultation was conduction August 6-12, 2016. The scoping study was designed to identify, inform, and receive input from potentially affected stakeholders and interested parties, as part of the engagement process.

Subsequent consultation was conducted October 16-28, 2016 to integrate stakeholder input into the ESIA, inform stakeholders, and establish the basis of a long-term relationship with Excelerate. More details regarding consultation undertaken to date, and plans for future stakeholder engagement can be found in Chapter 7: Public Consultation.

Environmental and Social Setting

The FSRU will be located nearshore, approximately 2.4 km from the coast, in waters approximately 30 m deep. Sediments discharged by Ganges and Brahmaputra Rivers into the

Bay of Bengal create fairly high levels of suspended solids in coastal waters, as well as a dynamic coastline that is subject to significant changes due to annual accretion and erosion. Seafloor sediments near the FSRU are soft bottom habitat comprised of clays, silts, and sands. The coastal zone has a large intertidal zone with expansive mudflats subject to tidal inundation, and occasional sandy beach. The coastal region adjacent to the FSRU is a distinct feature of Moheshkhali Island known as Sonadia Island, a nationally designated Ecologically Critical Area (ECA), and internationally recognized Important Bird Area. The inland areas adjacent to the intertidal zone are largely comprised of mangrove plantation. The mangrove plantation can be accessed (depending on the tide) by boat via a network of natural channels, but there are no roads. Inland areas are used sporadically to graze water buffalo, and nearshore waters are used frequently by artisanal fishermen. No industrial fishing is allowed in waters less than 40 m deep. Sonadia Island is a proposed Ramsar Wetland of International Importance, and winter habitat for approximately 10% of the Critically Endangered Spoon-billed Sandpiper population. Critical Habitat was identified in the study area, including the entirety of Sonadia Island where the Delivery Point is located.

The project pipeline will tie-in to a recently constructed pipeline owned and operated by the Bangladesh Gas Transmission Company Limited (GTCL), a subsidiary of Petrobangla, approximately 30 m inland from the maximum high-tide. The Delivery Point is within the boundary of the Sonadia Island ECA. The location of the Delivery Point was selected based on a feasibility study conducted on behalf of GTCL by Poten & Partners in 2009. Excelerate had no input into the selection of the site, and land required for Delivery Point construction and operation is owned by the Government of Bangladesh.

Site reconnaissance in August 2016 confirmed that there are no human settlements within about 5 km of the Delivery Point. Fishing is pursued offshore Moheshkhali and limited cattle and buffalo grazing was also observed. Local communities fish and set traps in the natural channels surrounding this site and throughout Sonadia and Moheshkhali islands. The only other active land/water use observed in this area is the gas pipeline that was recently constructed by the government of Bangladesh to tie the project into an existing gas pipeline network to the north. Also observed throughout the general area are man-made salt pans, used to cultivate salt for commercial sale. During the wet season, salt pans are used for aquaculture.

Impact Assessment

The impact evaluation resulted in assigning a rating of impact consequence (negligible, minor, moderate, major) and likelihood (improbable, seldom, occasional, probable), which together define a significance rating (low, medium, or high) for each identified impact. A description of the Methodology is provided in Chapter 5: Impact Identification and Evaluation. A summary of the medium and high significance impacts is provided in Table ES-1[3].

[3] Full tables, which include low significance impacts, are included in Chapter 5: Impact Evaluation and Identification.

Table ES-1: Summary of Potential Impacts with Medium and High Significance

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Text Ref.	Intensity	Scope	Dura-tion	Overall Consequence Level and Score	Likelihood Level and Score	Significance
Mobilization (Phase 1)										
Only low significance impacts										
Construction and Commissioning (Phase 2)										
2A3	Clearance and grading of construction yard and installation of Delivery Point	Flora	Damage to flora from clearance of construction yard	5.3.1.1	Reversible	Localized	Long-term	**Moderate (2)**	**Probable (3)**	**High**
2A4	Clearance and grading of construction yard and installation of Delivery Point	Fauna	Degradation of habitat and disruption from clearance and physical presence (including light and noise)	5.3.1.1	Reversible	Localized	Medium-term	**Moderate (2)**	**Occasional (2)**	**Medium**
2C1	Routine discharges	Soil	Degradation of soil quality from discharge of hydrostatic testing water and additives	5.3.2	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
2C2	Routine discharges	Water	Degradation of water quality from discharge of hydrostatic testing water and additives	5.3.2	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
2C3	Routine discharges	Fauna	Disruption of fauna from hydrostatic testing activities and additives	5.3.2	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
2F1	Enforcement of safety exclusion zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety exclusion zone	5.3.1.4	Reversible	Localized	Short-term	**Moderate (2)**	**Occasional (2)**	**Medium**
2G1	Accidental release	Soil	Degradation in soil quality from accidental release	5.3.4	Reversible	Localized	Long-term	**Moderate (2)**	**Seldom (1)**	**Medium**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Text Ref.	Intensity	Scope	Dura-tion	Overall Consequence Level and Score	Likelihood Level and Score	Significance
2G2	Accidental release	Water	Degradation of water quality from accidental release	5.3.4	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
2G3	Accidental release	Fauna	Harm to fauna from accidental release	5.3.4	Reversible	Localized	Short-term	**Major (3)**	**Seldom (1)**	**Medium**
Operation (Phase 3)										
3B1	Generation of air emissions	Air	Degradation of air quality and increase in greenhouse gas emissions from FSRU operations	5.3.3	Reversible	Dispersed	Long-term	**Moderate (2)**	**Occasional (2)**	**Medium**
3D2	Enforcement of safety exclusion zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety exclusion zone	5.3.1.4	Irreversible	Localized	Long-term	**Moderate (2)**	**Occasional (2)**	**Medium**
3E1	Job creation	Economic / Livelihood	Increase in economic activity from additional electrical supply, job creation, and generation of revenue for the government	5.3.5	Reversible	Dispersed	Long-term	**Moderate (2)**	**Probable (3)**	**High Positive Impact**
3F3	Accidental release	Fauna	Harm to fauna from accidental release	5.3.4	Reversible	Localized	Medium-term	**Moderate (2)**	**Seldom (1)**	**Medium**
3F4	Accidental release	Health	Harm to human health from accidental release	5.3.4	Reversible	Dispersed	Medium-term	**Moderate (2)**	**Seldom (1)**	**Medium**
Decommissioning (Phase 4)										
None. After the contract term, ownership of all permanent infrastructure will transfer to the Government of Bangladesh for continued use. No decommissioning is required.										
Ancillary Activities (Phase 5)										
5C1	Physical presence of vessels	Fauna	Potential damage to marine fauna from contact with hull or propeller	5.3.1.3	Irreversible	Localized	Long-term	**Moderate (2)**	**Seldom (1)**	**Medium**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Text Ref.	Intensity	Scope	Dura-tion	Overall Consequence Level and Score	Likelihood Level and Score	Significance
5E1	Job creation	Economic / Livelihood	Local job creation from project activities	5.3.5	Reversible	Dispersed	Long-term	**Negligible (0)**	**Probable (3)**	**Low** **Positive Impact**
5F3	Accidental release	Fauna	Harm to fauna from accidental release	5.3.4	Reversible	Localized	Medium-term	**Moderate (2)**	**Seldom (1)**	**Medium**

Mitigation and Management

As described in the ESIA methodology presented in Chapter 5, mitigation is required for potential impacts with pre-mitigation rankings of either high or medium to reduce the residual impact to low. There were 15 potential impacts identified for the project that were ranked as high to medium level prior to mitigation. After developing mitigation measures, the impacts were re-evaluated to determine the “residual risk”, or the risk remaining after the mitigation measures are put into place.

While low level impacts do not require mitigation, standard controls that will be implemented to ensure the impacts are minimized are provided in Chapter 6: Mitigation and Management. A matrix of proposed mitigation measures for medium and high ranked impacts, and residual impacts after application of mitigation measures, is presented in Table ES-2. The Project’s Environmental and Social Management Plan (ESMP) is presented in Table ES-3 and provides a tool for implementing recommended mitigation measures. The ESMP is a framework document that ties in a number of activity/impact specific management plans (e.g., ERP and WMP). Summaries of key management plans required are provided in Chapter 6.

Table ES-2: Recommended Mitigation Measures for Impacts with Medium and High Significance

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Measures	Residual Impact
Mobilization (Phase 1)						
No medium or high level impacts identified. See Ancillary Activities (Phase 5)						
Construction and Commissioning (Phase 2)						
2A3	Clearance and grading of construction yard and installation of Delivery Point	Flora	Damage to flora from clearance of construction yard	**High**	• Develop and implement a BAP • Develop and implement a Site Rehabilitation Plan • Minimize the footprint of temporary and permanent areas required on land and avoid areas with established mangroves to the extent possible • Prior to clearance document locations and area of mangroves to be cleared and ensure net gain of mangrove area after rehabilitation • Support conservation efforts of Sonadia Island • Conduct long term monitoring of Critical Habitat values • See standard controls listed in Table 6-5	**Low**
2A4	Clearance and grading of construction yard and installation of Delivery Point	Fauna	Degradation of habitat and disruption from clearance and physical presence (including light and noise)	**Medium**	• Develop and implement a BAP • Install sound barriers between construction yard and sensitive sites • Develop clear restricted areas/buffer zones for contractors and staff to avoid disturbance to bird sites (700m away) • Conduct monitoring of bird behavior by specialists during construction to ensure mitigation measures are sufficient and allow for adaptive management • Support conservation efforts to obtain net positive benefit to Critical Habitat values (e.g. training to communities, beach patrols, and/or other initiatives) • See standard controls listed in Table 6-5	**Low**
2C1	Routine discharges	Soil	Degradation of soil quality from discharge of hydrostatic testing water and additives	**Medium**	• Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring • Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones • See standard controls listed in Table 6-5	**Low**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Measures	Residual Impact
2C2	Routine discharges	Water	Degradation of water quality from discharge of hydrostatic testing water and additives	**Medium**	• Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring • Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones • See standard controls listed in Table 6-5	**Low**
2C3	Routine discharges	Fauna	Disruption of fauna from hydrostatic testing activities and additives	**Medium**	• Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring • Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones • See standard controls listed in Table 6-5	**Low**
2F1	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety zone	**Medium**	• Develop and maintain a Stakeholder Engagement Plan • Develop and implement a Grievance Mechanism • See standard controls listed in Table 6-5	**Low**
2G1	Accidental release	Soil	Degradation in soil quality from accidental release	**Medium**	• Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • See standard controls listed in Table 6-5	**Low**
2G2	Accidental release	Water	Degradation of water quality from accidental release	**Medium**	• Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • See standard controls listed in Table 6-5	**Low**
2G3	Accidental release	Fauna	Harm to fauna from accidental release	**Medium**	• Develop and implement a BAP • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • See standard controls listed in Table 6-5	**Low**
Also see Ancillary Activities (Phase 5)						

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Measures	Residual Impact
Operation (Phase 3)						
3B1	Generation of air emissions	Air	Degradation of air quality and increase in greenhouse gas emissions from FSRU operations	**Medium**	• Use diesel fuel with less than .5 percent Sulfur for auxiliary generators • Develop and implement an Emissions and Air Quality Monitoring Program • See standard controls listed in Table 6-5	**Low**
3D1	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety zone	**Medium**	• Develop and maintain a Stakeholder Engagement Plan • Develop and implement a Grievance Mechanism • See standard controls listed in Table 6-5	**Low**
3F3	Accidental release	Fauna	Harm to fauna from accidental release	**Medium**	• Develop and implement a BAP • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • Conduct long term monitoring of Critical Habitat values • See standard controls listed in Table 6-5	**Low**
3F4	Accidental release	Health	Harm to human health from accidental release	**Medium**	• Develop and implement a BAP • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • Develop a HSP • Conduct long term monitoring of Critical Habitat values • See standard controls listed in Table 6-5	**Low**
Also see Ancillary Activities (Phase 5)						
Decommissioning (Phase 4)						
No medium or high level impacts identified						
Ancillary Activities (Phase 5)						
5C1	Physical presence of vessels	Fauna	Potential damage to marine fauna from contact with hull or propeller	**Medium**	• Support vessels should maintain a safe distance from marine mammals and sea turtles. If seen, reduce vessel speed and maintain the following distances: o 50 m from dolphins, porpoises, and sea turtles o 100 m from whales • See standard controls listed in Table 6-5	**Low**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Measures	Residual Impact
5F3	Accidental release	Fauna	Harm to fauna from accidental release	**Medium**	• Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • Conduct long term monitoring of Critical Habitat values • See standard controls listed in Table 6-5	**Low**

Table ES-3: Environmental and Social Management Plan

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
Mobilization (Phase 1)							
No medium or high level impacts identified. See Ancillary Activities (Phase 5)							
Construction and Commissioning (Phase 2)							
2A3	Develop and implement a BAP	Throughout construction and commissioning	To be determined in plan. Long term monitoring required per IFC Performance Standard 6.	Awareness training to Geocean and Excelerate staff	Excelerate Senior Manager of Environmental Permitting	Monthly reports	$50,000
	Develop and implement a Site Rehabilitation Plan	Develop prior to construction and implement as soon as practical. Complete rehabilitation prior to operations.	Completion review and annually until vegetation is established	None	Excelerate Construction Manager	Site Rehabilitation Completion Report	$50,000
	Minimize the footprint of temporary and permanent areas required on land and avoid areas with established mangroves to the extent possible	Integrate into engineering and design, and implement throughout construction	Review siting prior to land clearance and confirm location is according to design	None	Excelerate Construction Manager	Monthly reports	No additional cost
	Prior to clearance document locations and area of mangroves to be cleared and ensure No Net Loss of mangrove area after rehabilitation	Document mangrove coverage before construction and monitor rehabilitation of site during operations	Document mangrove coverage before construction and monitor rehabilitation of site during operations	Awareness training to Geocean	Excelerate Construction Manager	Monthly Report Site Rehabilitation Completion Report	No additional cost
	Support conservation efforts of Sonadia Island	Throughout lifetime of project	Conduct monitoring of Critical Habitat values and activities conducted	To be determined in BAP	Excelerate Senior Manager of Environmental Permitting	To be determined in BAP	$1,000 per year

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
2A3	Conduct long term monitoring of Critical Habitat values	Throughout lifetime of project	To be determined in BAP	To be determined in BAP	Excelerate Senior Manager of Environmental Permitting	To be determined in BAP	$2,500 / month
2A4	Develop and implement a BAP	See 2A3 above					
	Install sound barriers between construction yard and sensitive sites	At outset of construction	Ensure installation before significant activity takes place onshore	Discuss with Geocean team prior to mobilization to ensure appropriate design	Excelerate Construction Manager	Monthly report	$5,000
	Develop clear restricted areas/buffer zones for contractors and staff to avoid disturbance to bird sites (700m away).	Include in engineering and apply throughout construction	On-going monitoring and enforcement of the restricted areas	Install signs on site and provide awareness training to any staff working onshore	Excelerate Construction Manager	Monthly reports	No additional cost
	Conduct monitoring of bird behavior by specialists during construction to ensure mitigation measures are sufficient and allow for adaptive management	Throughout construction	Conduct monitoring of bird behavior (frequency to be determined in BAP)	Ensure monitor is able to evaluate bird behavior	Excelerate Senior Manager of Environmental Permitting	Reports of species counts and notes of upset behaviour	Included in 2A3
	Support conservation efforts to obtain net positive benefit to Critical Habitat values (e.g. training to communities, beach patrols, and/or other initiatives)	Throughout lifetime of project	Conduct monitoring of Critical Habitat values and activities conducted	To be determined in BAP	Excelerate Senior Manager of Environmental Permitting	To be determined in BAP	$1,000 per year

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
2C1	Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring	Develop prior to construction and implement during hydrotesting	To be determined in plan. At a minimum, testing of hydrotest water must be completed prior to discharge, and location and rate if discharge must be recorded.	Awareness training to Geocean and Excelerate staff	Excelerate Construction Manager	Hydrotest water test results Monthly reports	$20,000
	Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones	During construction	Location and rate if discharge must be recorded	Awareness training to Geocean and Excelerate staff	Excelerate Construction Manager	Monthly reports	No additional cost
2C2	Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring	See 2C1 above					
	Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones	See 2C1 above					
2C3	Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring	See 2C1 above					
	Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones	See 2C1 above					

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
2F1	Develop and maintain a Stakeholder Engagement Plan	Develop plan prior to construction and implement throughout construction and commissioning	Track interactions with fishermen and other vessels entering the safety exclusion zone	Awareness training to Excelerate, Geocean and Svitzer staff on protocol for managing interactions with other vessels	Excelerate Senior Manager of Environmental Permitting	Stakeholder engagement tracker and meeting minutes Monthly reports	$25,000
	Develop and implement a Grievance Mechanism	Develop grievance mechanism (incl. procedure) prior to construction and implement throughout construction and commissioning	Track interactions with fishermen and other vessels entering the safety exclusion zone Track grievances	Awareness training to Excelerate, Geocean, and Svitzer staff on protocol for managing interactions with other vessels Communication with Bangladesh Navy on protocol for grievance mechanism	Excelerate Senior Manager of Environmental Permitting	Grievance tracker Monthly reports	$10,000
2G1	Develop and implement an ERP	Develop plan prior to construction and implement throughout construction and commissioning	Review records of training Conduct at least one drill during construction	Awareness training to Excelerate, Geocean and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate Senior Manager of Environmental Permitting	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	$50,000

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
2G1	Develop and Implement an OSRP	Develop plan prior to construction and implement throughout construction and commissioning	Review records of training Conduct at least one drill during construction	Awareness training to Excelerate, Geocean and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate Senior Manager of Environmental Permitting	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	$20,000 plus shared cost of ERP drill
	Develop and implement a WMP	Develop plan prior to construction and implement throughout construction and commissioning	Track waste volumes generated and chain of custody through ultimate disposal at licensed facility	Awareness training to Excelerate, Geocean and Svitzer staff on plan	Excelerate Senior Manager of Environmental Permitting	Waste manifests Transfer of custody forms Monthly reports	$20,000
2G2	Develop and implement an Emergency Response Plan	See 2G1 above					
	Develop and Implement an Oil Spill Response Plan	See 2G1 above					
	Develop and implement a Waste Management Plan	See 2G1 above					
2G3	Develop and implement a Biodiversity Management Plan	See 2A3 above					
	Develop and implement an Emergency Response Plan	See 2G1 above					
	Develop and Implement an Oil Spill Response Plan	See 2G1 above					
	Develop and implement a Waste Management Plan	See 2G1 above					

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
Also see Ancillary Activities (Phase 5)							
Operation (Phase 3)							
3B1	Use diesel fuel with less than .5 percent Sulfur for auxiliary generators	Throughout operations	Test fuel prior to acceptance to ensure Sulfur is within limits	Awareness training to Exmar and Excelerate staff	Excelerate HSE Compliance Coordinator	Bunker delivery notes Quarterly Reports	Market rates
	Develop and implement an Emissions and Air Quality Monitoring Program	Throughout operations	Continuous	Awareness training to Exmar and Excelerate staff	Excelerate HSE Compliance Coordinator	Quarterly Reports Annual Emissions and Air Quality Monitoring Report	$100,000 per year
3D2	Develop and maintain a Stakeholder Engagement Plan	Update plan prior to operation and implement throughout operations	Track interactions with fishermen and other vessels entering the safety exclusion zone	Awareness training to Excelerate, Exmar, and Svitzer staff on protocol for managing interactions with other vessels	Excelerate HSE Compliance Coordinator	Stakeholder engagement tracker and meeting minutes Monthly reports	$50,000

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
3D2	Develop and implement a Grievance Mechanism	Update grievance mechanism (incl. procedure) prior to operations and implement throughout operations	Track interactions with fishermen and other vessels entering the safety exclusion zone Track grievances	Awareness training to Excelerate, Exmar, and Svitzer staff on protocol for managing interactions with other vessels Communication with Bangladesh Navy on protocol for grievance mechanism	Excelerate HSE Compliance Coordinator	Grievance tracker Monthly reports	$25,000
3F3	Develop and implement a BAP	Throughout operations	To be determined in plan. Long term monitoring required per IFC Performance Standard 6.	Awareness training to Exmar, and Excelerate staff	Excelerate HSE Compliance Coordinator	Annual Monitoring Reports	$25,000 per year
	Develop and implement an ERP	Update plan prior to operations and implement throughout operations	Review records of training Conduct at least one drill annually	Awareness training to Excelerate, Exmar, and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate HSE Compliance Coordinator	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	$5,000

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
3F3	Develop and Implement an OSRP	Update plan prior to operations and implement throughout operations	Review records of training Conduct at least one drill during annually	Awareness training to Excelerate, Exmar, and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate HSE Compliance Coordinator	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	$5,000 plus $10,000 annually for drills
	Develop and implement a WMP	Update plan prior to operations and implement throughout operations	Track waste volumes generated and chain of custody through ultimate disposal at licensed facility	Awareness training to Excelerate, Exmar, and Svitzer staff on plan	Excelerate HSE Compliance Coordinator	Waste manifests Transfer of custody forms Monthly reports	$5,000 per year
	Conduct long term monitoring of Critical Habitat values	See 2A3 above					
3F4	Develop and implement a BAP	See 3F3 above					
	Develop and implement an ERP	See 3F3 above					
	Develop and Implement an OSRP	See 3F3 above					
	Develop and implement a WMP	See 3F3 above					
	Develop a HSP	Develop prior to construction and update prior to operations. Implement throughout the project lifecycle.	To be defined in plan. At a minimum, should include monitoring of training records, and tracking of incidents and near misses.	HSE induction training for Excelerate, Exmar and Svitzer staff	Excelerate HSE Compliance Coordinator	Records of training Monthly reports	$20,000 plus 10,000 per year

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
3F4	Conduct long term monitoring of Critical Habitat values	See 2A3 above					
Also see Ancillary Activities (Phase 5)							
Decommissioning (Phase 4)							
No medium or high level impacts identified							
Ancillary Activities (Phase 5)							
5C1	Support vessels should maintain a safe distance from marine mammals and sea turtles If seen, reduce vessel speed and maintain the following distances: • 50 m from dolphins, porpoises, and sea turtles • 100 m from whales	During entire project lifecycle	Track sightings of marine mammals and sea turtles in all vessels	Awareness training to Geocean, Exmar, and Svitzer staff	Excelerate Senior Manager of Environmental Permitting (during construction) and Excelerate HSE Compliance Coordinator (during operations)	Monthly reports	No additional cost
5F3	Develop and implement an ERP	During entire project lifecycle	Review records of training Conduct at least one drill annually	Awareness training to Excelerate, Geocean, Exmar, and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate Senior Manager of Environmental Permitting (during construction) and Excelerate HSE Compliance Coordinator (during operations)	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	Costs estimated in specific project phases above

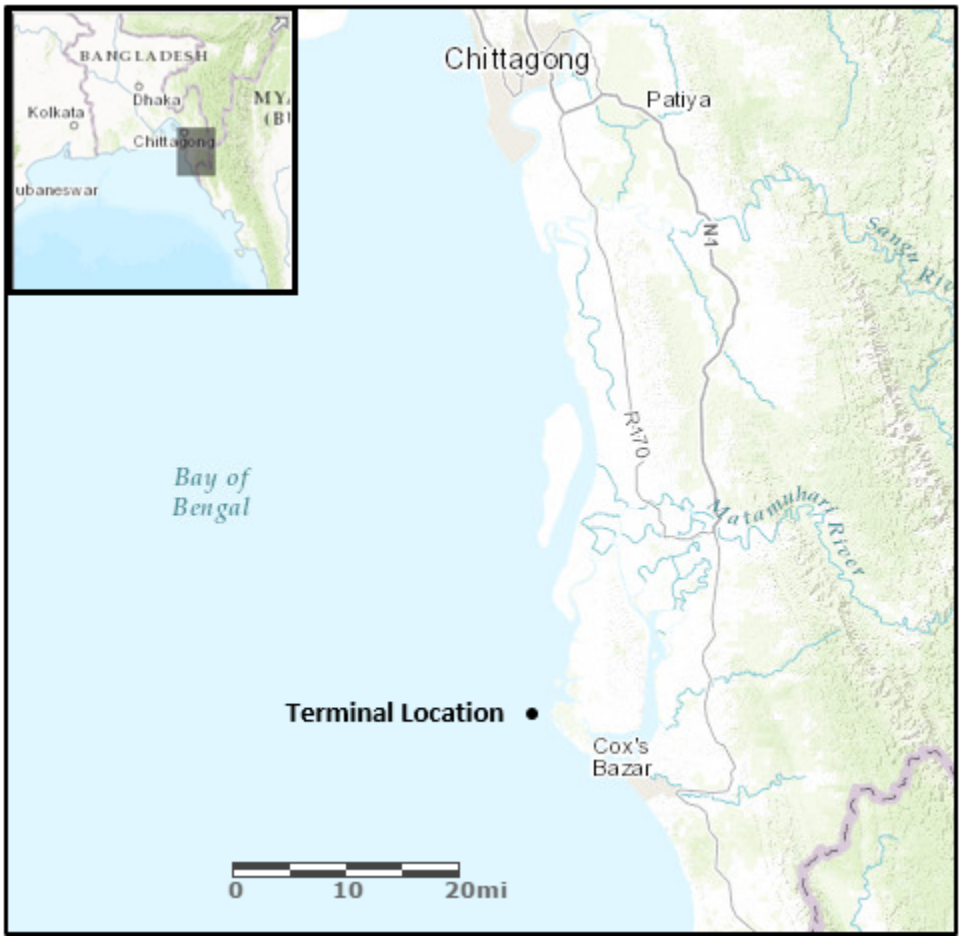
Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
5F3	Develop and Implement an OSRP	During entire project lifecycle	Review records of training Conduct at least one drill during annually	Awareness training to Excelerate, Geocean, Exmar, and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate Senior Manager of Environmental Permitting (during construction) and Excelerate HSE Compliance Coordinator (during operations)	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	Costs estimated in specific project phases above
	Develop and implement a WMP	During entire project lifecycle	Track waste volumes generated and chain of custody through ultimate disposal at licensed facility	Awareness training to Excelerate, Geocean, Exmar, and Svitzer staff on plan	Excelerate Senior Manager of Environmental Permitting (during construction) and Excelerate HSE Compliance Coordinator (operations)	Waste manifests Transfer of custody forms Monthly reports	Costs estimated in specific project phases above
	Conduct long term monitoring of Critical Habitat values	See 2A3 above					

1 Introduction

1.1 Project Overview

On July 18, 2016, Excelerate Energy Bangladesh, Ltd. (Excelerate), Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), and the Government of Bangladesh executed a Terminal Use Agreement and Implementation Agreement for the construction and operation of Bangladesh's first liquefied natural gas (LNG) import terminal – Moheshkhali Floating LNG (the "project" or the "terminal"). Moheshkhali Floating LNG will be located approximately 2.4 km offshore Sonadia Island (a distinct feature of the Island of Moheshkhali), approximately 20 km northwest of Cox's Bazar in Bangladesh (Figure 1-1).

Figure 1-1: Project Location



The terminal would include the provision of one of Excelerate's existing floating storage and regasification units (FSRU), the Excellence, and the installation of a turret loading buoy anchored offshore, flexible riser, pipeline end manifold (PLEM), and 7.5 km subsea pipeline with final tie-in connection at the Delivery Point (the battery limit with the existing onshore pipeline). Excelerate will also utilize a temporary construction area onshore, rent office and port space, during construction and operation, employ various support vessels during construction, and employ port service vessels (i.e. tugs and crew boat) during operation. Office and port activities are likely be based in Chittagong, although potential activities out of Cox's Bazar may be required.

The FSRU will have 138,000 cubic meters of LNG storage capacity and a base regasification capacity of 500 million standard cubic feet (MMSCFD) per day. LNG carriers will deliver LNG to the terminal approximately every 5 days at rated sendout of 500 MMSCFD. LNG will be vaporized using open-loop shell-and-tube vaporizers.

1.2 Project Justification and Context

Natural gas plays a critical role in the Bangladesh economy, supplying 62.98% of the country's installed electricity generating capacity.[1] While Bangladesh was a net gas exporter until 2005, increased demand and declining supply have resulted in gas shortages of approximately 500-650 MMSCFD and are forecasted to increase.[2] These shortages have caused disruption in industrial production, particularly in the clothing, ceramics, fabrics, and steel industries.[1] [3] [4]

Reliable long-term availability of natural gas is critical to the development of competitive industry in the country, economic growth, and well-being of the people of Bangladesh (40.1% of whom still have no access to electricity).[5]

To address the current and future shortages, the power sector master plan suggested for the addition of 30,000 MW of capacity by 2030.[6] The proposed Moheshkhali Floating LNG project will supply gas to local power plant(s) in the Chittagong region, an area particularly impacted by the energy shortage.

1.3 Project Setting

The FSRU will be located nearshore, approximately 2.4 km from the coast, in waters approximately 30 m deep. Sediments discharged by Ganges and Brahmaputra Rivers into the Bay of Bengal create relatively high levels of suspended solids in coastal waters, as well as a dynamic coastline that is subject to significant changes due to annual accretion and erosion. Seafloor sediments near the FSRU are soft bottom habitat comprised of clays, silts, and sands. The coastal zone has a large intertidal zone with expansive mud flats subject to tidal inundation, and occasional sandy beach. The coastal region adjacent to the FSRU is a distinct feature of Moheshkhali Island known as Sonadia Island, a nationally designated Ecologically Critical Area (ECA), and internationally recognized Important Bird Area. The inland areas adjacent to the intertidal zone are largely comprised of mangrove plantation. The mangrove plantation can be accessed (depending on the tide) by boat via a network of natural channels, but there are no

[1] Asian Development Bank. 2016. Sector Assessment (Summary): Energy (Power). Accessed from the ADB website: http://www.adb.org/sites/default/files/linked-documents/44192-016-ssa.pdf
[2] Gomes, L. 2013. Natural Gas in Pakistan and Bangladesh: Current Issues and Trends. Accessed form the Oxford University website: https://www.oxfordenergy.org/wpcms/wp-content/uploads/2013/06/NG-77.pdf
[3] Rasel, A.R. 2015. 'Gas crisis in Chittagong to go in 2 years'. Dhaka Tribune, 11 October 2015. Accessed form the Dhaka Tribune website: http://archive.dhakatribune.com/bangladesh/2015/oct/11/gas-crisis-chittagong-go-2-years
[4] Daily Star. 2016. '124 garment factories hit by gas shortage' Daily Star, 15 May 2016. Accessed from the Daily Star website: http://www.thedailystar.net/business/124-garment-factories-hit-gas-shortage-1224082
[5] World Bank. 2016. 'Access to electricity (% of population)'. Accessed from the World Bank website: http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS
[6] Ministry of Power, Energy and Mineral Resources. 2011. Bangladesh Power Sector Master Plan. Accessed from the Ministry of Power, Energy and Mineral Resources website: http://www.bpdb.gov.bd/download/PSMP/PSMP2010(Summary).pdf

roads. Inland areas are used sporadically to graze water buffalo, and nearshore waters are used frequently by artisanal fishermen. No industrial fishing is permitted in Bangladesh in waters less than 40 m deep.

The project pipeline will tie-in to a recently constructed pipeline owned and operated by the Bangladesh Gas Transmission Company Limited (GTCL), a subsidiary of Petrobangla, approximately 30 m inland from the maximum high-tide. The tie-in location, also called the Delivery Point, is within the boundary of the Sonadia Island ECA. The location of the Delivery Point was selected based on a feasibility study conducted on behalf of GTCL by Poten & Partners in 2009. Excelerate had no input into the selection of the site, and land required for Delivery Point construction and operation is owned by the Government of Bangladesh.

1.4 Background

In accordance with the procedures defined in the Environment Conservation Rules, 1997 (as amended in 2002, 2003 and 2010), the project was classified by the Department of Environment (DoE) as a Red category project, requiring Site Clearance and Environmental Clearance, based on a full Environmental Impact Assessment (EIA).

DoE issued the EIA Terms of Reference (ToR) for the project EIA November 13, 2011, and an EIA was submitted in 2012. DoE approved the EIA and provided Site Clearance and Environmental Clearance January 1, 2016, With Site Clearance and Environmental Clearance, the project has obtained key Bangladesh approvals to proceed.

Excelerate intends to receive financing from International Finance Corporation (IFC), a member of the World Bank Group. Prior to financing, a scoping study was conducted to:

- Evaluate status of project compliance with Bangladesh regulatory requirements
- Identify and define the potentially significant impacts associated with the Project and its alternatives, and review the original EIA to identify potential gaps
- Assess alignment with lender requirements, e.g. IFC Performance Standards on Environmental and Social Sustainability (Performance Standards) and World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines).
- Identify, inform and receive input from potentially affected stakeholders and interested parties

Scoping consultation was conduction August 6-12, 2016 and a scoping workshop was held to discuss findings of the scoping study on September 12. The Scoping Report was finalized September 19, 2016.

As the original EIA was largely completed in 2011/2012, prior to availability of many project details, scoping identified a number of gaps and it was determined that a new Environmental and Social Impact Assessment (ESIA) should be developed.

This ESIA builds off the original EIA to the extent feasible, and integrates a number of supplemental studies to support impact evaluation, namely:

- Air emissions inventory
- Air emissions dispersion modeling
- LNG leak simulation modeling
- Thermal plume dispersion modeling
- Sediment transport modeling

- Navigability and water suitability assessment
- Critical Habitat Assessment
- Pipeline 'windscreen' survey
- Geotechnical and environmental baseline survey

Subsequent consultation was conducted October 16-28, 2016 to integrate stakeholder input into the ESIA, inform stakeholders, and establish the basis of a long-term relationship with Excelerate.

1.5 Scope of Assessment

IFC Performance Standards state that the area of influence includes[7]:

- *The area likely to be affected by:*
  - *(i) the project[8] and the client's activities and facilities that are directly owned, operated or managed (including by contractors) and that are a component of the project;[9]*
  - *(ii) impacts from unplanned but predictable developments caused by the project that may occur later or at a different location; or*
  - *(iii) indirect project impacts on biodiversity or on ecosystem services upon which Affected Communities' livelihoods are dependent.*
- *Associated facilities, which are facilities that are not funded as part of the project and that would not have been constructed or expanded if the project did not exist and without which the project would not be viable.*
- *Cumulative impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned, or reasonably defined developments at the time the risks and impacts identification process is conducted.*

While the project will operate primarily offshore, gas from the project will be transported from the Delivery Point at Moheshkhali to the Chittagong City ring main gas network via a newly constructed 89.4 km pipeline. A separate EIA was prepared on behalf of the Bangladesh Gas Transmission Company Limited (GTCL) for the pipeline and related infrastructure (i.e. Custody Transfer and Monitoring Station [CTMS]) and approved by DoE December 18, 2012. As the pipeline is being built to transport gas from sources near Cox's Bazar (or offshore gas sources) to Chittagong, these activities are considered in the determination of the area of Influence.

Based on the above, the area of influence considered for this project includes:

- The physical footprint of the FSRU, including a safety zone, vessel maneuvering zones, and subsea infrastructure
- Physical footprint of permanent and temporary onshore areas needed during construction
- Any required office, port or storage routes (to be identified in early logistics studies) as well as transportation corridor to port
- Areas that may be impacted by project wastes, effluents, emissions, noise and light

[7] IFC. 2012. FC Performance Standards on Environmental and Social Sustainability. Accessed from the IFC website: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full-Document.pdf?MOD=AJPERES

[8] Examples include the project's sites, the immediate airshed and watershed, or transport corridors

[9] Four examples include power transmission corridors, pipelines, canals, tunnels, relocation and access roads; borrow and disposal areas; construction camps; and contaminated land (e.g., soil, groundwater, surface water, and sediments)

- Adjacent onshore areas that are within the viewshed of the FSRU and are home to communities that utilize the area for fishing, salt farming and other economic activities
- Footprint of the 89.4 km pipeline to Chittagong, including a buffer zone on both sides of the route which may be impacted by construction or operations
- Areas that could potentially be impacted by accidental events

IFC Performance Standards note: “In the event of risks and impacts in the project’s area of influence resulting from a third party’s actions, the client will address those risks and impacts in a manner commensurate with the client’s control and influence over the third parties, and with due regard to conflict of interest.”

While the 89.4 km pipeline is included in the evaluation, 88 km were already completed at the time the TUA was signed in July, 2016, and Excelerate has been informed the pipeline has achieved practical completion. Thus, Excelerate has little to no ability to influence pipeline construction practices, routing, and other aspects of design/mitigation. The ESIA team conducted a review of the pipeline project to characterize the risks to IFC and EE. Results of the study are provided in Chapter 5: Impact Identification and Evaluation.

1.6 Project Team

The ESIA Team was comprised Acorn International, LLC (Acorn International) of the United States, BETS Consulting Ltd. (BETS) of Bangladesh, and ArcCona Consulting of the UK (includes Bangladesh based biodiversity specialists), working in cooperation with Excelerate. Acorn International was the project manager and has performed more than 80 ESIAs for development projects worldwide, including more than 60 for oil and gas industry programs. BETS is a multi-disciplinary engineering, development, and environmental consulting firm that routinely conducts ESIAs in Bangladesh, and was the author of the original EIA for the project.

Acorn International and BETS have established a partnership to provide international industries operating in Bangladesh the benefit of local expertise and international best practice in ESIA and environmental and social impact management. Staff of Excelerate worked closely with Acorn International and BETS to conduct stakeholder engagement and complete this ESIA.

ArcCona Consulting is a specialized biodiversity consultancy headquartered in the UK, but is comprised of specialist experts worldwide. For this assignment, a team of Bangladeshi and international experts with specialized knowledge of species of concern were dedicated to the project to review and provide feedback on baseline, impact assessment and mitigation chapters. ArcCona was also directly involved in drafting the Critical Habitat Assessment and conducted a site visit to characterize specific conditions of the area of interest relative to the species of concern habitat requirements and sensitivities. Experts assigned have been leading conservation efforts in the project area of influence for more than 10 years and include:

- Dr. Christoph Zockler, Chair of Spoon-billed Sandpiper Task Force / ArcCona Consulting
- Sayam U. Chowdhury, Assistant Coordinator of Bangladesh Spoon-billed Sandpiper Task Force (based in Bangladesh)

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2 Project Description

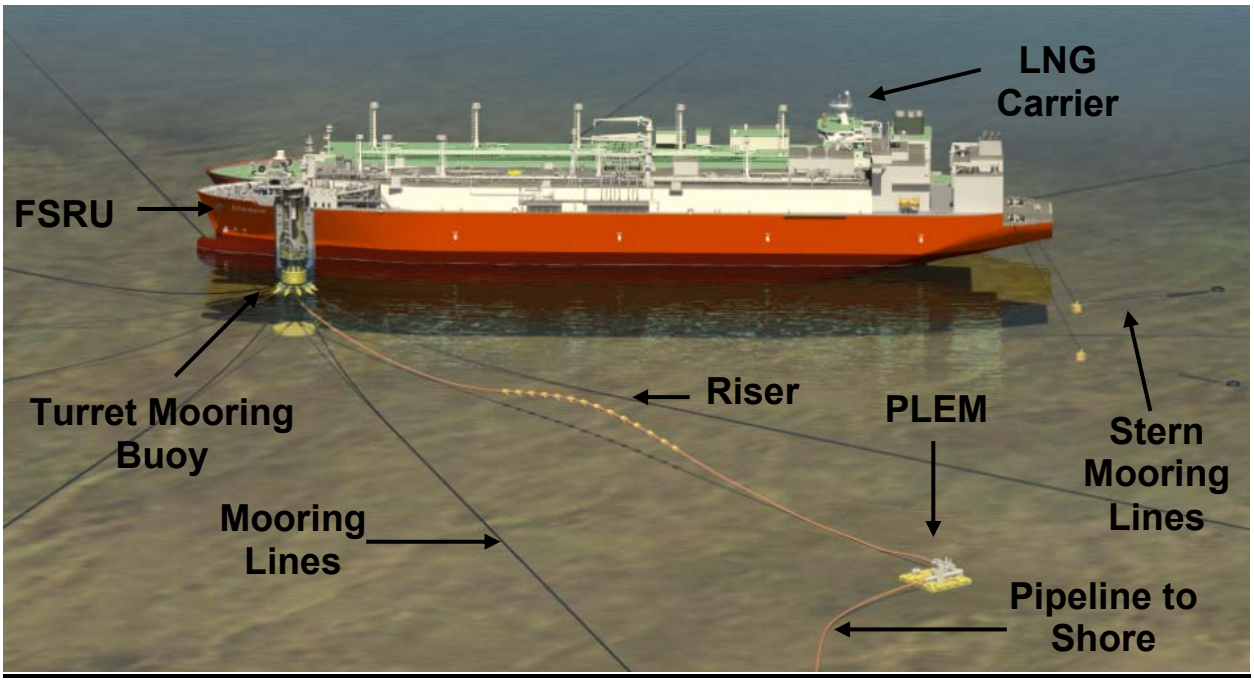
This section provides a description of the Moheshkhali Floating LNG project, including:

- Terminal Components
- Location
- Schedule
- Project Phases
- Personnel
- Natural Resource Use
- Discharges, Emissions and Wastes
- Project Alternatives

2.1 Terminal Components

A rendering of the terminal is shown in Figure 2-1, and key components described below.

Figure 2-1: Main Terminal Components



Source: Excelerate

2.1.1 FSRU Vessel

The terminal would include the provision of one of Excelerate's existing FSRUs, the *Excellence* (Figure 2-2). An FSRU is an LNG carrier ship modified to include the regasification systems. The Excellence will be moored to the seabed via a turret mooring system. The systems required for the LNG pumping, vaporization, boil-off gas (BOG) handling, and natural gas export to shore are located on the deck of the FSRU.

Figure 2-2: *Excellence* FSRU

Source: Excelerate

The FSRU will have 138,000 cubic meters (m^3) of LNG storage capacity and a base regasification capacity of 500 million standard cubic feet per day (MMSCFD). Boilers are used to generate steam to run the steam turbines which in turn generate electricity to power the ship, including vaporization. LNG will be vaporized using open-loop shell-and-tube vaporizers. Vessel specifications for the *Excellence* are provided in Table 2-1.

The primary support equipment, facilities, and systems on the FSRU include power generation equipment, recondensers and boil-off gas compressors, metering equipment, a ballast system, a utilities/seawater system, waste and water treatment systems, and crew quarters and command control facilities.

The *Excellence* has three turbine generators (3x3,700kW), one auxiliary generator (1x3,840kW), and two boilers capable of producing approximately 68,000kg/hr steam each. The primary means of electrical power comes from the steam driven generator-turbines. The steam is produced onboard by the two boilers, which are fueled using the natural gas from LNG boil off. In some occasions, heavy fuel oil may be used for safety reasons or as back-up for the natural gas. These boilers also provide the steam used by the main turbine for ship propulsion.

As secondary means, the auxiliary diesel generator engine, powered by combustion of Marine Diesel Oil, is provided as (partial) back-up in case of issues with the steam plant, or to provide surplus power to allow regas operation above 500 MMSCFD. The FSRU has a peak sendout rate of 600 MMSCFD. The sendout from the FSRU may at times exceed the contracted sendout rate of 500 MMSCFD. The amount of time it exceeds this rate, and the amount by which it exceeds it, depends on the demand for natural gas. It is difficult to estimate how often this may occur, but for the purposes of this impact assessment, the ESIA team has assumed that it may operate up to 10 percent of the year at a sendout rate of 600 MMSCFD.

Living quarters on the FSRU will accommodate a permanent crew of up to 40. 80 personnel will work on rotational shifts and will live on the support vessels and or FSRU during their on-duty schedule, but only half will be active at one time. For safety reasons, all living, dining, and

recreational areas would be contained within the crew quarters and separated from all processing areas.

Command and control facilities are located on the bridge and in the Cargo Control Room, inside the crew quarters area. These facilities include control and monitoring systems for LNG and natural gas processing, ballasting, communication, radar equipment, electrical generation, emergency systems, and thruster controls.

In accordance with international safety practices and local regulation, Excelerate will maintain a safety zone around the construction vessels (temporary) and FSRU (permanent). The purpose of the safety zone is to allow unencumbered operation of the terminal (i.e. vessel maneuvering), protection of the terminal from accidental or intentional harm (i.e. vessel collision and hull breach), and protection of public safety (e.g. from vessel collision). Excelerate is currently evaluating terminal design and reviewing navigability study results to determine the final size of the safety zone, but discussions with the Chittagong Port Authority and Department of Explosives by the ESIA team suggest the zone will include 500 m radius around the FSRU for small vessels (i.e. fishing boats) and 1,000 m radius for large vessels (i.e. cargo tankers).

Table 2-1: *Excellence* Specifications

Principal Dimensions	
Length overall	277.00 m
Breadth, moulded	43.40 m
Depth, moulded	26.00 m
Scantling draft, moulded	12.30 m
Gross tonnage	96,976
Air draft from the ballast water line to the top of the fixed part on the compass deck	Max. 41.20m
Technical Specifications	
Class	Bureau Veritas
LNG Capacity (100%)	138,000 m^3
LNG Capacity (max vol fill 98.5%)	135,930 m^3
Regas Facility Configuration	Submerged Turret Loading (STL) Buoy compartment
Regas System Configuration	Open Loop – Shell & Tube
Propulsion	Steam
Service Speed	19 knots
Fuel Oil Capacity	3,000 mt (actual capacity HFO 573mT, MDO 442 mT)
LNG Tank Working Pressure	0.25 barg (will be upgraded to 0.7 barg for regas service)
Natural Boil Off Rate	0.15%

Nominal NG Sendout	500 MMSCFD Open Loop
Peak NG Sendout	600 MMSCFD Open Loop
NG Sendout Pressure	75-78 Barg as measured at the exit of the FSRU
LNG Loading Rate	4,500 m^3/hr (w/sendout > 100MMSCFD)
Regas Sendout Quantity and Quality	Ultrasonic meter and Gas Chromatograph (calibrated to AGA 9)

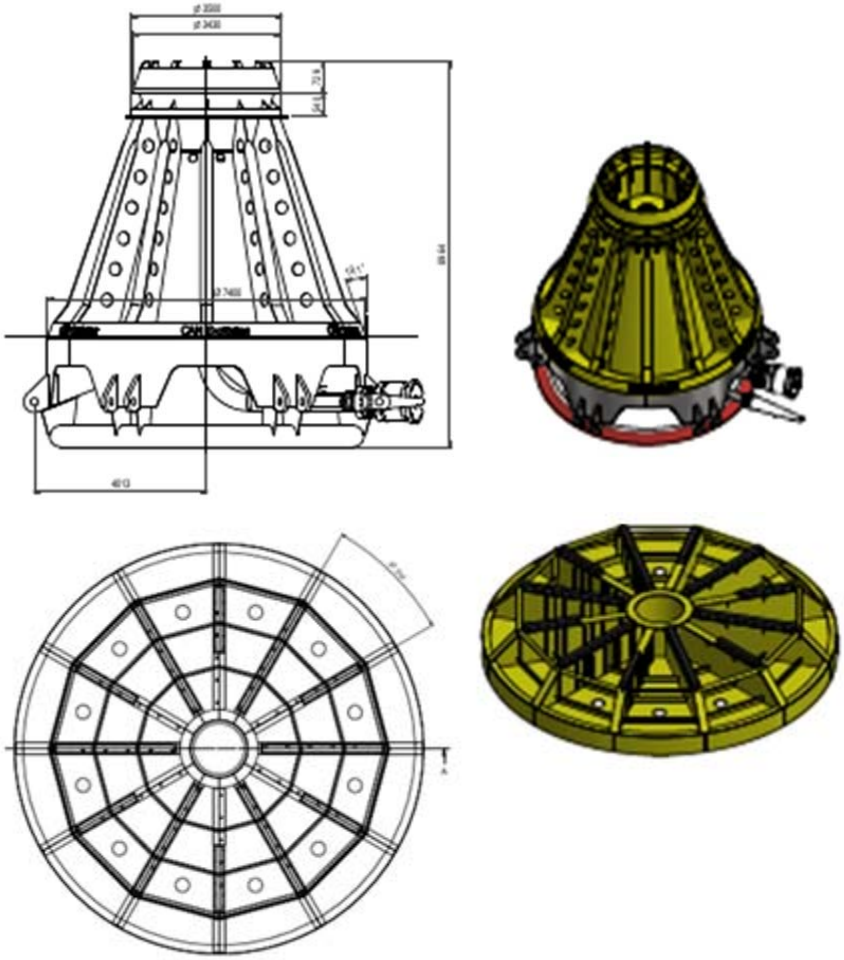
2.1.2 Mooring and Riser System

A turret mooring system will be utilized to maintain FSRU position and offload gas to the subsea pipeline.

2.1.2.1 Turret Buoy and Mooring

The FSRU connects with the buoy system by mating with a cone shaped turret, or plug (Figure 2-3) via a compartment at the forward end of the vessel. The plug is 7.4 m wide and 8.96 m tall. A circular landing pad, 14.6 m in diameter and 2.42 m in height, will be attached to the plug prior to installation. The landing pad is designed to support the impact load from buoy and supply enough friction for the buoy to stay in position (on the sea floor) during 100-year storm.

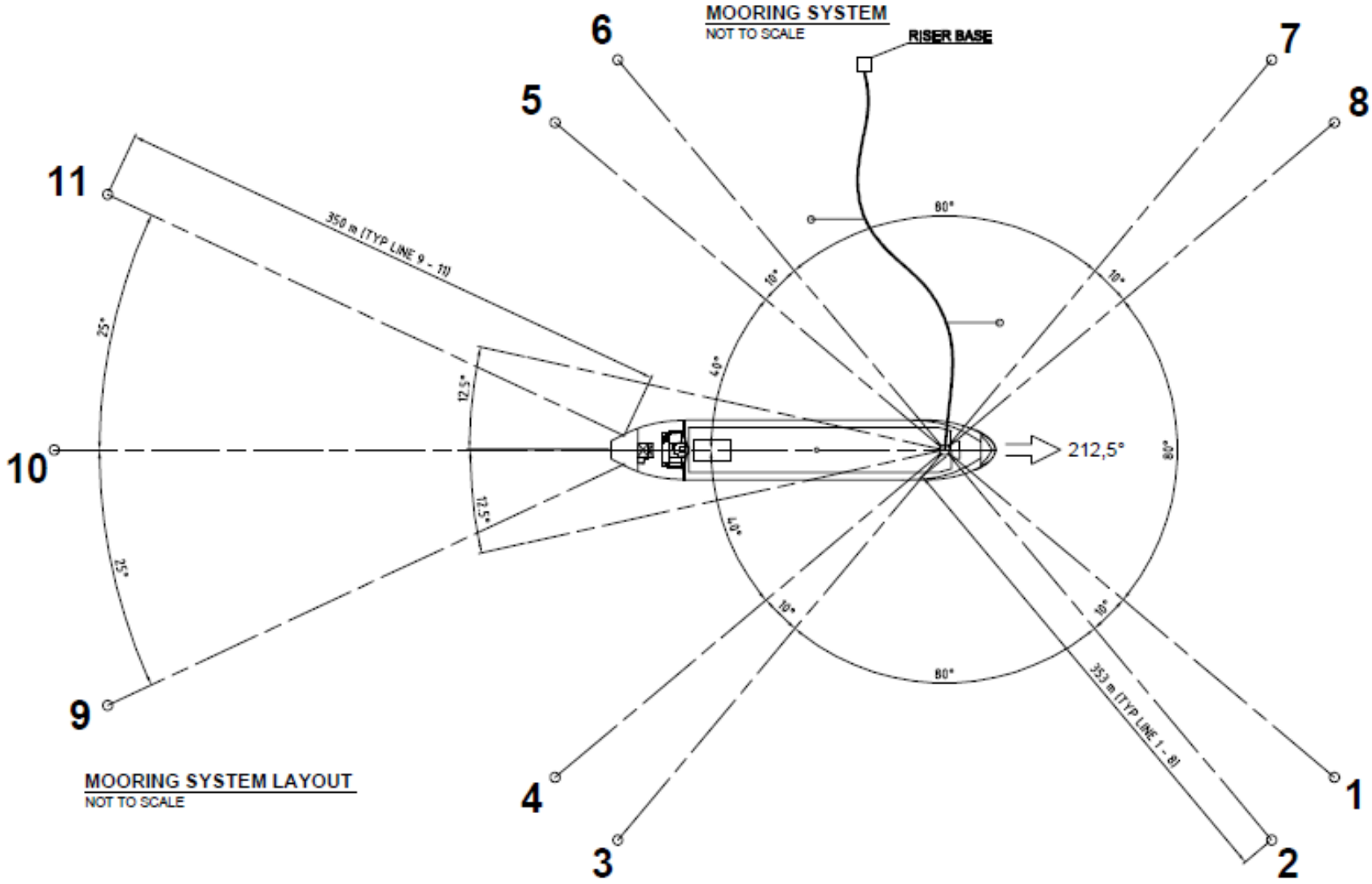
Figure 2-3: Turret and Pad



Source: Geocean

A layout of the mooring system layout is provided in Figure 2-4. Eight mooring lines and three stern heading control lines will connect to the bottom of the turret and each secured to the sea floor with suction piles (Figure 2-5 and Figure 2-6). Each pile is up to 10 m in diameter and 7 m in height. Combined, the eleven piles will permanently disturb approximately 864 m^2 of the ocean floor. The final anchor positions will be identified based on geotechnical survey results and continued engineering works.

Figure 2-4: Mooring System Layout



Source: Geocean

Figure 2-5: Suction Piles in Storage

Source: Excelerate

Figure 2-6: Suction Piles during Transportation

Source: Geocean

The mooring lines are 350 m in length, of which 300 m are 155 mm polyester rope and 50 m are 84 mm studless chain. The stern heading control lines are also 350 m in length, but entirely made of 155 mm polyester rope.

The turret connection is made via a swivel which allows the vessel to weathervane and naturally find the heading with least stress on the system when stern anchors are disconnected. The anchoring and mooring systems' design criteria ensure that the buoy is designed to bear the forces produced by both the FSRU and an LNG carrier moored alongside. The system is capable of withstanding a 100-year storm condition for safety and reliability.

2.1.2.2 Stern Heading Control System

As mentioned above, the turret allows for free weathervaning. However, during the early metocean analysis and availability study, it was determined that fixing the heading would allow for greater availability for ship-to-ship mooring. The system will consist of two active stern heading control lines and a third line for redundancy (lines "9", "10", and "11" shown in Figure 2-4). As recommended in the availability study performed by Marin, the system will have the ability to adjust seasonally to account for predominant current direction. The system is designed to bear the forces produced by both the FSRU and an LNGC moored alongside. The lines will be outfitted for quick release in the event of an emergency. Operationally in severe weather, the lines will be disconnected and the FSRU allowed to free weathervane.

2.1.2.3 Riser, Pipeline End Manifold and Pipeline

Natural gas sent out from the FSRU will flow into a 14-inch inner diameter flexible riser attached to the buoy. The flexible riser section will extend from buoy to the pipeline end manifold (PLEM) on the ocean floor. The riser will have sufficient flexibility to allow the buoy to move within the design range allowed by the moorings.

From the riser, natural gas will flow through the PLEM (Figure 2-7), which is where connection is made between the riser and the pipeline. The primary PLEM equipment is listed below, and a diagram is shown in Figure 2-8:

- Skirted foundation (design will be confirmed after geotechnical survey)
- 24" main header equipped with a manual operated ball valve (piggable)
- 14" branch equipped with a fail-safe closed valve over-ridable by ROV or by diver and a manual operated ball valve
- Bleed block welded to the 14" branch

Figure 2-7: PLEM Example

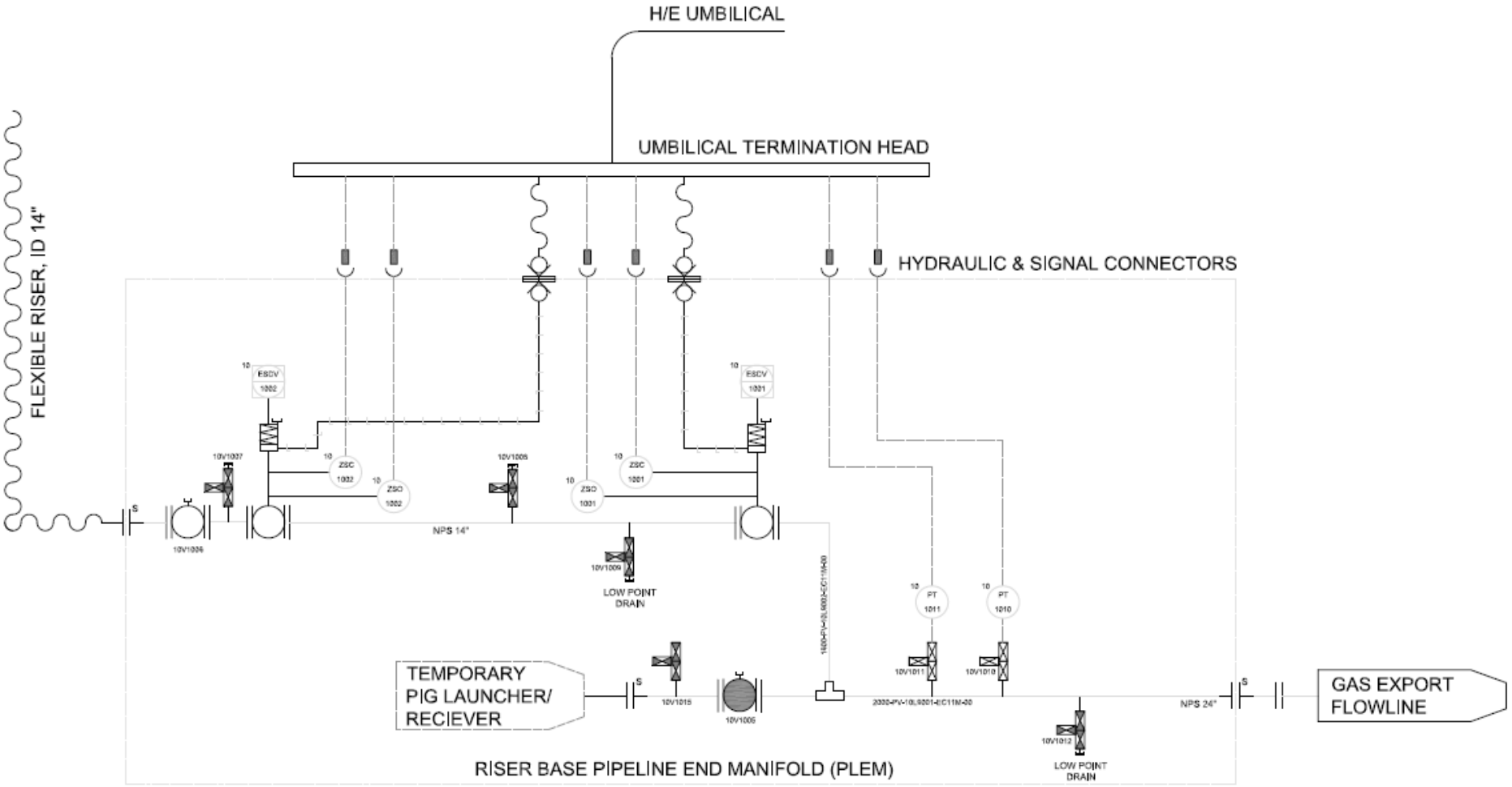
Source: Excelerate

The PLEM will be prefabricated specifically for the physical conditions at the terminal location. An umbilical will be installed parallel to the riser in a piggyback configuration to allow control of PLEM valves from the FSRU. If riser integrity is lost, a fail-safe valve on the PLEM would close.

In addition to providing the connection between the flexible riser and the pipeline, the PLEM will also host manual valves and pigging equipment for use during installation. The PLEM will be located on the seafloor and occupy an area of approximately 12 m^2 (3 m x 4 m).

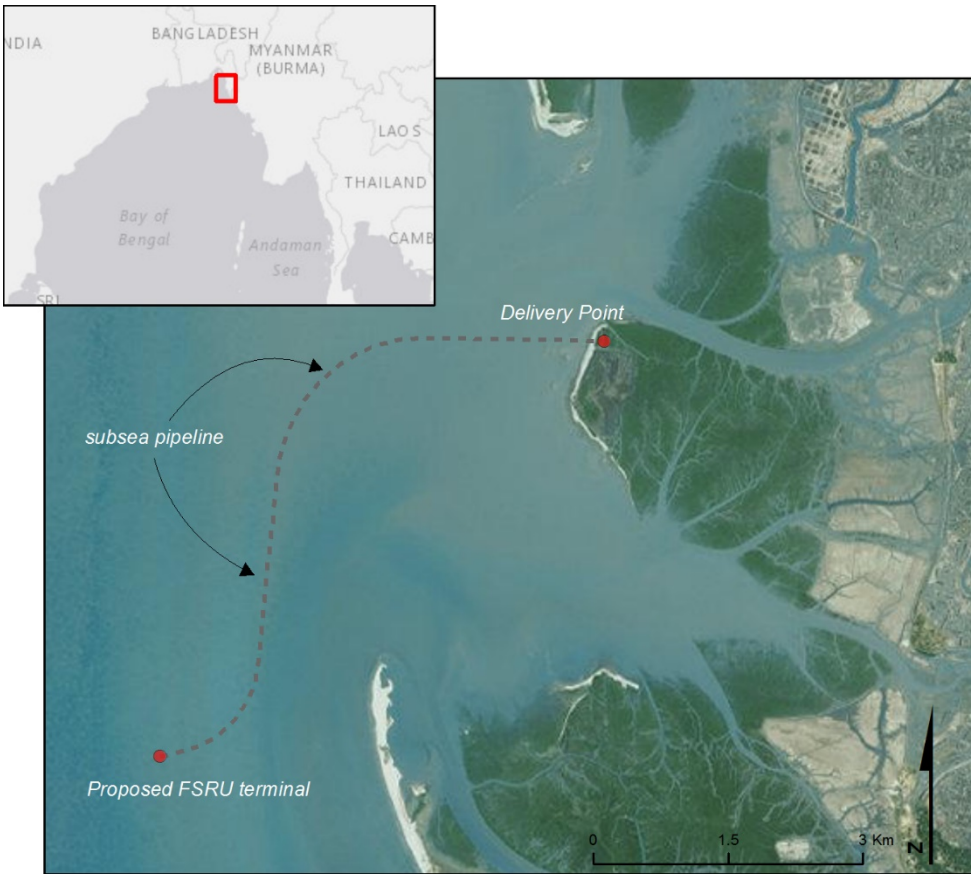
From the PLEM, natural gas will travel 7.5 km through a newly constructed 24” subsea pipeline to the Delivery Point onshore (Figure 2-9). From the Delivery Point, gas will travel through GTCL’s pipeline and feed the national grid.

Figure 2-8: Dual Emergency Shutdown PLEM Diagram



Source: Geocean

Figure 2-9: Preliminary Pipeline Route



Source: RPS ASA

2.1.3 Delivery Point

The onshore Delivery Point is the tie-in location of Excelerate's offshore pipeline to the existing onshore pipeline, and used for conducting routine pipeline maintenance, including pigging (during pre-commissioning only)[1], and to isolate the pipeline in case of emergency or as required for maintenance. The Delivery Point will include the following components, as depicted in Figure 2-10:

- Three (3) 24in class 600 manual ball valve
- One (1) 4in class 600 ESD valve
- One (1) 24in insulation joint
- One (1) 24in tee
- Seven (7) 24in flange class 600
- One (1) pig launcher/receiver
- Two (2) bends

[1] A temporary pig launcher will be installed on the sea floor during Pre-commissioning. No regular pigging anticipated.

Construction of the Delivery Point and installation of the pipeline will require temporary occupation of an approximately 90 x 90 m (8,100 m^2) area on the shore located adjacent to the Delivery Point, of which an area of approximately 75 x 70 m (5,250 m^2) are mangroves that will be cleared. Excelerate will primarily be storing materials on barges and thus minimizing the area needed for the construction yard. After construction, approximately 75% of the site will be reclaimed, and an area of approximately 45 x 45 m (2,025 m^2) will be used permanently. The onshore infrastructure will be fenced, and a roof installed over the equipment. No overland access or roads will be required. All access to the site will be from the sea.

2.1.4 Support Vessels

During construction, the Project will be supported by a number of offshore support vessels, including:

- Pipeline barge, the Geocean *Protis*
- Cargo barge
- Two ocean going tugs
- Multicat shallow draft vessel
- Fast crew boat

During operation, the project will be supported by:

- Three ocean going tugs (type Robert Allan RAstar 3200s or similar)
- One ocean going tug / support vessel (type SVITZER's 75/45 MSV or similar)
- Fast crew boat

LNG carriers will deliver LNG to the terminal approximately every 5 days based on a sendout rate of 500 MMSCFD. LNG carriers will have maximum cargo capacity between 125,000 to 220,000 m^3, a maximum overall length of 320 m and maximum permitted draft of 12.5 m.

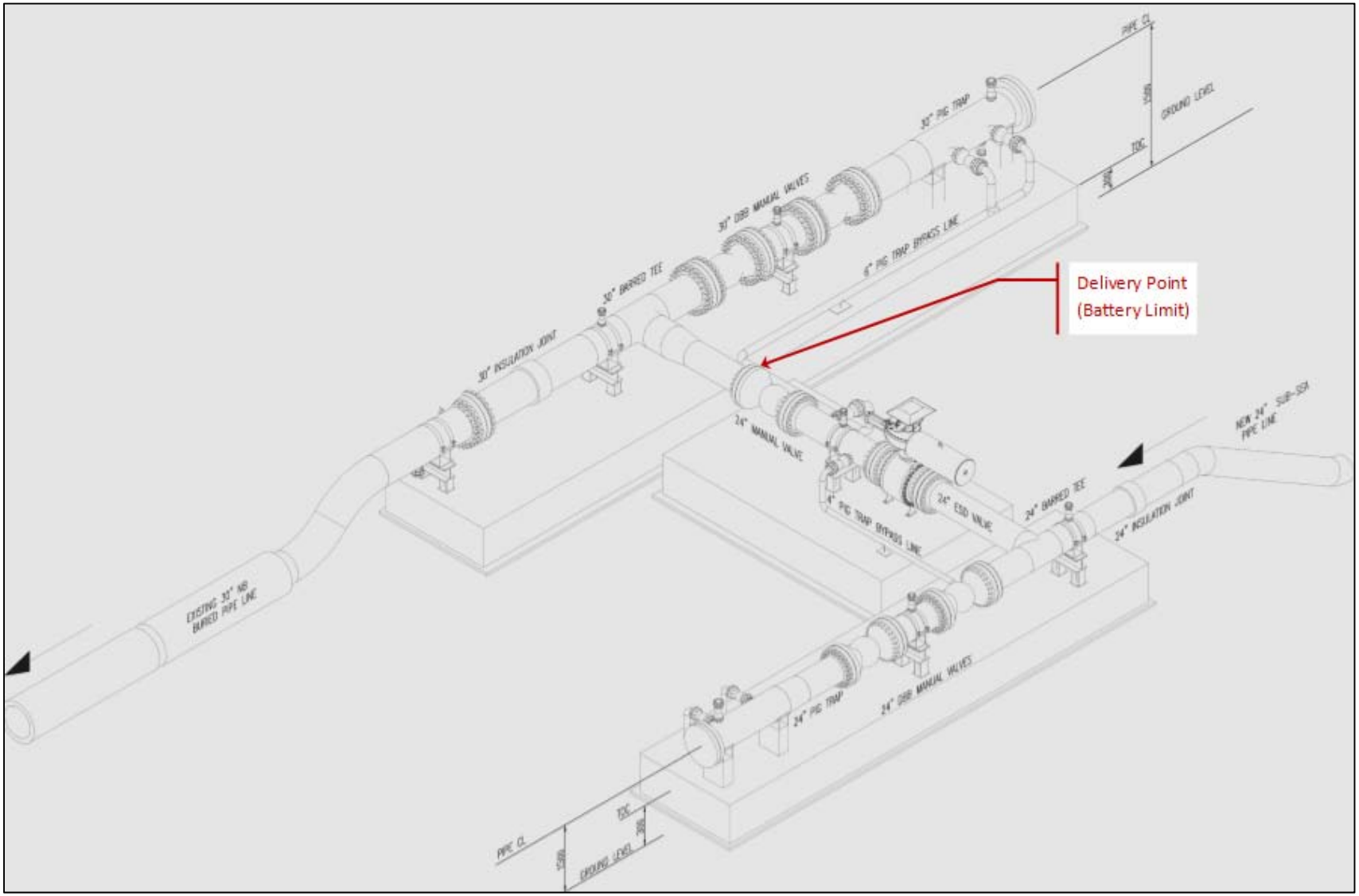
2.2 Location

Moheshkhali Floating LNG will be located approximately 2.4 km offshore Sonadia Island (a distinct feature of the Island of Moheshkhali), approximately 20 km northwest of Cox's Bazar in Bangladesh (Figure 2-11). Proposed coordinates for the Delivery Point and terminal location are provided in Table 2-2. Final siting will be determined pending results of the geotechnical and geophysical survey and navigability and waterway suitability assessment. The project will be located almost entirely offshore.

Table 2-2: Coordinates of Key Project Components

Point Name	Northing	Easting
Proposed Terminal Location (Subject to Change)	21° 32' 04.00"N	91° 49' 07.00"E
Delivery Point (Proposed)	21° 34' 22.74" N	91° 51' 46.83" E

Figure 2-10: Onshore Delivery Point Layout and Battery Limits



Source: Excelerate

Figure 2-11: Project Location

Source: Acorn International

2.3 Schedule

Construction is expected to begin in Q4 2017 and last approximately four months, and the terminal is expected to be in operation in 2018. Additional detail is provided in Table 2-3.

Table 2-3: Duration and Timing of Pre-Operational Project Phases

Project Phase	Expected Duration	Timing
Engineering, Procurement, and Mobilization	16 months	August 2016 – December 2017
Construction and Commissioning	4 months	December 2017 – March 2018

2.4 Project Phases

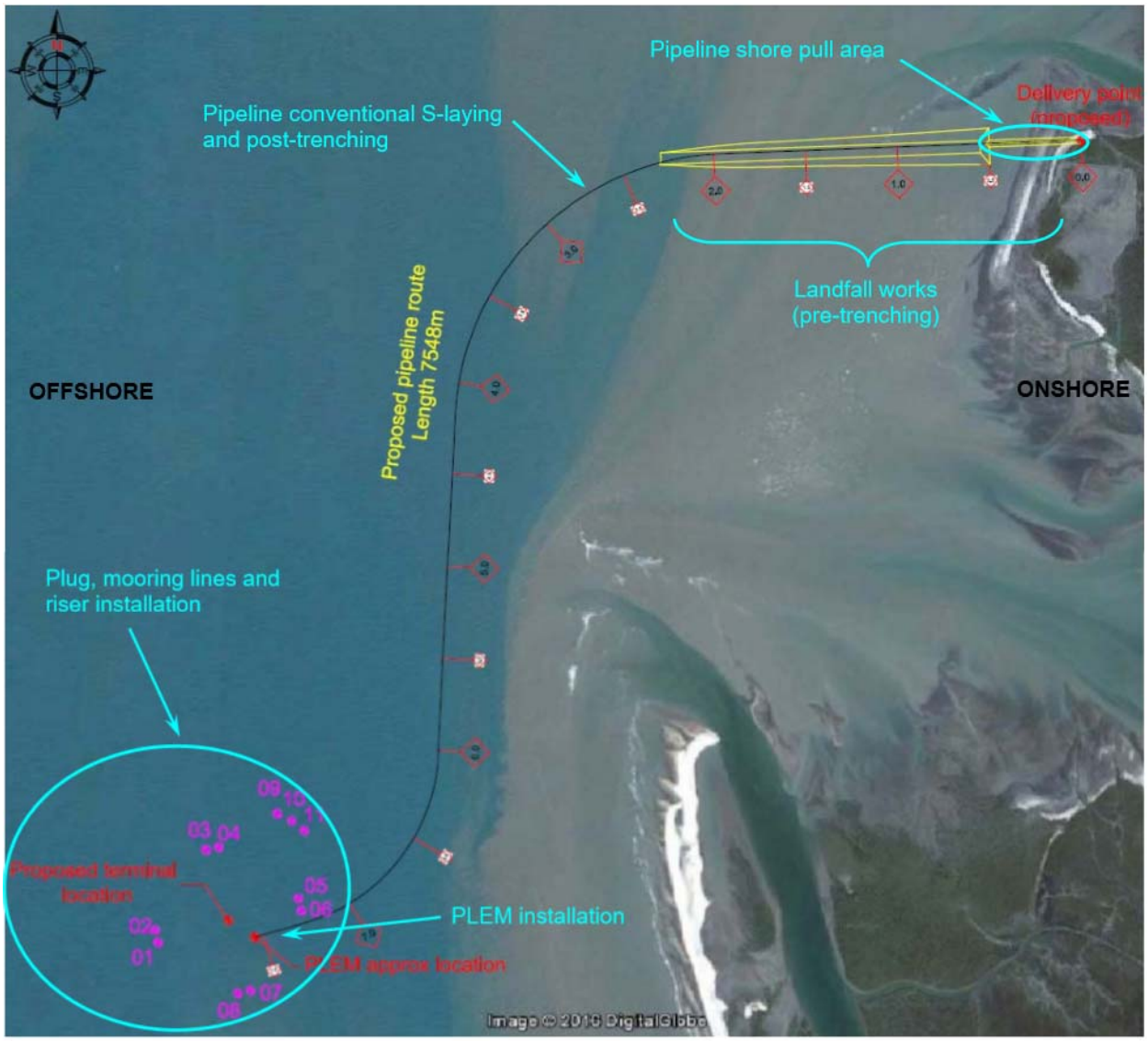
2.4.1 Engineering, Procurement and Mobilization

Engineering and design will be finalized after completion of geophysical and geotechnical surveys, site survey, and other studies. Once completed, Geocean/Excelerate will proceed with procurement of project components. Once procurement and fabrication are complete, equipment, vessels and personnel will be mobilized to the terminal location in Bangladesh.

2.4.2 Construction and Commissioning

Key stages of the construction and commissioning phase are described below. An overview of general works is shown in Figure 2-12.

Figure 2-12: General Works Overview



Note: pink numbers indicate locations of suction pile moorings

2.4.2.1 Landfall Preparation and Pre-trenching

Prior to any installation operations the landfall approach will be prepared. The pipeline will run approximately 7.5 km between the delivery point (0 km) and the FSRU (7.548 km). Pre-trenching will include:

1. Pre-trenching of the landfall channel by amphibious (land/water) excavators (0 km – 0.5 km).
2. Hydraulic dredging of the main approach area for lay barge access (0.5 km – 2.287 km).

In addition to offshore works, the onshore site will be prepared and equipment installed.

Landfall Channel Pre-trenching

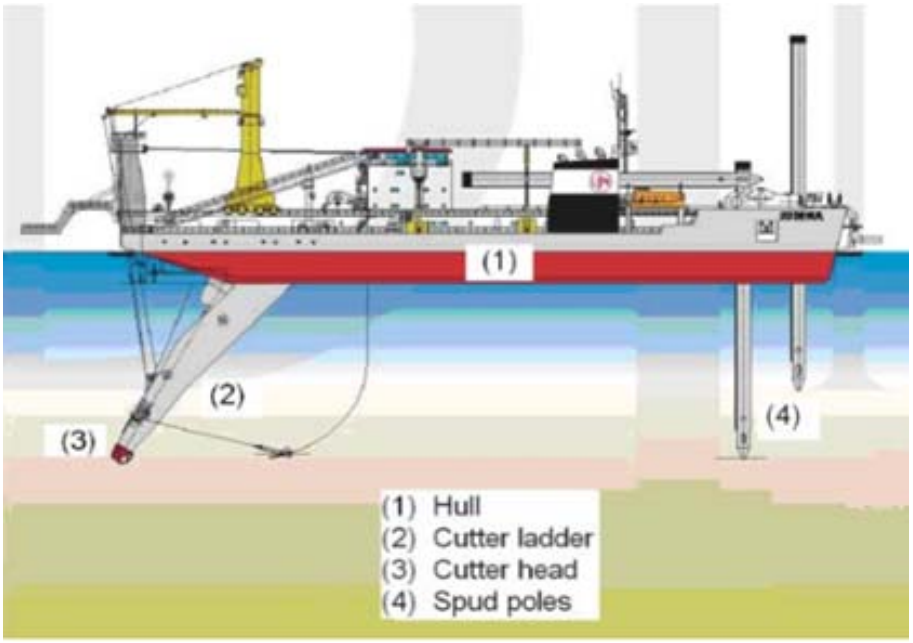
Landfall channel pre-trenching will take place prior to pipeline installation and will entail excavation of a landfall channel between the onshore delivery point and a location approximately 500 m seaward. Excavation will be achieved using a marine autonomous excavator (e.g. GEOCEAN MAX or SuperMAX). The first portion of this route will extend across the beach, into the intertidal zone and eventually to water depths of 3-4 meters. Approximately 350 m of the trench route lies seaward of the low tide line where sediment resuspension and transport by waves and currents are active processes. The sediment volumes for pre-trenching activities were calculated based on a 500 m long trench approximately 2 m deep and 5 m wide at the base.

Offshore Dredging

The second stage of construction involves the deepening of an offshore approach area from the landfall channel to a depth of 6 m below low tide (0.5 km- 2.287 km) to provide continuous access for the pipeline lay barge. The barge will remain in this channel during pipe laying operations until it reaches deeper areas. The dredged area will be 60 m in width and extend approximately 1,787 m in the cross-shore direction, roughly parallel to the pipeline route.

Excavation will take place by hydraulic dredging, either a cutter suction dredger (Figure 2-13) and/or trailing suction hopper dredger (Figure 2-14), with dredged sediments transported to an offshore discharge location by floating pipeline or hopper.

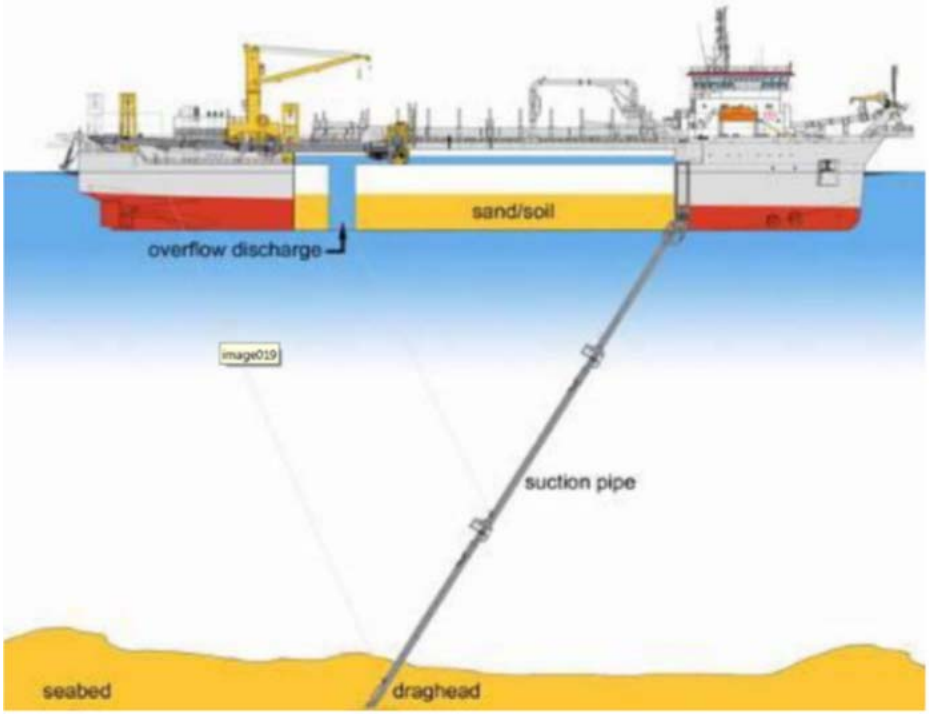
Figure 2-13: General Layout of Cutter Suction Dredger



Source: Geocean

The cutter suction dredger is a stationary vessel, equipped with a cutter ladder (or cutter arm) which pivots up and down around a pin that connects it to the vessel. At the end of the ladder is a cutter head, a rotating tool equipped with blades that create a mixture of soil and water that is pumped up the ladder to the main pump(s). The mixture is then discharged hydraulically through a floating hose towards the discharge location.

Figure 2-14: General Layout of Trailing Suction Hopper Dredger



Source: Geocean

The TSHD is equipped with a suction pipe fitted with a drag-head, which is trailed over the side of the vessel on the seabed. The soil is loosened and removed from the seabed to form the trench by a combination of: the suction provided by the dredge pump, the forward motion of the vessel, and the cutting and jetting actions of the drag-head teeth and jets. The dredged material is stored in the hopper, and then dumped offshore.

Onshore Preparation

In addition to the pre-trenching and offshore dredging, the temporary construction yard will need to be prepared, including potential clearance of vegetation and leveling. The onshore footprint is expected to be small (maximum of 90 x 90 m) and earthworks will be limited. Specialized equipment will be used to avoid installing a cofferdam, and to thus minimize environmental impact.

Once earthworks are complete, a 500t linear winch will be installed on the beach to support installation of the pipeline (Figure 2-15). The winch is powered by a hydraulic unit, and can be assisted by a storage winch to wind the pulling wire onto the spooler.

The linear winch is held in position with an anchor, typically a Stevshark which is previously buried below the surface, behind the winch spread. The Stevshark anchors are designed to drag and hold in soils from very soft clay to sand and hard clay. Holding capacity of the anchor and depth of burial will be defined with detailed design.

Figure 2-15: Onshore Winch

Source: Geocean

2.4.2.2 Pipe Laying and PLEM Installation

The 24” pipeline will be installed from the GEOCEAN PROTIS lay barge, with the pipeline pulled-in onto the beach towards the onshore proposed delivery point. The lay barge is assisted with anchor handling vessels, including one small draft multipurpose vessel (Multicat). The actual pulling distance is 2,300m, to be confirmed with detailed design. The typical sequence for the pulling wire deployment includes:

- A messenger wire rope is deployed from the beach to the lay barge location by means of workboat and Multicat
- On the beach, the messenger rope is connected to the pulling wire
- The Multicat or other assistance boat recovers the messenger rope with its winch, and recovers the pulling wire
- The pulling wire is laid on the seabed approximately at 0.5 km, with a recovery marking buoy
- On the beach, the pulling wire is set in the linear winch
- Offshore, the lay barge approaches 0.5 km, and recovers the other extremity of the pulling wire with the deck crane
- Pulling can then commence

Figure 2-16: Geocean Protis Lay Barge

Source: Geocean

The pipeline will be installed using the “S-lay” method. In the S-lay method, single lengths of steel pipe (“joints”), are welded, inspected and coated in a horizontal working plane (“firing line”) on board a pipelay vessel. The first joint is attached to the onshore winch, which maintains tension on the pipe. The vessel then moves forward and the pipe gradually exits the vessel, curving downward through the water until it reaches the seabed.

Cathodic protection will be applied by aluminium sacrificial anode. The pipe will be coated with concrete to provide stability, and additional stability will be provided by post trenching (see 2.4.2.3 below).

Once pipelaying is complete, the pipeline will be cut to length. The PLEM will then be lifted by crane to the deck of a barge, the pipeline recovered from the sea floor, PLEM installed on barge, then both will lowered in place to the sea floor.

2.4.2.3 Post Trenching

After the pipeline has been installed the following post-trenching activities will be required:

1. Post-lay trenching of the offshore portion of the pipeline via sledge (0.5 km – 7.548 km).
2. Burial of the landfall section following shore pull of the pipeline (0 km – 0.5 km).

Post-lay Trenching

The pipe will be direct laid on the bottom, then post trenching will be performed using a sledge that will lower the pipe by jetting water at the pipes edge. A diagram of process is shown in Figure 2-17 and example sledge shown in Figure 2-18. The lowering process using the sledge will take up to a month with several passes anticipated to reach desired depth (top of pipe 1m below sea bottom). Post trenching could potentially disturb 15 m width of sea bottom along the 7.5 km length of the pipeline, but it will be important to avoid damage to the pipeline and potential resulting impact to the seafloor and benthic communities from anchoring or trawling by other vessels in the area.

Figure 2-17: Post Trenching Diagram

Source: Geocean

Figure 2-18: Example Post-trenching Sledge

Source: Geocean

Landfall Burial

The first section of pipeline (approximately between 0 km and 0.5 km), after its installation by shore-pull in the landfall trench, will be buried using a marine autonomous excavator (e.g. GEOCEAN MAX or SuperMAX) depending on availability and tide level.

2.4.2.4 Mooring Installation

Prior to installation of the turret buoy, eight suction piles will be installed at the end of each mooring line. The suction piles will be transported horizontally to location then secured and lifted by crane to the vertical position and lowered to the sea floor. During lowering the piles will gain momentum and self-penetrate into the seabed. After an initial penetration into the seabed a subsea pump be applied within the pile, which forces the remainder of the pile to embed itself further to the desired depth. A visual inspection will be made by remote operated vehicle (ROV) or manually by a diver. Pump and rigging will then be released and the barge will proceed to the location of the next pile.

2.4.2.5 Buoy and Landing Pad Installation and Mooring Line Tie In

The buoy and landing pad will be physically connected together on a barge, then lowered with a crane to the sea floor. The mooring lines will be tied in to the plug manually by air divers.

2.4.2.6 Riser and Umbilical Installation

The flexible risers will be transported on reels on a dynamically positioned installation vessel and unreeled into position in the water. Divers will then connect a pull line and the riser will be threaded through the center of the buoy where it would be secured. The PLEM end of the riser will then be lowered to the seafloor and divers will then attach it to the PLEM.

2.4.2.7 Installation of Valve Station

A permanent onshore valve station will be installed. Construction of the valve station will involve clearing, grading, and compacting the site to the surveyed elevations where necessary for placement of concrete foundations for buildings and to support other equipment. Prefabricated segments of pipe, valves, fittings, and flanges are welded at a fabrication yard or on-site, and assembled at the site.

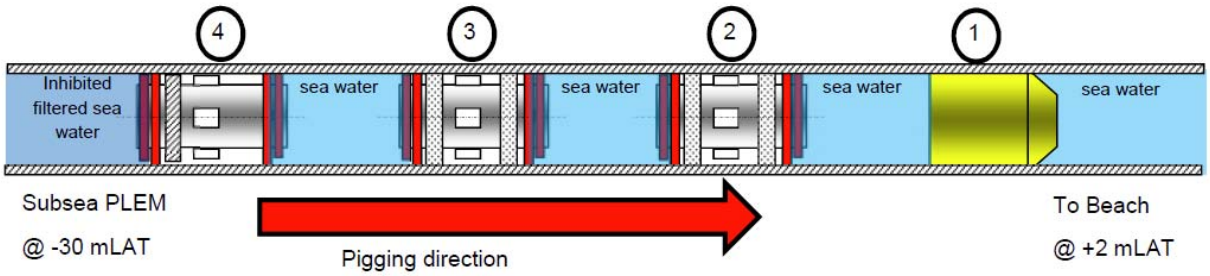
2.4.2.8 Pre-commissioning and Commissioning

Pre-commissioning involves verifying that the buoy system and pipeline are ready for service, e.g. equipment has been properly installed and is working, and controls and communications systems are functional. Commissioning involves acceptance testing, e.g. meeting the sendout requirements for a set period of time.

Pigging

To ensure the pipeline has been properly installed, it will be pigged from a support vessel via two downlines (4'' x 50 m long each connected to the pig launcher on the sea floor) after tie in to the PLEM. The pig train will include a sequence of four pigs, separated by sea water. No chemical additives are anticipated. However, if the pipeline is flooded for an extended period, sea water with dye and corrosion inhibitor (inhibited sea water) will be added, as indicated in Figure 2-19. This operation will require a one-time use of approximately 1,550 m^3 of water. Details of the potential chemical additives are shown in Table 2-4. Pigs will be recovered via the permanent pig receiver at the Delivery Point onshore. Hydrotesting fluids will be tested to ensure compliance with applicable standards prior to discharge. As required by the World Bank EHS Guidelines for Offshore Oil and Gas development, a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring will be prepared.

Figure 2-19: Pig Train Diagram (Quality)



Source: Geocean

Table 2-4: Potential Pigging Chemicals

Product Name	Company	Chemical Classification[2]	Function	Volume Required	Contingency Volume	Total Potential Volume
PRESERVA N 2140	Clariant Oil Services UK Ltd	Gold	Dye	141 L	141 L	282 L
PRESERVA N 650	Clariant Oil Services UK Ltd	Blue	Corrosion Inhibitor	705 L	705 L	1,410 L

Source: Geocean

Hydrostatic Testing

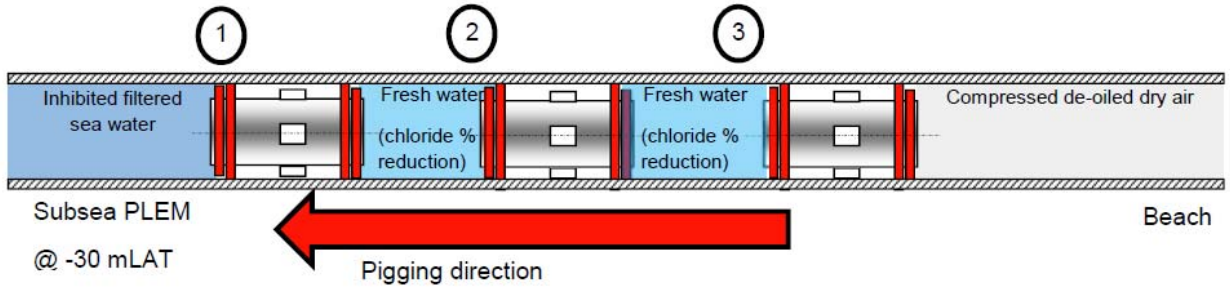
After pigging, the pipeline will be hydrostatically tested to ensure the system is capable of withstanding the designed operating pressure. This process involves pressurizing the pipeline from the beach with seawater (or inhibited sea water if required, per above) to the maximum allowable operating pressure, and then maintaining that pressure for a period of 24 hours.

Dewatering

Following successful hydrostatic testing, the pipeline will be dewatered using a second pig train. The pig train (Figure 2-20) will include a sequence of three pigs separated by 5.25 m^3 of fresh water, followed by compressed, de-oiled air. As no water intake is required, the dewatering will be performed from the beach. Sea water (or inhibited sea water, if required) will be discharged to sea after testing and treatment to applicable standards, and pigs recovered. As required by the World Bank EHS Guidelines for Offshore Oil and Gas development, a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring will be prepared.

[2] Using the Chemical Hazard and Risk Management (CHARM) model

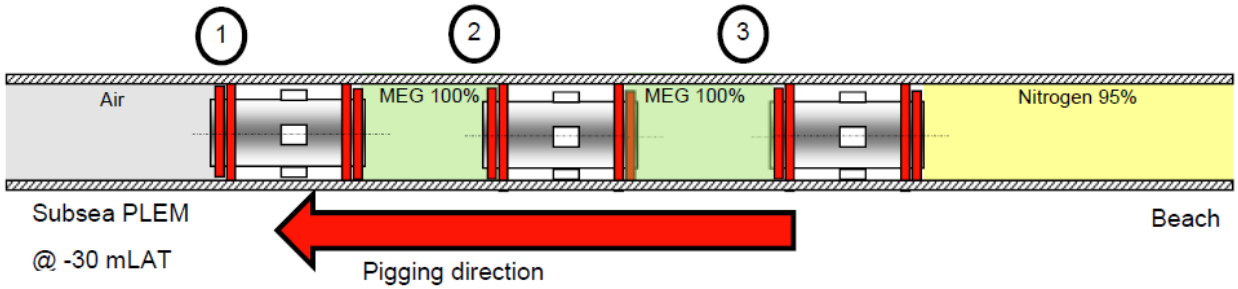
Figure 2-20: Pig Train Diagram (Dewatering)



Source: Geocean

Monoethylene Glycol Swabbing and Nitrogen Packing
Dewatering will remove most of the water in the pipeline. To remove the remaining water and prevent hydrate formation during first gas, the pipeline will be swabbed with Monoethylene Glycol (MEG), followed by compressed nitrogen air (Figure 2-21). Including a 20 percent contingency, 2.4 m^3 of MEG will be required. Nitrogen gas produced by membrane units will be injected into the pipeline from the Delivery Point after the pigs as a packing gas. It is anticipated that most of the MEG will remain distributed in the pipeline. The pigs and any residual MEG will be captured in the temporary pig trap, the valve sealed, and brought to the surface for proper disposal.

Figure 2-21: Pig Train Diagram (MEG Swab and Nitrogen Packing)



Source: Geocean

Riser Leak Test and Dewatering
After the pipeline is dewatered, the riser will be tested for leaks (particularly from riser/PLEM connection tightness) then also dewatered. This operation can be performed before or after buoy installation. To leak test, a mix of 80 percent MEG and 20% fresh water will be injected into the riser from the surface (total of 9.5 m^3) and pressure tested. A gel pig will then be used for riser dewatering. The gel pig will be propelled by compressed air from surface and extruded via bleed valves connected to a hose to the surface, where the liquids will be contained and disposed of at appropriate facilities. Any remaining water in the riser will be 80 percent MEG which will prevent hydrate formation during first gas introduction.

Commissioning
After successful pre-commissioning, the FSRU will begin commissioning (acceptance testing) which involves meeting the sendout requirements (i.e. 500 MMSCFD at 78barg) for a set period of time. Once full terminal commissioning is complete, offloading natural gas under normal operations will begin (see Section 2.4.3).

2.4.2.9 Restoration

After construction is complete, final clean-up and restoration will be completed. This involves removal of equipment and debris, and restoring the site. Grading, erosion prevention and revegetation will be conducted.

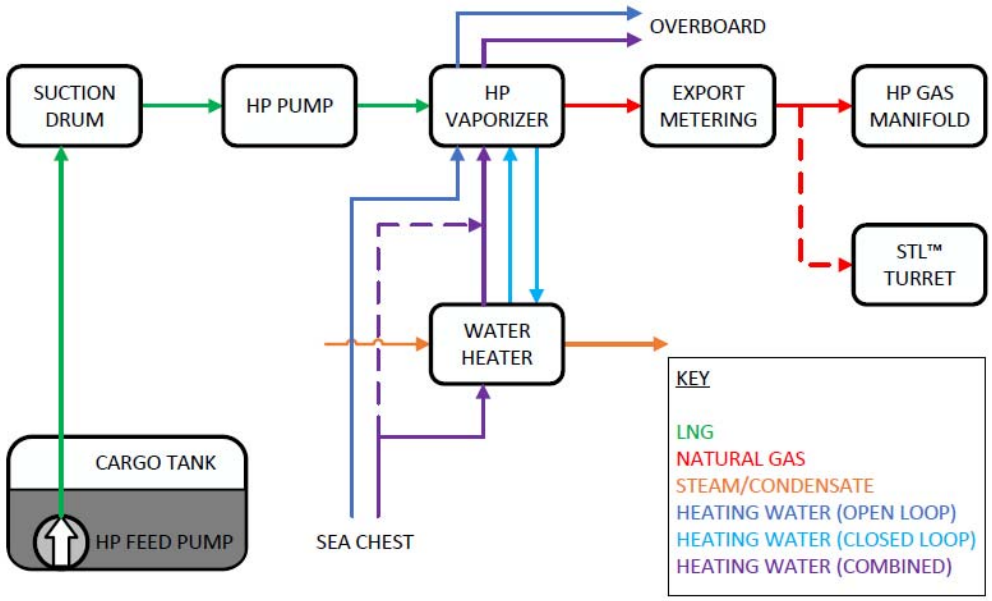
2.4.3 Operation

LNG will be transferred from LNG carriers to the FSRU storage tanks by the LNG carrier cargo pumps. During unloading, LNG will displace vapor inside the FSRU storage tanks, which will be returned to the LNG carrier via a vapor return line. Excess boil off gas ("BOG") generated during the transfer is routed to the FSRU BOG compressors and used as fuel or recondensed.

During normal operation, BOG is produced in tanks and lines as it is heated from the surroundings. BOG will be compressed, recondensed, and returned to the LNG stream feeding the regasification plant. LNG from the storage tanks is sent by the in-tank pumps to the recondenser on its way to the suction drum. This provides the cooling required to recondense the BOG. From the suction drum the LNG is fed into the multistage LNG High Pressure Pumps prior to vaporization in the vaporizers. After the vaporizers the gas is metered and discharged into the terminal piping via the turret connection.

A process flow diagram is provided in Figure 2-22.

Figure 2-22: Process Flow Diagram



Source: Excelerate

2.4.4 Decommissioning

After the 15 year contract term, ownership of all permanent infrastructure (e.g. turret buoy, moorings, PLEM, riser, pipeline, and onshore infrastructure) and the FSRU will transfer to the Government of Bangladesh.

2.4.5 Ancillary Activities

Port facilities, likely in Chittagong, will be required during construction and operation for material supply, waste management, and offices. No new port facilities are expected to be developed for this project. Three tugs and one tug/supply vessel will be required to support the project during operation. Support vessels will be located onsite near the FSRU, in port, likely Chittagong, or in route between the two locations. Required port, office, and storage facilities will be identified during early works.

A fast crew boat will be used to transfer personnel to the FSRU during operation.

2.5 Personnel

Construction will require approximately 280 personnel, ~80% of which will be onboard the vessels at all times. The number of persons working onshore will be limited to those supporting pulling assistance, onshore pipeline installation, and connection and pre-commissioning activities. All personnel will be housed on the vessels, except for those based at port which are expected to number up to 10. Once in operation, expected personnel present will decrease to 34, with beds available for maintenance/ specialist teams to visit the FSRU. Personnel will work on rotational shifts and will live on the support vessels and or FSRU during their on-duty schedule. At the conclusion of a duty schedule, workers will be transported by crew boat to Chittagong and will be replaced by relief workers. Expatriate off-duty workers will likely take commercial flights from Bangladesh to their home country for their off-duty schedule.

Personnel required for construction and operation will require specialized, trained workers likely to be sourced from outside of Bangladesh. Local labor is not required by local regulation or contracts, but may be sourced for the following:

- Dock workers for loading and unloading materials to and from supply vessels at the port
- Local hotels, restaurants, driver and security personnel to support in-country staff and offshore staff during any crew changes
- Agents for travel assistance and import/export clearance
- Selected crew for some positions on the support vessels

Indirectly, the project will also require:

- Government officials to support the project through permitting, security (i.e. Navy), and monitoring
- Assistance from port authorities and customs to clear vessels and cargo
- Support from international airport for staff entering and exiting Bangladesh

2.6 Natural Resource Use

The FSRU will utilize the open-loop vaporization mode which requires direct seawater intake and discharge for LNG regasification. Additionally, other standard vessel operations will require seawater use, whether the FSRU is in standby mode or vaporization mode. These operations include maintaining the vessel's main cooling systems, ballast water requirements, and saltwater desalination system for hoteling and sanitary purposes. Other uses for seawater may include maintaining the water curtain during ship-to-ship transfer, and the fire main systems. These emergency functions and systems have dedicated pumps with an approximate combined capacity of 880 m^3/hr to 890 m^3/hr, and will be periodically tested as part of emergency drill protocols.

The normal water use of the FSRU will be up to approximately 420,500 m^3/day, of which 215,800 m^3 support the vaporizer demand for regasification. Approximately 200,700 m^3 are used to support machinery cooling such as air conditioning compressors, heat exchangers and main condenser cooling.

The remaining 4,000 m^3 are used for the water curtain, only used during ship-to-ship transfer, the freshwater generator, and marine growth prevention system. There will also be intake and discharge of ballast water, which is subject to fluxes dependent upon LNG cargo loading, regasification processes, vessel stability, and sea conditions. Ballast management will vary with the regasification storage need and natural gas sendout demand. Hydrostatic testing will also require one-time use of approximately 1,550 m^3 of water. Key seawater intake and discharge volumes are summarized in Table 2-5.

All water used in support of FSRU operations will be drawn through two (2) sea chests: starboard low, port high. The high sea chest will be located on the rounded portion of the hull near the bilge, while the low sea chest will be located further down on the flat portion of the hull. Seawater is drawn horizontally through the high sea chests and vertically through the low sea chests.

The total open area for the high and low sea chests is approximately 18.12 m^2. Under normal water use capacity, the calculated through-screen velocity of water entering the sea chests is approximately 0.14 m/sec. Mesh size on grates of the sea chests are 2.21 cm slots will mitigate fish, turtles and other large fauna from entrainment, but will not act to abate entrainment of planktonic organisms. Water drawn through the sea chests will be circulated through seven main vessel operating systems (Vaporizer Heating Water, Main Condenser Cooling, Auxiliary Seawater Cooling, Water Curtain, and Freshwater Generator) and will then be discharged at various outfall locations along the deck and hull.

The Marine Growth Preventative System (MGPS) will withdraw a minor volume of water for the application of self-generated sodium hypochlorite (~0.5ppm) solution into the sea chests for the purpose of marine biofouling control.

Consumptive volume from the freshwater generator will be used for freshwater supply for sanitary water demand, boiler make up water and potable supply. Excess water not needed during operations will be discharged as part of the freshwater generator effluent.

Table 2-5: Summary of Key Seawater Intakes and Discharge Volumes

System	FSRU Seawater Intake*	FSRU Seawater Discharge*
	m^3	m^3
Vaporizer Heating Water	215,800	215,800
Main Condenser Cooling System	178,000	178,000
Auxiliary Seawater Cooling System	22,700	22,700
Safety Water Curtain (only during LNG transfer from LNG carriers)	2,270	2,270
Ballast Water	As needed**	As needed**
Freshwater Generator	1,135	1,025
Marine Growth Preventative System (MGPS)	606	606
Total	**420,511**	**420,401**
**Based on standard continuous operation of an Excelerate FSRU in open loop regasification.*		

** *Discharge based upon loading rate and buoyancy compensation needs for the FSRU*		

2.7 Discharges, Emissions and Wastes

Wastes will be generated from a variety of activities. Excelerate recognizes the need to minimize waste generation in the course of the proposed project and to handle such wastes in accordance with Bangladesh law, good international industry practices, international law, and lender standards. Main operational discharges, emissions, and wastes are described below.

2.7.1 Discharges

The project will result in routine discharges and non-routine discharges, as described below.

2.7.1.1 Vaporization Heating Water

LNG will be vaporized using open-loop shell-and-tube vaporizers. Approximately 215,800 m^3 of sea water will be used per day during the vaporization process to heat LNG at a sendout rate of 500 MMSCFD. The cooled sea water will be discharged to sea at a maximum rate of 9,000 m^3/hr. Vaporization water will be 9^o C colder than ambient ocean temperature when discharged. In accordance with the World Bank General EHS Guidelines, the discharge will not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone.

2.7.1.2 Main Condenser Cooling Water

The FSRU utilizes steam from the two (2) main boilers to drive the main propulsion turbine and turbo generators that provide power for the vessel's propulsion, auxiliaries, and electrical power generation. As part of the vessel's normal operation of systems, seawater is used for condensing exhaust steam in the main condenser. The FSRU's main condenser cooling system will be required to operate under normal capacity of water intake and discharge conditions. During each of these periods of normal capacity water use, this system will require the dedicated intake and discharge of up to approximately 178,000 m^3 of seawater per day.

Intake water will circulate through the main condenser cooling system and then be discharged through a 55-inch diameter pipe 5.3 to 7.4 meters below the sea surface. The primary role of this water is to provide for heat dissipation in the main condenser of the FSRU. Cooling water for main condenser will be discharged at a maximum rate of 7,400 m^3/hour from a subsea port at 5-10^o C warmer than the ambient ocean temperature. Cooling water from freshwater cooling system will be discharged at a maximum rate of 940 m^3/hour from a subsea port at 6.5^o C warmer than the ambient ocean temperature. In accordance with the World Bank General EHS Guidelines, the discharge will not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone.

2.7.1.3 Auxiliary Seawater Service Cooling

Other systems requiring seawater cooling services are supplied from the main seawater cooling pumps and provide seawater to the main condenser vacuum pump coolers, central fresh water cooler heat exchangers, and MGPS. In accordance with the World Bank General EHS Guidelines, the discharge from the auxiliary seawater cooling system will not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone.

2.7.1.4 Water Curtain

For safety purposes it is common practice for LNG vessels to maintain a constant flow of water, referred to as a “water curtain”, over the deck and hull of the vessel during the transfer of LNG between ships (“STS”). In the event of a leak of LNG during these operations, the water curtain will help protect the steel hull from potential cracking or stress. Approximately 2,270 m^3 of seawater per day will be required to maintain this water curtain during STS operations. The seawater used to support this system will enter into the vessel using either the high or the low sea chests. Water will then be pumped onto the deck of the FSRU before being discharged over the sides of the vessel as runoff. In accordance with the World Bank General EHS Guidelines, discharge will not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone.

2.7.1.5 Freshwater Generator

Water for the freshwater generator will enter the vessel through either starboard and port high and low sea chests. Non-used seawater within the systems will be discharged with slightly higher salinity content due to consumptive use of freshwater generator. The primary effluent component in this outfall will be brine-enriched seawater. Freshwater consumptive use will include potable supply for ship board use for drinking and sanitary supply. Freshwater supply will also be needed for boiler supply and make up water. Excess volume from the freshwater generator not used for sanitary use or boiler supply will be stored on the vessel in its Fresh Water and Distilled Water tanks. The freshwater cooling system will discharge excess seawater at a maximum rate of 42 m^3/hour from a subsea port at 22.5^o C warmer than the ambient ocean temperature. In accordance with the World Bank General EHS Guidelines, the discharge from the freshwater generator will not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone.

2.7.1.6 Ballast Water System

The *Excellence* and support vessels will operate in accordance with International Maritime Organization (IMO) regulations, including MARPOL 73/78. During international transit to Bangladesh, ballast water will be exchanged in international waters over 200 nautical miles from the shore in accordance with IMO requirements to prevent the introduction of non-native species to Bangladeshi waters. The regulation of ballast water discharges is primarily intended to prevent the import of non-native species from other sea areas.

Ballast water will also be discharged in response to on-going FSRU operations and vessel stability needs. Volume of ballast intake and discharge will vary by ballast tank volume, vessel operation status and sea conditions. Depending upon the regasification process demand, flows to / from ballast tanks could range as high as 10,000 m^3/hr when in use.

Since the FSRU is remains stationary onsite, the water drawn into and discharged from the tanks will be of same origin.

The *Excellence* has dedicated ballast tanks which are not used to store other liquids, so the water they contain cannot be contaminated with oil or chemicals. No biocide or other additives will be needed for ballasting.

Records of ballast transfers will be recorded and quantities noted.

2.7.1.7 Fire System

Seawater for the firewater system will be sourced through two firewater pump intakes located in the aft section of the FSRU. This system will be used only in an emergency and during monthly system tests.

2.7.1.8 Deck Drainage and Wash Water

Runoffs, such as clean rain water and wash waters, will be allowed to drain to sea through sea scuppers. All deck scuppers will be tightly plugged. During rainfalls, the aft scupper will have to be opened periodically in order to drain out the water retained on main deck, after checking for cleanliness. This may only be done upon instructions of the officer on the watch. Drain Plugs must be present on all driptrays around oil tank ventilations, manifold and hydraulic motors on deck, and must be in plugged position during cargo operations. As with scupper plugs, driptrays may have to be periodically opened during rain to drain excess water. Prior to opening, a visual inspection is carried out to ascertain that the water is clean and free from oil. Any oily residues are removed by absorbent sheets or similar techniques. Plugged driptrays are then put back when draining is finished. Deck drainage and wash water are permitted under MARPOL 73/78 Annex V as long as they are not harmful to the environment.

2.7.1.9 Bilge Water

Bilge wells and some drains are routed to the Bilge Holding Tank. This holding tank can be emptied by pumping it to the large evaporation tank. All water will be evaporated and normally the only residues in the evaporator tank are salt-like deposits. These residues can be cleaned out by hand and disposed as solid garbage.

Another tank, the Oily Bilge Tank, will receive dirty water/oil from the oily water separator, from maintenance activities (e.g. wash water, sinks), or from anything returning from the incinerator waste oil tank. From time to time the contents of the Oily Bilge Water tank will be pumped to the smaller waste oil incinerator tank where any water will be evaporated as well. Generally, all oils and other dirt accumulate in the Oily Bilge Tank and removed manually using drums which are shipped to shore for disposal. Under MARPOL 73/78 Annex I, bilge water only be discharged if en route, if discharge contains less than 15 PPM of oil, and if an oil discharge monitoring and control system and oil filtering equipment is operating.

2.7.1.10 Sanitary Waste

Operation of the FSRU will also result in generation of sanitary wastes. Sanitary wastes include grey water (drainage from dishwater, shower, laundry, bath, and washbasins) and sewage (drainage from toilets, urinals). Water contributing to these wastes will consist of the freshwater generated by the FSRU's on-board desalination system which will service these needs. All sanitary wastes will be treated via onboard Sewage Treatment Plant that meets IMO requirements and discharged. Under MARPOL 73/78 Annex IV, discharge of treated sewage can be discharged as long as the effluent does not produce visible floating solids, not discoloration of the surrounding water.

2.7.1.11 Food Waste

Food waste will be treated by a BioHiTech Eco-safe Digester and disposed of together with grey water discharges, in compliance with MARPOL 73/78.

2.7.1.12 Hydrotest Water

Following installation of the pipeline it will be filled with seawater for hydrostatic testing. This operation will require a one-time use of approximately 1,550 m^3 of water. If the pipeline is left submerged for an extended period, which is not anticipated, dye and corrosion inhibitors will be

added to the water (described above). After completion, the sea water (or inhibited sea water, if required) will be discharged to the ocean. As required by the World Bank EHS Guidelines for Offshore Oil and Gas development, a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring will be prepared.

2.7.2 Emissions

The operation of the *Excellence* FSRU will result in continuous and non-continuous air pollutant releases, primarily from combustion emission sources. Fugitive and vented releases of natural gas may also occur. The quantities released would be expected to be small under normal operations and consist primarily of methane, with much smaller amounts of volatile organic compounds in the gas.

The combustion sources on the FSRU include the two boilers, the auxiliary generator, and the emergency generator. An incinerator is also located on the FSRU, but the operating plan is to remove all waste from the vessel and not use the incinerator. Therefore, it will not be a source of emission as long as this plan remains in effect.

Each of these sources will emit nitrogen oxides (NO_x), sulfur oxides (SO_x, mostly sulfur dioxide), carbon monoxide (CO), methane (CH_4), and volatile organic compounds, as well as carbon dioxide (CO_2) resulting from the combustion of hydrocarbons. Since both boilers will be fueled with natural gas, NO_x emissions are of primary concern, with the other conventional air pollutants generally considered to be negligible. In the case of the diesel engines used on the generators, NO_x and SO_x emissions are of primary concern—the latter due to the sulfur in the fuel. Particulate matter emissions will also occur from the combustion of liquid fuels but given the expected fuel sulfur content, their emissions levels will be less than one-tenth of those of sulfur oxides.

2.7.2.1 FSRU Emissions at Contracted Sendout Rate

The FSRU emission sources are listed in Table 2-6. This table is based on the FSRU operating continuously at the contracted sendout rate of 500 MMSCFD. The grams per second emission rates shown in the table for each source are the instantaneous emissions for the indicated load, while the tonne/year figures are the total emissions for the indicated load and the indicated operating hours per year.

At the sendout rate of 500 MMSCFD, the auxiliary diesel generator is not used, as all of the electricity is generated by the steam turbine generators. Therefore, no operating hours are shown for it. The smaller emergency generator is assumed to run for only two hours each month for testing.

The result of this operating scenario is that virtually all of the emissions come from the two boilers, and that NO_x is the only significant conventional air pollutant of potential concern.

Table 2-6: FSRU Operating Air Pollutant Emissions at 500 MMSCFD Sendout

Source	Rating	Load	Operating hours/year	Fuel Consumption	SO_x		NO_x	
					g/sec	tonne/yr	g/sec	tonne/yr
Boiler 1	71 MWth	35.8%	8760	1511 kg NG/hr	0.031	0.99	1.95	61.6
Boiler 2	71 MWth	35.8%	8760	1511 kg NG/hr	0.031	0.99	1.95	61.6
Diesel Generator*	3650 kWe	NA	0	NA	0	0	0	0
Emergency Generator*	500 kWe	100%	24	93 kg Diesel/hr	0.78	0.07	1.68	0.15

*Fueled with MDO or MGO having a maximum sulfur content of 1.5%. SOx emissions are based on 1.5% S.

The NOx emissions for the boilers shown in Table 2-6 are based on a measured NO_x flue gas concentration of 157 ppm (dry). This figure is approximately the same as the World Bank Environmental, Health, and Safety (EHS) Guidelines value of 320 mg/Nm^3 (at 0 C and 1 atm.) which is equivalent to 156 ppm. This guideline value applies to boilers of up to 50 MWth heat input. Together the two boilers listed in the table will have a heat input of 46.6 MWth under the conditions shown.[3]

The NO_x emissions factor for the emergency generator, 12.1 g/kWh, was calculated using the emissions limit for marine diesel engines in MARPOL 73/78 ($45.0 \times n^{-0.2}$ g/kW-hr for $130 \leq n < 2000$ where n is the rpm of the engine) because the vessel was constructed to this MARPOL standard. The SO_x emissions were calculated based on a fuel sulfur content of 1.5 percent.

2.7.2.2 FSRU Emissions When Contracted Sendout Rate is Exceeded

The sendout from the FSRU may at times exceed the contracted sendout rate of 500 MMSCFD. The amount of time it exceeds this rate, and the amount by which it exceeds it, depends on the demand for natural gas. For the purposes of conducting an alternative emissions inventory, the ESIA team has assumed that it may operate up to 10 percent of the year at a sendout rate of 600 MMSCFD.

When the FSRU operates at sendout rates greater than 500 MMSCFD, continuous operation of the diesel generator is required. According to Excelerate, this is because the capacity of the turbine generators are exceeded under those conditions, and therefore the diesel generator must be used. The emissions that occur during this sendout rate are summarized in Table 2-7. The tonnes per year figures are based on 876 hours per year of operation at the higher sendout rate.

[3] World Bank Group. 2007. Environmental, Health, and Safety (EHS) Guidelines, General EHS Guidelines. Washington DC, April 30, 2007 (Table 1.1.2, p.7).

Table 2-7: Excellence FSRU Operating Air Pollutant Emissions during 600 MMSCFD Sendout

Source	Rating	Load	Operating hours/year	Fuel Consumption	SOx		NOx	
					g/sec	tonne/yr	g/sec	tonne/yr
Boiler 1	71 MWth	36.8%	876	1553 kg NG/hr	0.032	0.10	2.01	6.33
Boiler 2	71 MWth	36.8%	876	1553 kg NG/hr	0.032	0.10	2.01	6.33
Diesel Generator*	3650 kWe	30%	876	252 kg Diesel/hr	2.10	6.61	3.68	11.6

*Fueled with MDO or MGO having a maximum sulfur content of 1.5%. SOx emissions are based on 1.5% S.

As shown in Table 2-7, while operating, the diesel generator is the largest source of both NO_x and SO_x emissions. The latter would be expected since the fuel oil burned by the generator is assumed to have a sulfur content of 1.5 percent, while the natural gas consumed in the boilers contains negligible sulfur.

The NO_x concentrations in the boiler flue gas are the same in Table 2-7 as in Table 2-6: 157 ppm. The diesel NO_x emissions are based on the same emission factor for 12.1 g/kW-hr. This is equivalent to 1560 mg/Nm^3 in the exhaust gas. The corresponding IFC EHS Guidelines value for diesel engines is 1460 mg/Nm^3 (or up to 1,600 if justified to maintain high energy efficiency). The same publication gives a guideline value of 1.5 percent sulfur for the generator fuel oil, which is the limit for the fuel that will be burned.

Combining the figures in Table 2-6 and Table 2-7 for the scenario in which the FSRU operates 90 percent of the year at 500 MMSCFD and 10 percent of the year at 600 MMSCFD results in its having total annual NO_x emissions of 135 tonnes and total annual SO_x emissions of 8.7 tonnes, including all the sources listed in Table 2-8.

Table 2-8: Excellence FSRU Annual Operating Air Pollutant Emissions based on 90% Operation at 500 MMSCFD Sendout, 10% Operation at 600 MMSCFD Sendout

Source	Rating	Operating hours/year	SO_x, tonne/yr	NO_x, tonne/yr
Boiler 1	71 MWth	8760	0.99	61.8
Boiler 2	71 MWth	8760	0.99	61.8
Diesel Generator*	3650 kWe	876	6.61	11.6
Emergency Generator*	500 kWe	24	0.07	0.15

*Fueled with MDO or MGO having a maximum sulfur content of 1.5%. SOx emissions are based on 1.5% S.

2.7.2.3 Emissions from LNG Carrier

During the time that the FSRU is being filled with LNG, additional emissions will come from the LNG carrier. These emissions will result from the LNG carrier operating its boilers at partial load during the LNG unloading process.

LNG carriers are expected to arrive at the FSRU once per week, and to take two days to unload. This amounts to 2,503 hours of operation annually. While these operations are not part of the terminal itself, they will occur along with and adjacent to the terminal. The emissions resulting from a typical LNG carrier are shown in Table 2-9. The figures in this table are based on carrier operating at partial load burning natural gas with the emission rates per unit of fuel consumption equivalent to those of the FSRU.

Table 2-9: LNG Carrier Operating Air Pollutant Emissions

Source	Rating	Load	Operating hours/year	Fuel Consumption	SOx		NOx	
					g/sec	tonne/yr	g/sec	tonne/yr
Boiler 1	50 MWth	55.5%	2503	1652 kg NG/hr	0.034	0.30	2.11	19.0
Boiler 2	50 MWth	55.5%	2503	1652 kg NG/hr	0.034	0.30	2.11	19.0

2.7.2.4 Greenhouse Gas Emissions

Carbon dioxide is the principal greenhouse gas emitted by the FSRU. Any vented or fugitive emissions of methane (CH_4) are expected to be small in comparison. Carbon dioxide emissions associated with the principal FSRU combustion sources are shown in Table 2-10. Total annual CO_2 emissions are slightly below 75,000 tonnes per year. These emissions are based on the FSRU operating 90 percent of the year at a sendout rate of 500 MMSCFD and 10 percent of the year at a sendout rate of 600 MMSCFD. Emissions from the LNG carrier are not included in this table because greenhouse gas emissions are not of concern for local air quality and the accounting of the LNG carriers' emissions would be the responsibility of the owners or operators of the carriers.

Table 2-10: FSRU Annual Carbon Dioxide Emissions

Source	Operating hours/year	Annual Fuel Consumption, tonnes	Annual CO_2 Emissions, tonnes
Boiler 1	8760*	13,270 (Natural Gas)	37,026
Boiler 2	8760*	13,270 (Natural Gas)	37,026
Diesel Generator*	876	220.5 (Fuel Oil)	702
Emergency Generator	24	2.2 (Fuel Oil)	7
Total Emissions			74,761

*10 percent of these hours at a sendout rate of 600 MMSCFD, 90 percent at 500 MMSCFD

2.7.2.5 Emissions from Support Vessels

A variety of support vessels and associated equipment will be operated both during the construction of the FSRU terminal and during operations once the construction is complete. During construction, air emissions will be generated from supply vessels, excavators, bull dozers, generators, and other small sources. These emissions will be temporary and are considered negligible.

As listed in Section 2.1.4, during construction the Project will be supported by a number of offshore support vessels, including:

- Pipeline barge, the Geocean *Protis*

- Cargo barge
- Two ocean going tugs
- Multicat shallow draft vessel
- Fast crew boat

These vessels will be powered with diesel engines. Their principal air pollutant emissions will be of NO_x, SO_x and particulate matter. Total emissions will depend on the number of hours they operate during the construction period.

Also, as listed in Section 2.1.4, during operation, the project will be supported by:
- Three ocean going tugs (type Robert Allan RAstar 3200s or similar)
- One ocean going tug / support vessel (type SVITZER's 75/45 MSV or similar)
- Fast crew boat

Two of the tugs are expected to operate continuously for watch-keeping. Given this type of services, the engines would in most cases be run at a relatively small fraction of their rated loads. The other vessels would operate only when needed.

These vessels will also be powered with diesel engines, and the principal air pollutant emissions will be NO_x, SO_x and particulate matter. Due to their size and the mobile nature of the sources, which lead to dispersed emissions, these vessels' emissions are considered to be of minor significance in comparison to the emissions from the larger, fixed sources on the FSRU.

2.7.3 Wastes and Hazardous Materials

Non-hazardous and hazardous wastes routinely generated at LNG facilities include general office and packaging wastes, waste oils, oil contaminated rags, hydraulic fluids, used batteries, empty paint cans, waste chemicals and used chemical containers, used filters, spent sweetening and dehydration media (e.g. MEG), oily sludge from oil water separators, scrap metals, and medical waste, among others. All wastes will be stored, transported, and disposed of appropriately, per a Waste Management Plan that will be developed for the project.

2.8 Project Alternatives

Evaluating the alternatives to proposed projects is an important aspect of the ESIA Process. Feasible alternatives to the proposed project are limited, as the contract with the Government of Bangladesh mandated the location, vessel type and other key factors.

Alternatives considered for the project are described below.

2.8.1 Onshore vs. Offshore

The Government of Bangladesh selected to proceed with an offshore LNG import terminal utilizing FSRU. It is also considering development of an onshore LNG terminal at Moheshkali. Despite development of the offshore terminal, an onshore terminal may also be developed.

In this respect, these options are not mutually exclusive. The onshore alternative was eliminated from consideration because Excelerate proposed to use an FSRU that it currently owns and operates, and their proposal was selected.

From an environmental and social perspective, offshore development utilizing FSRU is clearly the preferred alternative given its limited footprint and distance from sensitive habitats.

2.8.2 Alternative Terminal Location

In 2011, Petrobangla commissioned Poten & Partners to conduct a site assessment for the FSRU development. The study concluded that terminal location options offshore Bangladesh are limited from a technical feasibility perspective, as at least 14 m water depth is required to accommodate LNG vessels and there are few locations nearshore Bangladesh that have sufficient depth. Locations far offshore were not considered feasible considering the metocean conditions. The Poten & Partners study considered two terminal locations. Both locations were offshore Sonadia Island, and were not materially different in terms of potential environmental and social impacts. Excelerate is currently conducting geophysical and geotechnical work to finalize the terminal location. However, any potential change in location from the proposed site would be limited, and is not considered to have a material difference in terms of potential environmental and social impact. Therefore, alternative location has been eliminated from further consideration.

Similarly, the onshore Delivery Point location was selected by Petrobangla and the pipeline has already been completed. Thus, no alternative pipeline route is technically or contractually feasible. Therefore, this alternative has been eliminated from consideration also.

2.8.3 Alternative Terminal Type

The Poten & Partners study also reviewed two terminal types, including:

1) Sea Island with dual berth
2) FSRU with fixed turret mooring

The sea island design was eliminated from consideration due to its requirement for siting in shallower water, its greater bottom disturbance and its potential for significant adverse impacts to coastal sensitivities and boating and fishing. It would also be more visually intrusive than the fixed turret mooring options due to its need to be located in water depths of less than 15 m, which would require it to be closer to shore.

2.8.4 Alternative Construction Schedule

Construction of the terminal will take approximately four months. Construction activities could potentially disrupt one critically endangered and two endangered wading birds, as well as other species that utilize habitats near the project site.

Based on the results of the month-by-month analysis of construction related effects, and the analysis of the seasonal abundance of each species, it is not possible to select a single, continuous, four-month construction window that is protective of all species of concern.

Further, Bangladesh has a seasonal climate with an extended rainy season. During the rainy season the seas become too rough for construction vessels to work. While small changes to specific activities within the construction window are considered in this report, schedules outside of the dry season are considered unfeasible and are not considered further.

2.8.5 No Action Alternative

If the Project did not take place, the potentially adverse impacts described in Chapter 5 would not occur. However, taking no action would also prevent the potential net positive benefits, such as increased electricity generation capacity and increased economic development. Based on the fact that the potentially adverse impacts are manageable and the potential benefits of the FSRU development, the “No-Action” alternative is not considered warranted.

2.9 Inherent Sector Risk

The oil and gas 'value chain' is complex and involves multiple market segments (i.e. exploration and production, transportation, refining, distribution, and marketing), each with a distinct set of risks and potential impacts. Moheshkhali Floating LNG includes transportation, storage and regasification of LNG, which has a lower risk profile than most oil and gas activities.

The physical and chemical properties of LNG render it safer than other hydrocarbons. LNG is a refined product composed almost entirely of methane. If LNG is spilled (on land or water), it vaporizes and leaves essentially no residue behind, unlike crude oil or other liquid hydrocarbons that can cause long-lasting impacts. Further, LNG facilities and vessels feature natural gas, fire, and smoke detection systems that identify hazardous situations and engage automatic shutdown systems that halt operations.

A 2014 report by the Society of International Gas Tanker and Terminal Operators (SIGTTO) estimates more than 77,000 commercial LNG cargoes have been safely delivered in the last 50 years with only 40 m^3 of LNG spills and "during this period there has been no loss of cargo tank containment and no fatalities directly attributable to the cargo." [4] Incidents that have occurred mainly involve problems with machinery (e.g. loss of propulsion and blackouts) and cargo handling systems (e.g. connection and disconnection of the marine loading arms). Of the four grounding events, none have resulted in loss of cargo.[5]

[4] Society of International Gas Tanker and Terminal Operators. 2014. LNG Shipping at 50.
[5] Woodward J.L. and R.M. Pitblado. 2010. LNG Risk Based Safety: Modeling and Consequence Analysis. Hoboken, New Jersey: John Wiley & Sons, Inc.

3 Regulatory Framework

This chapter details the regulatory framework applicable for the Moheshkhali Floating LNG project, including descriptions of: institutional structure, legislative framework, international treaties and conventions, and lender standards.

3.1 Institutional Structure

3.1.1 Ministry of Environment and Forests

The Ministry of Environment & Forest (MoEF) is responsible for planning, promotion, coordination and implementation of environmental and forestry programs[1]. MoEF oversees all environmental matters in the country and is a permanent member of the Executive Committee of the National Economic Council. The principal activities undertaken by MoEF include:

- Conservation and survey of flora and fauna
- Prevention and control of pollution
- Forest management and regeneration of degraded areas
- Protection of environment through promulgation and enforcement of environmental legislation

The MoEF includes the following sub-organizations:

- Department of Environment (DoE)
- Deportment of Forests
- Bangladesh Forest Industries Development Corporation (BFIDC)
- Bangladesh Forest Research Institute (BFRI)
- Bangladesh National Herbarium (BNH)
- Bangladesh Climate Change Trust (BCCT)

3.1.1.1 Department of the Environment

The Department of Environment (DoE) is the technical arm of the MoEF that is responsible for environmental planning and management. Responsibilities include: conducting surveys, managing the impact assessment and permitting procedures, inspection and monitoring of industry activities, knowledge management and training, environmental conservation, and pollution prevention.

DoE is the responsible body for implementing and enforcing Environmental Impact Assessment (EIA) requirements, pursuant to the Environment Conservation Act, 1995. DoE has six divisional offices and is authorized to review and approve the EIA reports and to process and issue Environmental Clearance Certificates (ECC).

3.1.1.2 Department of Forests

The Department of Forests (DoF) is tasked with conservation of forests, environment and biodiversity and socio-economic development. Responsibilities include: implementing international treaties related to forests and biodiversity; managing wildlife resources; expanding ecotourism; managing coastal wetlands; and mangrove revegetation.

[1] The Ministry of Environment & Forest (MoEF). 2016. Homepage. Accessed from the MoEF website: http://www.moef.gov.bd/

3.1.2 Ministry of Fisheries and Livestock

The Ministry of Fisheries and Livestock is responsible for ensuring sustainable utilization and management of fisheries and livestock in Bangladesh.

The Ministry of Fisheries and Livestock includes the following sub-organizations:

1) Department of Fisheries
2) Department of Livestock
3) Bangladesh Fisheries Research Institute
4) Bangladesh Fisheries Development Corporation
5) Marine Fisheries Academy
6) Fisheries and Livestock Information Department

3.1.2.1 Department of Fisheries

The Department of Fisheries is responsible for developing fisheries related policies, managing fisheries resources, enforcing fisheries rules, conducting stock assessments, disseminating aquaculture technologies, and supporting fishermen through targeted development support.

There are administrative representatives at Division, District and Upazila (sub-district) levels headed by Deputy Director, District Fisheries Officer, and Senior/Upazila Fisheries Officer, respectively.

DoF manages three fish inspection and quality control stations, marine fisheries stations, a fisheries training academy, fisheries training and extension centers, and fish hatcheries.

3.1.3 Ministry of Power, Energy, and Mineral Resources

The Ministry of Power, Energy, and Mineral Resources (MoPEMR) includes two divisions:

1) Power Division
2) Energy and Mineral Resources Division

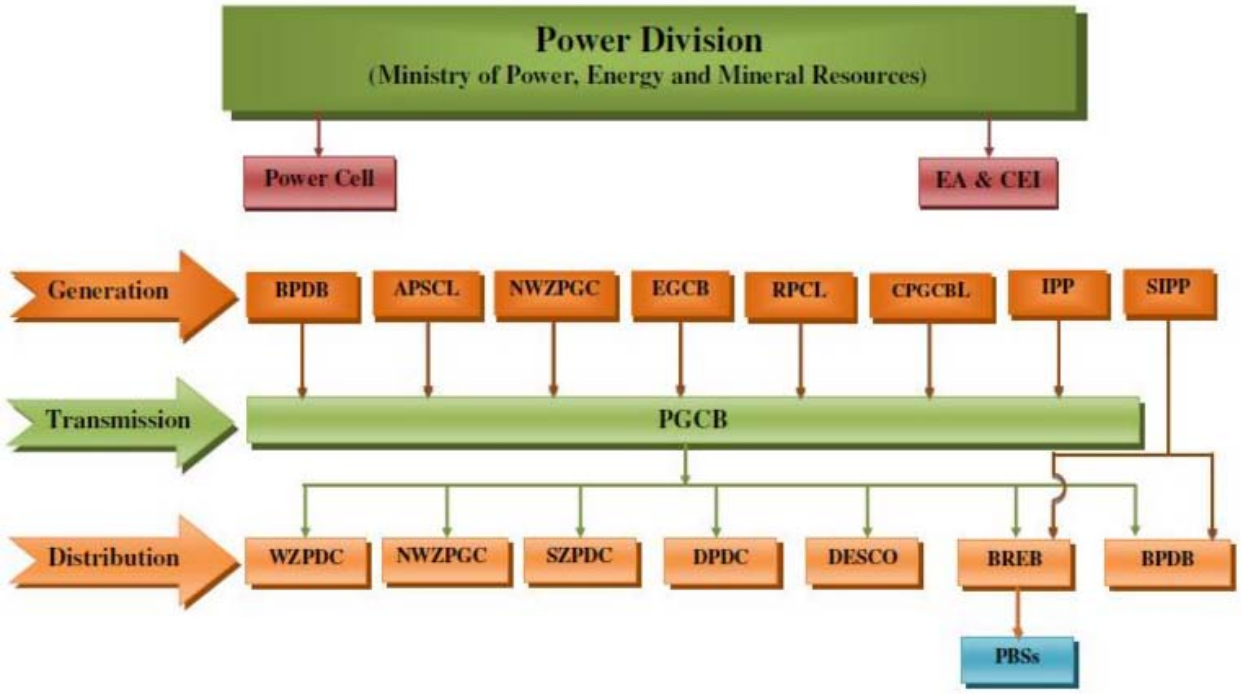
The Power Division's mission is to provide reliable electricity for all by 2021 through integrated development of power generation, transmission, and distribution system.

Major functions include:

- Managing all matters and policies related to the power sector
- Expanding, rehabilitating and modernizing power generation, transmission and distribution services in line with the increasing national demand and prepare action plans and programs accordingly
- Encouraging private and joint venture investment in the power sector, in addition to the government investment
- Improving the standard of living of the rural poor through rural electrification and the introduction of renewable energy
- Monitoring revenue earnings and commercial activities of the utilities
- Promoting renewable energy and energy efficiency through formulation of policy/regulation, different incentive mechanisms and research and design

The structure of the Power Division is shown in Figure 3-1.

Figure 3-1: Bangladesh Energy Sector Organizational Chart



Note: Acronyms include: EA & CEI: Electric Advisor and Chief Electric Inspector; BPDB: Bangladesh Power Development Board; APSCL: Ashuganj Power Station Company Ltd.; NWZPGC: North-West Zone Power Generation Company Limited; EGCB: Electricity Generation Company of Bangladesh Ltd.; RPCL: Rural Power Company Limited; CPGBL: Coal Power Generation Company Bangladesh Limited; IPP: Independent Power Producers; PGCB: Power Grid Company of Bangladesh Ltd.; WZPDC: West Zone Power Distribution Company Limited; SZPGC: South Zone Power Distribution Company Ltd.; DPDC: Dhaka Power Distribution Company Limited; DESCO: Dhaka Electric Supply Company Limited; BREB: Bangladesh Rural Electrification Board.
Source: Ministry of Power Energy and Mineral Resources, Power Division, 2016.[2]

3.1.3.1 Bangladesh Oil, Gas & Mineral Corporation

Bangladesh Oil, Gas & Mineral Corporation (Petrobangla) is the national oil company of Bangladesh. Although formally part of the MoPEMR, Petrobangla is intended to operate as a business enterprise. Through its subsidiaries it explores, produces, transports and sells oil, natural gas and other mineral resources. It also has the authority to enter into production sharing agreements with international oil companies for exploration and development of oil and gas resources in Bangladesh.[3]

Excelerate and Petrobangla signed a Terminal Use Agreement for the proposed project.

3.1.3.2 Department of Explosives

The Department of Explosives is part of the Energy and Mineral Resources Division. The mandate of the Department of Explosives is to prevent injury to people, and damage to property and the environment during manufacture, transport, transmission, storage, use, and/or handling

[2] Ministry of Power Energy and Mineral Resources, Power Division. 2016. Sector Structure. Accessed from the Power Division website: http://www.powerdivision.gov.bd/site/organogram/5733a5e4-2e3c-422d-8fbe-116b45a5597d/Sector-Structure
[3] Bangladesh Oil, Gas & Mineral Corporation (Petrobangla). 2016. Corporate History. Accessed from the Petrobangla website: http://www.petrobangla.org.bd/corp_history.php

of commercial explosives, compressed gases, flammable liquids, combustible solids, and oxidizing substances.[4]

The project is subject to safety regulation by the Department of Explosives.

3.1.3.3 Bangladesh Energy Regulatory Commission

The Bangladesh Energy Regulatory Commission (BERC) was established in 2003 by passage of the BERC Act to regulate electricity, gas, and petroleum products for the country.[5]
BERC is responsible for[6]:

- Ensuring efficient use, quality services, and safety of electricity generation and transmission, marketing, supply, storage and distribution of energy.
- Defining tariffs
- Approving and managing electricity licensing taking into consideration the load forecast and financial status
- Cooperating and advising the Government, if necessary, regarding electricity generation, transmission, marketing, supply, distribution and storage of energy
- Promoting competition and cooperation by licensees
- Ensuring control of environmental standards of energy under existing laws
- Ensuring appropriate remedy for consumer disputes, dishonest business practices or monopoly
- Resolving disputes between licensees and between licensees and consumers, and refer to arbitration if necessary
- Developing uniform methodology of accounting for all licensees to help ensure performance rating on a fair platform
- Collecting, reviewing, maintaining and publishing statistics of energy
- Framing and enforcing codes and standards in the sector
- Determining efficiency and standard of machinery and appliances, and conducting energy audits to verify, monitor, and analyze energy data
- Performing related functions to fulfill objectives of the Act

3.1.4 Ministry of Shipping

The Ministry of Shipping oversees shipping and port sectors, include national waterways, inland water transport, ports, ocean shipping, safety, and environmental matters related to shipping, and the regulatory aspects of maritime shipping and maritime education[7]. The Ministry is responsible for formulating policies and plans on the above subjects. Ministry of Shipping is comprised of 12 sub-organizations, including:

- Department of Shipping
- Chittagong Port Authority

3.1.4.1 Department of Shipping

The Department of Shipping is the “maritime safety administration of Bangladesh responsible for the formulation and implementation of national policies and legislation to ensure the safety of

[4] Department of Explosives. 2016. Objectives. Accessed from the Department of Energy website: http://www.explosives.gov.bd/objective.html
[5] Bangladesh Energy Regulatory Commission (BERC). 2003. BERC Act. Accessed from the BERC website: http://zhmbd.com/berc/berc_act_2003_English.pdf
[6] Bangladesh Energy Regulatory Commission (BERC). 2016. Homepage. Accessed from the BERC website: http://www.berc.org.bd/
[7] Ministry of Shipping. 2016. Organizations. Accessed from the Ministry of Shipping Website: http://www.mos.gov.bd/

life and ships at sea, development of shipping industry, maritime education and certification, employment and welfare of seafarers and other shipping related matters. The department is also responsible for ensuring the compliance of international conventions relating to maritime matters."[8]

Government shipping offices also play an important role regarding use of local citizens on national and international flagged vessels, as well as arbitrating settlements between ship owners and unions.

3.1.4.2 Chittagong Port Authority

The Chittagong Port is the principal seaport of Bangladesh handling about 92% of import-export trade of the country. The Chittagong Port Authority is responsible for[9]:

- Managing, maintaining, improving and developing the port
- Providing and maintaining adequate and efficient port services and facilities in the Chittagong Port (including approaches)
- Regulating and controlling berthing and movement of vessels and navigation within Chittagong Port
- Maintaining safety zones around ships/vessels (as will be necessary for this project)

A schedule of dues and tariffs can be found on the Chittagong Port Authority website.[10]

3.1.5 Ministry of Home Affairs

The Ministry of Home Affairs of Bangladesh is mainly responsible for internal security and related domestic policy.[11] It is made up of eight organizations, including the following that are most relevant to the project:

- Coast Guard
- Fire Service and Civil Defense

3.1.5.1 Bangladesh Coast Guard

Bangladesh Coast Guard is tasked with[12]:

- Controlling piracy and illegal trafficking
- Protecting fishery resources, oil and gas resources, and forest resources
- Preventing illegal immigration through the sea
- Preventing smuggling, trafficking of illegal arms, drugs and narcotics
- Protecting the environment from marine and coastal pollution
- Ensuring overall security, and law and order through security assistance to sea ports
- Conducing relief and rescue operations in the coastal areas
- Supporting the Navy in times of war

[8] Department of Shipping. 2016. Homepage. Accessed from the Department of Shipping website: http://dos.gov.bd/
[9] Chittagong Port Authority (CPA). 2016. Functions of CPA. Accessed from the CPA website: http://cpa.gov.bd/functions-of-cpa/
[10] CPA. 2016. Tariff on Goods and Vessels. Accessed from the CPA website: http://cpa.gov.bd/cpa-tariff-on-goods-vessels/
[11] Ministry of Home Affairs. 2016. Homepage. Accessed from the Ministry of Home Affairs website: http://mha.gov.bd/
[12] Bangladesh Coast Guard. 2016. Homepage. Accessed from the Bangladesh Coast Guard website: http://www.coastguard.gov.bd/

3.1.5.2 Fire Service and Civil Defense

The Bangladesh Fire Service and Civil Defense, an organization under the Ministry of Home Affairs, has two primary responsibilities:

1) Firefighting and fire safety
2) Rescue, both from fire and responding to natural disasters

The Fire Service and Civil Defense agency is comprised of approximately 6,500 people, led by the Director General.

3.1.6 Ministry of Defense

The Bangladesh Ministry of Defense is the cabinet level organization that is responsible for developing and executing military policy[13]. It has four wings: Army, Navy, Air Force, and Inter-Service. The Navy is of particular relevance to the project, but the Air Force could also be relevant.

3.1.6.1 Bangladesh Navy

The Bangladesh Navy is the warfare branch of Bangladesh Armed Forces, responsible for defense of Bangladesh's maritime territorial area, harbors, military bases, and economic zones[14].

3.1.6.2 Bangladesh Air Force

The Bangladesh Air Force is the aerial warfare branch of the Bangladesh Armed Forces, responsible for aerial defense.

3.1.7 Additional Related Institutions

The involvement of the following institutions (and sub institutions) will depend on contractual arrangements and/or project location/scope:

- Ministry of Civil Aviation and Tourism
- Bangladesh Comptroller General
- National Board of Revenue (NBR)
- Bangladesh Board of Investment
- Bangladesh Power Development Board (BPDB)
- Rural Electrification Board (REB)
- Bangladesh Water Development Board
- Ministry of Agriculture and sub agencies (including Bangladesh Fisheries Institute)
- Ministry of Disaster Management and Relief
- Ministry of Finance
- Ministry of Commerce
- Ministry of Industries
- Ministry of Land
- Ministry of Labour and Employment
- Ministry of Local Government, Rural Development and Cooperatives
- Ministry of Planning
- Ministry of Roads, Transport and Bridges
- Ministry of Science and Technology (MOST)

[13] Ministry of Defence. 2016. Homepage. Accessed from the Ministry of Defence website: http://www.mod.gov.bd

[14] Bangladesh Navy. 2016. General Operations. Accessed from the Bangladesh Navy website: http://www.navy.mil.bd/

- Ministry of Social Welfare
- Ministry of Water Resources
- National Environmental Council
- Cox's Bazar District Authority
- Union Parishad

A listing of all contact information for cabinet officials and other contacts are available online.[15]

3.1.8 Multi-Lateral Organizations

In addition to local agencies, Bangladesh is a member of many multi-lateral and/or regional organizations involved with environmental protection initiatives, including:

- Asian Development Bank
- Association of Southeast Asian Nations (ASEAN)
- Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
- Bay of Bengal Inter-Governmental Organisation on Coastal Fisheries
- South Pacific Regional Environment Programme
- South Asia Cooperative Environment Programme
- South Asian Association for Regional Cooperation
- United Nations
- World Bank Group, including the International Finance Corporation (IFC)

Some of these groups, including the Asian Development Bank, ASEAN, UN and IFC, have their own environmental and sustainability review and approval processes for developments or other activities that come within their purview.

3.2 Legislative Framework

3.2.1 Environmental Framework

Key environmental regulations of Bangladesh applicable to the proposed project are described below.

3.2.1.1 National Environmental Policy, 1992

The basic framework for environmental action is outlined by the Bangladesh National Environmental Policy, which was approved in 1992. This policy, accompanied by a set of broad, sectoral action guidelines, focuses on ensuring environmental performance as central to development. Key policy elements include:

- Environmental protection and conservation, with an aim to maintaining ecological balance and sustainable development
- Emphasis on environmentally-friendly development across economic sectors
- Sustainable natural resource management
- Alignment, as appropriate, with international environmental initiatives
- Protection from natural disasters
- The identification and regulation of all pollution-generating activity, and oversight regarding those activities with potential environmental impact

[15] Government of the People's Republic of Bangladesh. 2016. Cabinet Division. Accessed from the Cabinet Division Website: http://cabinet.portal.gov.bd/site/page/c3a1d735-abd6-4655-89ff-9e506d7537d7/Hon'ble-Ministers

Among other objectives, the Policy aims to ensure that roads, inland waterways, and other transport systems do not degrade natural resources or impact the environment. To that end, the Policy states that before projects (not defined at the Policy level) commence, EIA should be undertaken.

3.2.1.2 National Environment Management Action Plan, 1995

Building on the policy objectives of the NEAP[16], the National Environmental Management Action Plan (NEMAP) sets out an implementation framework that incorporates decisions and planning, legislative measures, and rules and regulations for environmental and natural resource management. NEMAP objectives include:

- Identification of Bangladesh's key environmental issues
- Identification of actions necessary to stop or reduce the rate of environmental degradation
- Environmental improvement
- Natural habitats and biodiversity conservation
- Sustainable development promotion
- Improvement of the quality of life of the people of Bangladesh

In order to meet these objectives, NEMAP has grouped actions in four categories, as follows:

1. *Institutional*: those with environmental challenges that require inter-sectoral cooperation, as well as potentially new national and local level institutional mechanisms;
2. *Sectoral:* actions that are clearly aligned with the mandates and/or organization of specific ministries and/or agencies;
3. *Location-specific*: priority actions associated with acute environmental challenges that need to be addressed locally; and
4. *Long-term*: actions associated with environmental degradation that may become a larger threat or risk if not addressed.

As noted in the NEMAP, Bangladesh's environmental policy includes specific statements regarding energy and fuel, and notes the aim to "(r)educe and discourage the use of those fuels that pollute the environment and encourage the use of fuels that are environmentally sound and less harmful."

3.2.1.3 Environmental Conservation Act, 1995

The Environmental Conservation Act (ECA) of 1995, as amended in 2000, 2002 and 2010, requires all industrial projects to obtain environmental clearance.[17] The ECA includes a number of important regulatory sections, including those that lay out:

- The establishment of the Department of the Environment (see below)
- Process of declaring 'ecologically critical' areas
- The formulation of environmental guidelines
- Sample collection and inspection
- Environmental Clearance
- Remediation approaches for environmental degradation
- Communication requirements for pollution, discharges, and environmental degradation

[16] People's Republic of Bangladesh. 1995. National Environment Management Action Plan: Volume II, Main report. Accessed from the GEF website: https://www.thegef.org/gef/sites/thegef.org/files/documents/multi_page.pdf

[17] UN Food and Agriculture Organization (FAO). 2016. Environmental Conservation Act, 1995. Accessed from the FAO website: http://faolex.fao.org/docs/pdf/bgd42272.pdf

- Parameters of environmental 'offences', including by companies, and compensation claims

The Director General (DG) is empowered to lead the Department of the Environment to protect the environment from pollution of any sources—solid waste, liquid, gaseous, heat, radiation or noise pollution—and rules and provisions are specified for damage from hazardous materials. As the DG is authorized to undertake any activity deemed necessary to enhance environment quality and control and mitigate pollution, the Department's remit includes promulgation of limits for discharge and emission of waste, and quality standards for air, water, soil, etc., and guidelines for meeting established standards.

The Department also is authorized to declare areas 'ecologically critical' by issuing notification in the Official Gazette.

The Delivery Point is located within Sonadia Island, which was designated as an Ecologically Critical Area in 1999.[18]

An Environmental Clearance Certificate must be obtained from the Director General before initiating new industrial or commercial activity. Environmental Clearance was granted to the project in January 2016 (Appendix A).

3.2.1.4 Environment Conservation Rules, 1997

Environmental Conservation Rules (ECR) were promulgated in 1997 (as amended in 2002, 2003 and 2010) to provide a procedure for granting environmental clearance under article 12 of the ECA.

The ECR includes:

- National Environmental Quality Standards
  - Air (Schedule 2)
  - Water (Schedule 3)
  - Sound (Schedules 4 and 5)
  - Emissions from motor vehicles and mechanized vessels (Schedules 6 and 7)
  - Odor (Schedule 8)
  - Sewage Discharge (Schedule 9)
  - Waste from industrial units or projects waste (Schedule 10)
  - Gaseous emissions from industry and projects (Schedule 11)
  - Industrial effluent by sector (Schedule 12)
- Categorization of industries, development projects and other activities. Depending on the project type and potential impacts, projects are categorized as:
  - Green (least potential impact)
  - Orange A
  - Orange B
  - Red (greatest potential impact)
- Procedure for obtaining Environmental Clearance Certificate
- Requirement for undertaking Initial Environmental Examination (IEE), and EIA (including Environmental Management Plan [EMP])
- Procedure for filing grievances to the state

[18] Islam, P and M. Mollah. 2015. Conservation of Sea Turtle in Cox's Bazar- Teknaf Peninsula and Sonadia Island Ecologically Critical Area (ECA) of Bangladesh. World Academy of Science, Engineering, and Technology International Journal of Geological and Environmental Engineering Vol:2, No:5, 2015.

Natural gas import and pipeline development are considered category red, and thus require an EIA. The EIA has been approved by DoE and Environmental Clearance granted for the project in January, 2016 (Appendix A).

Proponents are required to follow applicable Environmental Quality Standards, although DoE does not define which rules apply. When Environmental Quality Standards are not complete, the standards defer to the World Bank EHS Guidelines. The Environmental Quality Standards are focused to onshore activities, and their application to the project are limited. World Bank EHS Guidelines are largely more stringent. Applicable standards are integrated into the impact and management chapters.

3.2.1.5 Ecologically Critical Area Management Rules, 2016

The Ecologically Critical Area Management Rules were promulgated in September of 2016 to support protection of these areas.

The following activities are prohibited within Ecologically Critical Areas, without permission from the Director General of DoE:

- The felling or extracting of trees and forest products
- Hunting and poaching of wild animals
- Catching or collection of snails, corals, turtles and other creatures
- Any activity that may threaten the habitat of flora and fauna
- Activities likely to destroy or alter the natural characteristics of soil and water
- Controls over the establishment of industries that may pollute soil, water, air and/or create noise pollution
- Other activities that may be harmful for the fish and other aquatic life

Under the rules, industries have to carry out an EIA, install environmental treatment plants, conform to environmental quality standards, report accidents, or unforeseen discharges of pollutants, and take remedial measures. Environmental Clearance Certificate based on EIA is required for any development project in the Ecologically Critical Areas area.

The project is located within the Sonadia Island Ecologically Critical Area, but DoE has granted permission for project activities.

3.2.1.6 Bangladesh Wildlife (Conservation and Security) Act, 2012

The Bangladesh Wildlife (Conservation and Security) Act repealed the Bangladesh Wildlife (Preservation) Order, 1973, and revised the Wildlife Preservation (Amendment) Act 1974.

The Act defines various protected areas, including game reserves, national parks, eco-park and wildlife sanctuaries, and aims to preserve wildlife in those protected areas.

3.2.1.7 The Protection and Conservation of Fish Act, 1985

The Protection and Conservation of Fish Act, 1950 (as amended in 1982, 1995, and 2002) contains provisions for the protection and conservation of fish in waters of Bangladesh. This is relatively unspecific and simply provides a means by which the government may introduce rules to protect those waters not subject to private ownership. This is framework legislation with rule making powers, among others, some of these rules prohibited the destruction of, or any attempt to destroy, fish by the poisoning of water or the depletion of fisheries by pollution, by trade effluent or otherwise.

To date no fishing area or place within the Bangladesh territory has been declared a Fishing Reserve by the Government. The only restriction imposed was found from leaflets distributed by the Directorate of Fisheries, which referred to Bangladesh Gazette Extra-Ordinary dated October 27, 2005, adding section 13 to the Protection and Conservation of Fish Act, 1950. This required that certain areas be excluded from all fishing during high breeding periods.

3.2.1.8 The Protection and Conservation of Fish Rules, 1985

These are a set of rules in line with the overall objectives of the Fish Act. Section 5 of the Rules requires that "No person shall destroy or make any attempt to destroy any fish by explosives, gun, bow, and arrow in inland waters or within coastal waters". Section 6 of the Rules states "No person shall destroy or make any attempt to destroy any fish by poisoning of water or the depletion of fisheries by pollution, by trade effluents or otherwise in inland waters".

3.2.1.9 Environmental Court Act, 2000

The Environmental Court Act, and subsequent amendments in 2002 and 2010, sets out the authority, jurisdiction, and procedures for a legal court which may consider infractions of Bangladesh's environmental laws.[19]

The Court Act establishes definitions of offenses, trial procedures, powers of investigation as well as penalty and compensation that can be imposed for violation of the law and/or the Court's orders. This may include confiscation of equipment or vehicles used during the environmental offence.

3.2.1.10 National Forest Policy, 1994

The National Forest Policy of 1994 is the amended and revised version of the National Forest Policy of 1977 in light of the National Forestry Master Plan. The major target of the policy is to conserve existing forest areas, bring 20% of the country's land area under the Forestation Program, and increase the reserve forest land by 10% per year to 2015 through the coordinated efforts of GOB-NGOs and through the active participation of the people.

Amendments of existing laws (acts, rules, and regulations) relating to the forestry sector and creation of new laws for sector activities have been recognized as important conditions for achieving the policy goals and objectives. The Forestry Policy also recognizes the importance of fulfilling the responsibilities and commitments under international conventions, treaties, and protocols.

3.2.1.11 National Industrial Policy, 1999

The National Industrial Policy of 1999 aims to ensure a high rate of investment by the public and private sectors, a strong productive sector, direct foreign investment, development of labor intensive industries, introduction of new appropriate technology, women's participation, development of small and cottage industries, entrepreneurship development, high growth of export, infrastructure development and environmentally sound industrial development.

WTO guidelines have been proposed to be followed in the Industry Policy. Following the guidelines may result in conflicts with intellectual property rights. Guidelines for mitigating such possible conflicts are absent in the policy document. No specific guidelines are given for sustainable extraction and utilization of raw materials for different industries.

[19] FAO. 2016. Environment Court Act. 2000 (Act No. 11 of 2000). Accessed from the FAO website: http://faolex.fao.org/docs/pdf/bgd42277.pdf

One of the 17 objectives of the policy (Section 2.12; Chapter II) is "To ensure a process of industrialization which is environmentally sound and consistent with the resource endowment of the country".

3.2.1.12 National Water Policy, 1999

The National Water Policy of 1999 was passed 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.

The water policy, however, fails to address issues like consequences of trans-boundary water disputes and watershed management.

3.2.1.13 EIA Guidelines

There are several non-binding guidelines that provide input to conducting environmental impact assessments in Bangladesh. These include:

- EIA Guidelines for Industry, issued by the Department of Environment 1997;
- EIA guidelines for the water sector, prepared under the Flood Action Plan, 1992 and updated in 2003;
- The Water Resources Planning Organization (WARPO) – EIA guideline
- The Local Government Engineering Department (LGED) – EIA guideline

As part of the Bangladesh Environmental Institutional Strengthening Project (BEISP, 2006-2010), the DoE drafted EIA guidelines for several sectors, including mining, gas, pharmaceuticals, cement factories, water and transport sectors. While these guidelines are in draft, the DoE may ultimately finalize and gazette them.

The DoE's *EIA Guidelines for Industry* is a handbook that consists of EIA preparation and review procedures. It is intended to be useful for Bangladesh development partners, EIA Consultants, reviewers, and academics.

3.2.1.14 Additional Environmental Legislation

Key legislation relative to the project are described above. The legislation listed below are also in place, but are considered less relevant to the project.

- Bangladesh Biodiversity Act, 2012
- Ship Breaking and Recycling Rules, 2011
- Conservation of Playing Field, Open Space, Garden and Natural Water Body Act, 2000
- Bangladesh Climate Change Trust Act, 2010
- Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009
- Ozone Depleting Substance (Control) Rules, 2004
- National Biodiversity Strategy and Action Plan for Bangladesh, 2004
- Social Forestry Rule, 2004 (amended in 2010 & 2011)
- National Conservation Strategy, 1992
- Mines and Mineral (Development and Control) Act, 1992
- The Maritime Fisheries Ordinance, 1983
- Acquisition and Requisition of Immovable Property Ordinance, 1982
- The Environment Pollution Control Ordinance, 1977
- The Water Pollution Control Ordinance, 1970

- Mines and Mineral Rules, 1968
- Forest Act, 1927 (and its Supplementary Rules of 1959)
- Explosive Substances Act, 1908

3.2.2 Energy Sector Framework

The energy sector in Bangladesh includes many government agencies and government owned entities. While the Ministry of Power Energy and Mineral Resources is responsible for overall functioning of the sector, the Bangladesh Energy Regulatory Commission is the primary regulator, Power Grid Company of Bangladesh Ltd. has responsibility for transmission, and distribution is provided by a number of regional companies (plus Bangladesh Power Development Board and Bangladesh Rural Electrification Board).

The focus of this report is on environmental and social governance and approvals, but other key legislation and documents relevant to the project are described below.

3.2.2.1 Power Sector Master Plan, 2010

The Power Sector Master Plan (PSMP 2010) was developed to optimize power development opportunities and identify potential power plant sites based on a fuel diversification study.[20] The plan was developed based on demand forecast, feasibility of procurement of energy resources, optimum power development evaluation, and future optimum power supply structure. The fundamental objectives of the plan are to achieve stable power supply to facilitate economic growth, energy security, and environmental protection simultaneously.

PSMP 2010 aims to acquire the fuel composition ratio would be coal 50% (30% domestic coal and 20% imported coal), natural gas 25% (including LNG), 5% liquid fuel, and 20% nuclear and renewable.

There are a number of recommendations related to LNG import and natural gas use, including improvements to the electrical transmission system and gas transmission lines.

3.2.2.2 National Energy Policy, 1995

The National Energy Policy provides for utilization of energy for sustainable economic growth, supply to different zones of the country, development of the indigenous energy sources and environmentally sound sustainable energy development programs. The Policy highlights the importance of protecting the environment by requiring an EIA for any new energy development project, as well as the introduction of economically viable and environment friendly technology.

One of the seven objectives (Section 1.2) addresses the environment and states, "(vi) to ensure environmentally sound sustainable energy development Programs causing minimum damage to the environment".

Seven specific policy recommendations are listed under Chapter 1.9. Of those, the following three are relevant to the present project:

- EIA should be made mandatory and should constitute an integral part of any new energy development project;
- Use of economically viable environment friendly technology is to be promoted; and

[20] Ministry of Power Energy and Mineral Resources, Power Division. 2016. Power Sector Master Plan 2010. Accessed from the Power Division website: http://powerdivision.portal.gov.bd/sites/default/files/files/powerdivision.portal.gov.bd/page/7fd4a674_56a2_4726_ba2b_1cc0ad020813/SUMMARYPSMP2010.pdf

- Public awareness is to be promoted regarding environmental conservation.

3.2.2.3 Petroleum Policy, 1993

The Petroleum Policy has the primary objective of promoting, monitoring, and regulating all activities in the oil and gas sector in relation to exploration, development, refining, marketing, and export. The Petroleum Policy indicates the need to "promote Environmental Impact Assessment" in the oil and gas sector and to formulate various laws, rules and policies for fostering safety and environmental protection. The Petroleum Policy further states that private companies, in consultation with the Ministry of Power, Energy and Mineral Resources and Petrobangla, are to contribute toward improving the state of the environment in their area(s) of operation. The Petroleum Policy is now an integral part of the Energy Policy.

3.2.2.4 Energy Regulatory Commission Act, 2003

The Energy Regulatory Commission Act of 2013 establishes the Bangladesh Energy Regulatory Commission to encourage private investment in the generation of electricity, and transmission, transportation and marketing of gas resources and petroleum products (Chapter 2).[21] The Act gives government the power to make policy directives for the development and overall planning in the energy sector (Chapter 5). The Bangladesh Energy Regulatory Commission issues licenses for the following activities: power generation; energy transmission; distribution and marketing of energy; supply of energy; and, storage of energy (Chapter 6). The Act also gives the Commission the ability to set tariffs on power generation and on supply of energy (Chapter 7).

3.2.2.5 Natural Gas Safety Rules, 1991

This document is derived mainly from the American Petroleum Institute (API), American Society of Mechanical Engineers (ASME), American National Standard Institute (ANSI), British Standards (BS), codes and practices etc. and Petroleum Act, 1934. These rules deal with the materials, design and construction of gas pipelines, pipeline crossings of railways, testing and commissioning, protection against corrosion, pipeline operation and maintenance, storage and distribution, and reporting of accidents. The Rules are quite prescriptive and include stipulations as to the separation distances between pipelines and the public properties and thoroughfare. The provisions of the rules of the Natural Gas Safety Rules, 1991 have been updated through amendment in 2003.

The Natural Gas Safety Rules (as well as the Vessel Pressure Rules) require the proponent to submit technical drawings and engineering documents to the Department of Explosives, followed by an inspection prior to first gas flow. Annual renewal and inspection is also required.

3.2.2.6 Fire Safety Regulations

Significant safety related agreements have been implemented in recent years to address fire safety concerns in response to events that resulted in worker fatalities and international attention. The most recent such agreements is the Accord on Fire and Building Safety in Bangladesh that aims to implement health and safety measures in garment factories.

Multiple regulations also require proponents to obtain Fire License. For example, storage of petroleum products requires obtaining a Fire License by the Petroleum Act, 1934. LNG is also considered an explosive and is subject to requirements of the Explosives Rules, 2004.

[21] FAO. 2016. Energy Regulatory Commission Act, 2003 (Act No. 13 of 2003). Accessed from the FAO Website: http://faolex.fao.org/docs/pdf/bgd65122.pdf

Explosives Rules, 2004
Under the provisions of Explosives Rules, 2004 (rules made under the provision of Section 5 of the Explosives Act, 1884), project proponent will be required to obtain a licenses for explosive related activities, including: import, transport and possession.[22]

3.2.2.7 Additional Energy Sector Legislation
In addition to the above, the following legislation are relevant to management and functioning of the energy sector:

- Bangladesh Energy & Electricity Research Council Act, 2015
- Power & Energy Fast Supply Enhancement (Special Provision) (Amendment) Act, 2015
- Draft Electricity Act, 2015
- Bangladesh Rural Electrification Board (BREB) Act, 2013
- Sustainable & Renewable Energy Development Authority (SREDA) Act, 2012
- Gas Development Fund Policy, 2012
- Power & Energy Fast Supply Enhancement (Special Provision) Act, 2010
- Remote Area Power Supply System (RAPSS) Guidelines, 2009
- Policy Guidelines for Commercial IPP, 2008 (amended in 2010)
- Renewable Energy Policy, 2008
- Policy Guidelines for Power Purchase from Captive Power Plant, 2007
- The CNG Rules, 2005
- The Explosives Rules, 2004
- The LP Gas Rules, 2004
- Policy Guidelines for Small Power Plant, 1998 (Revised in 2008)
- Private Sector Power Generation Policy, 1996
- Coast Guard Act, 1994
- The Gas Cylinders Rules, 1991
- Bangladesh Petroleum Act, 1974
- The Territorial Waters and Maritime Zone Act, 1974
- The Bangladesh Power Development Boards Order, 1972 (President's Order)
- The Protection and Conservation of Fish Act, 1950
- Petroleum Act, 1934
- The Electricity Act, 1910
- Private Sector Infrastructure Guidelines, 2004
- The Explosives Act, 1884
- The Contract Act, 1872
- The Penal Code, 1860

3.2.3 Socio-Economic Framework

3.2.3.1 Public Participation and Stakeholder Engagement
EIA guidelines suggest public participation at the early stage of EIA study and recognize the need to consider socio-cultural, physical, and biological impacts. According the EIA guidelines for industries, opportunities for the public to participate are under the discretion of the Director General of DoE.

While public consultation is not required at the local level, this is a critical component of complying with IFC's Performance Standards on Environmental and Social Sustainability.

[22] Department of Explosives. 2004. Explosives Rules. Accessed from the Department of Explosives Website: http://www.explosives.gov.bd/function.html

3.2.3.2 Land/Property Rights

Since 1971, the issue of land reform has been among the top priorities of the Government of Bangladesh, as evidenced by the legislative land reforms. Efforts have been made to redistribute land more equitably; despite this, 52% of the rural population (which accounts for almost 75% of the country's population) is landless or holds less than .5 acres of land. Tenure security and access to land remain very limited, and cumbersome, expensive registration requirements impede formal land transactions. Land-related conflict and political tension remains high, and land disputes—fueled by the scarcity of land and the critical role land plays in rural livelihoods and status—are common. The IFC ranks Bangladesh 176th (of 183) in terms of "registering property".[23]

Land registration requirements are time-consuming and expensive. An individual or entity (domestic or foreign) purchasing real estate can expect the registration process to take 245 days and to cost 10% of the property's value for registration. The registration process includes the following steps:

1. Verification of the record of rights from the Land Office (Land Revenue Office)
2. Conversion into the current survey of property titles created before the last cadastral survey
3. Inspection for the aforementioned conversion (mandatory only on some properties)
4. Issuance of a non-encumbrance certificate from the relevant sub-registration office (such as the Municipal Deed Registration Office)
5. Preparation of the deed and payment of the stamp duty
6. Payment of the capital gains tax, registration fee, VAT, and other taxes
7. Application for registration at the relevant sub-registration office
8. Registration of the change in ownership at the Land Office.

The legal framework relevant to land/property rights is rooted in the Constitution of the People's Republic of Bangladesh, 1972 (amended 2004), which provides that all citizens shall have the right to hold, acquire, transfer and dispose of property. Article 42 of the Constitution, however, provides that land can be acquired, nationalized, or requisitioned upon authority of law and with compensation.

Acquisition and Requisition of Immovable Property Ordinance, 1982

The Acquisition and Requisition of Immovable Property Ordinance (April, 1982) permits government land acquisition as needed for any public purpose, and details the process for the acquisition or requisition of property (note that property may be kept under requisition for up to two years; prior approval from the government is required for a longer requisition period). For the acquisition of property, the process includes publication of a preliminary notice of acquisition, 15 days allowance for any objections against the acquisition, and award of compensation (if any such claims have been made). For the requisition of property, the process includes an award of compensation (in an amount determined by the Deputy Commissioner), and requires proper maintenance of the property to be the responsibility of the Deputy Commissioner during the requisition period (repairs deemed necessary by the Deputy Commissioner to prevent deterioration of the property will be the financial responsibility of the occupier). However, compensation for either process is limited to persons who are listed as

[23] USAID. USAID Country Profile: Property Rights and Resource Governance, Bangladesh. Accessed from the USAID website: http://www.usaidltpr.com/sites/default/files/country-profiles/full-reports/USAID_Land_Tenure_Bangladesh_Profile.pdf

owners in the land administration records.[24] As per USAID, providing proof of ownership is a lengthy process and landowners are unlikely to receive market value for seized land.[25]

The Acquisition and Requisition of Immovable Property Ordinance also sets forth guidelines for arbitration, should such measures become necessary.

In addition to the above, key land-related legislation includes:

- Transfer of Property Act of 1882
- Registration Act 1908
- Non Agricultural Tenancy Act of 1947
- State Acquisition and Tenancy Act of 1950
- Acquisition of Waste Land Act of 1950
- Bangladesh Land Holding Limitation Order of 1972
- Land Reforms Ordinance of 1984
- Land Reform Board Act of 1989
- Chittagong Hill Tract Regulation Act of 1990

Key ministries and departments for land use and registration include the following:

Ministry of Lands
The Ministry of Lands, which acts through the Directorate of Land Records and Surveys (DLRS) and the Land Reform Board (LRB), is entrusted with land administration and management. The Ministry is responsible for land acquisition, record-keeping, land-use planning, land surveys, collection of land development tax, implementation of land reforms, and management of government land development programs.

Department of Land Registration
The Department of Land Registration in the Ministry of Law, Justice, and Parliamentary Affairs records land transactions and collects the Immovable Property Transfer Tax.

Ministry of Agriculture
The Ministry of Agriculture is primarily concerned with development, planning, and monitoring of agricultural policy. The Bangladesh Agricultural Development Corporation is responsible for project delivery.

3.2.3.3 Employment Regulations
Bangladesh has promulgated significant labor-related legislation in recent years in response to numerous events that resulted in worker fatalities and international attention. A robust database of these laws can be found at the ILO Country Profile for Bangladesh.[26] Key laws are described below.

[24] Government of Bangladesh. 1982. The Acquisition and Requisition of Immovable Property Ordinance. Accessed from http://bdlaws.minlaw.gov.bd/print_sections_all.php?id=619
[25] [25] USAID. USAID Country Profile: Property Rights and Resource Governance, Bangladesh. Accessed from the USAID website: http://www.usaidltpr.com/sites/default/files/country-profiles/full-reports/USAID_Land_Tenure_Bangladesh_Profile.pdf
[26] ILO. 2016. Bangladesh Country Profile. Accessed from the ILO website: http://www.ilo.org/gateway/faces/home/ctryHome?locale=EN&countryCode=BGD&_adf.ctrl-state=5lidxfff2_14

Labour Act, 2006
The Labour Act, 2006, as amended in 2013, is a wide ranging law that addresses major labor issues in Bangladesh, including: conditions of service and employment; employment of adolescents; maternity benefits; health and hygiene; safety; welfare; working hours and leave; wages and employment; wage boards; workmen's compensation; trade unions and industrial relations; settlement of labor disputes; profit sharing; apprenticeships; penalties and procedures; administration and inspection.[27]

Bangladesh Labour Rules, 2015
A summary of requirements of the recent (September 2015) Bangladesh Labour Rules is provided below.

Employment Policy/Service Rules: If any establishment wants to have its own Employment Policy/Service Rules, it must obtain approval from the Chief Inspector of Labour.
Establishment Organogram: Every owner of an establishment must prepare an organogram for the establishment and must obtain the approval of Chief Inspector of Labour for such organogram.
Appointment Letter: Under the Labour Act, an appointment letter must be issued for hiring any labour. The Labour Rules makes it mandatory that the appointment letter must contain certain information such as salary, other financial benefits, applicable rules etc.
Registers: The Labour Rules prescribe certain forms for various registers such as service book, labour register, leave register, etc.
Misconduct and punishment: The Rules prescribe the process for investigation of misconduct.
Two festival bonuses: The Rules makes it mandatory that a labour, who continuously works for a year, must receive two festival bonuses in every year. Each bonus shall not be more than a basic salary.
Provident fund elaborated: the Rules provide detailed guidelines regarding provident fund. New additions includes provisions related to selection of nominee, management of the fund, activities of the trust for managing provident fund.
Holiday: The Rules detailed the provisions related to holidays. It also clarifies the provisions related to compensatory weekly holiday.
Health and fire safely: The Rules provide a detail guideline on health and fire safety.
Wages: the Rules details the provisions related to wages. Clarification is provided for the mechanism of calculating wages for fraction of month and deduction from wages.
Prescribe from for filling case in Labour Court: The Rules introduces some prescribe form for filling cases in the Labour Court."[28]

3.2.3.4 Local Content
No local content requirements were identified.

[27] ILO. 2006. Handbook on Bangladesh Labour Act. Accessed from the ILO website: http://www.ilo.org/dyn/travail/docs/352/A%20Handbook%20on%20the%20Bangladesh%20Labour%20Act%202006.pdf
[28] OGR Legal Resource Portal. 2016. Bangladesh Labour Rules. Accessed from the OGR Legal Resource Portal website: https://resource.ogrlegal.com/bangladesh-labour-rules-2015-published/

3.3 International Treaties and Conventions

Bangladesh is party to a number of international treaties and agreements that are applicable to the project, including[29]:

- Agreement for the Establishment of the Indo-Pacific Fisheries Council
- Association of the South Asia Cooperative Environment Programme
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
- Convention of International Trade in Endangered Species of Wild Fauna and Flora
- Convention on Wetlands (Ramsar Convention)
- Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification
- Convention on Biological Diversity and Cartagena Protocol
- Convention Concerning the Protection of the World Cultural and Natural Heritage
- Convention on the Conservation of Migratory Species of Wild Animals
- Framework Convention on Climate Change and the Kyoto Protocol
- Convention on the International Regulations for Preventing Collisions at Sea (COLREG)
- International Convention for the Prevention of Pollution from Ships (MARPOL), including Annexes I – VI
- International Convention for the Safety of Life at Sea
- International Convention for the Prevention of Pollution of the Sea by Oil
- International Convention on Oil Pollution Preparedness, Response and Cooperation and Protocol for Incidents by Hazardous and Noxious Substances
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
- International Convention on the Law of the Sea
- International Convention Relating to Intervention on The High Seas in Cases of Oil Pollution Casualties
- Montréal Protocol on Substances that Deplete the Ozone Layer
- Stockholm Convention on Persistent Organic Pollutants (POP)
- Vienna Convention for the Protection of the Ozone Layer

With regard to this project, key treaties relate to:

1) Biodiversity conservation
2) Conservation of culture and world heritage
3) Transboundary movement of wastes
4) Maritime safety
5) Marine pollution
6) Training and certification of seamen

Key treaties relative to these topics are described below.

3.3.1 Convention on Biodiversity

This treaty was adopted at the Earth Summit in Rio de Janeiro, Brazil in June 1992 as the first treaty to provide a legal framework for biodiversity conservation. The Convention established three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from the use of genetic resources.

[29] Mitchell. R.B. 2015. International Environmental Agreements Database Project (Version 2014.3). Accessed from the University of Oregon Website: http://iea.uoregon.edu/ .

The emphasis of the Convention is to place the main decision-making at the national level, to be implemented as overall goals and policies, and mainstream issues across all sectors of the national economy and policy-making framework. Bangladesh has developed a National Biodiversity Action Plan (NBSAP) which facilitates cross-sectoral support for biodiversity. At an institutional level, the MoEF, through its National Technical Committee on Biodiversity (NTCB), oversees activities related to biodiversity conservation.

3.3.2 Convention on Migratory Species

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention) aims to conserve terrestrial, aquatic, and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the auspices of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. Since the Convention's entry into force, its membership has grown steadily to include 122 Parties from Africa, Central and South America, Asia, Europe and Oceania.

This convention aims to conserve endangered migratory species (Appendix I) and Migratory species conserved through Agreements (Appendix II), which includes several marine mammals, birds and turtles that occur in the Bangladesh EEZ.

The convention has authored a Single Species Action Plan for the Loggerhead Turtle and Spoon-billed Sandpiper, and an Action Plan for whales and dolphins (including the Blue Whale and the Indo-Pacific Humpback Dolphin). The convention has also put forth a Central Asian Flyway Action Plan for the Conservation of Migratory Waterbirds and their Habitats, which includes the Spoon-Billed Sandpiper.

The convention has also undertaken several Memoranda of Understanding (MoU) which aim to conserve species occurring in Bangladesh's EEZ such as:

- Marine Turtles and their Habitats of the Indian Ocean and South-East Asia
- Dugongs and their Habitats

3.3.3 Convention Concerning the Protection of the World Cultural and Natural Heritage

The Convention Concerning the Protection of the World Cultural and Natural Heritage seeks to encourage the identification, protection, and preservation of cultural and natural heritage around the world considered to be of outstanding value to humanity.[30] The Convention defines the kind of natural or cultural sites which can be considered for inscription on the World Heritage List. Sites formally adopted into the World Heritage List are subject to special protections.

However, there are no current or proposed World Heritage sites near the project.

3.3.4 Convention on Wetlands

The Convention on Wetlands (Ramsar Convention) is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Bangladesh is party to this Convention, but none of the listed Ramsar Wetlands of International Importance are located near the project. However, under the terms of the Convention, Bangladesh is still expected to ensure sustainable use and conservation of all its wetland areas.

[30] UNEP. 2016. About World Heritage. Accessed from the UNEP website: http://whc.unesco.org/en/about/

According to the text of the Convention, marine wetlands are considered to be wetlands up to a depth of six meters at low tide but the treaty also provides for waters deeper than six meters, as well as islands, to be included within the boundaries of protected wetlands. Hence, the project activities, in particular pipeline installation, will need to take this into account and minimize the likelihood of damage to the coastal habitats. Wetlands are important for maintaining key ecological processes for rich flora and fauna, and for the benefits that they provide to local communities and to human society in general.

Sonadia Island was proposed as a Ramsar wetland in 2007 by Department of Forests.

3.3.5 Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention)

The overarching objective of the Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention) is to protect human health and the environment against the adverse effects of 'hazardous wastes' through control of transboundary movement said waste.[31]

The convention aims to:

- Reduce hazardous waste generation and promote environmentally sound management and disposal
- Restrict transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management
- Apply regulatory systems where transboundary movements are permissible

The key requirement of the Basel Convention for companies includes mandating written consent by environmental regulators in the country of origin and country of destination, prior to export.

3.3.6 Convention on the International Regulations for Preventing Collisions at Sea

In 1971, the IMO Assembly adopted a resolution stating that observance of all marine traffic control is mandatory. Convention on the International Regulations for Preventing Collisions at Sea (COLREG) adopted and clarified this requirement.

COLREG was designed to update and replace the Collision Regulations of 1960, which were adopted at the same time as the 1960 SOLAS Convention. COLREG includes 38 rules divided into five sections: Part A - General; Part B - Steering and Sailing; Part C - Lights and Shapes; Part D - Sound and Light signals; and Part E - Exemptions. There are also four Annexes containing technical requirements concerning lights and shapes and their positioning; sound signaling appliances; additional signals for fishing vessels when operating in close proximity to other vessels, and international distress signals.

One of the most important innovations of COLREG was the recognition given to traffic controls and safe distance requirements. Rule 10 gives guidance in determining safe speed, risk of collision and conduct of vessels operating in or near other vessels. This rule requires vessels to avoid the path of other vessels that have limited maneuverability due to the need to stay on position or course as part of an activity requiring precise location or placement. The FSRU is considered to have limited maneuverability.

[31] United Nations Environment Programme (UNEP). 2016. Basel Convention Website: Accessed on the UNEP website: http://www.basel.int/TheConvention/Overview/tabid/1271/Default.aspx

3.3.7 Convention for the Prevention of Pollution from Ships

International Convention for the Prevention of Pollution from Ships (MARPOL) is one of the most important international marine environment conventions and is relevant to the FSRU and associated vessels.

MARPOL 73/78 is a combination of two treaties adopted in 1973 and 1978, respectively, and updated by amendments through the years. The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes the following six technical Annexes, shown in Table 3-1.

Table 3-1: MARPOL Annexes

Annex	Description
Annex I	Regulations for the Prevention of Pollution by Oil
Annex II	Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
Annex III	Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
Annex IV	Prevention of Pollution by Sewage from Ships
Annex V	Prevention of Pollution by Garbage from Ships
Annex VI	Prevention of Air Pollution from Ships

Compliance with MARPOL is industry standard practice that is required for registration of international vessels. Examples of requirements under MARPOL include:

- Ship Oil Pollution Emergency Plan (SOPEP)
- Garbage Management Plans
- International Sewage Pollution Prevention Certificate

3.3.8 Convention on Standards of Training, Certification and Watchkeeping for Seafarers

The 1978 Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW Convention) was the first to establish basic requirements on training, certification, and watchkeeping for seafarers on an international level. The Convention prescribes minimum standards relating to training, certification, and watchkeeping for seafarers which countries are obliged to meet or exceed.[32] Topics covered by the Convention include: ship construction; fire protection, fire detection and fire extinction; fife-saving appliances and arrangements; radio communications; safety of navigation; carriage of cargoes; carriage of dangerous goods; nuclear ships; management of safe operation of ships; safety for high speed craft; maritime security; bulk carriers; verification; and operation in polar waters.

The regulations contained in the Convention are supported by sections in the STCW Code. The minimum standards of competence required for seagoing personnel are given in detail in a series of tables.

3.4 Lender Standards

3.4.1 IFC Performance Standards

The IFC Performance Standards (updated in January 2012) are recognized as the benchmark for international financial institutions. The principles provide a framework for an accepted

[32] International Maritime Organization (IMO). 2016. International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers. Accessed from the IMO website: http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Standards-of-Training,-Certification-and-Watchkeeping-for-Seafarers-(STCW).aspx

international approach to the management of social and environmental issues and integration of these issues into loan agreements

While the project must comply with all eight Performance Standards[33], only the following are applicable based on the potential impacts and risks identified:

- PS 1 – Assessment and Management of Environmental and Social Risks and Impacts
- PS 2 – Labor and Working Conditions
- PS 3 – Resource Efficiency and Pollution Prevention
- PS 4 – Community Health and Safety
- PS 6 – Biodiversity Conservation and Sustainable Management of Living Natural Resources

The project is located 2.4 km offshore, with a minimal onshore footprint that will not result in the physical or economic displacement of communities, or adverse impacts on Indigenous Peoples or areas of cultural heritage value. Consequently, PS 5, PS 7 and PS 8 are not triggered.

3.4.1.1 Performance Standard 1: Assessment and Management of Social and Environmental Risks and Impacts

IFC Performance Standard 1, which applies to all IFC funded projects, underscores the importance of managing environmental and social performance throughout the life of a project. Performance Standard 1 requires the client to conduct a process of environmental and social assessment and to establish and maintain an Environmental and Social Management System (ESMS), appropriate to the nature and scale of the project and commensurate with the level of its environmental and social risks and impacts.

Performance Standard 1 aims to:

- Identify and evaluate environmental and social risks and impacts of the project;
- Adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, affected communities, and the environment;
- Promote improved environmental and social performance of clients through the effective use of management systems;
- Ensure that grievances from affected communities and external communications from other stakeholders are responded to and managed appropriately;
- Promote and provide means for adequate engagement with affected communities throughout the project cycle on issues that could potentially affect them; and
- Ensure that relevant environmental and social information is disclosed and disseminated.

IFC Performance Standard 1 applies to all IFC funded projects.

3.4.1.2 Performance Standard 2: Labor and Working Conditions

IFC Performance Standard 2 recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers.

Performance Standard 2 aims to:

[33] International Finance Corporation. 2012. IFC Performance Standards on Environmental and Social Sustainability. Accessed from the IFC website: http://www.ifc.org/wps/wcm/connect/c8f524004a73daeca09afdf998895a12/IFC_Performance_Standards.pdf?MOD=AJPERES

- Promote fair treatment, non-discrimination and equal opportunity of workers;
- Establish, maintain and improve the worker-management relationship;
- Promote compliance with national employment and labor laws;
- Protect workers, including vulnerable categories of workers such as children, migrant workers engaged by third parties and workers in the client's supply chain; and
- Promote safe and healthy working conditions and the health of workers; and avoid the use of forced labor.

The project will require use of workers and potentially hazardous duties, thus IFC Performance Standard 2 is applicable.

3.4.1.3 Performance Standard 3: Resource Efficiency and Pollution Prevention

IFC Performance Standard 3 recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels.

Performance Standard 3 aims to:
- Avoid or minimize pollution from project activities;
- Promote more sustainable use of resources (including energy and water); and
- Reduce project-related Greenhouse Gas (GHG) emissions.

The project involves routine discharges to water and air, will generate wastes, will consume energy and other natural resources, thus IFC Performance Standard 3 is applicable.

3.4.1.4 Performance Standard 4: Community Health, Safety and Security

IFC Performance Standard 4 recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts.

Performance Standard 4 aims to:
- Anticipate and avoid adverse impacts on the health and safety of affected communities during the project life from both routine and non-routine circumstances; and
- Ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the affected communities.

The project could result in emergency scenarios in which the public health and safety may be at risk, thus IFC Performance Standard 4 is applicable.

3.4.1.5 Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

IFC Performance Standard 6 recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development.

Performance Standard 6 aims to:
- Protect and conserve biodiversity;
- Maintain the benefits from ecosystem services; and
- Promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

Performance Standard 6 is of particular importance to the project, as Sonadia Island is a habitat for multiple endangered or threatened species (including the critically endangered Spoon-Billed Sandpiper), and is an important protected area, both nationally and internationally.

3.4.2 World Bank Group Environmental, Health and Safety Guidelines

The World Bank Group Environmental, Health, and Safety (EHS) Guidelines are technical reference documents that define Good International Industry Practice (GIIP). There are general EHS guidelines that apply to all projects, as well as sector specific guidelines that define performance requirements for specific project types.

The EHS Guidelines contain the performance levels and measures consistent with the requirements of IFC Performance Standard 3 on Resource Efficiency and Pollution Prevention and are generally considered to be achievable in new facilities at reasonable costs by existing technology and/or applicable for existing facilities over time.

Applicable EHS Guidelines include the General EHS Guidelines, which are cross-cutting and apply to all projects, and components of the following Industry Sector Guidelines:

- Liquefied Natural Gas (LNG) Facilities
- Crude Oil and Petroleum Product Terminals
- Shipping
- Offshore oil and gas development

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4 Baseline Conditions

4.1 Introduction

This chapter provides baseline information on the physical environment, biological environment, and socioeconomic conditions. These conditions are based on primary data collected by Fugro in 2016 as part of a geotechnical and environmental baseline program for Moheshkhali Floating LNG project (Appendix L), as part of an LNG terminal site assessment conducted by Poten & Partners in 2011 on behalf of Petrobangla, and hydrodynamic modeling developed for the project by RPS ASA.[1] [2] [3]

4.2 Study Area and Location

As described in Chapter 1, the area of influence for the project includes[4]:

- *The area likely to be affected by:*
  - *(i) the project[5] and the client's activities and facilities that are directly owned, operated or managed (including by contractors) and that are a component of the project;[6]*
  - *(ii) impacts from unplanned but predictable developments caused by the project that may occur later or at a different location; or*
  - *(iii) indirect project impacts on biodiversity or on ecosystem services upon which Affected Communities' livelihoods are dependent.*
- *Associated facilities, which are facilities that are not funded as part of the project and that would not have been constructed or expanded if the project did not exist and without which the project would not be viable.*
- *Cumulative impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted.*

Based on the above, the area of influence considered for this project includes:

- The physical footprint of the FSRU, including a safety zone, vessel maneuvering zones, and subsea infrastructure
- Physical footprint of permanent and temporary onshore areas needed during construction
- Any required office, port or storage routes (to be identified in early logistics studies) as well as transportation corridor to port
- Areas that may be impacted by project wastes, effluents, emissions, noise and light
- Adjacent onshore areas that are within the viewshed of the FSRU and are home to communities that utilize the area for fishing, salt farming and other economic activities

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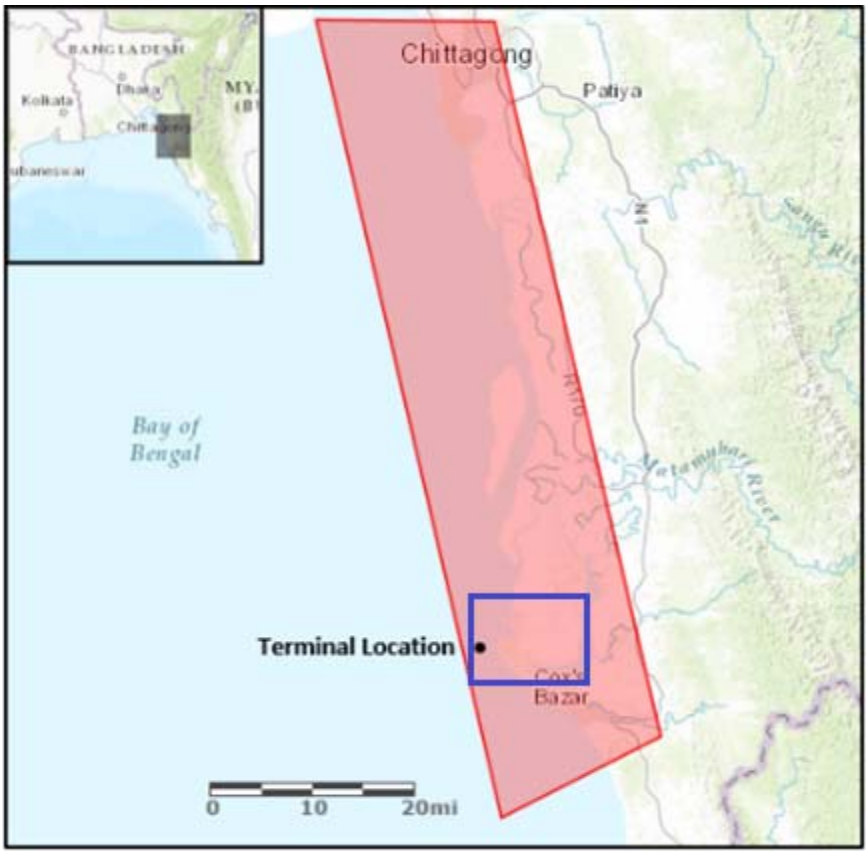
[1] Fugro 2017. Geotechnical and Environmental Baseline Survey Services Environmental Baseline Survey Report. Unpublished Report.
[2] Poten & Partners. 2011. Site Assessment Report. Bangladesh Offshore LNG Terminal. Prepared for Petrobangla.
[3] RPS ASA. 2016. Sediment Dispersion Modeling for Post-Trenching at Moheshkhali, Offshore Bangladesh. Unpublished Report.
[4] IFC. 2012. FC Performance Standards on Environmental and Social Sustainability. Accessed from the IFC website: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full-Document.pdf?MOD=AJPERES
[5] Examples include the project's sites, the immediate airshed and watershed, or transport corridors
[6] Four examples include power transmission corridors, pipelines, canals, tunnels, relocation and access roads; borrow and disposal areas; construction camps; and contaminated land (e.g., soil, groundwater, surface water, and sediments)

- Footprint of the 89.4 km pipeline to Chittagong, including a buffer zone on both sides of the route which may be impacted by construction or operations
- Areas that could potentially be impacted by accidental events

The full study area for the ESIA is shown in Figure 4-1.The study area is bound by urban areas of Chittagong to the north and Cox's Bazar to the south, and includes coastal marine waters and coastal plains. The study area is bound to the east by the Chittagong Hills, which host markedly different ecosystems than are found along the shore, and the west by the Bay of Bengal.

Figure 4-1: Study Area



Notes: Study area shown in Red. Focus area outlined in blue.
Source: Acorn International / ESRI

The study area is particularly large as a result of the associated pipeline that travels from the shoreline adjacent to the terminal to Chittagong. As the associated pipeline was completed prior to this ESIA, this chapter focuses on the onshore and coastal areas near the terminal site (outlined in blue above), although the entire area is covered in sufficient detail to document baseline conditions and evaluate impacts in the entire study area. Further detail of the baseline conditions along the pipeline route can be found in the EIA completed for the pipeline project, titled: "EIA of the Proposed Maheshkhali - Anowara Transmission Pipeline Project". A synthesis of the risks and impacts of the associated pipeline can be found in Section 5.3.6.

4.3 Physical Environment

4.3.1 Geology

Bangladesh lies between $20^0 34'$ and $26^0 38'$ N, and $88^0 01'$and $92^0 41'$ E in the northeastern corner of the Indian subcontinent at the head of the Bay of Bengal. The area of the country is 147,570 km^2 with more than 700 km of coastline.

Bangladesh is characterized by distinct physio-geographic regions (Figure 4-2). Approximately 80% of the land is flat, intersected by numerous rivers.[7] Moheshkhali Island is situated in Cox's Bazar district between latitude 21°28´N and 21°45´N and longitude 91°05´E and 92°01´E. It is located in the coastal plain of the Chittagong Hill Tracts. In this region, the anticlines form the hills and synclines the valleys. The hills of Moheshkhali run on the eastern side of the island, parallel to the mainland coast, trending NNW-SSE. The highest elevation is 86.26m above mean sea level.

Bangladesh lies at the junction of three plates: the Indian Plate, the Eurasian Plate and the Burma Platelet. Tectonically Bangladesh is divided broadly (Figure 4-3) into the following divisions:

1. Indian Platform and Shelf
    a. Dinajpur slope (Himalayan Fore Deep)
    b. Rangpur Platform
    c. Bogra Shelf
    d. Hinge Zone (Eocene slope break)
2. Bengal Fore Deep
    a. Folded Flank
    b. Basinal Area
        i. Sylhet Trough
        ii. Chandpur-Barisal Gravity High
        iii. Faridpur Trough
        iv. Patuakhali Depression (Hatia Trough)

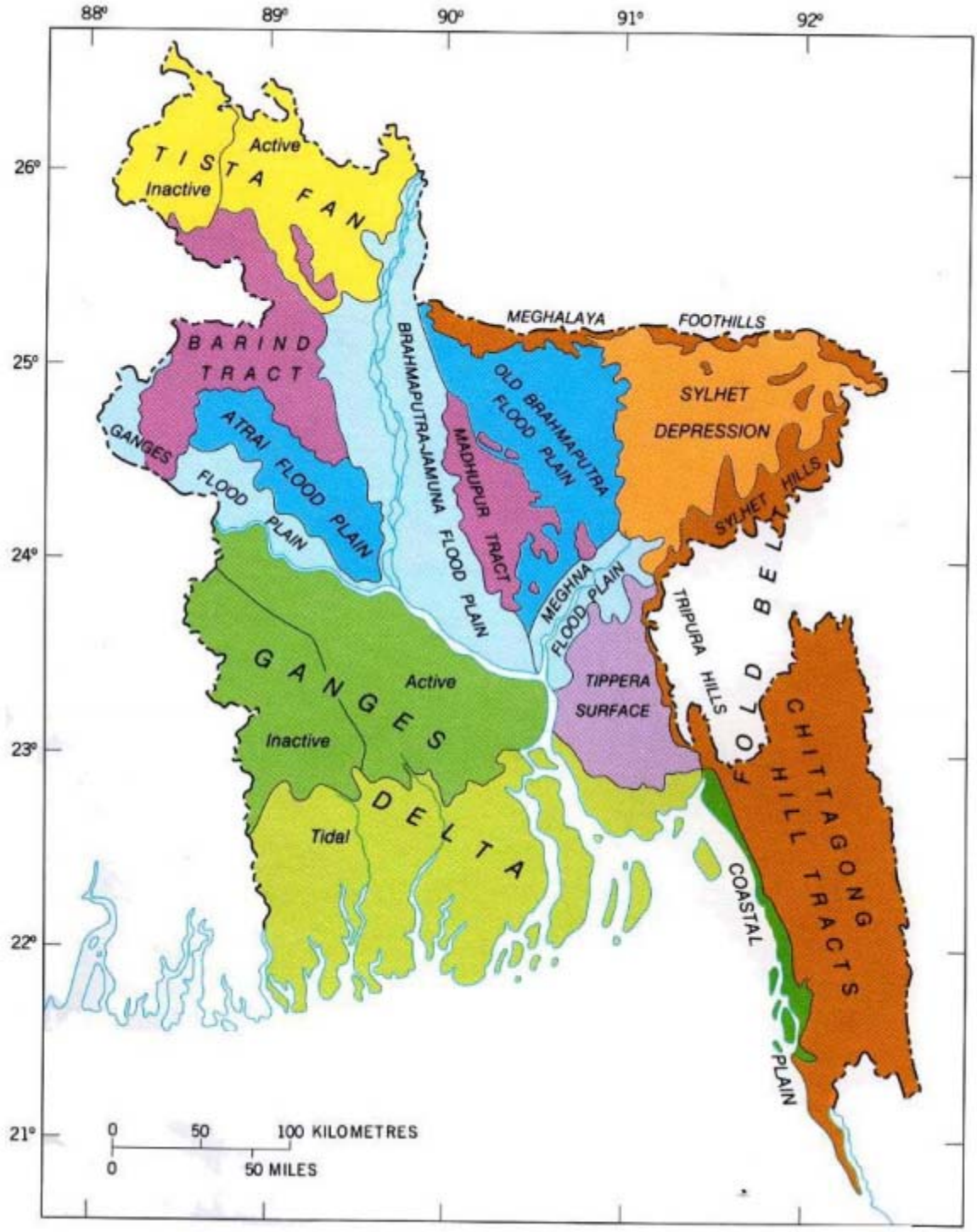
Moheshkhali is located in a region known as the eastern fold belt, a fold-and-thrust belt comprised of series of north to south-trending, curvilinear anticlines and synclines.[8] The dominant fold-generating mechanism is believed to be the east to west-directed compressional force arising from oblique subduction of the Indian plate beneath the Burma plate.

Quaternary sediments cover approximately 82% of the country.[7] The basin is characterized by thick (>20 km near the basin center) sedimentary rocks, mostly sandstone and shale of tertiary age. A generalized stratigraphic sequence of Bangladesh is provided in Table 4-1.

[7] Ministry of Local Government, Rural Development & Co-operatives, Local Government Division. 2002. Report of the Groundwater Task Force. Accessed from the Harvard University website: http://users.physics.harvard.edu/~wilson/arsenic/countries/bangladesh/National%20Water%20Policy%202003/Ground%20Water%20TAsk%20Force%202002/4-Main%20report.pdf

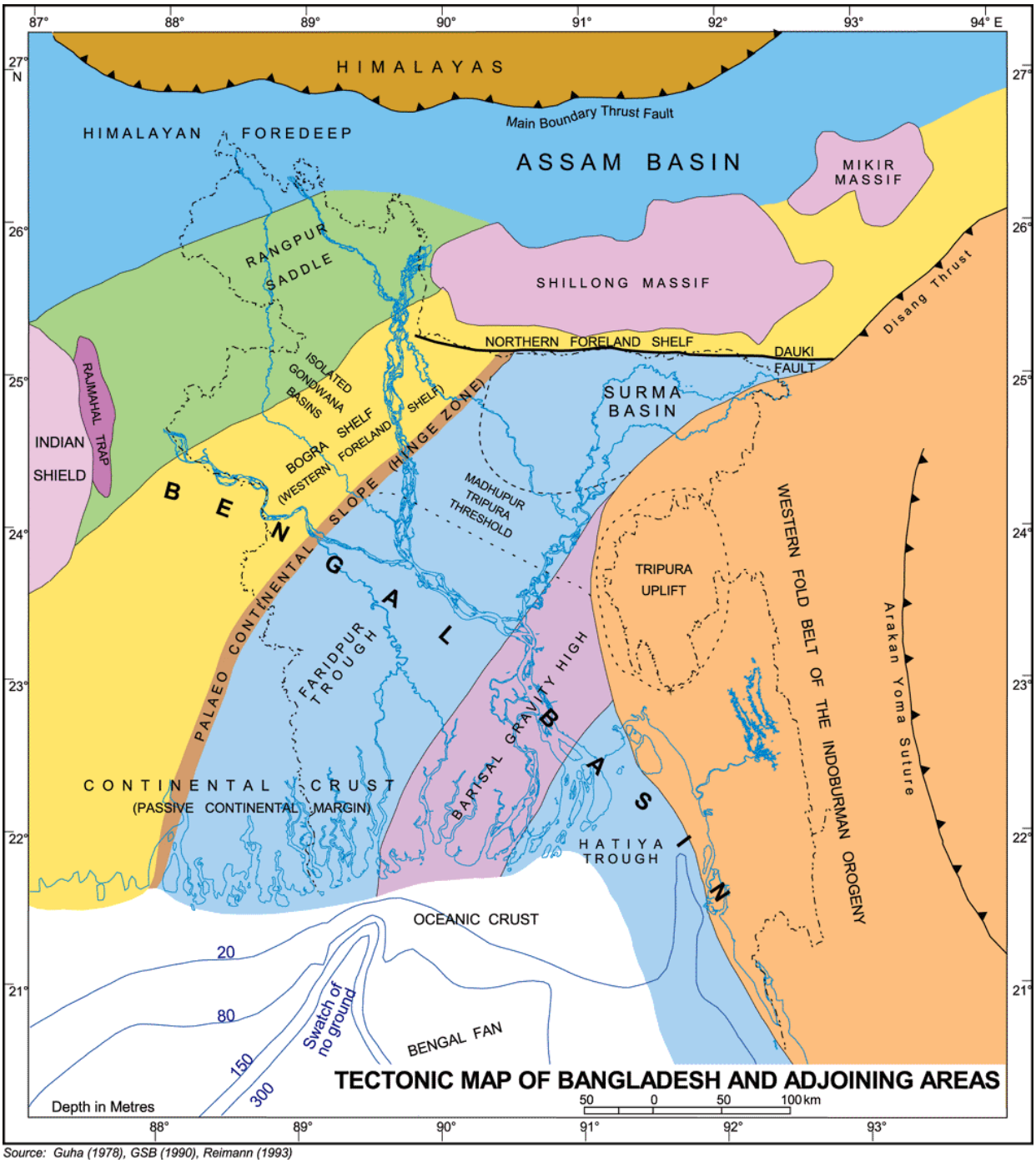
[8] Sikder, A.M, and M.M Alam. 2001. 2-D Modelling of the Anticlinal Structures and Structural Development of the Eastern Fold Belt of the Bengal Basin, Bangladesh. Sedimentary Geology 155 (2003) 209 – 226.

Figure 4-2: Physiographic Regions of Bangladesh



Source: Ministry of Local Government, Rural Development & Co-operatives, Local Government Division, 2002[7]

Figure 4-3: Plate Tectonic Map of Bangladesh and Adjoining areas



Source: Maps of Bangladesh, 2016[9]

[9] Maps of Bangladesh. 2016. Tectonic Plate: Bangladesh. Accessed from the maps of Bangladesh website: https://mapofbangladesh.blogspot.com/2012/02/tectonic-plates-bangladesh.html

Table 4-1: Generalized Stratigraphic Sequence of Bangladesh

Age	Formation / Group	Lithologic Description	Comment
Holocene	Alluvium	Sand, silt and clay: Grey; layered and interlayered with peat and decomposed vegetal matters.	Top and Middle or Main Aquifers
Pleistocene	Madhupur Clay	Red clay with patches of sandstone: Deeply oxidized, variegated colors, contains ferruginous nodules and laterite	Stable Paleosol
Pio-Pleistocene	Dihing	Sandstone: Variegated colors with pebbles and laterites.	
	Dupi Tila Sandstone	Sandstone with clay beds: Grey, oxidized to variegated colors, coarse, pebbles and petrified woods present	Deep Aquifers
Miocene	Tipam Sandstone	Top: Girujan Clay; Grey Bottom: Tipam Sandstone: Grey, Medium to coarse with lignite bands	Very Deep Aquifers
	Bokabil	Sandstone and Shale	Gas producing zone
	Bhuban	Sandstone and Shale	
Oligocene	Barail	Sandstone	
Eocene	Kopili	Shale with sandstone and fossiliferous beds	
	Sylhet Limestone	Lime stone with sandstone beds	Limestone deposits
Paleocene	Tura Sandstone	Sandstone	Oldest exposed rock of BD
Cretaceous	Rajmahal Trap	Volcanic trap with sandstone and shale	
Permian	Gondwana	Sandstone with shale and coal beds	Coal deposits
Pre-Cambrian	Basement	Granite, Granodiorite, Gneiss and Schist	Igneous & metamorphic rock

Source: Ministry of Local Government, Rural Development & Co-operatives, Local Government Division, 2002[7]

4.3.2 Seabed Morphology

The Bay of Bengal is characterized by thick Bengal Fan sediments that cover the entire basement, leaving the ocean floor bathymetry virtually featureless (Figure 4-4). The sediment cover is exceptionally thick (about 22 km) at the apex of the Bengal fan in the Bangladesh offshore region and decreases gradually to about 8 to 2 km in the central and southern parts.[10]

[10] Curray, J.R. 1991, Geological history of the Bengal Geosyncline: Jour. Assoc. Expl. Geophys, v. XII, p. 209-219.

The deltaic river processes influence morphology of the offshore river grabens, mass movement, and turbidity currents. "V" shaped canyons, fan valleys, and fault valleys are some of the prominent morphological features of the offshore Bengal Basin. The outer shelf of the basin is associated with sediment slumps and neo-tectonic faults.

Sarma et al. (2000) suggest that though the Bengal Fan in general has a smooth topography, there exist several valleys like features in the north and isolated highs in the southern Bay of Bengal.[11] The mass movement, turbidity currents, sea level fluctuations, tectonics and the effect of Himalayan uplift might have played a significant role for the morphological development of the fan.

Figure 4-4: Bathymetry of the Bangladesh Continental Shelf

Source: Chowdhury, 2014[12]

[11] Sarma et al. 2000. Morphological features in the Bay of Bengal. Journal of Indian Geophysical Union (2000) Vol. 4, No.2, pp. 185-190.
[12] Chowdhury, S.R. 2014. Maritime Province of Bangladesh (Map). University of Chittagong.

4.3.2.1 Sediment Dynamics

The Bengal Fan is one of the world's largest submarine fans in the world with an area of almost 3 million km^2. [11] It extends from Ganges/Brahmaputra delta around 20° N latitude to south of 7° S, with a maximum width of about 1000 km around 15" N latitude.

Large volumes of continental sediments are being discharged by Ganges and Brahmaputra Rivers into the Bay of Bengal and the finer sediment particles reach even 7° S latitude. The sediments rest on the early cretaceous ocean floor characterized by the Mesozoic anomalies

Another study shows that a substantial amount of the suspended sediments (1.2 billion tons per year) pass through the Ganges, Brahmaputra and Meghna river system, continuing through the lower Meghna estuary, situated in the north of the Moheshkhali Island which contains the project area, and ultimately settling in the Bay of Bengal.[13]

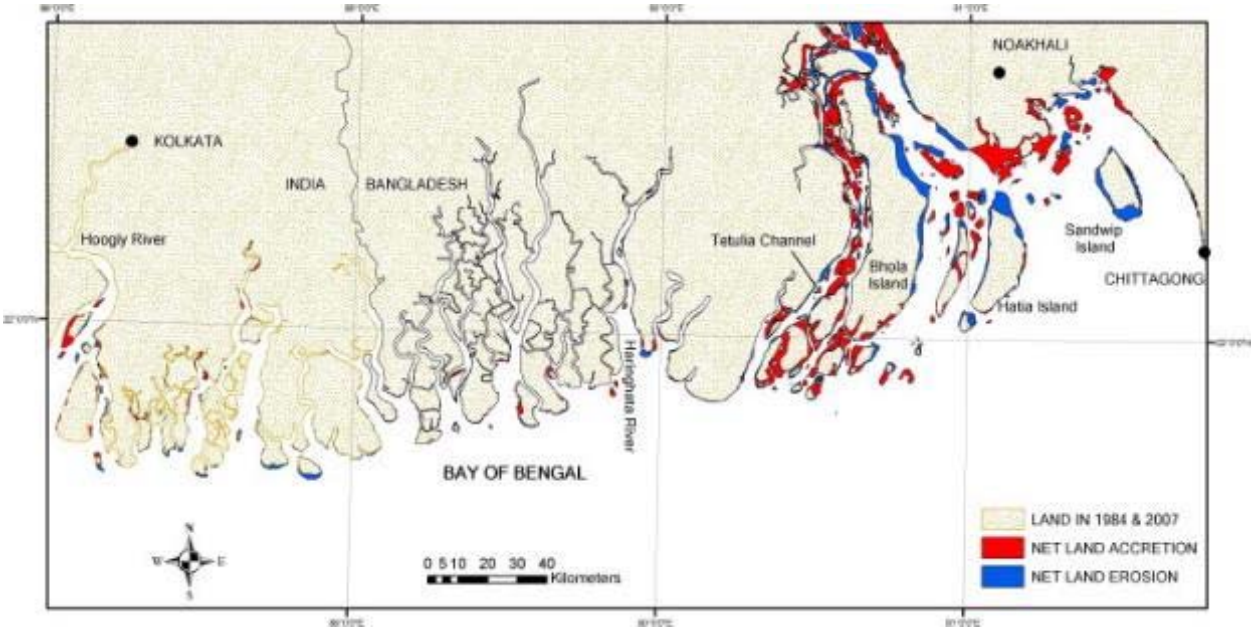
Approximately 60% of the sediments reach the estuary and are responsible for the formation of the present delta lobe that includes the Sundarbans west to Chittagong and south to Cox's Bazar and Moheshkhali Island. The remaining 40% of the sediments flow westward from the Meghna estuary through the 'Swatch of No Ground', a submarine canyon, into the deep seawater.

4.3.2.2 Coastal Erosion and Deposition

The physical geography of Bangladesh's coastal area is diverse and dynamic (Figure 4-5). Land accretion and erosion are taking place at different rates along the coast. These changes include natural reasons, but also human induced, particularly by embankments built to prevent flooding by saline tidal water or seasonal river floods. Brammer (2014) notes that in the southeast of Bangladesh "[erosion and deposition] changes are generally small or undetectable on the coast of the Chittagong Coastal Plains, except in the south of Kutubdia Island which lost approximately 10% of its previous area." [14] Hoque, et al. (2013) notes increasing accretion on Sonadia Island, particularly in the south and east.[15] However, these areas are also most prone to sea level rise and storm surge, which may increase erosion and decrease land area.

[13] Kudrass, H.R., Michels, K.H., Wiedicke, M. and A. Suckow. 1998. Cyclones and Tides as Feeders of a Submarine Canyon Off Bangladesh. Geology 26:715-718.
[14] Brammer, H. 2014. Bangladesh's Dynamic Coastal Regions and Sea Level Rise. Climate Risk Management Volume 1, 2014, pp 51-62.
[15] Hoque, M.E., Chowdhury, S.R. Uddin, M.M., Alam, M.S. and M.M. Monwar, 2013. Grain Size Analysis of a Growing Sand Bar at Sonadia Island, Bangladesh. Open Journal of Soil Science, 2013, 3, 71-80.

Figure 4-5: Gains and Losses of Land on the Brahmaputra–Ganges–Meghna Delta, 1984–2007



Source: Brammer, 2014

4.3.2.3 Seabed Features

A geophysical survey was conducted to identify any potential seafloor and subsurface hazards. Water depths range from -0.6m (i.e. drying heights above chart datum) and 38.2 m.

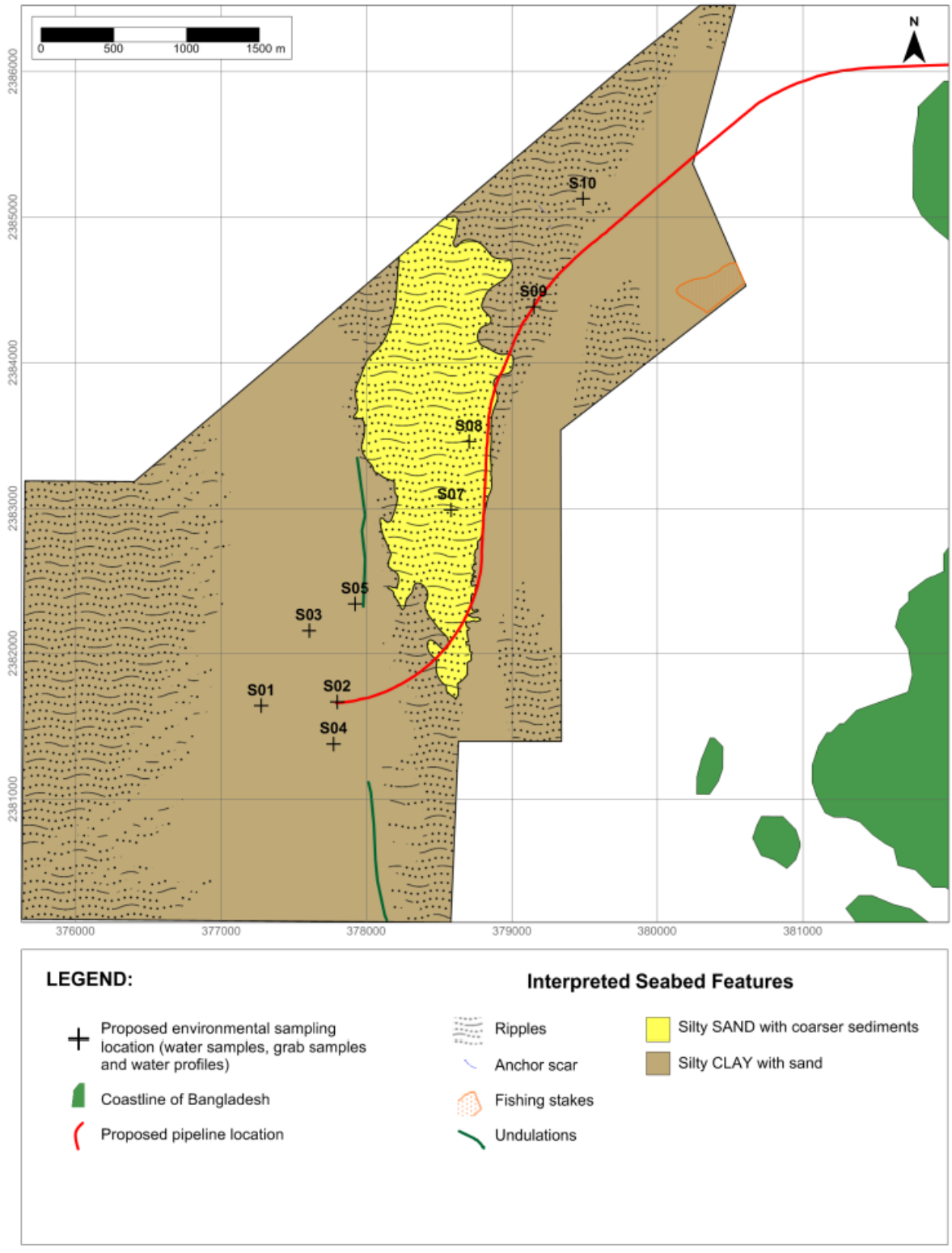
In general, the seafloor morphology in the project area shows a topography steadily sloping down from the east reaching maximum depth in the central part and gently sloping up towards west, thus representing a channel like feature in the center of the survey corridor trending in the North-South direction.

Based on the acoustic reflectivity of the side scan sonar data and multibeam echosounder backscatter data, seabed sediments within the survey area were classified into two sediment types. Low to medium reflectivity sediments as ‘Silty CLAY with Sand’ and high reflectivity sediments interpreted as ‘Silty SAND with coarser sediments’.

Grab sampling allowed groundtruthing of the acoustic facies identified and showed that sediments in the area interpreted as ‘Silty CLAY with Sand’ comprised fine silt, coarse silt, fine sand and very fine sand. The stations in the area interpreted as ‘Silty SAND with coarser sediments’ were shown to comprise coarse silt and very fine silt, but this overlay a consolidated clay, which appeared to have been the cause of the high acoustic reflectivity evident from the side scan sonar data.

Seabed features are shown in Figure 4-6. Sand ripples dominate the south-western and south eastern part of the survey area. A few small sediment undulations, seabed depressions, scattered irregular sediment lumps and disturbed seabed (attributed to fishing activity) were observed in the surveyed corridor.

Figure 4-6: Seabed Features of the Study Area



Source: Fugro, 2017

4.3.3 Sediment Characterization and Quality

The Environmental Baseline Survey[16] (Appendix L) found sediment was variable across the survey area, with three stations being dominated by sand sediments, two stations dominated by mud sediments and three containing almost equal proportions of sand and mud sediment. All of the samples contained little (<1%) or no gravel. Total organic carbon (TOC) was consistently low across the site (mean of 0.48%) and total organic matter (TOM) was also present at low levels (mean 0.86%)

In an evaluation of sediment samples of eight stations, all but one of the USA Environmental Protection Agency (EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) concentrations were below detectable limits from all stations. The single detectable PAH was benzo(a)pyrene, which was present at very low levels and would not be expected to have a major detrimental effect on sediment dwelling biotic communities.

Sediment samples were also analyzed to evaluate concentrations of metals. The majority of the metals results displayed low to moderate inter-station variability. Comparison of the sediment metals concentrations against indicative ecological effect thresholds (Effects Range Low - ERLs) showed the majority of metal concentrations were below the values where they would be likely to cause any adverse effects on sediment biota. The only exception was nickel, which was present at concentrations that slightly exceeded the ERL value. Most metals were shown to strongly trend with particle size data, with most being shown to increase, but some decrease, in response to variation in fines (silt and clay) content.

4.3.4 Climate and Meteorology

4.3.4.1 Climate

The climate of Bangladesh is mostly determined by its location in the tropical monsoon region: high temperature, heavy rainfall, often excessive humidity, and distinct seasonal variations. The reversal of the wind circulation between summer and winter is another important feature of the climate of the country. The climate of Cox's Bazar is mostly similar to the rest of the country and has three main seasons:

- Summer/pre-monsoon - March to April
- Rainy season/monsoon - May to October
- Winter season - November to February

A summary of monthly climate data is presented in Table 4-2.

[16] Fugro 2017. Geotechnical and Environmental Baseline Survey Services Environmental Baseline Survey Report. Unpublished Report.

Table 4-2: Climate Data for Cox's Bazar, 1986-2016

Climate Data for Cox's Bazar													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Average temp °C	20.9	22.8	25.8	28	28.7	28	27.6	27.6	28.3	28	25.6	22	26.1
Average high °C	26.7	28.5	30.9	32.1	32.3	30.7	30	30.2	31.6	31.6	30	27.5	30.2
Average low °C	15	17	20.7	23.9	25.1	25.2	25.1	25	25	24.3	21.1	16.5	22
Precipitation mm	3	13	38	107	323	790	902	706	389	183	84	25	3,559

Source: Weatherbase, 2016[17]

4.3.4.2 Rainfall

The average annual rainfall in Cox's Bazar is 3,559 mm. A majority of the rainfall occurs during the monsoon season (May – October).

4.3.4.3 Temperature

Temperatures in the region do not vary significantly throughout the year. The monthly average temperatures in the region range from 20.9 to 29.5°C. The average temperature in Cox's Bazar is 26.1°C, annual average high temperature is 30.2 °C, and annual average low temperature is 21.7°C.

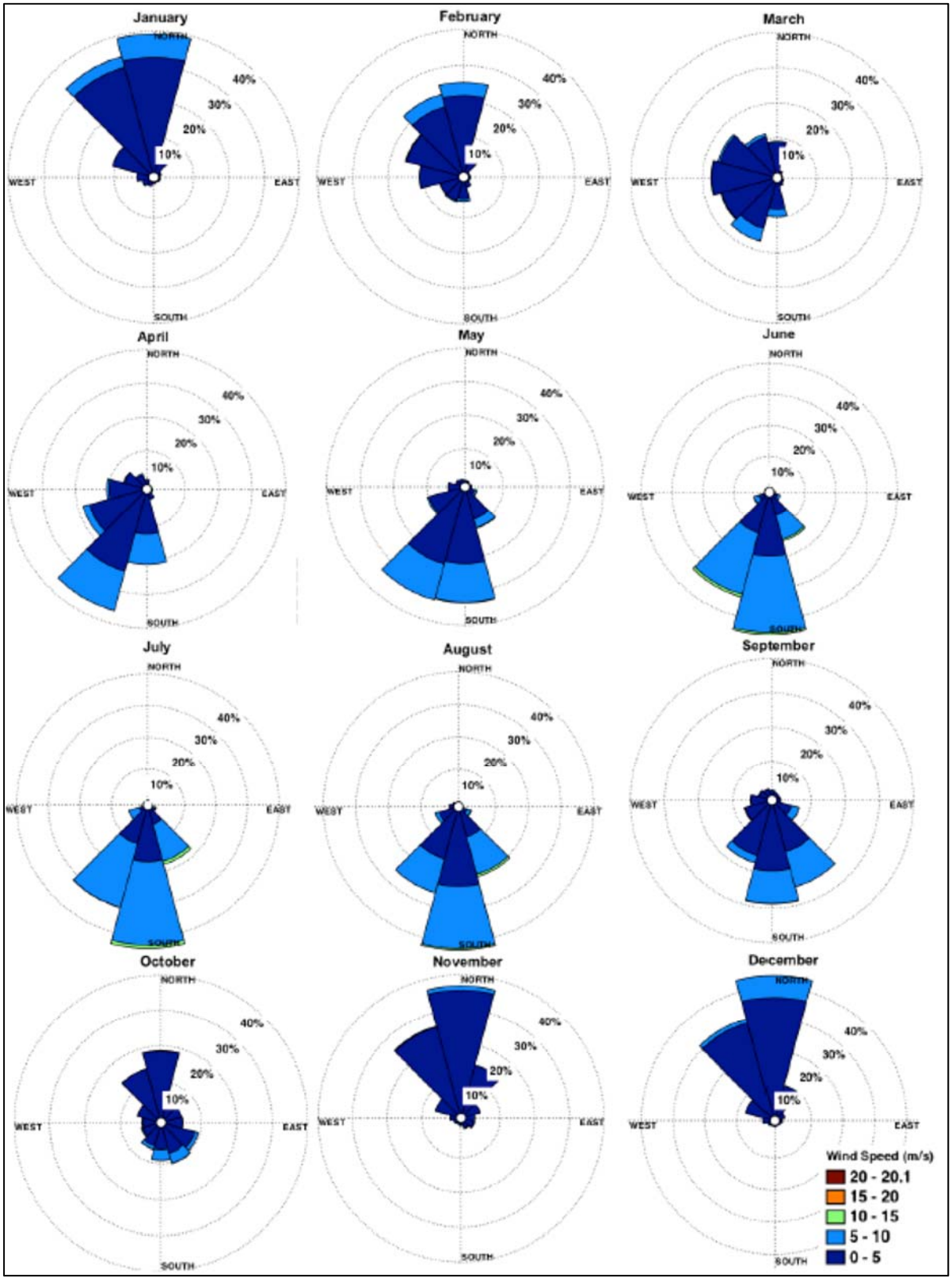
The relative humidity in the region averages 79.5% annually. During the dryer winter season, the average relative humidity in January is 71.0%. During the peak of the wet season, the July average relative humidity is 88.6%

4.3.4.4 Wind

There are two general wind regimes at the project location (Figure 4-7). During the winter months (December to February) the wind comes predominantly from the north. During the rest of the months in spring, summer and wet season, the winds are predominantly from the south. Peak winter winds occur during the month of January, and peak winds during the wet season occur during July (Figure 4-8).

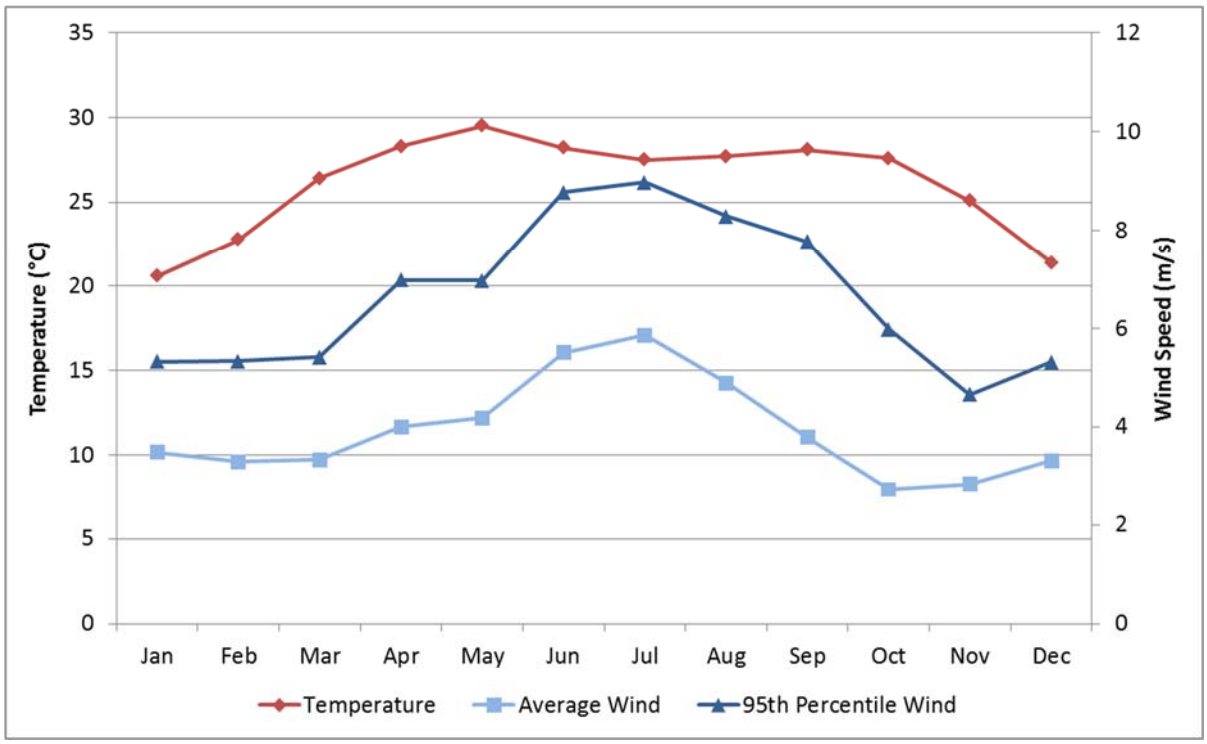
[17] Weatherbase.com. 2016. Cox's Bazar, Bangladesh. Accessed from the weatherbase.com website: http://www.weatherbase.com/weather/weatherall.php3?s=5914&cityname=Cox%27s-Bazar-Chittagong-Bangladesh&units=metric

Figure 4-7: Monthly Wind Roses Near Proposed FSRU Location



Note: Wind speeds in m/s, using meteorological convention (i.e., direction wind is coming from).
Source: RPS ASA, 2016[18]

Figure 4-8: Average Temperature, Average Wind Speed, and 95th Percentile Wind Speed by Month for the Region



Source: RPS ASA. 2016. LNG Atmospheric Dispersion Modeling, Bangladesh.

Additional detail on cyclones and other natural hazards are presented in Section 4.3.9.

4.3.5 Ambient Air Quality

Air quality monitoring in Bangladesh is conducted continuously in eight cities (11 stations), including: Dhaka (three stations), Gazipur, Narayagonj, Chittagong (two stations), Sylhet, Khulna, Rajshahi, and Barisal.[19] However, none of the monitoring stations are located near the terminal location.

The prevailing conditions at the terminal location are typical of offshore and rural Bangladesh, and generally good. The FSRU is approximately 9 km from the nearest village and there is little to no industry located on southern Moheshkhali Island. Therefore, the study area is comparatively free of air pollution in relation to other areas of Bangladesh. Generally, air pollution in the study area would be from road dust, (few) vehicles, construction dust, windblown dust from agricultural lands, domestic heating and cooking, and brick kilns. The principal source of pollutants in the region is from vehicular traffic, which is extremely limited on Moheshkhali.

The first ambient air quality standards were published by DoE as part of the Environmental Conservation Rules, 1997 based on categories (i.e., industry, residential and rural, etc.), but

[18] RPS ASA, 2016. LNG Atmospheric Dispersion Modeling, Bangladesh.
[19] Ministry of Environment and Forests. 2016. Clean Air and Sustainable Environment (CASE) Project. Accessed from the CASE website: http://case.doe.gov.bd/

these limits were replaced in July 2005.[20] [21] The new standards are the same as the ambient air quality limits set by the US Environment Protection Authority for Particulate Matter (PM10, PM2.5), NO2, SO2, CO, and ozone (O3), and the limit for lead (Pb) is from the guideline value set by the World Health Organization.

Table 4-3: Bangladesh Standard for Ambient Air Quality

Pollutant	Averaging Period	Bangladesh Standards[a]
CO	8-hour	10,000 µg/m^3 (9 ppm)
	1-hour	40,000 µg/m^3 (35 ppm)
Pb	Annual	0.5 µg/m^3
NO_x	Annual	100 µg/m^3 (0.053 ppm)
TSP	8-hour	200 µg/m^3
PM_{10}	Annual	50 µg/m^3
	24-hours	150 µg/m^3
$PM_{2.5}$	Annual	15 µg/m^3
	24-hours	65 µg/m^3
O_3	1-hour	235 µg/m^3 (0.12 ppm)
	8-hour	157 µg/m^3 (0.08 ppm)
SO_2	Annual	80 µg/m^3 (0.03 ppm)
	24-hour	365 µg/m^3 (0.14 ppm)

CO = Carbon Monoxide; NO_x = Nitrogen oxide; O_3 = ozone; Pb = lead; PM_{10} = particulate matter with a diameter of not more than 10 microns; $PM_{2.5}$ = particulate matter with a diameter of not more than 2.5 microns; So_2 = Sulfur dioxide; TSP = Total Suspended Particulates; µg/m^3 = micrograms per cubic meter; ppm = parts per million
Source: ADB, 2006[21]

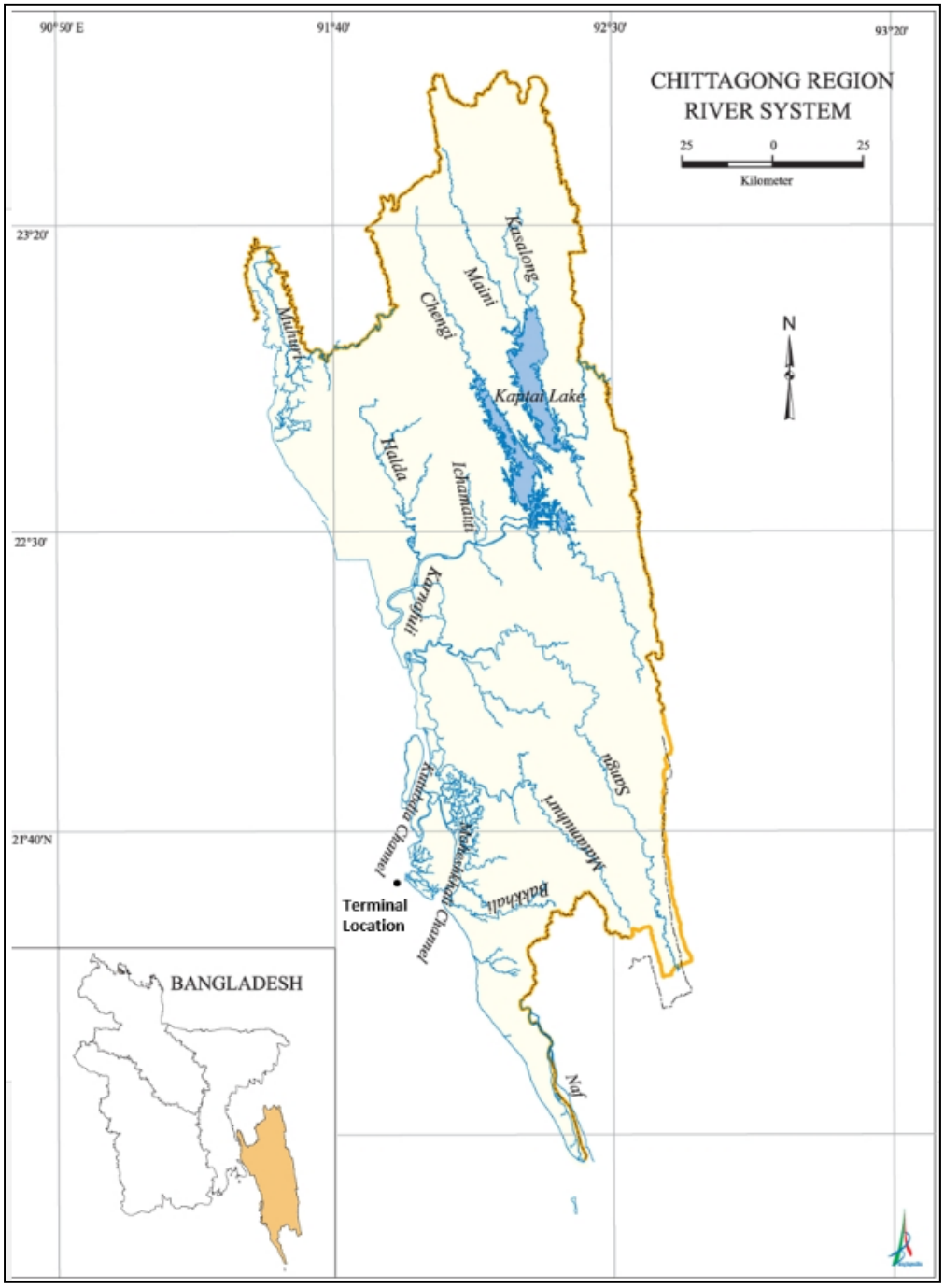
4.3.6 Hydrology

4.3.6.1 Surface Water

The delivery point is located approximately 30m from the high tide mark. There is one stream named Barer Khal flowing nearby the project site, and a number of canals that drain from Sonadia Island. The main rivers of the Chittagong region (Figure 4-9) are the Karnafuli, Halda, Sangu, Matamuhuri, Bakkhali, Naf, Kasalong, Chingri, and Mayani. Moheshkhali Channel is also a prominent feature in the study area. The channel carries the combined flow of the Matamuhuri and its tributaries and of other rivers such as Bharuakhali Khal, Bura Matamuhuri, Mangla Khal and Manikchhari Khal. The length of the channel is 35 km, ending at the Bay of Bengal. Similarly, the Kutubdia channel is north of the Terminal location and separates the mainland from Kutubdia Island.

[20] Department of Environment. 1997. Environmental Conservation Rules. Accessed from the UN website: http://faolex.fao.org/docs/pdf/bgd19918.pdf
[21] ADB. 2006. Country Synthesis Report on Urban Air Quality Management. Bangladesh. Accessed from the ADB website: http://cleanairasia.org/wp-content/uploads/portal/files/documents/bangladesh_0.pdf

Figure 4-9: Chittagong Region River System



Source: Khan, 1990[22]

4.3.6.2 Ground Water

Bangladesh is located over a subsiding basin of tectonic origin with thick sedimentary strata. This is an unconsolidated alluvial deposit of Recent to sub-Recent age overlying marine

[22]Khan, M. 1990. 'Environmental Aspects of Surface Water Development Projects in Bangladesh', in Rahman et al. (ed), Environment and Development in Bangladesh, Vol 2, University Press Ltd, Dhaka, 1990.

sediments. The recent delta and alluvial plains of the Ganges, Brahmaputra, and the Meghna Rivers constitute the upper formation. The near surface Quaternary alluvium contains good aquifer characteristics (transmission and storage coefficients). The groundwater storage reservoir has three divisions; upper clay and silt layer, a middle composite aquifer (fine to very fine sand) and a main aquifer consisting of medium to coarse sand.

Groundwater table fluctuations indicate the recharge and discharge to the groundwater reservoir. The highest groundwater table occurs in the study area during the month of August-September when the aquifer recharges fully and the lowest is during February-March due to natural discharge and groundwater use for domestic and irrigation purposes.

Groundwater is abundant in Bangladesh and the aquifers are highly productive. The sediments are predominantly non-indurate and easy to drill by hand, at least to shallow levels. Water tables vary across the country but are typically shallow at around 1–10 m below the ground surface. These factors have made groundwater an attractive and easily accessible resource and have led to a rapid proliferation in the use of groundwater over the last few decades. Today, 97% of the population relies on groundwater for potable supplies and groundwater is also an important source for irrigation and industry.

Groundwater levels across Bangladesh become depressed during the dry season, but the aquifers replenish fully during the monsoon. In the study area, Moheshkhali Upazila is no exception. Saline intrusion can be a concern, however, as well as groundwater contamination. In the project area, more than 90% of the residents use ground water as a source of drinking water.

4.3.7 Water Quality

A review of nearshore and groundwater quality from the Original EIA are provided below. Offshore water quality presented is based on the environmental baseline conducted for this ESIA.

4.3.7.1 Nearshore Water Quality

A sample of sea water collected from the see water from the shore line of the onshore project site was tested and the report is attached included as Annex-1 of the original EIA and summarized in Table 4-4.

Table 4-4: Laboratory Test Results for Seawater Field Sample from Kaladia Char, Collected on 14 February, 2012

Sl. No	Water Quality Parameters	Unit	Concentration Present	Bangladesh Discharge Standards (ECR-1997)		
				Discharge in Inland Water	Discharge into Public Water	Discharge on Irrigated land
1	pH		7.9	6.9	6.9	6.9
2	Electrical Conductivity(EC)	µS/cm	50000	1200	1200	1200
3	Alkalinity (as $CaCO_3$)	mg/L	65	-	-	-
4	Total Dissolved Solids (TDS)	mg/L	25000	2100	2100	2100
5	Total Suspended Solids (TSS)	mg/L	15	150	500	200
6	Total Solids (TS)	mg/L	25015	-	-	-
7	Chloride (Cl)	mg/L	19260	600	600	600
8	Chemical Oxygen Demand (COD)	mg/L	365	200	400	400
9	Biochemical Oxygen Demand (BOD) 5 days	mg/L	80	50	250	100

4.3.7.2 Ground Water

Table 4-5 shows the ground water quality of the Chittagong and Cox's Bazar districts; Moheshkhali is within Cox's Bazar district.

Total Dissolved Solids, Nitrite, Sulphate, Cadmium, Arsenic, Iron, and Manganese contents were seen to exceed Bangladesh Standard and Testing Institutes (BSTI) standard.

Table 4-5: Ground Water Quality of the Project area

Parameters	Cox's Bazar	Chittagong	BSTI Standard
Ambient Temp. (^0C)	33	27.53	-
Water Temp. (^0C)	27.08	27.15	-
pH	7.19	7.38	6.4-7.4
EC. (μScm^{-1})	1646.86	2822.13	-
TDS (mgL^{-1})	823.86	787	Max 500
% NaCl	3.01	2.54	-
DO (mgL^{-1})	2.27	1.75	Max 6
Acidity (mgL^{-1})	20.56	40.55	-
T. Alkalinity (mgL^{-1})	283.63	355.83	-
T. Hardness (mgL^{-1})	243.75	224.59	Max 500
Chloride (mgL^{-1})	404.63	378.28	Max 600
NO^{2-}-N (mgL^{-1})	0.09	0.14	Nil
NO^{3-} -N (mgL^{-1})	0.925	2.47	Max 4.5
O-PO_4^{3-} -P (mgL^{-1})	2.02	3.35	Max 6
SO_4^{2-} -S (mgL^{-1})	404.99	88.67	Max 400
Ni (mgL^{-1})	BDL	0.02	-
Zn (mgL^{-1})	BDL	0.015	Max 5
Cu (mgL^{-1})	BDL	0.01	Max 1
Co (mgL^{-1})	0.005	0.008	-
Cr (mgL^{-1})	BDL	0.005	Max 0.5

Parameters	Cox's Bazar	Chittagong	BSTI Standard
Cd (mgL^{-1})	BDL	0.011	0.005
Pb (mgL^{-1})	0.045	0.049	Max 0.05
As (mgL^{-1})	BDL	0.413	Max 0.05
Fe (mgL^{-1})	2.8	1.67	0.3-1.0
Mn (mgL^{-1})	0.52	0.19	Max 0.1

BDL: Below detected limit
Source: Ahmed, et al., 2010[23]

4.3.7.3 Offshore Water Quality

Full results of the water quality analysis from the environmental baseline survey are provided in Appendix L. Results presented below were based on samples collected at eight offshore stations. Water samples were acquired at two depths per station using 5 litre Niskin bottles - these water samples were subsampled for nutrient, hydrocarbon and heavy/trace metal analyses.

Total Petroleum Hydrocarbons (TPH) concentrations were consistently low throughout the survey area, with all values below detectable limits. Metals concentrations in the water column samples were generally low with all metals measured at concentrations less than the US EPA saltwater quality standards, with the exception of copper which exceeded the Criterion Continuous Concentration (CCC) at four stations. The proportion of total suspended solids and depth had a positive correlation with many heavy and trace metals. Nutrient levels were generally low, with some below levels of detection.

4.3.8 Oceanography

A description of key oceanographic conditions is described below.

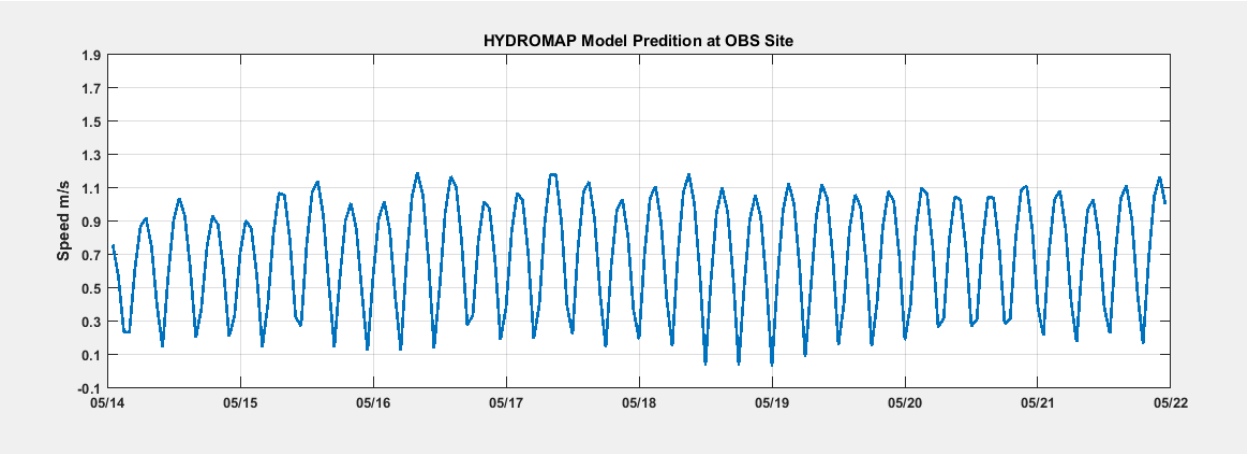
4.3.8.1 Tides and Currents

Predicted current conditions for the FSRU location are shown in Figure 4-10 based on data provided in the LNG terminal site assessment conducted by Poten & Partners, as well as observation data from a single location close to the study area, as shown in Figure 4-11. The peak speeds during the May 2008 period are relatively constant and peak at approximately 1.1 m/s whereas during the February 2009 time period the tidal current amplitude nearly doubles between neap and spring tide from 0.6 m/s to 1.20 m/s respectively. A summary of current speed statistics are provided in Table 4-6.

The tidal currents are relatively strong in this area with magnitude variable depending on time. The tidal constituents result in variable speeds due to the timing of individual constituents. The semidiurnal constituents dominate the tidal regime and as such the area is subject to two high and two low tides a day, which results in reversing currents twice a day. The direction of the reversing currents is predominately a north-south flow, however in areas closer to the shoreline the directions vary in response to the effects of bathymetry and shoreline where flow moves in and out of channels and rivers. Illustrations of predicted current patterns during flood and ebb tides are shown in Figure 4-12 and Figure 4-13. Current roses at the Observation station and FSRU location are provided in Figure 4-14.

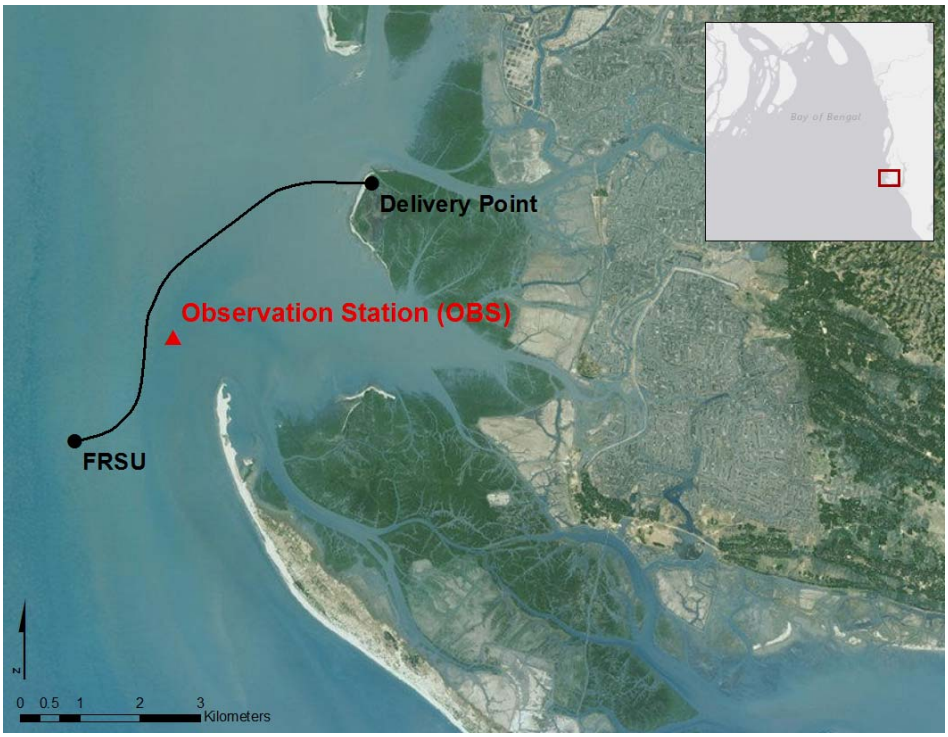
[23] Ahmed, M.J., Haque, M. R., Ahsan, A. Siraj, S., Bhuiyan, M. H. R., Bhattacharjee, S. C., and S. Islam. 2010. Physicochemical Assessment of Surface and Groundwater Quality of the Greater Chittagong Region of Bangladesh. Pakistan Journal of Environmental Chemistry Vol. 11, No. 2 (2010) 1 – 11.

Figure 4-10: Predicted Current Conditions



Source: RPS ASA, 2016

Figure 4-11: Location of Observation Station near the FSRU



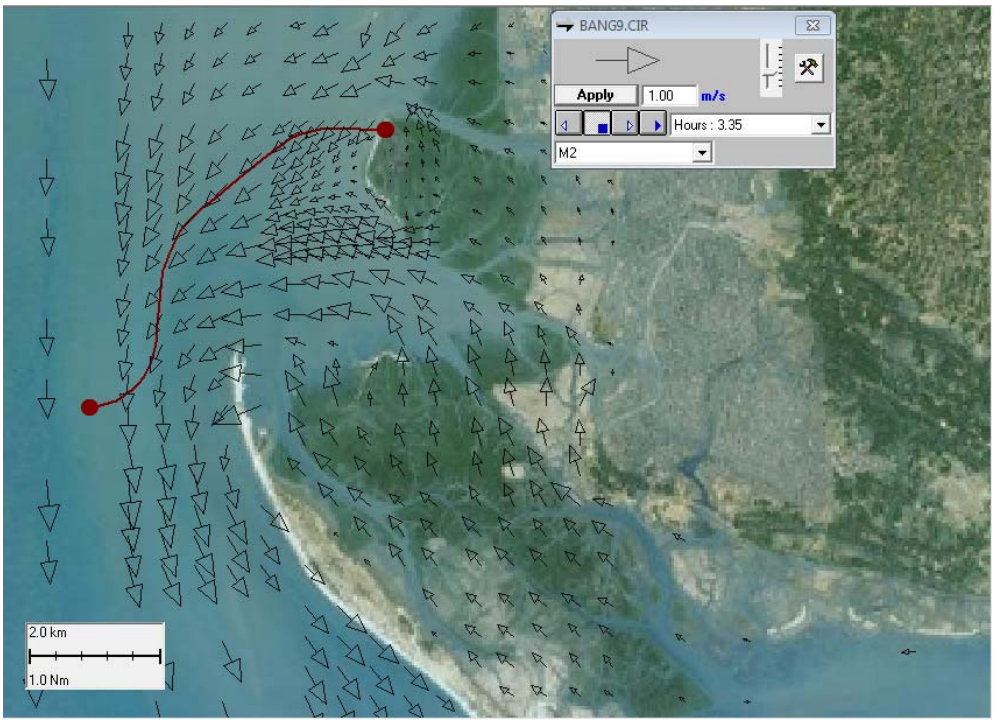
Source: RPS ASA, 2016

Table 4-6: Summary of Current Speed Statistics at Points of Interest

Percentile	Terminal	OBS Site
	cm/s	cm/s
5	14.0	10.4
10	20.5	14.7
15	27.0	19.4
20	34.2	24.8
25	41.9	30.7
30	49.7	36.8
35	57.8	43.1
40	66.0	49.5
45	74.3	56.0
50	82.6	62.6
55	91.1	69.3
60	99.8	76.3
65	108.8	83.6
70	118.5	91.4
75	128.8	99.8
80	140.0	109.0
85	153.0	119.8
90	169.6	133.5
95	191.8	151.9
100	252.0	201.6

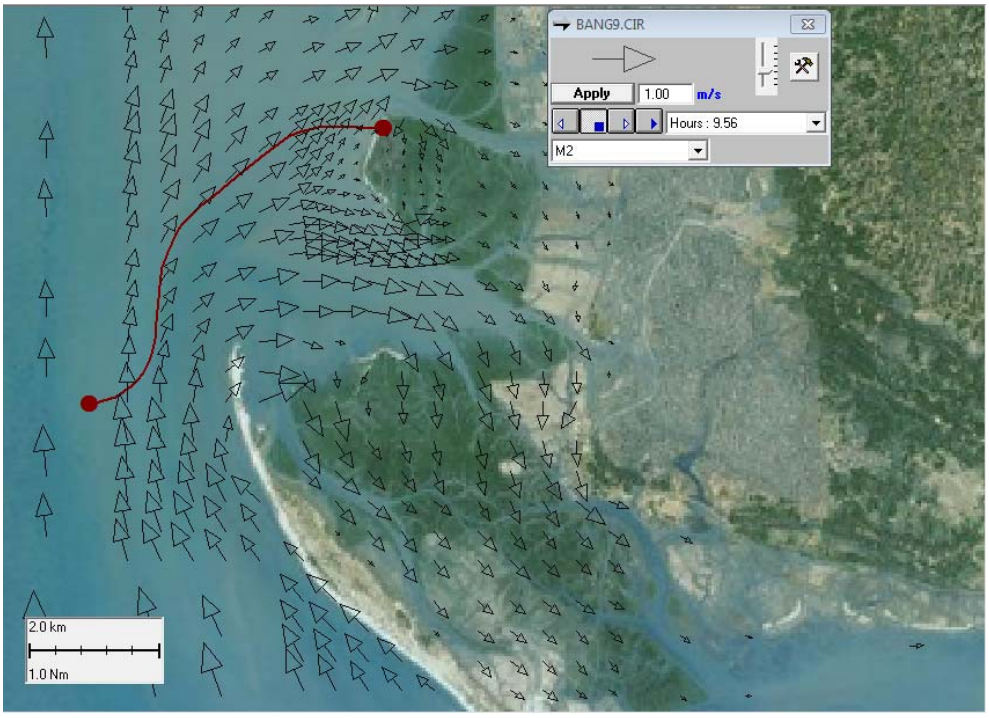
Source: PRS ASA, 2016

Figure 4-12: Illustration Showing Flood Current Pattern



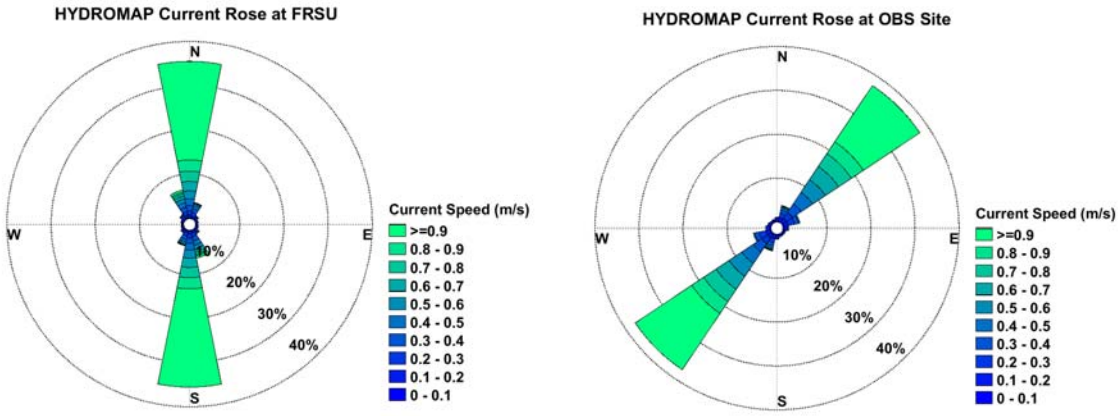
Source: RPS ASA, 2016

Figure 4-13: Illustration Showing Ebb Current Pattern



Source: RPS ASA, 2016

Figure 4-14. Current Rose at FRSU (Left) and Observation Site (Right)



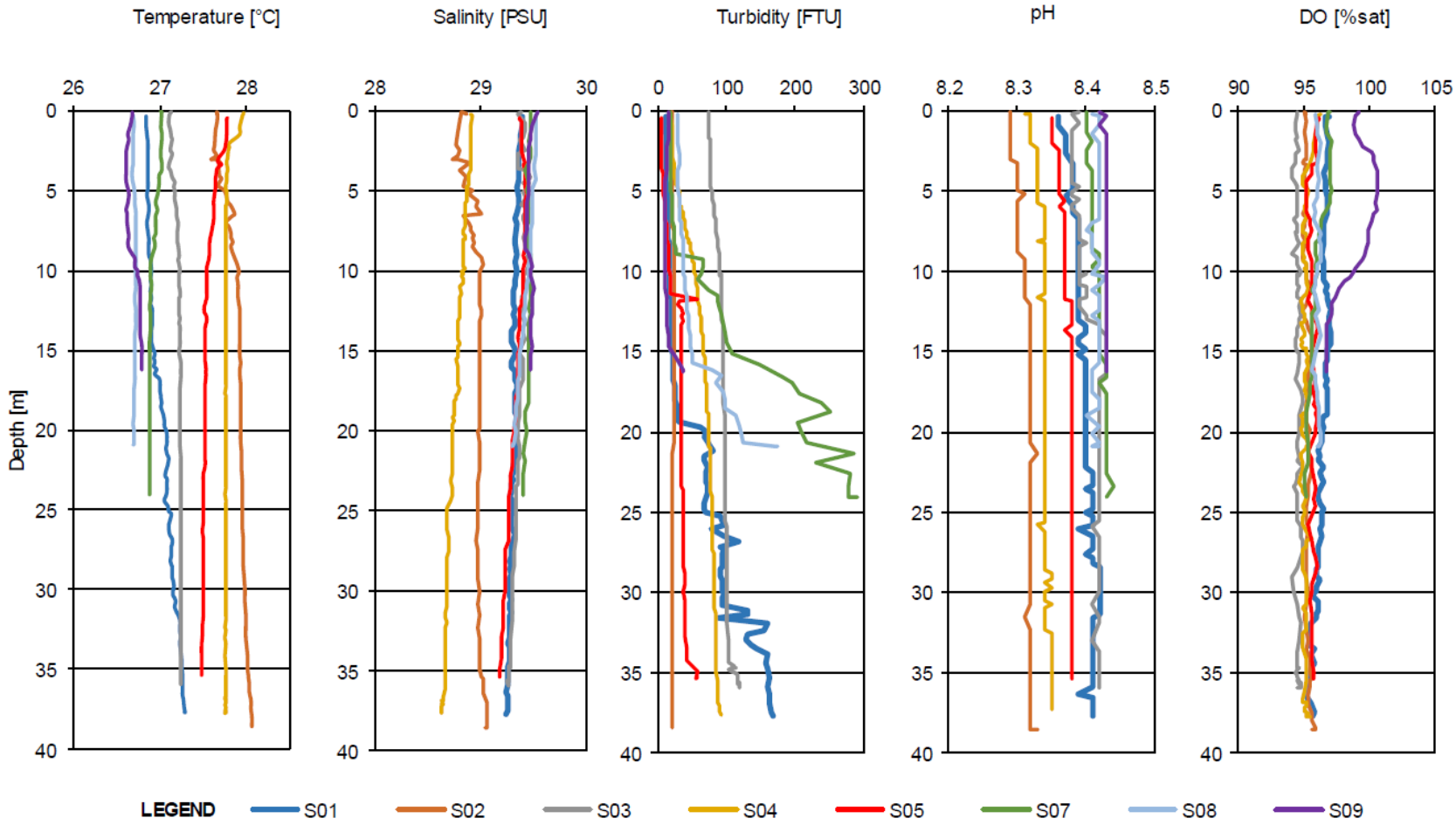
Source: RPS ASA, 2016
Note: Current roses show direction currents are flowing towards

4.3.8.2 Water Profile

The water profile in Bangladesh varies by location and season, and the region is highly influenced by seasonal factors (precipitation) and inflows of surrounding rivers (Ganga, Brahmaputra, Irrawaddy, Godavari, and others) which have large catchment areas.

The Fugro environmental baseline survey conducted for this ESIA found water profiles for temperature, salinity, pH and dissolved oxygen showed a well-mixed water column at all stations with no thermocline or halocline (Figure 4-15). A subsurface increase in dissolved oxygen was observed at one station and was attributed to wave and tidal action in shallower water causing oxygen over-saturation. Turbidity values were more variable and increases in turbidity with depth were observed at all stations. Variation in pH, temperature and salinity were recorded between stations but this was attributed to temporal changes from changes in environmental conditions during the survey period, rather than inter-station spatial variation.

Figure 4-15: Water Profiles of the Study Area Showing Temperature, Salinity, Turbidity, pH and Dissolved Oxygen from December 2016



Source: Fugro, 2017

4.3.9 Natural Hazards

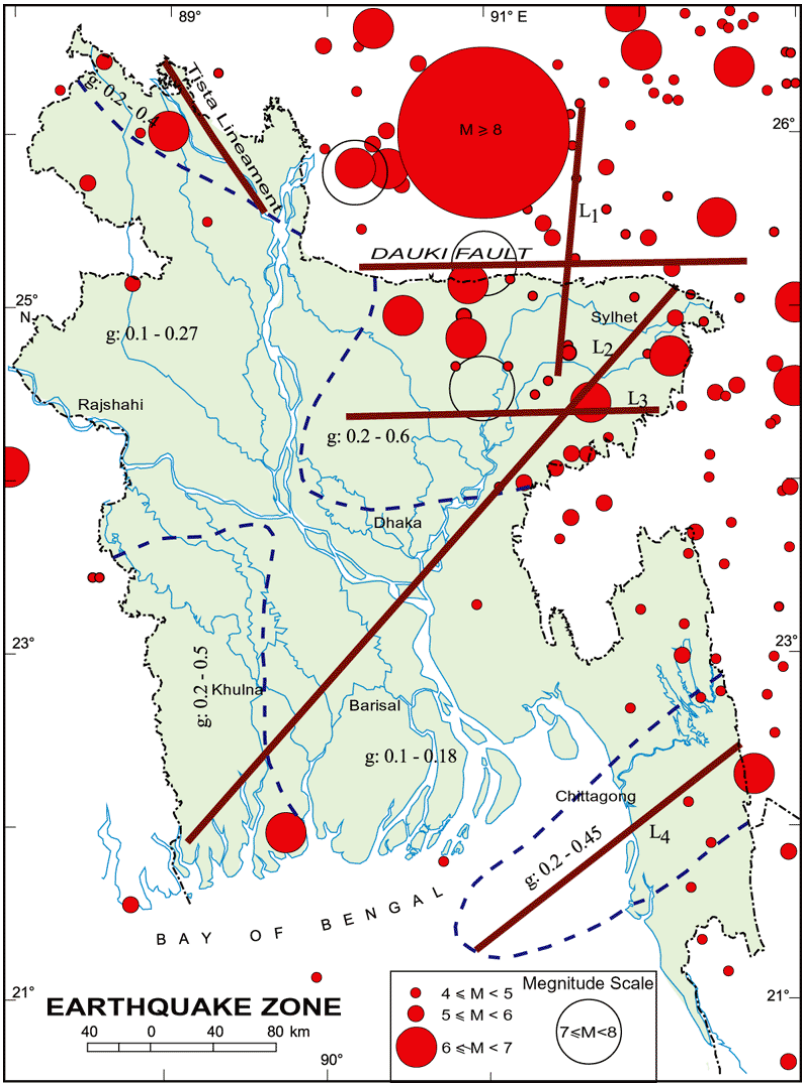
4.3.9.1 Seismicity

As noted in Section 4.3.1, Bangladesh is positioned at the juncture of several active tectonic plate boundaries. Bangladesh is surrounded by regions of high seismicity, including the Himalayan Arc and Shillong plateau in the north; the Burmese Arc and Arakan Yoma anticlinorium in the east; and, complex Naga-Disang-Jaflong thrust zones in the northeast. Bangladesh is also the site of the Dauki Fault system, along with numerous subsurface active faults and a flexure zone called the Hinge Zone. These weak regions are believed to provide the necessary zones for movements within the basin.

Information on earthquakes in and around Bangladesh is available for the last 250 years. The earthquake record suggests that since 1900 more than 100 moderate to large earthquakes occurred in Bangladesh, out of which more than 65 events occurred after 1960. This increase in earthquake activity is an indication of fresh tectonic activity or propagation of fractures from the adjacent seismic zones.

The location of earthquake epicenters in Bangladesh between 1548 and 2006 are shown in Figure 4-16.

Figure 4-16: Earthquake Zone of Bangladesh (1598-2006)



Source: National Encyclopedia of Bangladesh, 2006[24]
Note: Brown lines are faults or lineaments.

Bangladesh is divided into three seismic zones: Zone I – Severe (Seismic Factor, 0.08g), Zone II – Moderate (Seismic Factor, 0.05g), and Zone III – Minor (Seismic Factor, 0.04g). The project area is located in Zone II – Moderate.

4.3.9.2 Tsunami

The US National Oceanographic and Atmospheric Administration of the United States (NOAA), National Centers for Environmental Information notes only five tsunami events have occurred in Bangladesh.[25] The most recent event occurred in 1988 near the border of India and Bangladesh. While Bangladesh felt the earthquake associated with the 2004 tsunami, the country was not impacted significantly by the tsunami itself.

[24] National Encyclopedia of Bangladesh. 2006. Banglapedia, CD Edition.
[25] NOAA. 2017. Historical Tsunami Database. Accessed from the NOAA website: https://www.ngdc.noaa.gov/hazard/tsu_db.shtml

4.3.9.3 Cyclones and Storm Surge

Cyclones are common in Bangladesh, most frequently between April - May or October-November. Dasgupta et al. notes that, “Between 1877 and 1995 Bangladesh was hit by 154 cyclones (including 43 severe cyclonic storms, 43 cyclonic storms, 68 tropical depressions). Since 1995, five severe cyclones hit coast of Bangladesh coast in May 1997, September 1997, May 1998, November 2007, and May 2009. On average, a severe cyclone strikes Bangladesh every three years.[26]

Historical cyclone tracks (1877-2016) that passed within 100 km from the terminal location are shown in Figure 4-17. Tracks are not shown for tropical depressions or tropical storms.

There is also a significant risk of storm surge associated with cyclones (and normal monsoon events). Dasqupta notes Bangladesh is particularly vulnerable to storm surge given:

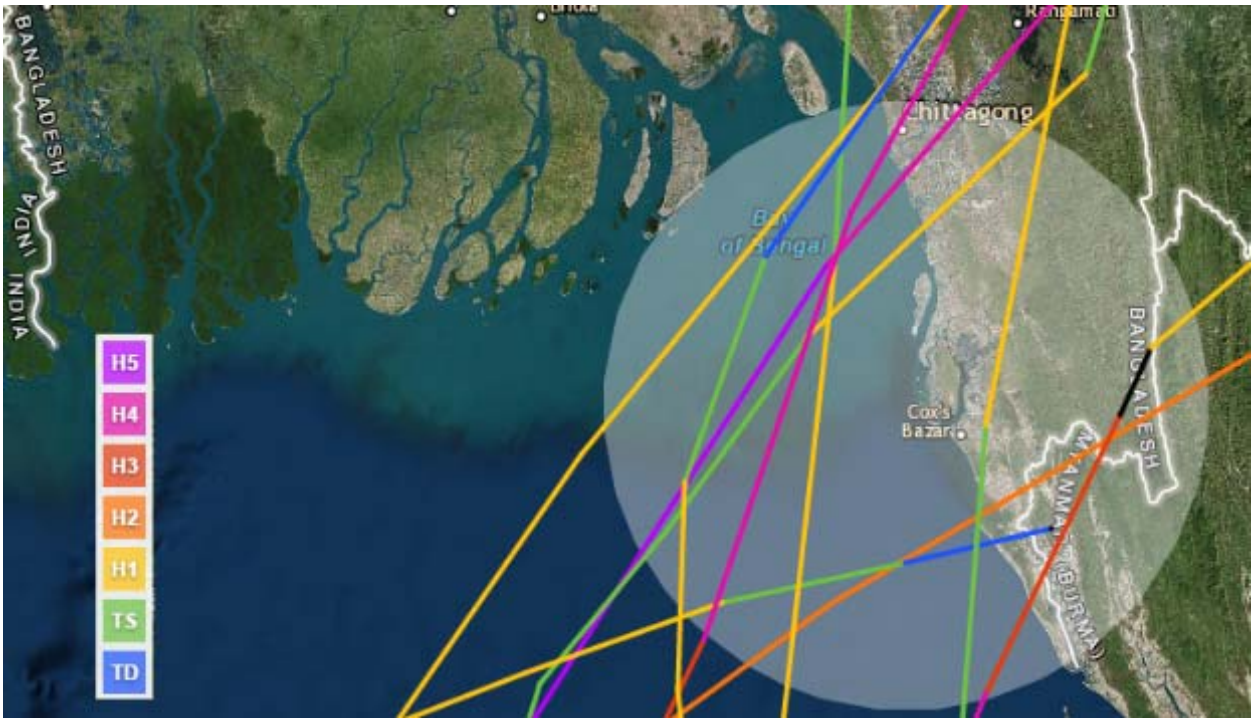
- The phenomenon of recurvature of tropical cyclones in the Bay of Bengal
- Shallow continental shelf, especially in the eastern part of Bangladesh
- High tidal range
- Triangular shape at the head of the Bay of Bengal
- Almost sea-level geography of the Bangladesh coastal land
- High density of population and coastal protection system

The Chittagong cyclone of 29 April 1991 had a maximum wind speed of 235 km/hr with storm surge of 6.9 m. The cyclone resulted in significant loss of life, and damage to livestock, crops, and property. Vast areas in the districts of Cox's Bazar, Chittagong, Noakhali, and Bhola were submerged. The depth of water at Chittagong Airport exceeded 2m.

Hazard risk maps for cyclones and storm surge are shown in Figure 4-18 and Figure 4-19.

[26] Dasgupta, S., Huq, M., Khan, Z.H., Ahmed, M.M.Z., Mukherjee, N., Khan, M.F., and K. Pandey. 2010. Vulnerability of Bangladesh to Cyclones in a Changing Climate: Potential Damages and Adaptation Costs. Accessed from the World Bank Group Website: https://openknowledge.worldbank.org/bitstream/handle/10986/3767/WPS5280.pdf;sequence=1

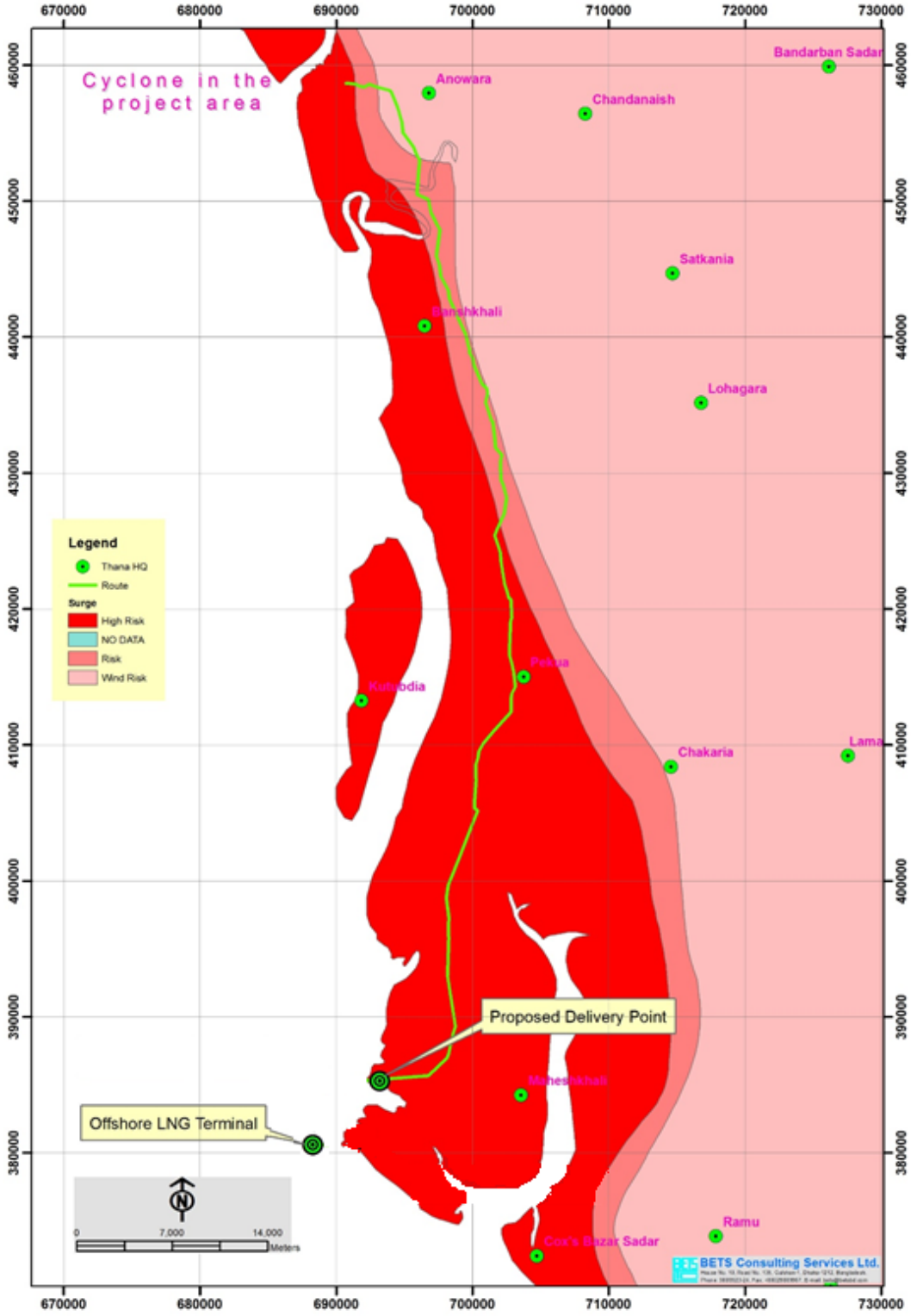
Figure 4-17: Historical Cyclone Tracks (1877-2016) Paths within 100 km from Terminal



Source: NOAA, 2016[27]

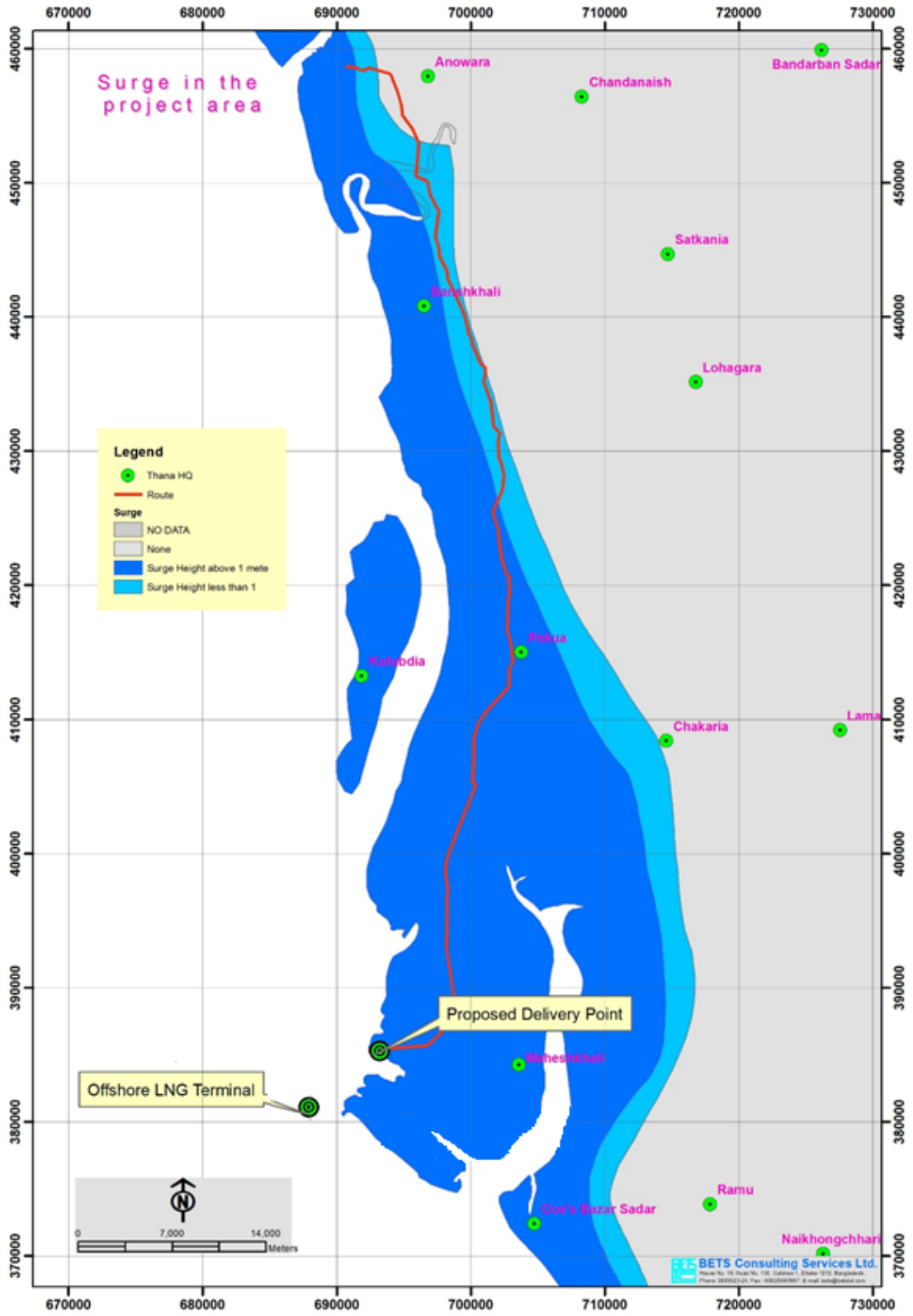
[27] NOAA. 2016. Historical Hurricane Tracks. Accessed from the NOAA website: https://coast.noaa.gov/hurricanes/

Figure 4-18: Cyclone Hazard Risk Map



Source: BETS

Figure 4-19: Storm Surge Hazard Risk Map



Source: BETS

4.4 Biological Environment

The baseline evaluation presented below incorporates desktop review and field work shown in Table 4-7. The complete Environmental Baseline Survey is included as Appendix L and shorebird survey report appended to the Critical Habitat Assessment (Appendix C). Details of stakeholder engagement can be found in Chapter 7 and relevant appendices.

Table 4-7: Primary Baseline Surveys Conducted

Baseline Surveys	Activity	Conducted by	Timing
Water Quality (nearshore)	• One sea water sample at Delivery Point shoreline. This water sample was analyzed, per Bangladesh discharge standards (ECR 1997), for: pH, Electrical Conductivity(EC), Alkalinity (as CaCO3), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Solids (TS), Chloride (Cl), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD) 5 days	• BETS	• 22 August 2012
Water Quality (offshore)	• Eight sample stations for water profiles (measuring conductivity (salinity), temperature, depth, dissolved oxygen, pH and turbidity) using Hydrolab DS5X CTDs and water samples were acquired at two depths per station using 5 litre Niskin bottles; these water samples were subsampled for nutrient, hydrocarbon and heavy/trace metal analyses.	• Fugro	• 23 November - 7 December 2016
Sediment Quality (offshore)	• Benthic samples were acquired at eight sampling stations using a dual 0.1m^2 van Veen grab, with the resultant samples processed for particle size, organic carbon, hydrocarbon, and heavy/trace metals.	• Fugro	• 23 November - 7 December 2016
Terrestrial Ecology	• Bird survey: The shorebird survey was conducted over two days at Kaladia (Sonadia Island) to determine the boundaries of the foraging and roosting areas. Observations were made using 10x42 binoculars and 25-50x spotting scopes. During the field visit one Garmin e-trex GPS unit was used to track survey route and record	• Bird survey: BSCP (Sayam U. Chowdhury and Md. Foysal)	• The field visits and surveys took place during approaching tide on 10 August 2016 and receding tide on 11 August 2016

Baseline Surveys	Activity	Conducted by	Timing
	coordinates of the sensitive site boundaries. • Site walk over o Two visits • Sensitivity mapping and remote sensing	• Site walk over: 1. BETS 2. Acorn International / BETS • Sensitivity mapping and remote sensing: Acorn International	• Site walk over: 1. August 2012 2. August 2016 • Sensitivity mapping and remote sensing: June – December 2017
Marine Ecology	• Benthic samples were acquired at eight sampling stations using a dual 0.1m^2 van Veen grab, with the resultant samples processed for macrofaunal analyses • Incidental observations of marine life (seabirds, sea turtles, marine mammals, and pelagic fish)	• Fugro	• 23 November - 7 December 2016
Social / Health / Economic	• Stakeholder engagement, including surveys, structured interviews, focus groups, and public meetings with project affected people and other key stakeholders	• BETS • Acorn International / BETS	• The original consultation was conducted by BETS in 2012 • Acorn International and BETS conducted scoping consultation in August 2016, ESIA consultation in October 2016, and a survey of the associated pipeline route in December 2016

A discussion of the baseline characterization gaps is included in Section 5.4.

4.4.1 Priority Ecosystem Services

The project is mostly offshore, although the onshore component is located in a sensitive area comprised of mudflats, dunes and mangrove forests. Priority ecosystem services of the project area include:

- Supporting Services:
  - Habitat and biodiversity: Sonadia Island is nationally protected and internationally recognized as an area of high conservation value. In particular, the mud flats are key migratory habitat for Critically Endangered and Endangered wading birds. Mangroves are also important nursery areas for fish species. Land cover data is provided in Section 4.4.3, protected areas are discussed in Section 4.4.4, flora is discussed in Section 4.4.5, fauna is discussed in Section 4.4.6, and fishing is discussed in Section 4.5.12.
- Regulating Services:
  - Soil stabilization and storm surge protection: The mangroves of Sonadia Island are some of the largest tracts remaining in Bangladesh and provide protection from coastal erosion and storm surge. Sediment dynamics are discussed in Section 4.3.2.1, coastal erosion and deposition are discussed in Section 4.3.2.2, natural hazards are discussed in Section 4.3.9, land cover discussed in Section 4.4.3, and flora discussed in Section 4.4.5.
- Provisioning Services:
  - Fishing: Interviews with fisheries officers at Upazila level indicated that as many as 35,000 Moheshkhali fishermen work in the Bay of Bengal, and fishing is a key source of income and sustenance. Health is discussed in Section 4.5.7 and fishing is discussed in Section 4.5.12.
- Cultural Services:
  - While the site does present some recreation and aesthetic value, no cultural services are considered priority ecosystem services.

4.4.2 Ecological Characterization

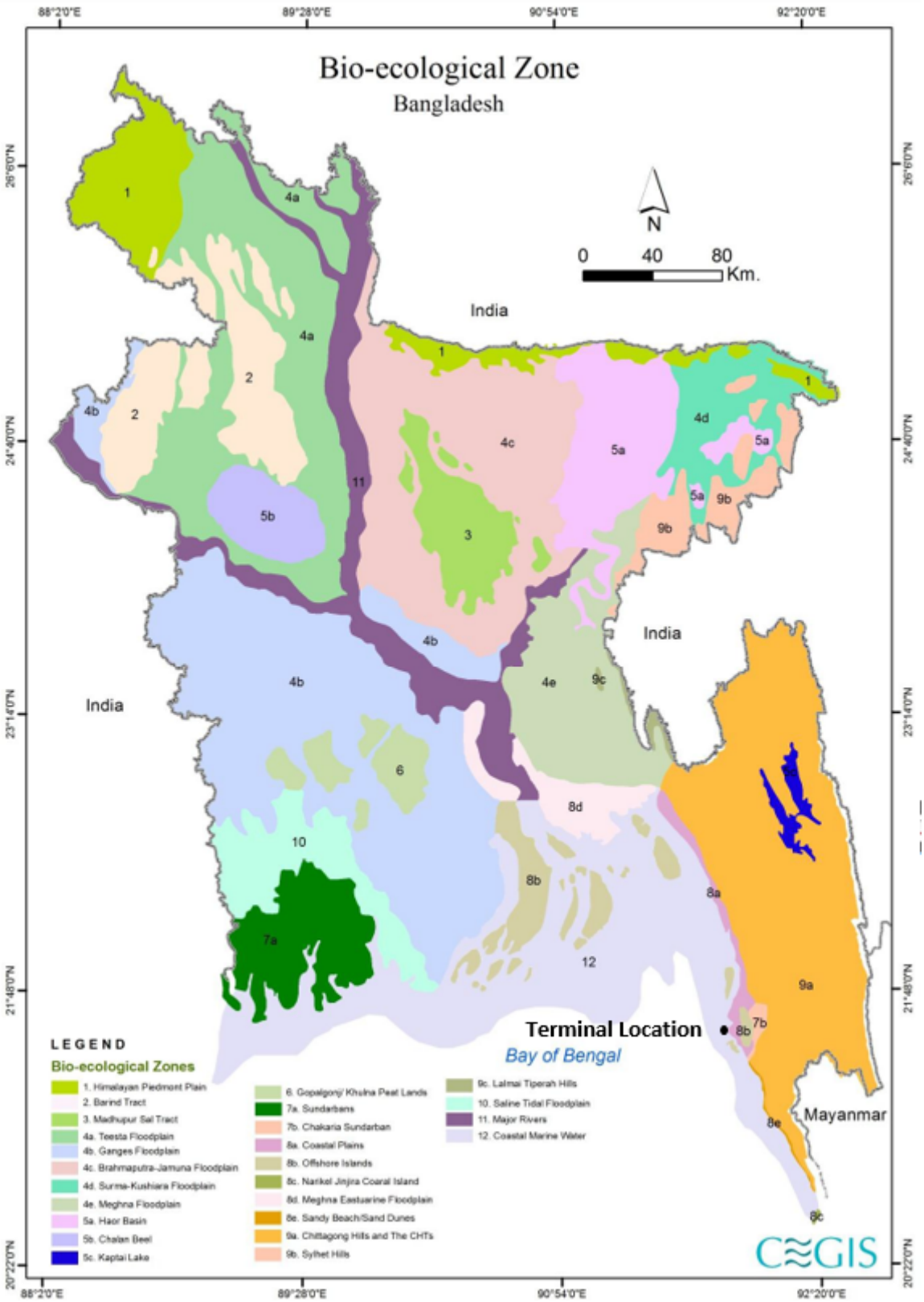
International Union for Conservation of Nature (IUCN) has delineated 25 bio-ecological zones in Bangladesh (Figure 4-20), based on physiographical, hydrological, meteorological, and ecological features.[28] Only five of these are present in the study area, including:

1. Coastal plains
2. Sandy beach / sand dunes
3. Chakaria Sundarbans
4. Offshore islands
5. Coastal marine waters

A brief description of each is provided below, based on characterizations described by Nishat et al. As described in above, the study area is bound to the east by Chittagong Hills, a distinct bio-ecological zone. This region is not considered in the evaluation, given the differences in flora and fauna present compared to the area of influence, which is only marine and coastal areas.

[28] Nishat, A., Huq, S.M., Imamul, Barua, Shuvashish, P., Reza, Ali A.H.M., Khan, A.S. Moniruzzaman (eds.). 2002. Bio-ecological Zones of Bangladesh. IUCN Bangladesh Country Office, Dhaka, Bangladesh.

Figure 4-20: Bio-ecological Zones of Bangladesh



Source: Economics Division, Planning Commission, Government of Bangladesh. 2015.[29]

4.4.2.1 The Coastal Plains

The coastal plains encompass most of the coastline in the study area. This region rises slightly above sea level and is dissected by numerous rivers and streams (Figure 4-9). The coastal plains are underlain by heavy marine or tidal clays, with sand or silt deposits near the foot of the hills and along the courses of rivers and streams. The coastline in the plains is comprised primarily of mud flats and submerged sands, and is important for a wide variety of waterfowl.

4.4.2.2 Sandy Beach/Sand Dunes

Sandy beach and sand dunes in Bangladesh primarily occur from the mouth of the Bakkhali River in Cox's Bazar south to the border of Myanmar. Cox's Bazar is at the southern bound of the study area, so this bio-ecological zone is limited with in the study area. However, approximately 10 km of sandy beach and sand dunes are present on Sonadia Island, adjacent to the terminal location. Sandy beaches on Sonadia are known to support sea turtle nesting for Green Turtle (*Chelonia mydas*) and Olive Ridley Turtle (*Lepidochelys olivacea*), as well as high tide roosts for shorebirds and gulls.

4.4.2.3 Chakaria Sundarbans

Chakaria Sundarbans are a complex of deltaic mangrove forest of the Mathamuhuri River at Chakaria in Cox's Bazar district. This bio-ecoregion was once a mosaic of newly formed grassy islands, river channels, tidal creeks, aquaculture ponds, mangrove forests and inter tidal mudflats; however, most of this ecosystem has been converted into salt pans and agricultural land[30]. The initial area of the Chakaria Sundarbans is estimated at 18,200 ha. Encroachment of human settlements prompted the government to set aside 8,510 ha as protected forest in 1906, but the entirety of that set-aside was subsequently leased to farmers between 1926 and 1996.

4.4.2.4 Offshore Islands

There are many offshore islands in Bangladesh that are continuously changing as a result of erosion and tidal surge. Within the study area, the three main offshore islands include Moheshkhali Island, Sonadia Island, and Kutubdia Island. Offshore islands include many features that support biodiversity, including extensive intertidal mudflats, shoals, and mangrove forests.

4.4.2.5 Coastal Marine Water

Costal marine water includes all of Bangladesh's territorial waters and Exclusive Economic Zone, over 25 million acres in total.

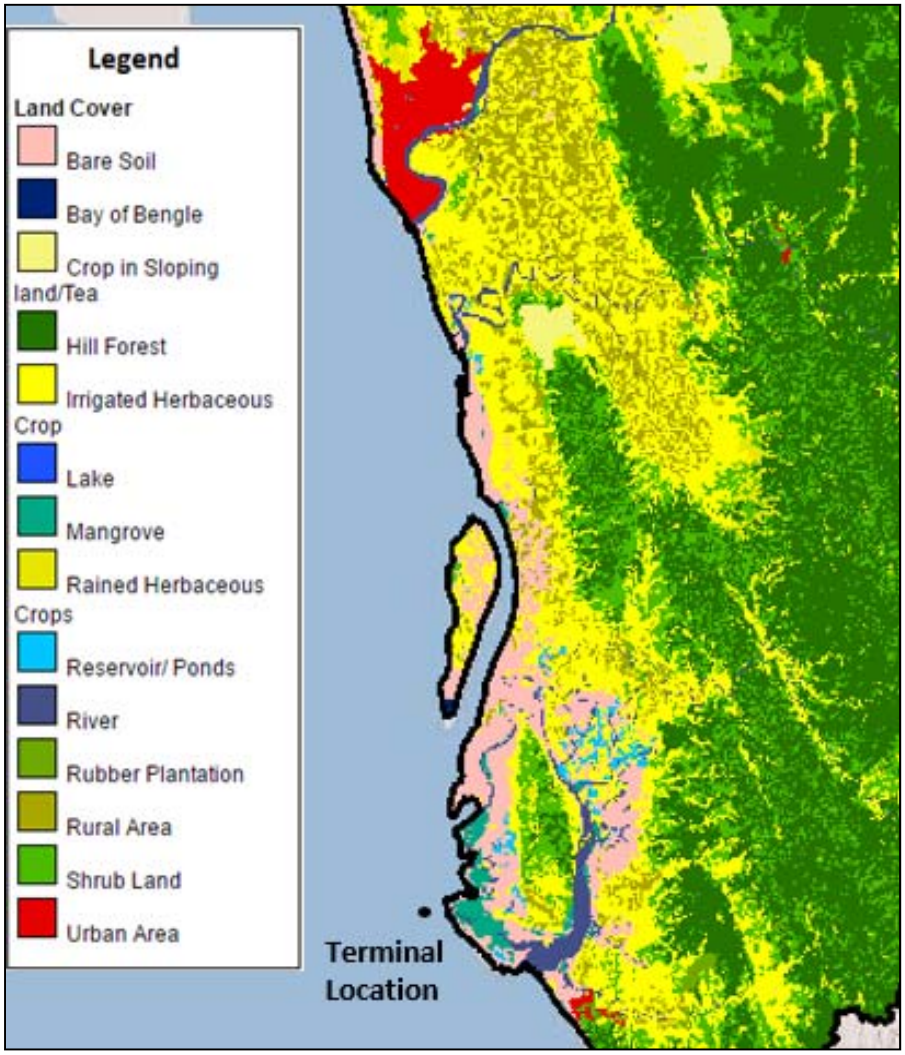
4.4.3 Land Cover

Land cover in the study area is shown in Figure 4-21, and a detailed view of the land cover near the LNG terminal is shown in Figure 4-22. Sonadia Island is largely covered by a mangrove plantation, planted over the past 50 years for conservation values.

[29] General Economics Division, Planning Commission, Government of Bangladesh. 2015. Bangladesh Delta Plan 2100: Ecological Settings. Accessed from the project website: http://www.bangladeshdeltaplan2100.org/

[30] Siddique, M. 2012. Destruction of Hundred Years Oldest Mangrove Chakaria-Sunderban Forest: Socio-economic Impact on Coastal Communities. Proceedings of the International Conference: Meeting on Mangrove Ecology, Functioning, and Management. 2-6 July, 2012, Galle, Sri Lanka.

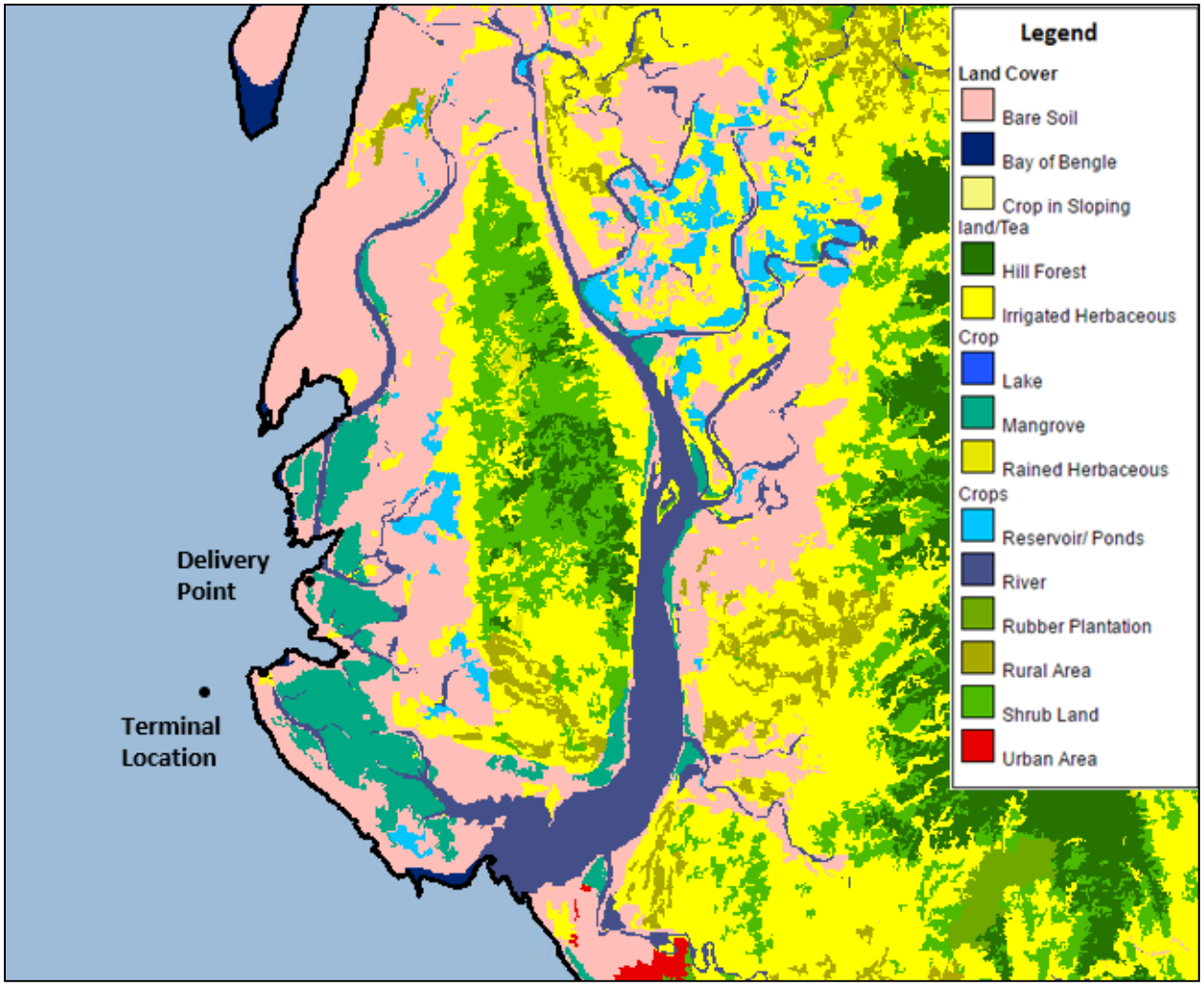
Figure 4-21: Land Cover in Study Area



Source: Acorn International / The International Centre for Integrated Mountain Development (ICIMOD). 2016.[31]
Note: "Bay of Bengle" indicates intertidal substrate area on the southern tip of Kutubdia Island.

[31] The International Centre for Integrated Mountain Development (ICIMOD). 2016. Mountain GeoPortal: Land Cover Dynamics of Greater Chittagong Area. Accessed from the ICIMOD website: http://apps.geoportal.icimod.org/BDLandcover/#

Figure 4-22: Land Cover near Terminal Location



Source: Acorn International / ICIMOD. 2016[31]

The IFC Performance Standard 6 define natural and modified habitat as:

> *"Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition."*
>
> *"Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands."*

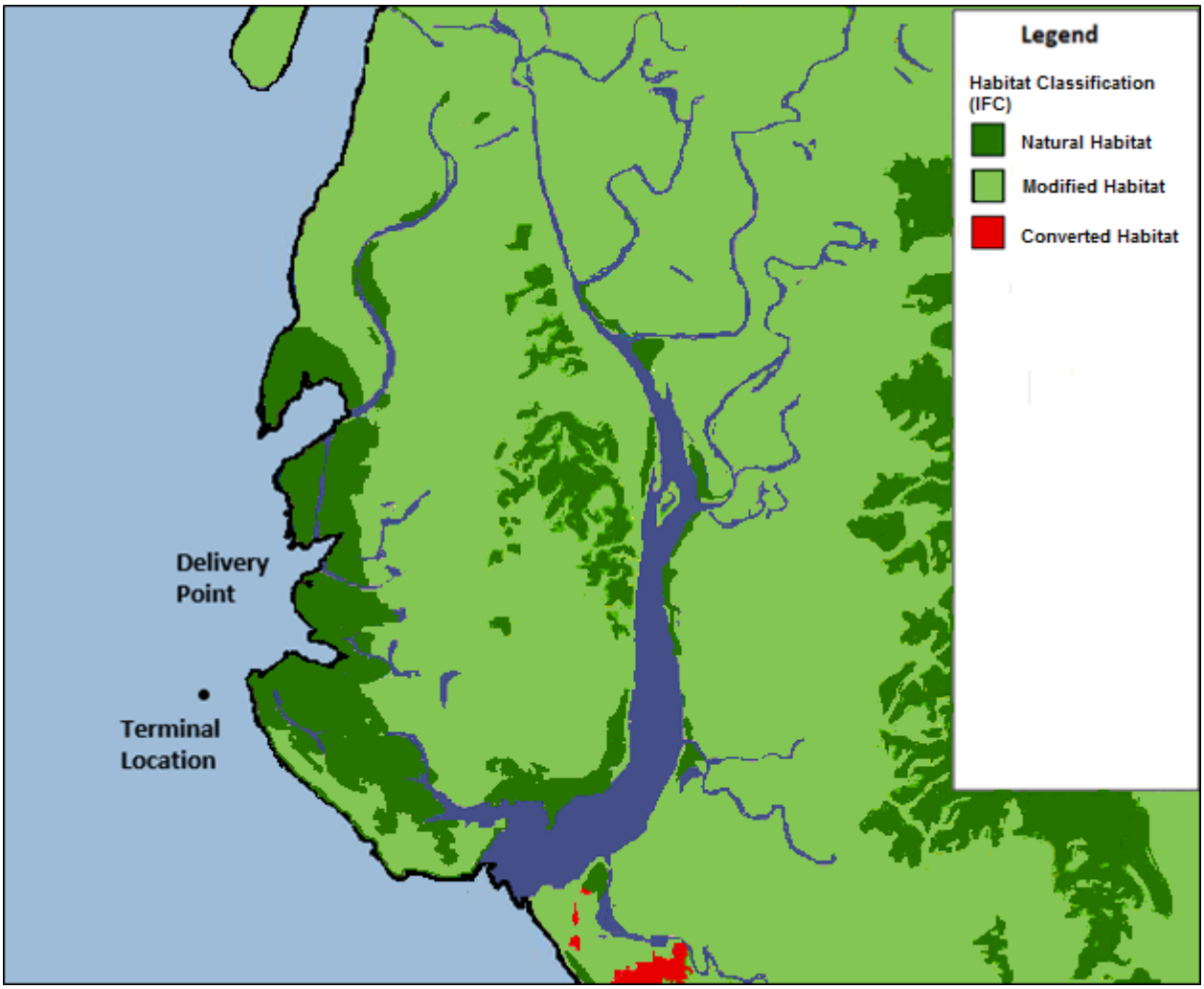
Based on these definitions, the ESIA team characterized each cover type (as defined in the land cover data) as Modified or Natural Habitat to develop a binary map of habitat types. Urban areas were classified as "Converted Habitat". The land cover classifications and rationale are provided in Table 4-8, and a map of Modified and Natural Habitats are provided in Figure 4-23.

Table 4-8: Natural and Modified Habitat Classification by Land Cover Type

Land Cover Type	Natural or Modified Habitat Classification	Rationale
Bare Soil	Mixed	This land cover type is broad, and includes both Natural and Modified Habitats. In order to distinguish the two, the ESIA team evaluated satellite imagery and compared with site visit observations. Beaches, dunes, and intertidal mudflats included in the original land cover mapping were characterized as Natural Habitat. Salt pans, bare soil in agricultural areas, and other cleared lands were characterized as Modified Habitats.
“Bay of Bengle”	N/A	This land cover type was grouped with open ocean, and not categorized.
Crop in Sloping Land / Tea	Modified Habitat	This land cover type includes cleared lands used for crops.
Hill Forest	Natural Habitat	Hill Forests are present in the higher elevations on eastern Moheshkhali Island and hills east of Moheshkhali Channel. For the purposes of this mapping the Hill Forests were considered Natural Habitat, although outside of core areas Hill Forests were often part of a mosaic of secondary and/or cleared areas and it is unclear if these fragmented habitats maintain natural species composition and ecological function.
Irrigated Herbaceous Crop	Modified Habitat	This land cover type includes cleared lands used for crops.
Lake	N/A	This land cover type was not present in the study area.
Mangrove	Natural Habitat	Much of Sonadia Island is mangroves that were reclaimed over the past 60 years (both naturally and with planting programs). While flora species composition is low compared to truly natural mangrove, the ecological function remains.

Land Cover Type	Natural or Modified Habitat Classification	Rationale
		Based on the recommendation of our regional biodiversity experts, we classified these mangroves as Natural Habitat.
Rained Herbaceous	Modified Habitat	This land cover type includes cleared lands used for crops.
Reservoir / Ponds	Modified Habitat	The ESIA team reviewed satellite imagery of areas classified as Reservoirs / Ponds, but could not distinguish these in the landscape from the ponds used for salt pans and aquaculture. Thus, this cover type was classified as Modified Habitat along with those other habitat types.
River	N/A	Surface water bodies were not characterized.
Rubber Plantation	Modified Habitat	This land cover type includes cleared lands used for crops.
Rural Area	Modified Habitat	This land cover type homesteads that have been replanted with fruiting and other food production species, as well as ornamentals.
Shrub Land	Modified Habitat	This land cover type includes secondary growth on areas that were previously cleared.
Urban Area	Converted Habitat	This land cover type includes areas largely covered with buildings and other impermeable surfaces that provide little value.

Figure 4-23: Map of Natural and Modified Habitat



Source: Acorn International / ICIMOD. 2016[31]

4.4.4 Protected Areas

4.4.4.1 Nationally Protected Areas

Protected areas in Bangladesh were first declared under the Wildlife Preservation Act, 1974 (as amended) and include national parks, wildlife sanctuaries, and game reserves. Areas protected under the Wildlife Preservation Act in and adjacent to the study area are shown in Figure 4-24 and listed in Table 4-9.

The Environmental Conservation Act of 1995 also gives the Department of Environment (DoE) authorization to declare Ecologically Critical Areas (ECAs) by issuing notification in the Official Gazette. On April 19, 1999, a notice declaring ECAs was issued for nine sites in Bangladesh, including Sonadia Island and Cox's Bazar-Teknaf Peninsula (southern extent of the study area). In these ECAs, a ban is imposed on certain activities, including the felling or extracting of trees and forest products; hunting and poaching of wild animals; catching or collection of snails, corals, turtles and other creatures, any activity that may threaten the habitat of flora and fauna; activities likely to destroy or alter the natural characteristics of soil and water; controls over the establishment of industries that may pollute soil, water, air and/or create noise pollution and other activities that may be harmful for the fish and other aquatic life. An Environmental

Clearance Certificate, based on Environmental Impacts Assessment (EIA) is required for any development project in the ECA area. The project was granted an Environmental Clearance Certificate in January 2016, allowing the project to proceed as planned.

Figure 4-24: National Parks, Wildlife Sanctuaries, and Game Reserves in the Study Area

Source: Adapted from UNEP-WCMC, 2016[32]

[32] UNEP-WCMC. 2016. World Database on Protected Areas. Accessed from the UNEP-WCMC website: www.protectedplanet.net

Table 4-9: National Parks, Wildlife Sanctuaries, and Game Reserves in the Study Area

Protected Area Name	IUCN Category	Approximate Distance to Project Site
Himchari National Park	V	22 km
Medhakachhapia National Park	IV	27 km
Bangabandhu Safari Park Coxbazar	Not Reported	28 km
Fasiakhali Wildlife Sanctuary	IV	29 km
Sangu Wildlife Sanctuary	II	29 km
Marine Reserve	Not Reported	37 km
Inoni National Park	Not Reported	40 km
Chunati Wildlife Sanctuary	IV	46 km
Teknaf Wildlife Sanctuary	IV	59 km
Dudpukuria-Dhopachari Wildlife Sanctuary	IV	78 km

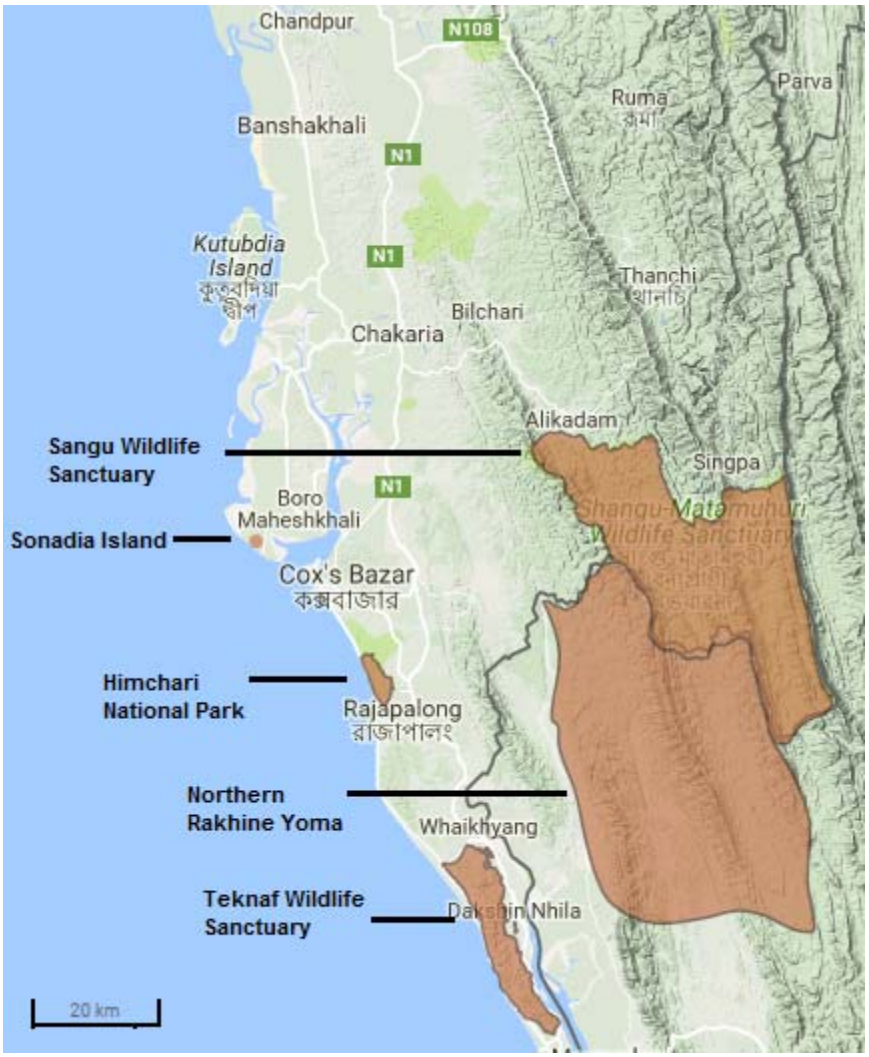
4.4.4.2 Internationally Recognized Areas

In 2007, the Bangladesh Ministry of Environment and Forests, Forest Department proposed Sonadia Island as a designated wetland under the Ramsar Convention. The Island was designated an Important Bird Area (IBA) by BirdLife International in 2013. Internationally recognized areas in the study area are shown in Figure 4-25 and listed in Table 4-10. Sonadia Island is also part of the Indo-Burma Biodiversity Hotspot (Figure 4-26).

Table 4-10: Internationally Recognized Areas in the Study Area

Protected Area Name	International Recognized Area Type	Approximate Distance to Project Site
Sonadia Island	Important Bird Area and Key Biodiversity Area	0 km
Himchari National Park	Important Bird Area and Key Biodiversity Area	22 km
Sangu Wildlife Sanctuary (also known as Sangu Matamuhari)	Important Bird Area and Key Biodiversity Area	29 km
Northern Rakhine Yoma	Key Biodiversity Area	29 km
Teknaf Wildlife Sanctuary	Important Bird Area and Key Biodiversity Area	59 km

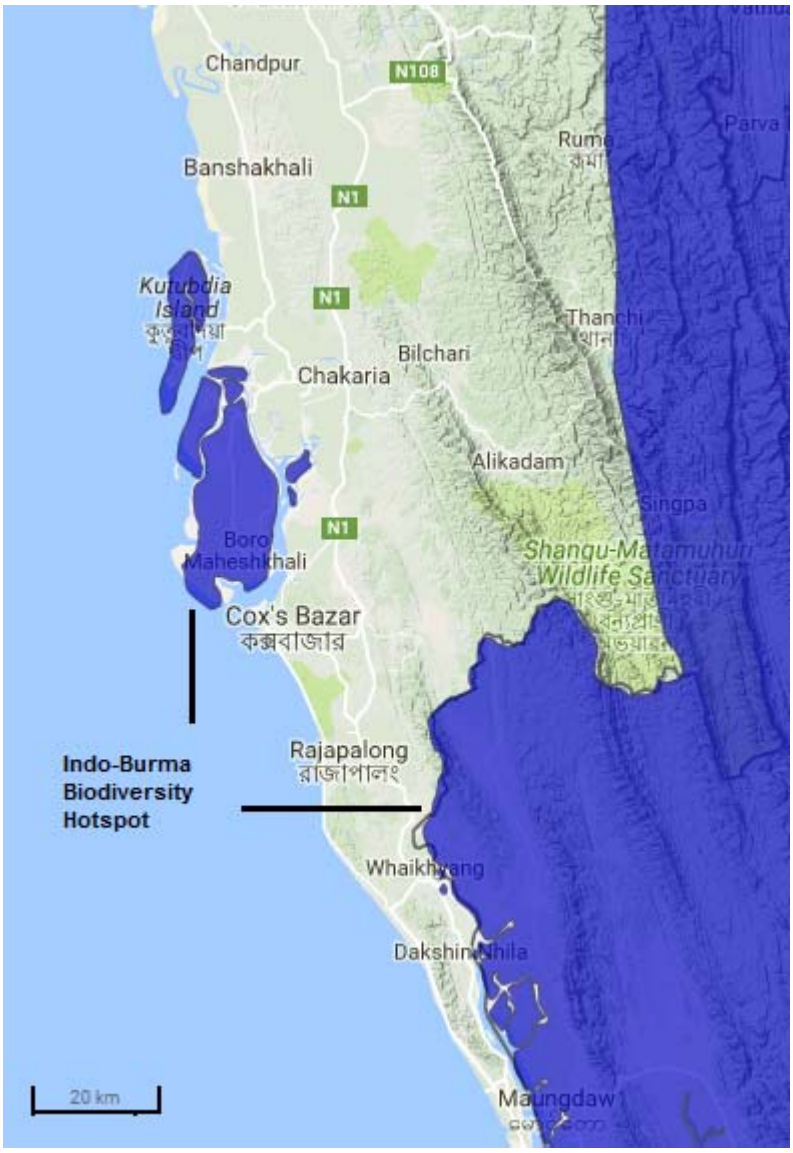
Figure 4-25: Internationally Recognized Areas in the Study Area



Source: Adapted from Birdlife International, 2016[33]

[33] BirdLife International (on behalf of the KBA Partnership), 2016. Key Biodiversity Areas: December 2016 version. Downloaded under license from the Integrated Biodiversity Assessment Tool. http://www.ibatforbusiness.org

Figure 4-26: Areas of Regional Conservation Importance



Source: Conservation International, 2011[34]

4.4.5 Flora

The project footprint is located entirely offshore, except for the pipeline tie-in at the Delivery Point. The Delivery Point is on land separated from the main Moheshkhali Island by natural salt water channels, forming a separate feature named Sonadia Island. Sonadia Island comprises a wide variety of wetland habitats including mudflats, sand dunes, mangroves, sand bars, lagoons, man-made saltpans, and beaches.

Mangroves are the dominant vegetation on Sonadia Island. Twenty-seven mangrove species and mangrove-associated vegetation were recorded from Sonadia Island, the common species include *Avicennia officinalis, A. marina, A. alba, Sonneratia apetala, Aegiceras corniculatum,*

[34] Conservation International, 2011. Biodiversity Hotspots - digital boundaries. Downloaded under license from the Integrated Biodiversity Assessment Tool. http://www.ibatforbusiness.org

Ceriops decandra (Globally Near Threatened) and *Aegialitis rotundifolia*.[35] The distribution of mangroves is largely on the inland part of the site with a very narrow distribution in the intertidal areas on the edge of the estuary.

A review of the flora in the project area from a site visit by two specialists was carried out as part of the original EIA. This survey provided a general evaluation of the flora on site, but no detailed flora survey was conducted.

Bangladesh Forest Department studied the species composition of six sites on Sonadia Island and found the sites were mainly dominated by either *Avicennia alba* or *A. marina.* [35] Sonadia Purbapara and Kaladia were dominated by *A. marina*, while *A. alba* was the dominant species in Mogchar, Sonadia Paschimpara, and Belekardia. Another mangrove species *Aegialitis rotundifolia* was the least abundant species at all the sites. It is believed that the species composition is low because the site is a plantation (targeted mangrove replanting and natural revegetation).

The total intertidal mudflat area has been estimated at 1,175 ha in 1999 by the Department of Environment (DoE) and has not changed considerably since. Mangroves within the site are clustered at the sheltered inland part of Sonadia Island and along the edge of the estuary, covering a total mangrove area of around 500 ha.

4.4.6 Fauna

Sonadia Island includes a variety of coastal habitats that support a diverse range of fauna. Most notably, the site has extensive mud flats, shoals, and estuarine areas and a large intact mangrove system. Sonadia is a designated Ecologically Critical Area in Bangladesh, is recognized as an Important Bird Area by Birdlife International and the area has been proposed as a RAMSAR Wetland of International Importance.[36]

The area is an important site in the East Asian - Australasian Flyway as it supports significant numbers of adult birds in wintering, and small numbers of first-year juvenile birds in over-summering periods, including Spoon-billed Sandpiper (*Calidris pygmaea*), Nordmann's Greenshank (*Tringa guttifer)*, Great Knot (*Calidris tenuirostris*) and Eurasian Curlew (*Numenius arquata*). The three most abundant species are Lesser Sand Plover (*Charadrius mongolus)*, Greater Sand Plover (*Charadrius leschenaultia*) and Eurasian Curlew (*Numenius arquata*).[37] [38]

The Bangladesh Spoon-billed Sandpiper Conservation Project (BSCP) has been conducting monthly water bird surveys during the winter (October – March) in Sonadia since 2009, and monthly (all year) in 2012, 2013, 2014, and 2015. Annual observation data for key species are provided in Section 4.4.7. BSCP observation indicate there are four key areas used by waterfowl, as shown in Table 4-11 and Figure 4-27. This long-term and recent independent monitoring by national experts provided a robust baseline to inform this project assessment. As

[35] Rabbi, G. No date. Habitat Management Plan and Conservation of Threaten Waterbirds in Sonadia Island. Accessed from the East Asian-Australasian Flyway Partnership website: http://www.eaaflyway.net/documents/Habitat%20Management%20Plan%20and%20Conservation%20of%20Threaten%20WaterBirds%20in%20Sonadia%20Island.pdf

[36] Birdlife International. 2016. Sonadia Island Important Bird Area Factsheet.

[37] Chowdury, S. 2012. A survey of Over-summering Shorebirds at Sonadia Island, Cox's Bazar, Bangladesh. Stilt 61 (2012): 34–36

[38] Chowdhury, S.U., Foysal, M., Das, D.K., Mohsanin, S., Diyan, M.A.A. & Alam, A.B.M.S. 2011. Seasonal occurrence and site use by shorebirds at Sonadia Island, Cox's Bazar, Bangladesh. Wader Study Group Bull. 118(2): 77–81.

a result, only a few targeted surveys were commissioned to answer specific questions related to the project.

Table 4-11: Observed Sensitive Sites for Waterfowl within Sonadia Island Key Biodiversity Area

Site Name	Habitat Function
Tajiakata	Mudflat (waterfowl forage), high tide roost and staging area
Belekardia	Mudflat (waterfowl forage), high tide roost, staging area, and sea turtle nesting beach
Kaladia	Mudflat and high tide roost
Khorir Char	Mudflat and high tide roost

As noted in the table above, mudflats are important habitats on the island for threatened species for forage and roosting. Mangroves can also be used for roosting, but to a lesser extent.

Given the proximity of Kaladia (Sonadia Island) to the project site and the existence of independent long term monitoring baselines by national experts that pre-dated the project, an additional targeted two-day field survey of avian fauna was carried out by two local waterfowl experts (Sayam U. Chowdhury and Md Foysal, Mr. Chowdury is the BSCP Coordinator) to determine the detailed boundaries of the foraging and roosting areas nearest the project site. During the field visit one Garmin e-trex GPS unit was used to track survey route and record coordinates of the boundaries (Figure 4-28). Observations were made using 10x42 binoculars and 25-50x spotting scopes. The field visits and surveys took place during approaching tide on 10 August 2016 and receding tide on 11 August 2016. Maps were generated using Garmin Base Camp software and Google Earth. This is the same methodology used to conduct the BSCP surveys. A total of 256 shorebirds of 13 species were recorded (Table 4-13). One threatened species was recorded (80 individuals of the Endangered Great knot). The field visit findings further confirmed previous long term monitoring data that the closest area used by waders is approximately 700 m south of the Delivery Point.

Beaches of Sonadia also support nesting of the Endangered Green Turtle *(Chelonia mydas)*, and the Vulnerable Olive Ridley Turtle *(Lepidochelys olivacea).* [39] The key nesting season is December through March. MarineLife Alliance has been conducting independent long term monitoring of sea turtle nesting on Sonadia Island since 2005. From October through May, 4-6 observers patrol 12 km of nesting beaches every night. Nightly surveys are also carried out from June through September, although only 3 observers are used and surveys are only conducted every other day. Night surveys span >6 hours starting 3 hours before and ending 3 hours after high tide. Observers collect information on nesting activity and threats. Data on nesting (Table 4-12) is only available from 2005-2010, but it is believed to be ongoing. The average clutch size for Olive Ridley Turtle nests is 115 and average clutch size for Green Turtle nests is 122.

[39] Islam, P, and M. Mollah. 2015. Conservation of Sea Turtle in Cox's Bazar- Teknaf Peninsula and Sonadia Island Ecologically Critical Area (ECA) of Bangladesh. World Academy of Science, Engineering, and Technology International Journal of Geological and Environmental Engineering Vol: 2, No: 5, 2015.

Table 4-12: Sea Turtle Nesting Activity on Sonadia Island (2005 – 2010)

Season	Olive Ridley Nests	Green Turtle Nests
2005 – 2006	155	0
2006 – 2007	142	1
2007 – 2008	162	3
2008 – 2009	151	3
2010 – 2011	158	2

Source: MarineLife Alliance[39]

Olive Ridley nest are the most numerous and widely dispersed on Sonadia Island. The key nesting habitat is found from Belekardia to Moghchar on the southwest coast of Sonadia (~2.4 km east of the FSRU and 4+ km south-southwest of the Delivery Point). Records indicate Olive Ridley nests were found on Kaladia near the Delivery Point up until 2008, when nesting habitat was lost from coastal erosion. This long-term and recent independent monitoring by national experts provided a robust baseline to inform this project assessment. However, the data need to be updated, as discussed in the data gaps section of the report (Section 5.4).

Seven species of dolphins could occur within the study area, including the Vulnerable Irrawaddy Dolphin (*Orcaella brevirostris*), Indo-Pacific Humpbacked Dolphin (*Sousa chinensis*), Spinner Dolphin (*Stenella longirostris*), Indo-Pacific Bottlenose Dolphin (Tursiops aduncus), Finless Porpoise (*Neophocaena phocaenoides*), Endangered Ganges River Dolphin (*Platanista gangetica gangetica*), and Pantropical Spotted Dolphins (*Stenella attenuate*) (Least Concern). Records indicate the Irrawaddy Dolphin sightings in the Moheshkhali Channel and strandings of Ganges River Dolphin on Sonadia Island.[40] [41] Ganges River Dolphin is listed as an Evolutionarily Distinct and Globally Endangered (EDGE) species.[42]

Smith et al. (2008) conducted a 1,018 vessel-based line transect survey of Bangladesh nearshore waters in 2004 and noted 111 cetacean sightings. [43] Irrawaddy dolphins were most common (n=75), followed by Finless Porpoises (n= 11), Indo-Pacific Humpback Dolphins (n=6), Indo-Pacific Bottlenose Dolphins (n=3), Pantropical Spotted Dolphins (n=1), Bryde's whales (*Balaenoptera edeni/brydei*) (n=1). Smith et al. also noted "Cetacean distribution was closely tied to environmental gradients, with Irrawaddy dolphins and finless porpoises occurring most often in nearshore, turbid, low-salinity waters, Indo-Pacific humpback dolphins in slightly deeper waters where the colour turned from brown to green and Indo-Pacific bottlenose dolphins and Bryde's whales in deep, clear, high-salinity waters of the Swatch-of-No-Ground."

No marine mammals were observed during the geotechnical and environmental baseline surveys conducted for the project.

[40] Smith, B.D., Braulik, G.T. & Sinha, R. 2012. Platanista gangetica ssp. gangetica. The IUCN Red List of Threatened Species 2012. Accessed from the IUCN website: http://www.iucnredlist.org/details/41756/0
[41] Hossain, M.D.M, Alam, S.M.I., Baki, M.A., and N.A. Bhouiyan. 2016. Ganges River Dolphin. The Bulletin of the Ecological Society of America. Volume 97, Issue 2. Accessed from the Wiley Online Library: http://onlinelibrary.wiley.com/doi/10.1002/bes2.1227/pdf
[42] Zoological Society of London. 2016. South Asia River Dolphin (Platanista gangetica). Accessed from the Zoological Society of London website: http://www.edgeofexistence.org/mammals/species_info.php?id=65
[43] Smith BD, Ahmed B, Mansur R, and S. Strindberg. 2008. Species occurrence and distributional ecology of nearshore cetaceans in the Bay of Bengal, Bangladesh, with abundance estimates for Irrawaddy dolphins *Orcaella brevirostris* and finless porpoises *Neophocaena phocaenoides*. J Cetacean Res Managment 2008;10:45–58.

Table 4-13: Summary of Avian Survey

Species	IUCN Red List Status	Number
Kentish Plover *Charadrius alexandrinus*	Least Concern	15
Lesser Sand Plover *Charadrius mongolus*	Least Concern	60
Greater Sand Plover *Charadrius leschenaultii*	Least Concern	20
Bar-tailed Godwit *Limosa lapponica*	Near Threatened	1
Whimbrel *Numenius phaeopus*	Least Concern	12
Eurasian Curlew *Numenius arquata*	Near Threatened	10
Common Redshank *Tringa tetanus*	Least Concern	8
Terek Sandpiper *Xenus cinereus*	Least Concern	3
Common Sandpiper *Actitis hypoleucos*	Least Concern	1
Great Knot *Calidris tenuirostris*	Endangered	80
Sanderling *Calidris alba*	Least Concern	3
Curlew Sandpiper *Calidris ferruginea*	Near Threatened	13
Little Tern *Sterna albifrons*	Least Concern	30
Total		256

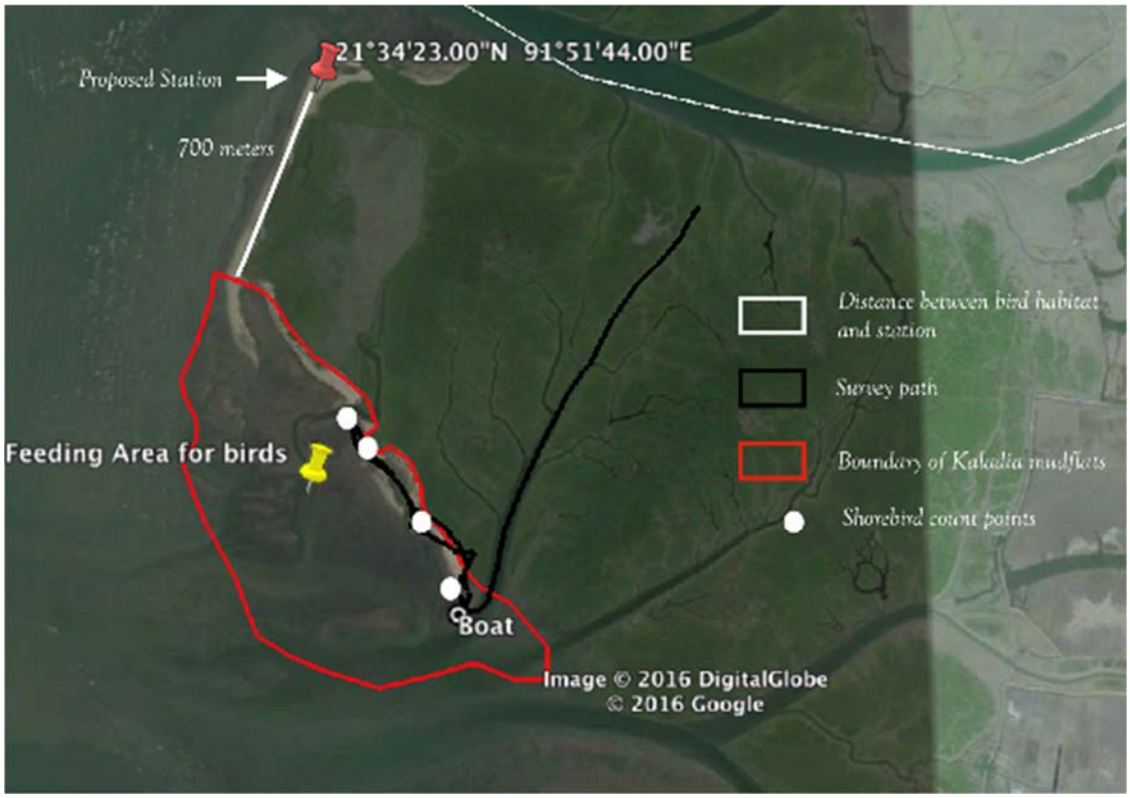
Source: Chowdhury, 2016

The environmental baseline survey conducted by Fugro for this ESIA found the macrofauna community across the survey area was observed to be highly variable between samples and overall faunal richness and diversity was low. Several of the species recorded were relatively large bodied and robust organisms, typically associated with mobile sediment habitats. Data interpretation suggested that a single community occurred throughout the survey area and that this is probably typical of similarly dynamic, physically disturbed environments in the region.

Figure 4-27: Observed Key Biodiversity Areas on Sonadia Island

Source: BSCP / Acorn International / Google Earth

Figure 4-28: Survey Locations



Source: Chowdhury, 2016
Note: "Proposed Station" is the approximate Delivery Point.

FAO reports, based on secondary data, that there are 265 species of freshwater finfish and 475 marine fish species reported in Bangladesh, together with 68 shrimps and prawns, 26 marine and freshwater turtles and tortoises, 24 amphibians, more than 300 mollusks, 2 crocodiles, 1 gavial, 20 water snakes, 182 aquatic or wetland birds, and 12 aquatic mammal species.[44] The important fish families present include *Sciaenidae, Ariidae, Nemipteridae, Carangidae, Mullidae, Synodontidae, Trichiuridae, Leiognathedae, Pomadasyidae, and Clupeidae*. A list of important commercial pelagic and demersal species is provided in Appendix B.

4.4.7 Threatened and Endangered Species

A full list of threatened species potentially found within the study area, developed using IUCN's Red List of Threatened Species range maps, is provided in Appendix C.[45] A list of Endangered and Critically Endangered species potentially present is provided in Table 4-14.

[44] FAO. 2012. Fishery Country Profile: Bangladesh. Accessed from the FAO website: http://www.fao.org/fishery/facp/BGD/en
[45] IUCN, 2016. The IUCN Red List of Threatened Species grid analysis of range maps. Version 2016.1. Downloaded under license from the Integrated Biodiversity Assessment Tool. http://www.ibatforbusiness.org

Table 4-14: Endangered and Critically Endangered Species with Potential to Occur in Study Area

Taxonomic group	Species	Common name	IUCN Classification
Birds	*Asarcornis scutulata*	White-winged Duck	EN
Birds	*Calidris pygmaea*	Spoon-billed Sandpiper	CR
Birds	*Calidris tenuirostris*	Great Knot	EN
Birds	*Emberiza aureola*	Yellow-breasted Bunting	EN
Birds	*Tringa guttifer*	Nordmann's Greenshank	EN
Corals	*Acropora rudis*		EN
Fishes	*Anoxypristis cuspidata*	Narrow Sawfish	EN
Fishes	*Carcharhinus hemiodon*	Pondicherry Shark	CR
Fishes	*Glyphis gangeticus*	Ganges Shark	CR
Fishes	*Lamiopsis temminckii*	Broadfin Shark	EN
Fishes	*Pristis*	Largetooth Sawfish	CR
Fishes	*Sphyrna lewini*	Scalloped Hammerhead	EN
Fishes	*Sphyrna mokarran*	Squat-headed Hammerhead Shark	EN
Mammals	*Balaenoptera musculus*	Blue Whale	EN
Mammals	*Hoolock*	Western Hoolock Gibbon	EN
Mammals	*Platanista gangetica*	Ganges River Dolphins	EN
Mammals	*Trachypithecus phayrei*	Phayre	EN
Other invertebrates	*Holothuria lessoni*	Golden Sandfish	EN
Other invertebrates	*Holothuria scabra*	Golden Sandfish	EN
Other invertebrates	*Thelenota ananas*	Prickly Redfish	EN
Plants	*Heritiera fomes*		CR
Plants	*Sonneratia griffithii*		CR
Reptiles	*Chelonia mydas*	Green Turtle	EN
Reptiles	*Gavialis gangeticus*	Gharial	CR

Source: IUCN, 2016[46]

Of the species listed above, most are aquatic species that have large ranges and low abundance and do not trigger Critical Habitat under IFC Performance Standard 6. However, the onshore component of the project is located in a sensitive area that is habitat for threatened species, including the Critically Endangered Spoon-billed Sandpiper (*Calidris pygmea*). In order to clarify the status of potential Critical Habitat triggers and applicability of requirements of IFC Performance Standard 6 on biodiversity, a Critical Habitat Assessment was conducted (Appendix C). The main objectives of the Critical Habitat Assessment were to:

- Make a determination on whether Critical Habitat is triggered for the landscape in which the project is located
- Obtain an understanding of the set of "biodiversity values", if any, that trigger Critical Habitat status for the landscape in which the project is located

Biodiversity features were screened based on the quantitative thresholds required by the Critical Habitat determination criteria described in IFC Performance Standard 6. These criteria include:

[46] IUCN. 2016. Red List of Threatened Species.

Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species
Criterion 2: Endemic and/or restricted-range species
Criterion 3: Migratory and/or congregatory species
Criterion 4: Highly threatened and/or unique ecosystems
Criterion 5: Key evolutionary processes

Based on the assessment conducted, Critical Habitat is present in the study area. Critical Habitat triggers, biodiversity values present, rationale, and Critical Habitat deamination are described in Table 4-15 and Critical Habitat is shown in Figure 4-29.

Table 4-15: Critical Habitat Summary

Critical Habitat Trigger	Biodiversity Value	Rationale	Critical Habitat
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species, and Criterion 3: Migratory and/or congregatory species	Spoon-billed Sandpiper *(Calidris pygmaea)*	• Habitat required to sustain ≥ 10 percent of the global population of an IUCN Red-listed CR species. • Meets BirdLife International's Criterion A4i for congregations and Ramsar Criteria 6 for Identifying Wetlands of International Importance •	Critical Habitat, Tier 1
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species	Great Knot (*Calidris tenuirostris)*	• Represents nationally important concentrations of an EN species.	Critical Habitat, Tier 2
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species, and Criterion 3: Migratory and/or congregatory species	Nordmann's Greenshank (*Tringa guttifer)*	• Represents nationally important concentrations of an EN species. • Meets BirdLife International's Criterion A4i for congregations and Ramsar Criteria 6 for Identifying Wetlands of International Importance	Critical Habitat, Tier 2

Figure 4-29: Discrete Management Unit Considered Critical Habitat (Light Orange Shading) and Sensitive Sites for Critical Habitat Values within DMU (Dark Orange Shading)

Source: Acorn International, BSCP, Google Earth

A description of each biodiversity value that triggers Critical Habitat is provided in the following text.

Spoon Billed Sandpiper

The Spoon-billed Sandpiper is listed by IUCN as Critically Endangered with estimates of less than 120 breeding pairs. Estimated population in the wintering areas is between 242 and 378 individuals, based on surveys[47].. It is an endemic breeder to Russia's far northeast and migrates down the western Pacific coast through Russia, Japan, North Korea, South Korea, mainland China, Taiwan, and Vietnam, to its main wintering grounds at select locations in Bangladesh and Myanmar. Approximately 80% of the entire global population appears to winter in Myanmar and Bangladesh.[48] Winter distribution of Spoon-billed Sandpiper shown in Figure 4-30.

Regular winter surveys in Bangladesh from October 2009 – present, under the BSCP, confirm that Sonadia Island is an important wintering location.[49] Annual Spoon-Billed Sandpiper observations in Sonadia from 2012-2015 are shown in Figure 4-31. Key sighting locations are shown in Figure 4-27 and listed in Table 4-11.

On the wintering grounds and during migration Spoon-billed Sandpiper feed on a variety of marine invertebrates including polychaete worms and shrimp.[50]

During migration and winter Spoon-billed Sandpipers occupy coastal marine sites, especially mudflats on the outer reaches of tidal estuaries.

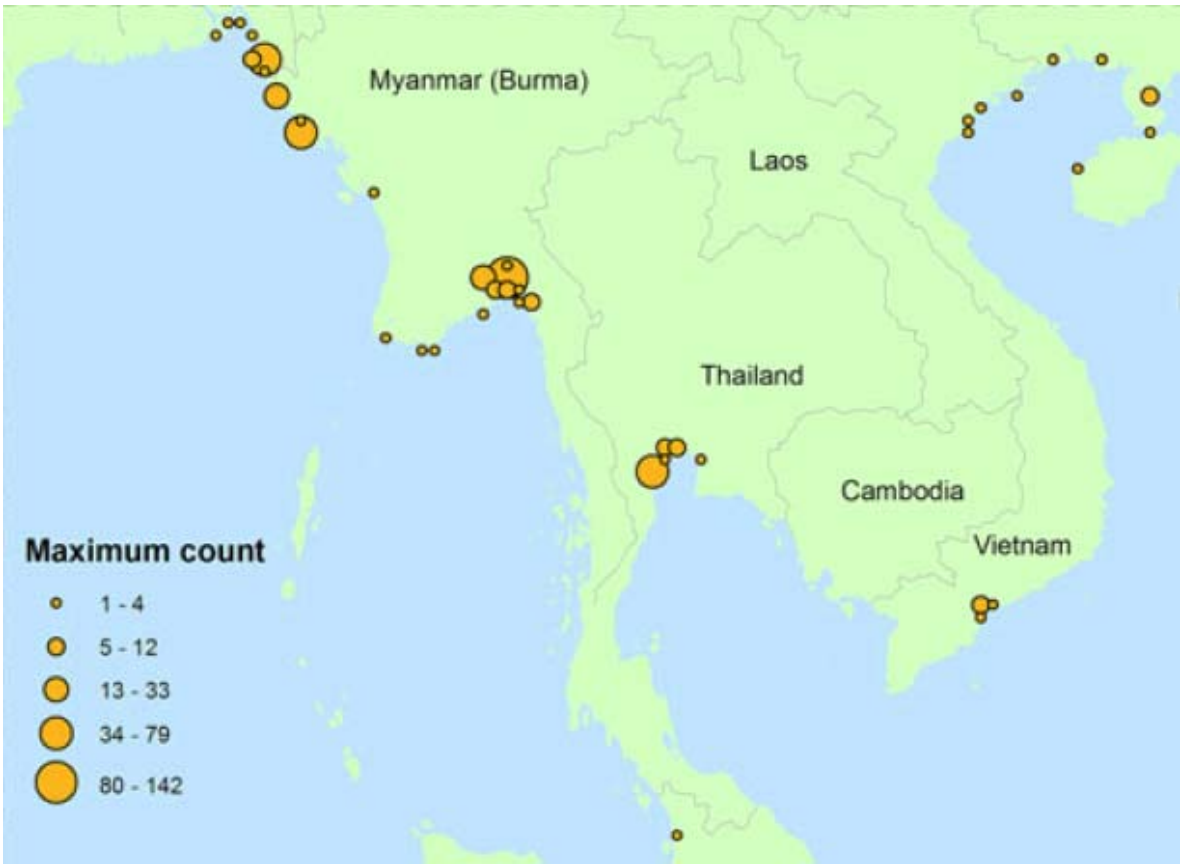
[47] Zockler, C., Beresford, A.E., Bunting, G., Chowdury, S.U., Clark, N.A., Fu, V.W.K., HLA, T.H., Morozov, V.V., Syroechkovskiy, E.E., Kashiwagi, K., Lappo, E.G., Tong, M., Long, T.L., Yu, Y.T., Huettmann, F., Akasofu, H.K., Tomida, H., and G.M. Buchanan. 2016. The winter distribution of the Spoon-billed Sandpiper Calidris pygmaeus. Bird Conservation International, May 2016. Accessed July 1, 2016: http://www.eaaflyway.net/wordpress/documents/tf/Winter%20Distribution.pdf

[48] IUCN. 2015. IUCN Red-list: Calidris pygmaea (Spoon-billed Sandpiper, Spoonbill Sandpiper). Accessed July 1, 2016: http://www.iucnredlist.org/details/22693452/0

[49] Personal communication with Sayam U. Chowdury and Christoph Zockler, Bangladesh Spoon-billed Sandpiper Conservation Project

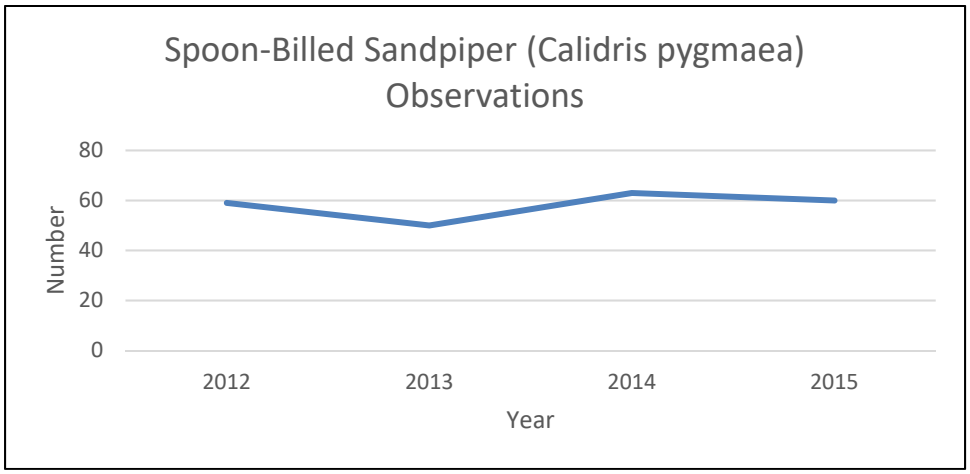
[50] Cornell Lab of Ornithology. 2016. Spoon-billed Sandpiper Facts. Accessed from the Cornell Lab of Ornithology website: http://www.birds.cornell.edu/page.aspx?pid=2536

Figure 4-30: Winter Distribution of Spoon-billed Sandpiper



Source: Zockler et. al, 2016

Figure 4-31: Spoon-Billed Sandpiper Observations in Sonadia, 2012-2015



Source: BSCP, 2015

Great Knot (Calidris tenuirostris)
The Great Knot (*Calidris tenuirostris*) is listed by IUCN as Endangered with estimates of 292,000 - 295,000 individuals remaining in the world.[51] This species breeds in north-east Russia, and while it winters mainly in Australia it is also know to migrate throughout coastal areas of South-East Asia. Regular winter surveys in Bangladesh from October 2009 – present, under the BSCP, confirm that Sonadia Island is important habitat for this species and, based on observations, the estimated population wintering in Sonadia is between 400 and 450 individuals. Annual Great Knot observations in Sonadia from 2012-2015 are shown in Figure 4-32.

In its wintering range the species occurs in sheltered coastal habitats, including estuaries and lagoons with large intertidal mud and sandflats, oceanic sandy beaches with nearby mudflats, and muddy shorelines with mangroves. [52] [53] It roosts in refuges such as shallow water in sheltered sites, on coastal dunes or on saltflats amongst mangroves during high tides.[54]

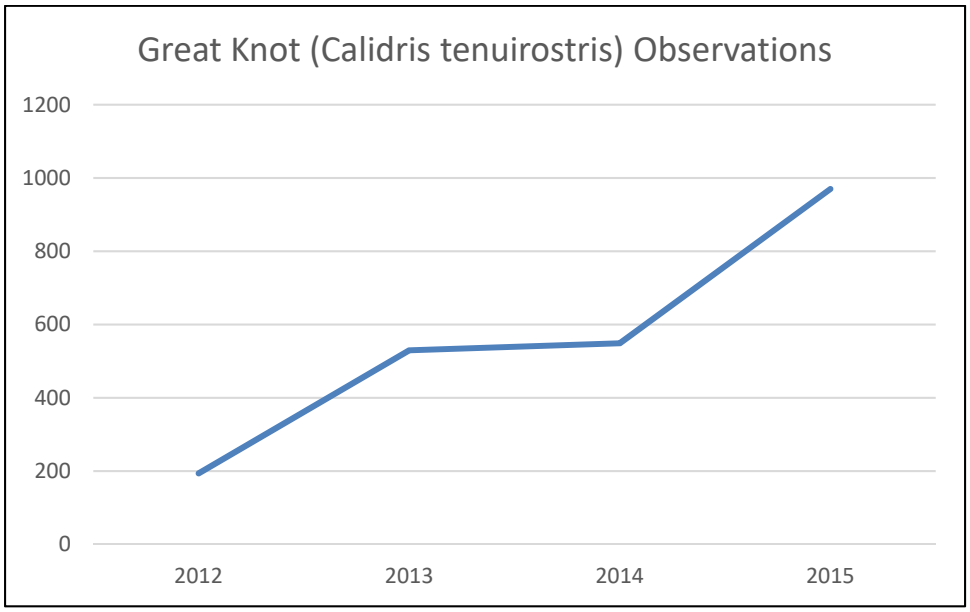
On passage the species stages in estuaries and on intertidal mudflats.[55]

During the winter and on passage the species' diet consists of bivalves up to 36 mm long from intertidal mudflats as well as gastropods, crustaceans, annelid worms and echinoderms (e.g. sea cucumbers).

It arrives in wintering grounds between August and October and return migration to the breeding grounds takes place from March to April.

[51] BirdLife International. 2016. *Calidris tenuirostris*. The IUCN Red List of Threatened Species 2016. Accessed from the IUCN website: http://www.iucnredlist.org/details/22693359/0
[52] del Hoyo, J., Elliott, A., and J. Sargatal. 1996. Handbook of the Birds of the World, vol. 3: Hoatzin to Auks. Lynx Edicions, Barcelona, Spain.
[53] Higgins, P. J.; S. J. J. F. Davies. 1996. Handbook of Australian, New Zealand and Antarctic birds vol 3: snipe to pigeons. Oxford University Press, Oxford.
[54] Rogers, D. I., Piersma, T., C.J. Hassell. 2006. Roost availability may constrain shorebird distribution: Exploring the energetic costs of roosting and disturbance around a tropical bay. Biological Conservation 133(2): 225-235
[55] Tomkovich, P. S. 1997. Breeding distribution, migrations and conservation status of the Great Knot Calidris tenuirostris in Russia. Emu 97(4): 265-282.

Figure 4-32: Great Knot Observations in Sonadia, 2012-2015



Source: BSCP, 2015

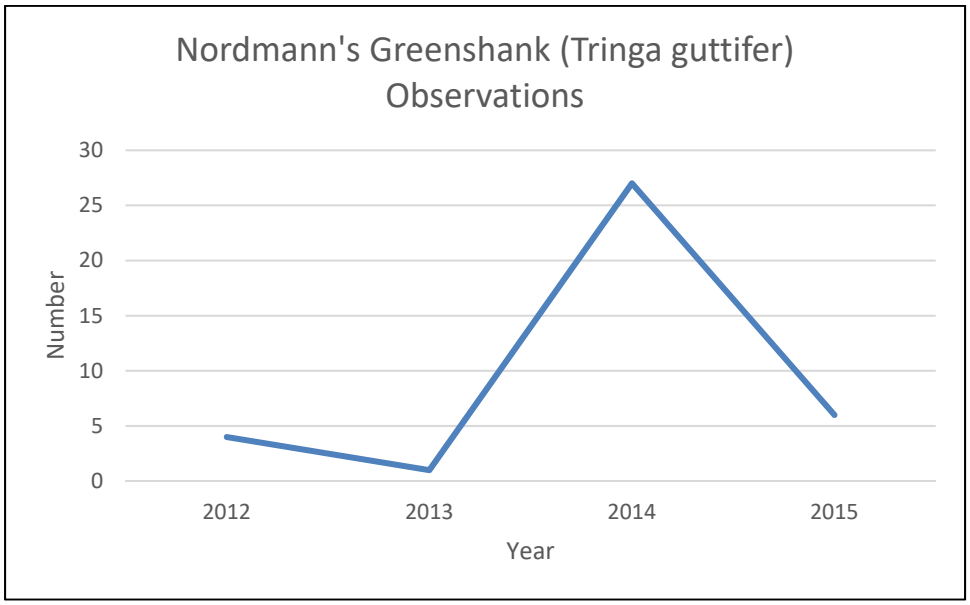
Nordmann's Greenshank (Tringa guttifer)
The Nordmann's Greenshank (*Tringa guttifer*) is listed by IUCN as Endangered. The global population is estimated at 500-1,000 individuals. Regular winter surveys in Bangladesh from October 2009 – present, under the BSCP, confirm that Sonadia Island is important habitat for this species. Annual Nordmann's Greenshank observations in Sonadia from 2012-2015 are shown in Figure 4-33.The estimated wintering population of Sonadia Island is 28 individuals.[49]

While its breeding range is in Russia, its non-breeding range is not well understood.[56] Significant numbers have been recorded during migration in China, Taiwan, and South Korea, and lesser numbers have been recorded in Bangladesh, Myanmar, Thailand, Cambodia, Vietnam, and Malaysia.

Wintering birds usually frequent estuaries, coastal mudflats and lowland swamps, and sometimes damp meadows, saltpans and rice-fields.

[56] BirdLife International. 2016. Tringa guttifer. The IUCN Red List of Threatened Species 2016. Accessed from the IUCN website: http://www.iucnredlist.org/details/22693225/0

Figure 4-33: Nordmann's Greenshank Observations in Sonadia, 2012-2015



Source: BSCP, 2015

4.4.8 Invasive Alien Species

Species were routinely introduced to Bangladesh in the 20th century. There is no complete list of invasive alien species found in Bangladesh, although there are reports of introduction of over 300 species, predominantly herbaceous species followed by trees and shrubs.[57] Abridged lists of invasive alien species found in Bangladesh are provided in Table 4-16 and Table 4-17. The most prominent invasive alien species are freshwater fish species introduced for aquaculture, including African magur (*Clarias gariepinus*), pangas (*Pangasius sutchi*), giant pangas (*Pangasius giganticus*), tilapia (*Tilapia mossambica*), and nilotica *(Oreochromis niloticus)*.[58] Other ornamental tree species that are common in homesteads, include acacia and eucalyptus. Water hyacinth (*Eichhornia crassipes*) is perhaps the most widespread invasive species, however, having spread to most wetlands in Bangladesh.

Of the species noted, none are noted in the coastal environment of the project area.

Table 4-16: Abridged List of Invasive Plant Species Found in Bangladesh

Scientific Name	Common Name
Acacia auriculaeformis	Akashmoni
Acacia mangium	Mangium
Albizia falcataria (L)	Malacana
Dalbergia sissoo	Sissoo
Eucalyptus brassian	Eycalyptus
Eucalyptus camaldulensis	Eycalyptus

[57] Uddin, Herrn Mohammad Belal. 2011. Exotic Species Invasion and Biodiversity in Bangladesh Forest Ecosystems. Accessed from the University of Bayreuth website: https://epub.uni-bayreuth.de/328/1/Belal_PhD_Thesis.pdf

[58] Convention on Biological Diversity. 2016. Bangladesh – Convention on Biological Diversity. Accessed from the CBD website: https://www.cbd.int/doc/world/bd/bd-nr-ais-en.pdf

Scientific Name	Common Name
Eucalyptus tereticornis	Eycalyptus
Leucaena leucocephala	Telekadam
Pinus caribaea	Caribaea pine
Pinus oocarpa	Pine
Swietenia macrophylia	Mahogany
Swietenia mahogani	True Mahogani
Tectona grandis	Teak
Xylia dolabriformis	Pynkado
Eichhornia crassipe	Water hyacinth

Source: Barua, et al., N.D[59]

Table 4-17: Abridged List of Invasive Animal Species Found in Bangladesh

Scientific Name	Common Name
Trichogaster pectoralis	Siamese Gourami
Carassius auratus	Goldfish
Tilapia mossambica	Tilapia
Lebistes reticulatus	Guppy
Cyprinus carpio	Common carp
Ctenopharyngodon idellus	Grass carp
Hypopthalmichthys molitrix	Silver carp
Oreochromis niloticus	Nilotica
Puntius gonionotus	Thai Sarpunti
Cyprinus carpio	Mirror Carp
Aristichthys nobilis	Bighead carp
Mylopharyngodon piceus	Black carp/ Snail carp
Clarias gariepinus	African magur
Pangasius sutchi	Pangas
P. giganticus	Giant Pangas

Source: Barua, et al., N.D[59]

4.5 Social Baseline

4.5.1 Political and Administrative Structures

Bangladesh is divided into seven administrative divisions (Figure 4-34), each named after their respective divisional headquarters: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur and Sylhet. Divisions are subdivided into districts (Zila). There are 64 districts in Bangladesh, each further subdivided into sub districts (Upazila). The area within each Upazila, except for those in metropolitan areas, is divided into several unions, with each union consisting of multiple villages. In the metropolitan areas, Upazila are divided into wards, which are further divided into Mahallas. At the level of local government, representatives are elected as union council officials.

[59] Barua, S.P., Khan, M.M.H., and A.H.M.A. Reza. N.D. The Status of Alien Invasive Species in Bangladesh and their Impact on the Ecosystems. Accessed from the Biodiversity Asia website: http://www.biodiversityasia.org/books/alien/Chapter%201.pdf

Figure 4-34: Divisions of Bangladesh

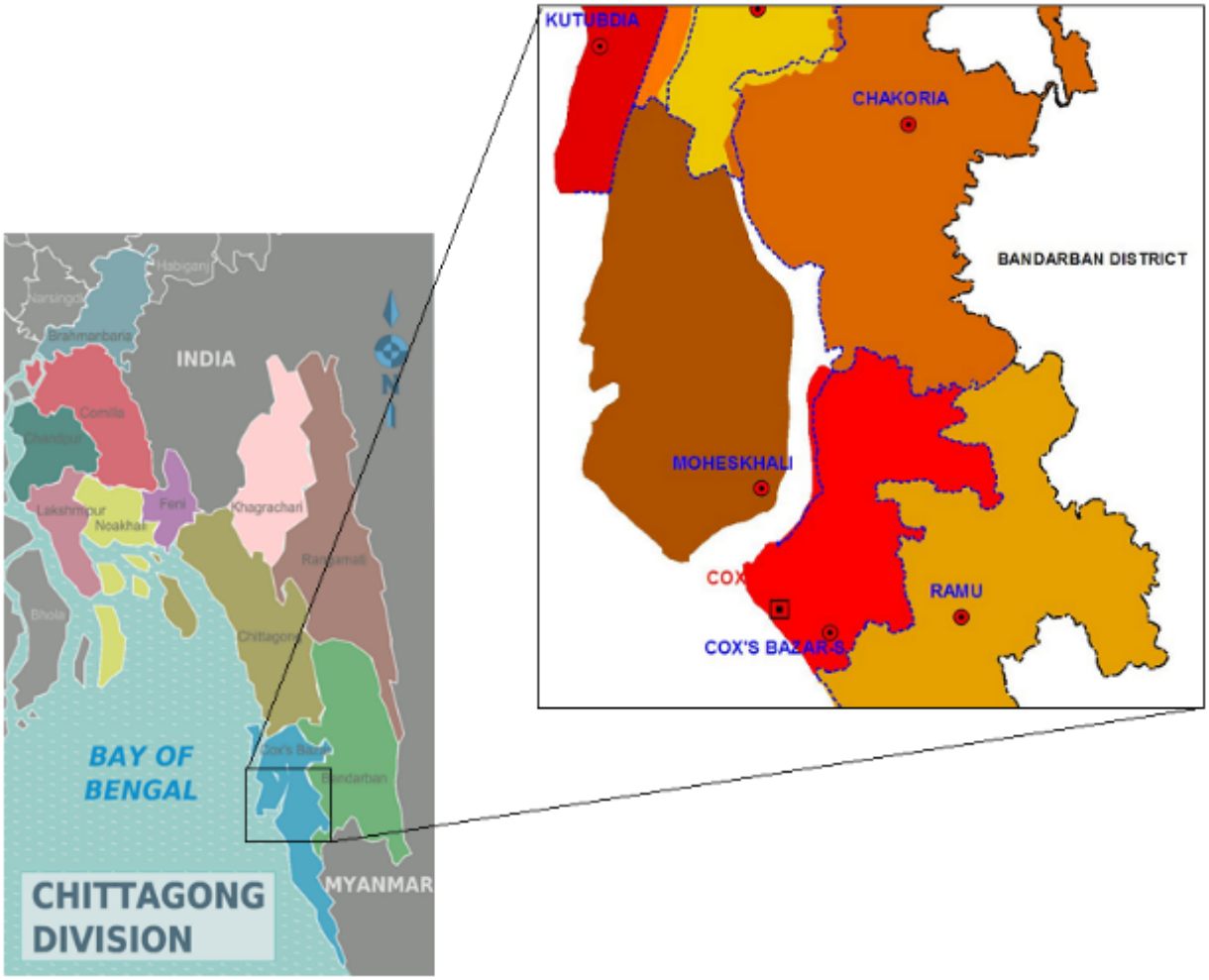
Source: University of Texas at Austin, 2015[60]

The proposed project site is located in the Upazila of Moheshkhali, Cox's Bazar District, Chittagong Division (Figure 4-35). Cox's Bazar became a sub-division in 1854 and was upgraded to Zila status in 1984. It is bounded on the north by Chittagong Zila, on the east by

[60] University of Texas at Austin. 2015. Administrative Divisions of Bangladesh. Accessed from the University of Texas at Austin website: https://www.lib.utexas.edu/maps/bangladesh.html

Bandarban Zila and Myanmar, and on the west by the Bay of Bengal. Cox's Bazar Zila now includes 8 Upazila, 71 unions, and 989 villages.

Figure 4-35: Sub-Districts (Upazila) of Cox's Bazar District, Chittagong Division



Note: Areas shown in red, orange, and brown are Upazila
Source: Adapted from Adams, J., 2012, and Ministry of Local Government, Rural Development and Cooperatives, 2015 [61] [62]

As noted above, unions consist of groups of villages. Villages typically include households clustered around a mosque, and are traditionally led by an elder or influential person who has authority regarding marriages and typical social transactions.

[61] Adams, J. 2012. Colour-coded map of the districts of Chittagong Division in Bangladesh. Accessed from WikiMedia Commons Website: https://commons.wikimedia.org/wiki/File:Chittagong_Division_districts_map.png
[62] Ministry of Local Government, Rural Development, and Cooperatives. 2015. Cox's Bazar District Map. Accessed from the Local Government Engineering Department website: http://www.lged.gov.bd/UploadedDocument/DistrictMap/cox's%20bazar/cox's%20bazar.jpg

There are eight unions in Moheshkhali, including[63] :

1. Boro Moheshkhali
2. Choto Moheshkhali
3. Dholghata
4. Hoanak
5. Kalamarchora
6. Kutubjom
7. Matarbari
8. Shaplapur

4.5.2 Geographic Scope

The FSRU is planned to be stationed approximately 2.4 km offshore Moheshkhali Island in waters 25-30 meters (m) deep. The onshore area near the Delivery Point is on land separated from the main Moheshkhali Island by natural salt water channels, forming a separate feature named Sonadia Island. There are no settlements within about >5 km of the Delivery Point.[64]

Within the Moheshkhali Upazila are three Union Council jurisdictions—Boro Moheshkhali, Hoanak and Kutubjom—that are inhabited by people who live within 5-10 km of the Delivery Point. Boro Moheshkhali consists of 29 villages, Hoanak includes 27 villages, and Kutubjom has 24 villages. The proposed Delivery Point is about 9 km from village Boro-Dale (within Boro Moheshkhali Union) and about 9 km from village Panirchara (within Hoanak Union).[65] Ghatibhanga, located within Kutubjom union, is situated approximately 6.5 km from the Delivery Point.

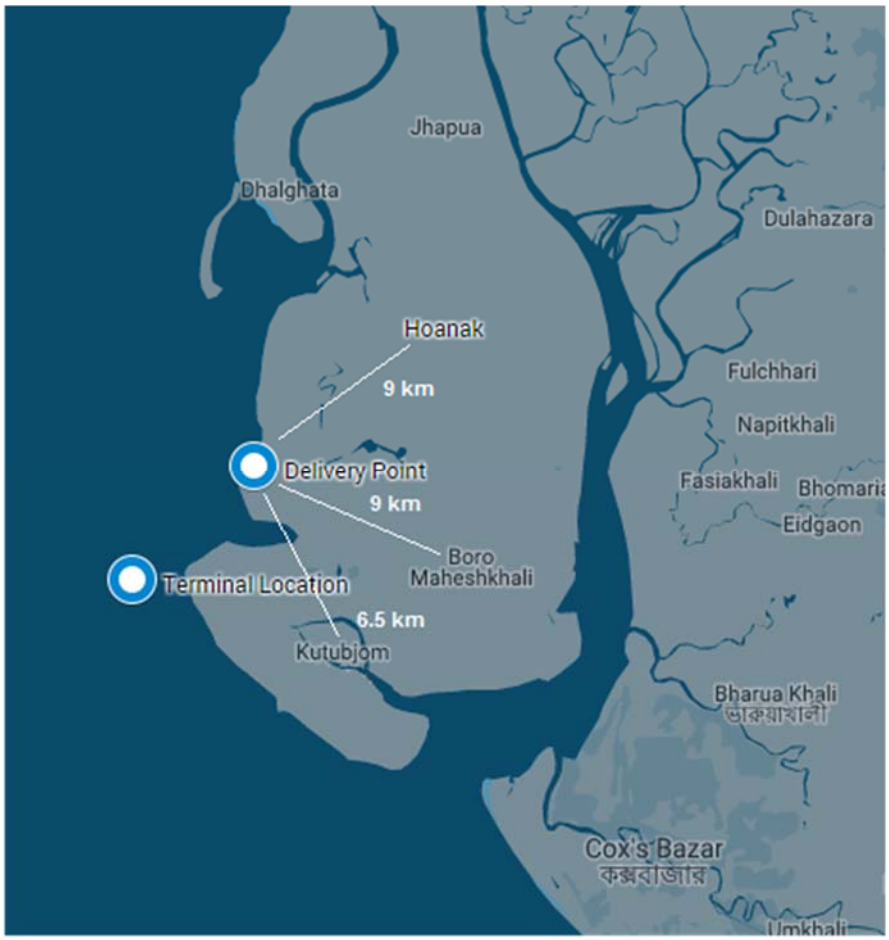
The location of the FSRU relative to the unions of Kutubjom, Hoanak, and Boro-Moheshkhali is shown in Figure 3. This social baseline summarizes demographic, cultural, and socioeconomic conditions in Moheshkhali, with focus on the villages making up the three closest unions (Boro Moheshkhali, Hoanak, and Kutubjom).

[63] Upazila Level Disaster Management Plan, 2014. Moheshkhali, Cox's Bazar District. Accessed from http://kmp.dmic.org.bd/bitstream/handle/123456789/330/Moheshkhali%20Upazila%20DM%20Plan_English%20version.pdf?sequence=1

[64] Confirmed in an August 2016 site reconnaissance.

[65] Field observation made during a 2012 visit by ESIA project team.

Figure 4-36: Unions Nearest to Delivery Point



Source: Acorn International / ESRI

4.5.3 Demographics and Culture

4.5.3.1 Population

Bangladesh's most recent census was conducted in 2011 and finalized in 2014. The survey presents results at the national, division, Zila, union and village level. While current (2016) population estimates for Bangladesh are typically cited at approximately 156.6 million people, the data presented below is sourced directly from 2011-2012 enumerated and estimated census results.

The population, male/female distribution, urban/rural distribution, growth rates, household size and population densities in are presented in the following tables.

Table 4-18: Population Statistics, 2001-2011

Population	Bangladesh	Chittagong Division	Cox's Bazar Zila	
			2011	2001
Total (enumerated)	144,043,697	28,423, 019	2,289,990	1,773,709
Male	72,109,796	13,933,314	1,169,604	927,196
Female	71,933,901	14,489,705	1,120,386	846,513

Population	Bangladesh	Chittagong Division	Cox's Bazar Zila	
			2011	2001
Urban	27,468,789	5,768,695	292,523	120,480
Rural	110,480,514	21,517,539	1,790,979	1,501,314
Annual growth rate	1.47	1.63	2.55	2.25
Households	32,173,630	5,626,310	415,954	296,109
Average household size	4.44	5.01	5.45	5.99
Area sq. mile	56,976	13,092	962	962
Density per sq. mile	2,528	2,171	2,380	1844

Source: Bangladesh Bureau of Statistics, 2014[66]. Note: statistics shown for Bangladesh and Chittagong are for 2011.

Table 4-19: Population, 2011 Census

Population	Cox's Bazar Zila	Moheshkhali	Unions		
			Boro Moheshkhali	Hoanak	Kutubjom
Total (enumerated)	2,289,990	321,218	45,068	51,587	30,637
Male	1,169,604	165,693	23,466	26,515	15,766
Female	1,120,386	155,525	21,602	25,072	14,871
Households	415,954	58,177	8,149	9,373	5,367

Population	Moheshkhali	Villages		
		Boro Moheshkhali: **Boro-dale**	Hoanak: **Panirchhara**	Kutubjom: **Ghatibhanga**
Total (enumerated)	321,218	3,461	3,519	8,449
Male	165,693	1,846	1,842	4,363
Female	155,525	1,615	1,677	4,086
Households	58,177	629	559	1,445

Source: Bangladesh Bureau of Statistics, 2014[66]

The majority of the population of these unions consists of adults, followed by children and young people, as shown in the following table.

Table 4-20: Population Structure, 2011 Census

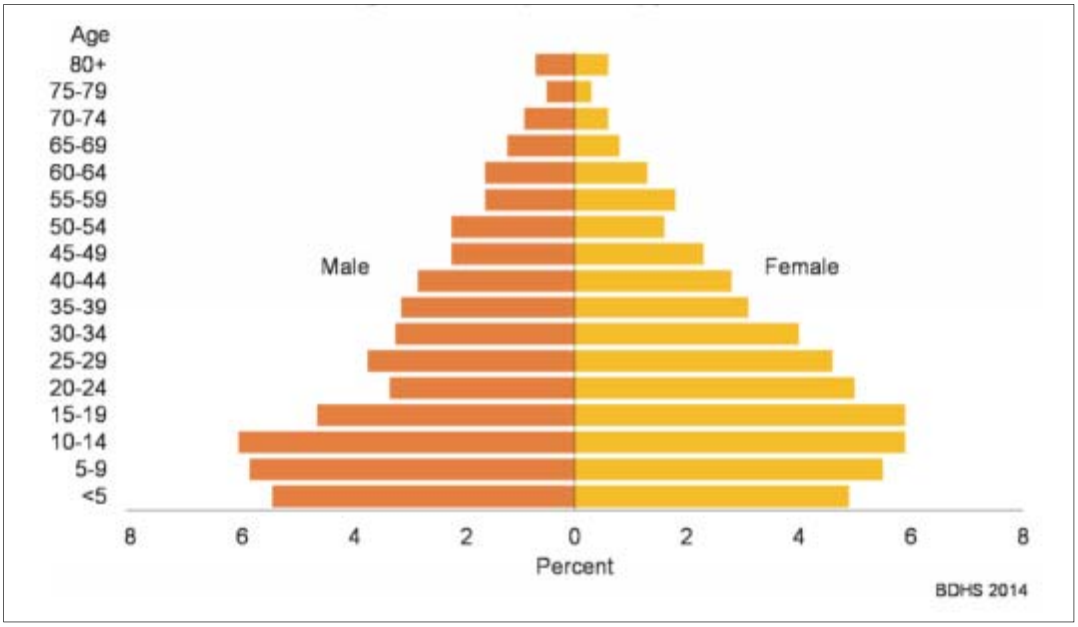
Union	Total population	Children (5-9 years)	Youth (10-14)	Adults (18+)
Bara-Moheshkhali	45,068	15.2%	13.20%	52.3%
Hoanak	51,587	15.6%	14.2%	50.2%
Kutubjom	30,637	15.9%	13.8%	50.2%

[66] Bangladesh Bureau of Statistics, Ministry of Planning, Government of Bangladesh. 2014. Population & Housing Census – 2011. National Volume 2: Union Statistics.

Village	Total population	Children (5-9 years)	Youth (10-14)	Adults (20+)
Bara-Moheshkhali: **Boro-dale**	3,461	16.4%	13.8%	46.5%
Hoanak: **Panirchhara**	3,519	18.2%	14.0%	43.2%
Kutubjom: **Ghatibhanga**	8,449	17.2%	14.4%	44.4%

Source: Bangladesh Bureau of Statistics, 2014[66]

Figure 4-37: Population Distribution



Source: National Institute of Population Research and Training, 2014[67]

These statistics indicate shifting population dynamics within Cox's Bazar, and in the study area. At the Zila level (Cox's Bazar) and Upazila (Moheshkhali), the percentage of population that is female declined from 2001-2011. Likewise, the percentage of Cox's Bazar's urban population has nearly doubled from 7% in 2001 to almost 13% in 2011 (although it is still well under the roughly 20% urban of both Chittagong and Bangladesh as a whole. Moheshkhali has also seen an increase in urbanization. This shift to an increasingly urban population in the local District may be explained by gains in access to education, and a broadening of economic and vocational choices, along with the significantly higher rate of population growth in this District compared with the Province and Country.

There are approximately 23,000 households within the unions closest to the Project Delivery Point, and an approximate population of 127,000 people. The three villages closest to the delivery point had a combined population of 15,429 people, all classified as rural residents, in the most recent completed census.

[67] National Institute of Population Research and Training. 2014. Bangladesh Demographic and Health Survey.

4.5.4 Ethnic Composition

Bangladesh is predominantly an ethnically homogenous population, with an estimated 98% of the nation belonging to the Bengali ethno-linguistic group, and a minority population of Biharis and other groups (2%). According to the 2011 census, Bangladesh's total 'ethnic and tribal' population is 1.6 million people. These indigenous peoples live primarily within the Chittagong Hill Tracts, Syhlhet, and Mymensingh districts.

Census data does indicate the presence) of ethnic groups within the study area of Moheshkhali. There are displaced Rohingya people—a Muslim ethnic group from Rakhaine in Myanmar—within the Upazila, including 7 noted in the 2011 census as residing in the union of Hoanak. No ethnic households were noted in Bara-Moheshkhali or Kutubjom.

4.5.5 Cultural Heritage, Traditions and Religious Practices

Cox's Bazar Zila includes a number of archaeological and cultural heritage sites. These include the Adinath Temple (in Moheshkhali), the tomb of Shah Umar (in Chakoria), Buddhist keyangs (religious buildings), a single domed mosque at Jhilanga, and other Hindu and Muslim religious structures[68]. None of these sites are within proximity of the proposed terminal tie-in location.

Bangladesh is a majority (90.4%) Muslim country; other religions include 8.5% Hindu and 1.1% other (Buddhist, Christian) population. Census information not report the geographic aspects of religious identification. The unions of Bara-Moheshkhali, Hoanak, and Kutubjom were all listed as 100% Muslim in the 2011 census.

4.5.6 Educational Attainment and Literacy

Education in Bangladesh is delivered by a range of providers, including both secular formal schooling and religious education. Primary education in Bangladesh includes grades 1-5. Secondary education includes grade 6-10, whereas higher secondary education covers grades 11-12, administered under the Ministry of Education (MoE). Technical and vocational training (TVET) remains a relatively small subsector.

As of 2013, according to World Bank estimates, there are 103 universities in Bangladesh; 71 are privately operated. Both public and private universities are managed by a University Commission.

Educational access has increased significantly over the last decade particularly at the primary and secondary levels, however the Bangladesh labor force continues to lack education. Approximately 96% of the labor force has less than a secondary education, and two-thirds have less than a primary education. About a third of the primary graduates acquire the basic literacy skills they are expected to have by the time they complete their schooling[69].

[68] Community Report, Cox's Bazar Zila. June 2012. Population and Housing Census, 2011. Bangladesh Bureau of Statistics, Ministry of Planning. Accessed from the LCG website: http://www.lcgbangladesh.org/HCTT/JNA%20materials%20update/Census/Chittagong%20Division/Cox's%20Bazar%20at%20a%20glance.pdf

[69] Bangladesh Bureau of Statistics. 2015. Policy and planning survey on Socioeconomic and Demographic Conditions, pre-final draft.

The following tables provide a reference for understanding the average level of literacy and educational attainment in the unions and villages nearest to Project site, and in the broader region.

Table 4-21: Literacy[70]

	Bangladesh	Chittagong District	Cox's Bazar Zila	Moheshkhali	Unions		
					Boro Moheshkhali	Hoanak	Kutubjom
Literacy Rate	51.8	52.7	39.3	30.8	34.2	29.9	25.7
Male	54.1	53.9	40.3	30.5	34.1	28.8	26.2
Female	49.4	51.5	38.2	31.1	34.3	31.1	25.2

	Cox's Bazar Zila	Moheshkhali	Villages		
			Boro Moheshkhali: Boro-dale	Hoanak: Panirchhara	Kutubjom: Ghatibhanga
Literacy Rate	39.3	30.8	22.4	27.3	20.9
Male	40.3	30.5	22.5	26.3	22.9
Female	38.2	31.1	22.2	28.4	18.9

Source: Bangladesh Bureau of Statistics, 2015[66]

Per the 2011 census, approximately 52% of the Bangladesh population is literate.

Table 4-22: Educational Attainment and Type of Schooling

Highest Class Passed	Population 5+, %	Field of Education
No Schooling	32.2	n/a
Grades 1-5	32.9	General 63.%
Grades 6-10	21.7	Vocational or Technical .5%
Higher Secondary	10.5	Religious 3.8%
University Degree	1.9	
Post-Graduate Degree	.8	

Source: Bangladesh Bureau of Statistics, 2015[66]

Table 4-23: School Attendance (% of population 5-24 years)

	Bangladesh	Chittagong	Cox's Bazar	Moheshkhali
Total	52.7	52.6	46.5	40.6
Male	54.6	54.2	45.6	37.6
Female	50.8	51.0	47.5	43.8

[70] The Bangladesh census defines literacy as the ability, in the population aged 7 years and above, to write a letter.

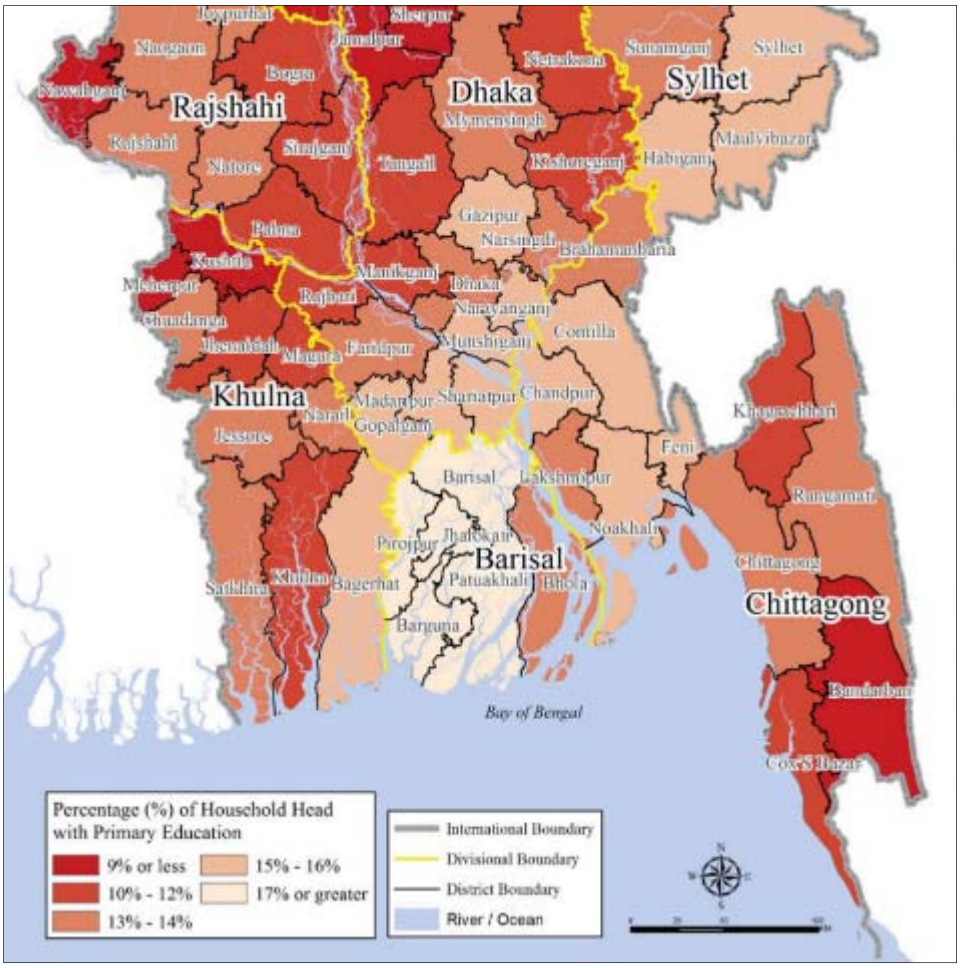
Table 4-24: School Attendance (% of population 6-19 years)

Village	Boro Moheshkhali: Boro-dale	Hoanak: Panirchhara	Kutubjom: Ghatibhanga
Total	55.1	58.1	42.9
Male	51.4	54.0	38.6
Female	59.4	62.6	47.4

Source: Bangladesh Bureau of Statistics, 2015[66]

As shown in the tables above, there are slight differences in literacy, attainment, and attendance rates between male and female populations nationally and locally. While overall rates have increased significantly (e.g., Moheshkhali Upazila literacy was surveyed at 22.5% in 2001, and 30.8% in 2011), under-education remains a significant challenge. Poverty rates may often be seen to correspond with literacy and primary educational attainment. Figure 4-38 presents the World Bank and World Food Program data map of household heads' educational attainment in 2010.

Figure 4-38: Household Head with Primary Education, 2010



Source: World Bank, 2010[71]

4.5.7 Health Profile

Infant and child mortality rates are good indicators of socioeconomic development, quality of life, and directions for health trends. Mortality levels are one of the main indicators of the standard of living or development of a population. At the time of the most recent health survey, under-5 mortality (the mortality rate for children under five years old) for the preceding five-year period was 46 deaths per 1,000 live births. At this level, Bangladesh achieved the Millennium Development Goal 4 target—48 deaths per 1,000 live births. In the last two decades, under-5 and infant mortality declined by 65 percent and 56 percent, respectively.[72]

Access to safe water and sanitation are key determinants of health, and drivers of improved public health performance. In Bangladesh, the leading preventable diseases are diarrheal ailments, acute respiratory infections and skin diseases—all associated with limited access to

[71] World Bank. 2010. Poverty Maps of Bangladesh. Accessed from the World Food Program Website: https://www.wfp.org/sites/default/files/Poverty%20Map%202010_Key%20Findings_BBS%20WB%20WFP.pdf

[72] National Institute of Population Research and Training. 2014. Bangladesh Demographic and Health Survey, 2014, pg. 99.

safe drinking water and sanitation facilities and poor hygiene. Respiratory infection remains the leading cause of child deaths in Bangladesh. However, diarrheal deaths and prevalence of diarrheal diseases among children under age 5 have declined in recent years. [73]

Life expectancy at birth is approximately 70 years, exceeding the world average of 69 years, calculated by the World Health Organization. Nevertheless, Bangladesh faces major health challenges. Although infant and child mortality is decreasing, poor nutrition is a critical health problem in Bangladesh.

The World Bank's most recent Development Update noted that in rural Bangladesh, 16.5% of households remain severely food energy-deficient. The southern region host a population of which 40% lived below the poverty line of $1.25/per/day in 2011.[74] This is reflected in the country's health profile, including the unions Bara-Moheshkhali, Hoanak, and Kutubjom. About half of children age 6-59 months suffers from anemia; 40% are stunted; and 33% are underweight. Bangladesh has one of the worst burdens of childhood malnutrition in the world.

Communicable diseases are a major cause of death and disability. While the prevalence of tuberculosis (TB) has declined substantially, Bangladesh still ranks among the top ten countries with a high TB burden. The disease is found primarily among the poor and least educated populations. Pneumonia and water-borne diseases also are prevalent.

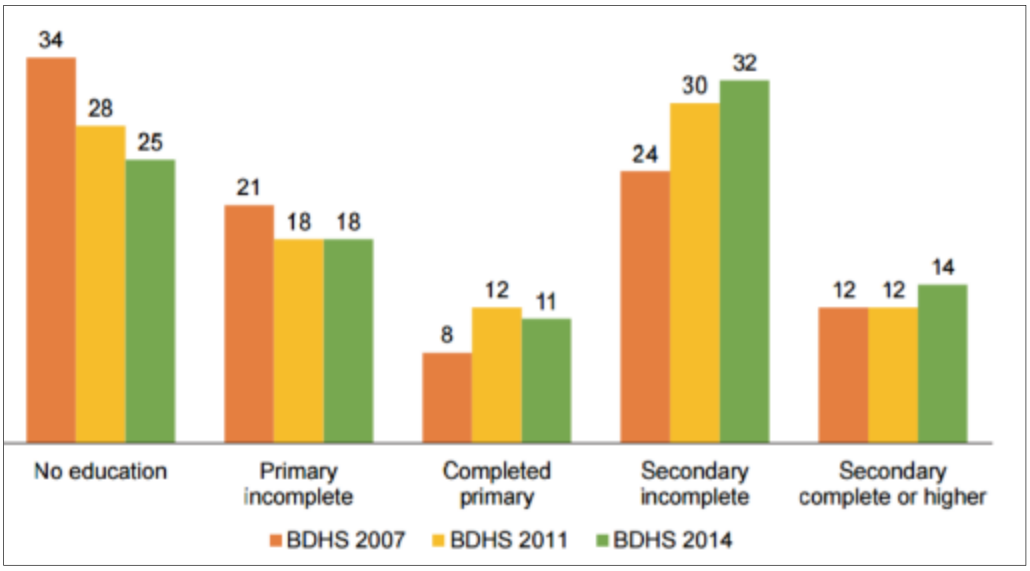
Non-communicable diseases — chronic diseases, cancer, diabetes, cardiovascular diseases, and chronic respiratory diseases — are increasing in Bangladesh as the population becomes more urbanized. Cancer is the sixth leading cause of death in Bangladesh, accounting for more than 150,000 deaths annually.[75]

4.5.8 Gender Equity

As reported by the United Nations Development Program's (UNDP) 2015 Human Development Report, Bangladesh ranks 142 out of 187 countries on the Gender Inequality Index, "a composite measure reflecting inequality in achievements between women and men in…reproductive health, empowerment, and the labor market".[76] The 2014 Global Gender Gap Index, developed by the World Economic Forum, ranks Bangladesh's gender equality performance as 68 out of 142 countries. Yet while these two indices rank Bangladesh performance poorly, there are positive gender equity trends in recent years.

[73] National Institute of Population Research and Training. 2014. Bangladesh Demographic and Health Survey, 2014, pg. 10.
[74] Poverty reduction in Bangladesh has shown considerable progress: since 1992, when the overall incidence was 58.8% nationally, to about 48.9% in 2000, and an estimated 32% in 2010.
[75] See health toolkits, at https://www.k4health.org/toolkits/bangladesh-health-journalists/overview-health-bangladesh
[76] UNDP. 2015. Human Development Report. Accessed from the UNDP website: http://hdr.undp.org/sites/default/files/2015_human_development_report_1.pdf

Figure 4-39: Women in School - Completion Rates



Source: National Institute of Population Research and Training, 2014.[72]

Surveys found that 25% of married Bangladeshi women (age 15-49) have no education; however, this percentage has decreased since 2007, and the percentage of women with secondary or higher education has gradually increased over the same period. Surveys conducted in 2007, 2011, and 2014 show increases in rates of women attending secondary and post-secondary school.

In the year preceding the Bangladesh Demographic and Health Survey, 36% of women were working, with the highest percentages employed in raising of poultry/cattle (41%), semi-skilled services (14%), and factory or blue collar services (8%).

As a key measure of gender equity, the Demographic and Health Survey reports than in 2014, 32% of married and employed women who earn cash "make decisions mainly by themselves on how to use their own earnings", while 44% participate in decisions regarding their own health care, their child's health care, major household purchases, and visits to their family or relatives.[77]

4.5.9 Vulnerable Groups

Vulnerable groups are defined as those within a project's area of influence that may be particularly disadvantaged and who could experience adverse impacts from a proposed project more severely than others. This disadvantage may stem from ethnicity or race, skin color, religion, political status, culture, sickness, physical or mental disability, age, or other factors. In the project area, no data was found to indicate the presence of vulnerable ethnic minorities or other politically or culturally disadvantaged groups. The Moheshkhali Disaster Management Plan indicates the presence of elderly as well as disabled people, which may be considered relatively vulnerable in comparison to the general population. Population figures are reproduced in Table 4-25, below.

[77] National Institute of Population Research and Training. 2014. Bangladesh Demographic and Health Survey, 2014, pg. 187.

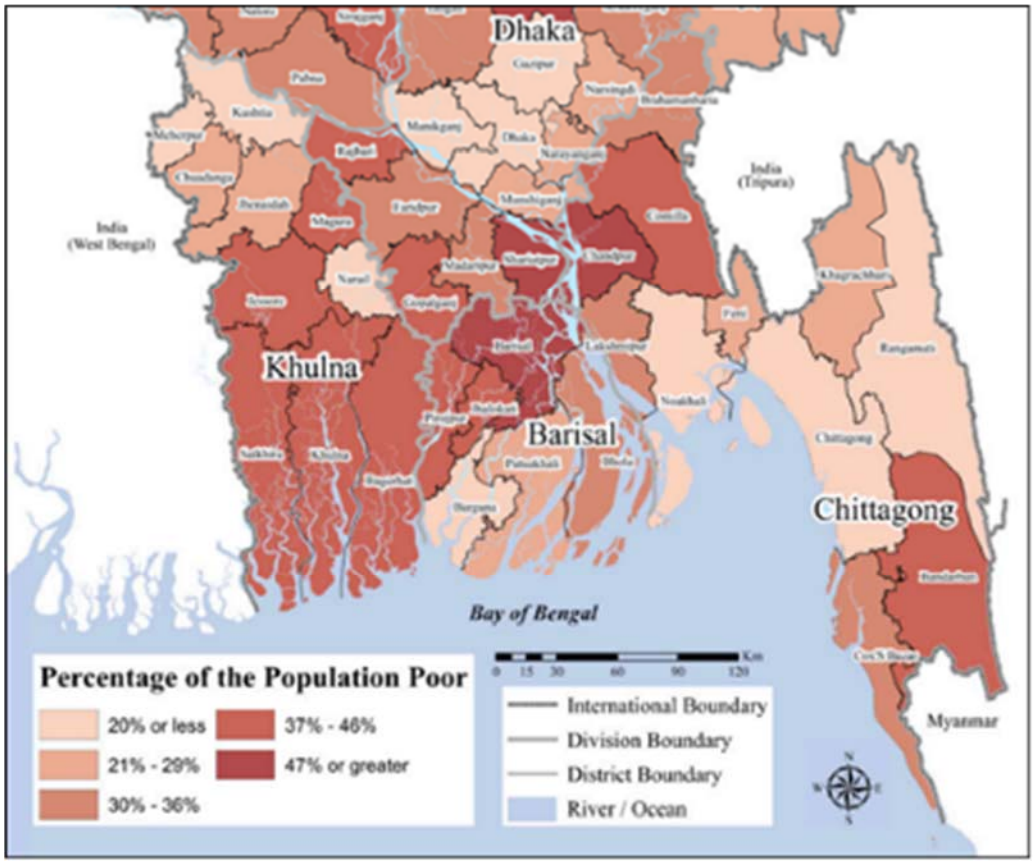
Table 4-25: Vulnerable Populations

Union	Older Persons (60+ years)	Disabled
Boro Moheshkhali	2,569	750
Hoanak	2,889	456
Kutubjom	1,593	540

Source: Moheshkhali Disaster Management Plan, 2014.[78]

Poverty is another aspect of vulnerability; lack of resources can limit choices regarding far more than response to potential temporary project impacts. Food scarcity, inadequate shelter, limited educational opportunity are all aspects of poverty that amplify a group or individual's vulnerability. Figure 4-40 below presents the World Bank's poverty map for 2010 Bangladesh; it shows poverty levels of in Cox's Bazar are similar to (and notably, not among the least poor) levels throughout the country.

Figure 4-40: Poverty Rates, 2010



Source: World Bank, 2016[79]

[78] Disaster Management Bureau, Disaster Management, & Relief Unit. 2010. Moheshkhali Disaster Management Plan.
[79] World Bank. 2010. Poverty Maps of Bangladesh. Accessed from the World Food Program Website: https://www.wfp.org/sites/default/files/Poverty%20Map%202010_Key%20Findings_BBS%20WB%20WFP.pdf

4.5.10 Socioeconomic Conditions

Recent GDP growth in Bangladesh has been impressive; the World Bank's Bangladesh Development Update notes that the country is on track to sustain 6 plus percent growth, with previous years showing GDP increases of 6.5-6.6% in fiscal years 2011-2015.[80] This is despite stagnation in rice production, which is limited by (among other factors) lack of land expansion opportunity, overuse and change in resource quality.[80] The following section details economic activity in the unions closest to the project site, in comparison with national statistics and trends.

Recent demographic surveys indicate that men are more likely to be employed (65% versus 24%), and employment rates are higher in urban rather than rural settings (Table 4-26). The survey data also indicates a labor force that is active from the teenage years well into many people's mid to late sixties.

Table 4-26: Employment Rates (%) by Age, Sex, Setting

	Male			Female		
Age	Urban	Rural	Total	Urban	Rural	Total
8-9	1.2	0.9	1.0	1.4	0.5	0.7
10-14	10.9	9.7	10.0	7.7	2.6	3.9
15-19	43.6	39.6	40.8	21.1	12.8	15.1
20-24	73.4	74.9	74.4	30.6	26.7	27.9
25-29	90.7	91.9	91.5	35.3	37.0	36.5
30-34	96.9	97.2	97.1	36.0	41.5	39.9
35-39	98.6	98.2	98.4	39.7	41.4	40.9
40-44	96.0	98.2	97.5	38.1	43.3	41.8
45-49	98.8	97.5	97.9	33.4	38.2	36.8
50-54	94.3	94.8	94.6	22.8	26.5	25.5
55-59	90.4	89.7	89.9	23.8	26.1	25.6
60-64	78.8	81.9	81.1	12.3	16.1	15.2
65+	50.8	48.4	48.9	5.8	6.2	6.1
Total	68.8	63.1	64.7	25.2	23.7	24.1

Source: National Institute of Population Research and Training, 2014[81]

4.5.11 Local Economic Activity - Agriculture

According to recent surveys, agriculture remains the key sector of the Bangladesh economy, with more than 70% of people directly or indirectly employed. Rice is the dominant crop, accounting for 80% of land area.[82] Ownership records indicate that approximately 10% of farmers control half of agricultural land, with 60% of farmers dependent on sharecropping. On average, farm sizes are very small and barely adequate to support single families. The World Bank notes that "almost all of the 13 million farm families grow rice; on about 10.5 million hectares which has remained almost stable over the past three decades."

[80] World Bank. 2016. Bangladesh Development Update. Accessed from the World Bank website: http://documents.worldbank.org/curated/en/579721475673660627/pdf/108745-WP-SAREC-PUBLIC-FinalBangladeshDevelopmentUpdateOctober.pdf

[81] National Institute of Population Research and Training. 2014. Bangladesh Demographic and Health Survey, 2014, pg. 26

[82] Food Planning and Monitoring Unit, Ministry of Food, and Disaster Management. 2015. Policy and planning survey on Agriculture and Food Security, pre-final draft. August 2015.

The 2011 census results show main crops grown in Cox's Bazar Zila to include: rice, potatoes, onions, garlic, ginger, betel leaf, betel nut, wheat, sugarcane, ground nut, tobacco. Fruits include mango, jackfruit, pineapple, banana, papaya, and coconut.

Land use patterns of the area closest to the proposed terminal tie-in predominantly comprise of salt and shrimp cultivation, as well as agriculture. This is typical of the Upazila; recent land use mapping indicates that of Moheshkhali' s total irrigable land (approximately 5,300 hectares) 2,070 hectares are used for salt production, 2,100 are used for shrimp cultivation, 1,700 hectares are fallow, and around 23%, (1,200 hectares) are used consistently for agriculture. The areas surrounding shrimp and salt production fields are generally agricultural or residential areas, markets, ponds, channels and mud flats. In 2015, it was estimated that 25% of the working population of Cox's Bazar are directly involved in agricultural activities.[83]

Crops are grown in a pattern as follows: 2 crops in the Kharif (monsoon) season—March to June, and July to October, and a Rabi (winter) season from November to February. Many households in Moheshkhali raise poultry and livestock, which may include cows, buffalo, goats, sheep, ducks, and chickens.

As was indicated in the previous Project EIA, the study area population resides in villages (including Boro-dale, Panirchhara, and Ghatibhanga) focused on seasonal agricultural and fish farms. Farm sizes are typically small, ranging from 1 acre to 5 acres of land. Salt and shrimp production are the main sources of income, with approximately 95% of families depending on these artisanal industries as a primary means of livelihood, with the remaining 5% dependent on business and services. While roughly 75% of farmers cultivate their own land, 20% work as share croppers.

4.5.12 Local Economic Activity - Fishing

Fish production has continued to grow in Bangladesh, with close to 17 million people involved in the sector.[80] In the Moheshkhali Upazila, the majority of households are engaged in artisanal and not commercial fishing. Fish are caught in the nearby tidal floodplain, rivers, khals (canals) as well further offshore in the Bay of Bengal. [84]

Fishing is carried out using push nets, beach seine nets, shrimp nets, estuary and marine set bag nets and long lines. Push nets are used for shrimp cultivation (catching shrimp fry), and not used during the dry (salt) season.

Department of Fisheries catch are grouped into 9 categories. Marine hilsha contributed the most (41.44 percent of total catch of 198 850 t), followed by shrimp (48 119 t; 10.03 percent), Bombay duck (Herpodonidae) (37 331 t; 8.20 percent); Jew fishes (32 538 t; 6.78 percent); catfishes (18 151 t; 3.78 percent); pomfret (12 023 t; 2.51 percent); sharks and rays (4 448 t; 0.93 percent); and miscellaneous marine fishes (125 332 t; 26.12 percent).[85]

In Bangladesh, waters less than 40 m are reserved for artisanal fishermen. The artisanal fishing sector utilizes powered and unpowered traditional boats, using gill nets (57.7 percent of catch),

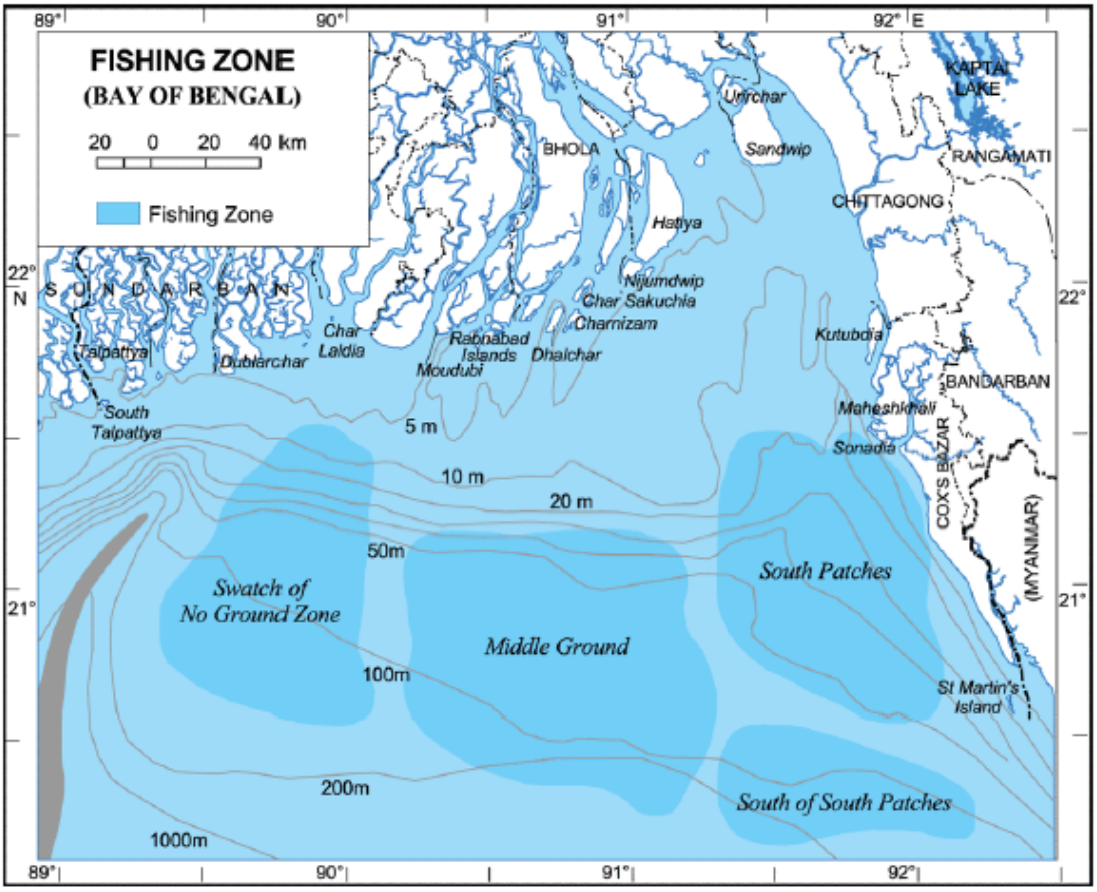
[83] Coal Power Generation Company Bangladesh Limited. Environmental Impact Assessment. Moheshkhali Road Construction. October 2015. See http://www.cpgcbl.gov.bd/?page_id=81

[84] During 1996-97, total fish production both inland and marine was 1.373 MMT; contribution of marine fisheries was 28.46% of the total production. In and around the project area there are twelve fishing catch collection points.

[85] FAO. 2007. Fishery Country Profile: Bangladesh.

set bag nets (29.0 percent), trammel net (2.5 percent), long lines (6.0 percent) and other fishing gear (4.8 percent).

Figure 4-41: Fishing Zones Offshore Bangladesh

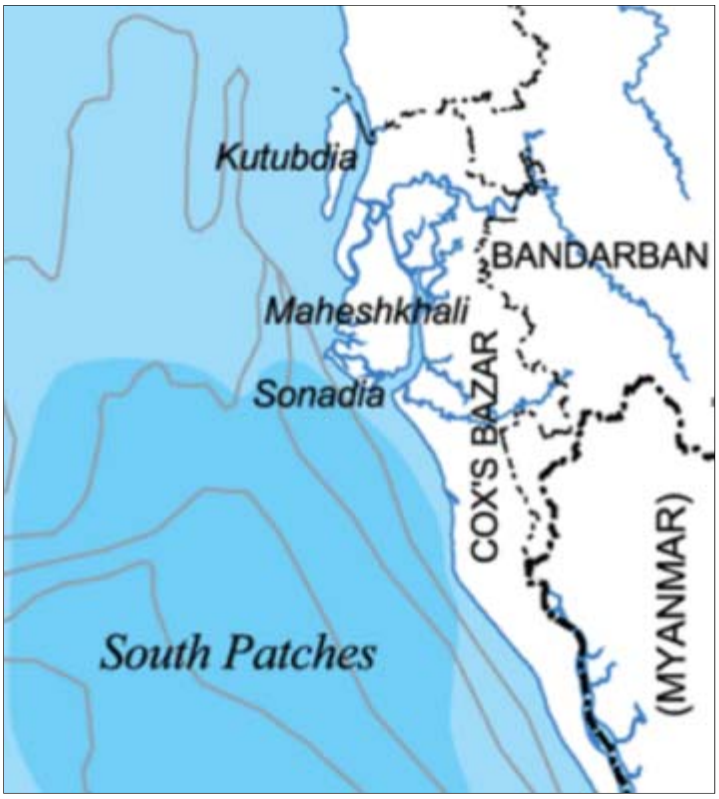


Source: Department of Fisheries, 2015.[86]

As Figure 4-41 and Figure 4-42 illustrate, both the Project's proposed Terminal Location and Delivery Point are situated north of the border of the South Patches fishing zone, utilized by commercial fishing only.

[86] Department of Fisheries. 2015. Policy and Planning Survey on Fisheries, pre-final draft. August 2015

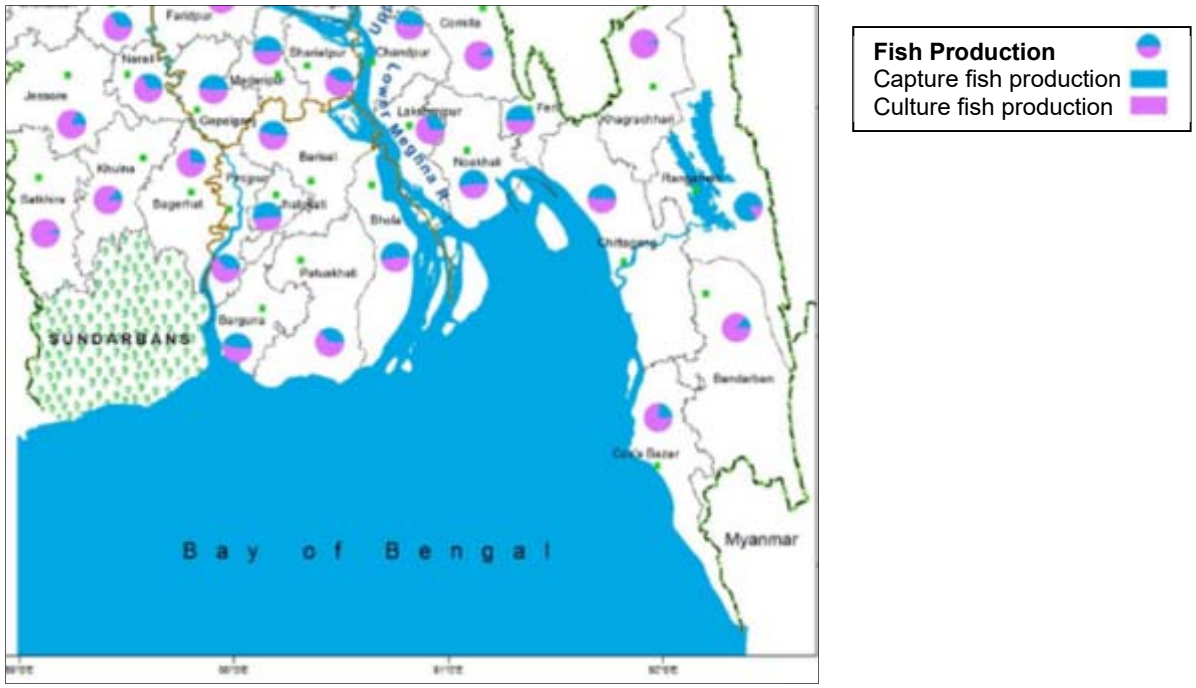
Figure 4-42: South Patches and Moheshkhali



Source: Department of Fisheries, 2015.[86]

As shown in Figure 4-43, fisheries production in Bangladesh overall, and offshore Cox's Bazar in particular, is predominantly by fish culture, rather than capture. Nonetheless, interviews with Fisheries officers at Upazila level indicated that as many as 35,000 Moheshkhali fishermen work in the Bay of Bengal. Among them are the residents of the 3 villages closest to the Project, Boro-dale, Panirchhara, and Ghatibhanga.

Figure 4-43: Bangladesh Fish Production



Source: Department of Fisheries, 2015.[86]

4.5.13 Local Economic Activity – Villages Nearest to the Delivery Point

The working populations of rural villages closest to the proposed Delivery Point, Boro-Dale, Panirchara, and Ghatibhanga, pursue economic activities typical of the broader Upazila and Zila. This includes agriculture, industry, and services. Table 4-27 below presents the breakdown of economic pursuits in the three villages, per the 2011 census[87].

Table 4-27: Fields of Employment (% of working population)

	Boro Moheshkhali: Boro-dale	Hoanak: Panirchhara	Kutubjom: Ghatibhanga
Agricultural			
Male	*91.3*	*97.3*	*97.3*
Female	*88.9*	*100*	*88.4*
Total	91.2	97.4	96.7
Industry			
Male	*5.8*	*1.0*	*.9*
Female	*0.0*	*0.0*	*4.2*
Total	5.6	1.0	1.1
Service			
Male	*2.9*	*1.7*	*1.8*
Female	*11.1*	*0.0*	*7.4*
Total	3.2	1.6	2.2

Source: Bangladesh Bureau of Statistics, 2015[66]

[87] Census materials do not detail the distinctions between agriculture, industry, and service. Given the response data, and evidence in the field, one can surmise that 'agricultural' includes fish farming.

4.5.14 Local Economic Activity – Tourism

While Sonadia Island is a designated Ecologically Critical Area, it is only accessible by boat. Further, Cox's Bazar, the only nearby port, lacks infrastructure (i.e. docks and service providers) to facilitate significant expansion of tourism to Sonadia Island. Despite these challenges, approximately 30 to 50 visitors travel to Sonadia Island each year.[88] Most of the visitors are wildlife photographers, and travel in small groups of three to five.

4.5.15 Social Infrastructure

4.5.15.1 Public Health

The 2014 Bangladesh Demographic and Health Survey found that 87% of surveyed sample areas had a health facility within 1km, irrespective of urban or rural setting. Satellite clinics were also found to be readily available, with 76% of areas reporting such a facility within 1km. However, only 24% of rural areas have a government health facility within 1km.

Figure 4-44: Health Facility by Distance, Location, and Type

Distance in kilometers (km)	Type of facility					
	Any facility	Government facility[1]	NGO facility	Private facility	Rural dispensaries	Satellite Clinics
			URBAN			
<1 km	88.2	24.0	25.6	37.5	0.6	69.0
1 to <2 km	9.5	30.5	20.8	23.2	0.6	6.5
2 to <5 km	2.4	32.9	24.4	22.6	0.6	3.0
5 km or more	0.0	12.6	13.1	16.7	0.0	0.0
No facility	0.0	0.0	16.1	0.0	98.2	21.4
Total	100.0	100.0	100.0	100.0	100.0	100.0
Number of clusters	169	169	169	169	169	169
			RURAL			
<1 km	86.5	39.8	2.3	3.2	0.0	78.0
1 to <2 km	6.3	21.8	4.4	4.6	0.2	4.2
2 to <5 km	7.2	32.6	16.2	17.8	0.2	8.1
5 km or more	0.0	5.8	37.6	73.1	0.2	1.2
No facility	0.0	0.0	39.4	1.2	99.3	8.6
Total	100.0	100.0	100.0	100.0	100.0	100.0
Number of clusters	431	431	431	431	431	431
			TOTAL			
<1 km	87.0	35.4	8.8	12.8	0.2	75.5
1 to <2 km	7.2	24.2	9.0	9.8	0.3	4.8
2 to <5 km	5.8	32.7	18.5	19.2	0.3	6.7
5 km or more	0.0	7.7	30.7	57.3	0.2	0.8
No facility	0.0	0.0	32.9	0.8	99.0	12.2
Total	100.0	100.0	100.0	100.0	100.0	100.0
Number of clusters	600	600	600	600	600	600

[1] Government facility includes government hospital, upazila health complex, family welfare center, maternal and child welfare center, and community clinic.

Source: Bangladesh Demographic and Health Survey, 2014

As the above table suggests, the unions in proximity of the Project area face similar health resource challenges. The Moheshkhali Upazila Disaster Management Plan notes that there are:

- 1 sub-district health complex (Government Hospital)
- 7 Union Health and Family Welfare Centers (Government)

[88] Personal communication with Sayam Chowdhury, Assistant coordinator of the Spoon-billed Sandpiper Task Force.

- 26 Community Clinic (Government)
- 3 NGO-operated Healthcare Centers, and
- 1 Private Healthcare Center.

Residents typically travel to Cox's Bazar, Chakaria, or Chittagong for healthcare services beyond the basic care provided in Moheshkhali.

4.5.15.2 Potable Water

In 2014, the Bangladesh Demographic and Health Survey estimated that "everyone (98 percent) in Bangladesh has access to an improved source of drinking water"; this figure includes water from "pipe, tube well, protected well, rain or bottle".[89] However, the survey also found that only 10% of households used an appropriate water treatment method, including boiling, bleaching, filtering, and solar disinfecting—a rate that had not changed since 2011.

Access to an improved source of drinking water is almost universal in Bangladesh (98%). The most common sources of drinking water in urban areas are tube wells or boreholes (67%), followed by piped water (23%), and a public tap or standpipe (8%). In contrast, tube wells or boreholes are practically the only source of drinking water in rural areas (94%).

People in Cox's Bazar depend upon ponds, shallow wells, and tube-wells for drinking water and everyday use. There are shallow tube wells in all unions in Moheshkhali, from which 200 to 300 families collect their drinking water. The level of iron and salinity has increased over the last 30 years. In response, several deep tube wells have been installed in some of the unions by the Public Health Engineering Department—and these are free of contamination. The Moheshkhali Disaster Management Plan notes that (in 2014), 40% of families in Moheshkhali suffered from a lack of safe water, with many of the tube wells in Kutubjom and other unions having become tainted by salt water.

Box 1: Social Infrastructure Summary – Bangladesh 2014

A national survey of social infrastructure and community resources progress found:

- 45% households with an improved toilet facility, not shared with other households, (vs 34% in 2011)
- 4% households lacking toilet facilities
- 73% households with electricity (vs 60% in 2011).
- 11% households use solar electricity
- 82% households use solid fuel for cooking
- 89% households possess mobile phones (vs 78% in 2011)
- 53% of household members age 13 and older own a mobile phone
- 13% households headed by a woman

These statistics indicate considerable human convenience improvements between 2011 and 2014.

Source: Bangladesh Demographic and Health Survey, 2014.

4.5.15.3 Electricity

Close to 73% of households in Bangladesh have access to electricity, either from the national grid or solar power connections. The national grid covers 62% of households throughout the country, with more coverage in urban areas (91%) and less in rural areas (51%). In contrast, solar power is predominantly used in rural areas, it serves 11% of households in Bangladesh.

[89] Bangladesh Demographic and Health Survey, 2014, pg. 9.

Overall, access to electricity increased substantially from 2011 to 2014, from 60 to 73%. This expansion took place mostly in rural areas.

4.5.15.4 Roads

According to the Moheshkhali Disaster Management Plan, most of the roads within the Upazila are paved—a "significant improvement over the last 5-10 years". However, the Plan also reports that the road system within the unions is in terrible condition, with only the main roads connecting the unions being paved. The roads that "lead to the villages from the main road are either haphazardly laid with bricks or they are simply dirt roads. In most places the bricks have become dislodged." Moheshkhali sub-district has roads spanning a total of 575 km, out of which nearly 75 km are paved, 182 km are brick, and 354 km are unimproved dirt roads.[90]

4.5.15.5 Housing

The unions within Moheshkhali Upazila generally consist of mud houses with straw or tin roofs, bamboo, or wooden house with straw or tin roofs, tin houses with tin roofs, and concrete houses. Approximately 60% of dwellings are mud houses, 20% are wooden, 10% are tin, and the remainder are concrete or a blend of concrete and other material.

Table 4-28 presents a summary of housing in the unions closest to the Project tie-in location.

Table 4-28: Summary of Housing in Nearby Unions

Union	Total Number of Houses	Mud Houses	Bamboo / Wooden Houses	Tin Houses	Concrete or Blend Houses
Boro Moheshkhali	11,267	5,634	3,605	1,690	338
Hoanak	12,896	6,448	4,127	1,934	387
Kutubjom	7,659	3,829	2,451	1,149	230

4.5.15.6 Sewage and Waste Management

Moheshkhali's residents, particularly those in Boro Moheshkhali and two other unions, endure a majority of substandard and unhygienic toilets. In Moheshkhali, some residents use permanent, installed latrines, while others use pits, or open areas. Data presented by the Moheshkhali Upazila is summarized in Table 4-29 below.

Table 4-29: Summary of Sewage Types in Nearby Unions

Union	Hygienic	Pit	Open	Waste Management
Boro Moheshkhali	820	4,074	2,848	30% of inhabitants in the whole of Moheshkhali use hygienic latrines; these are predominantly the wealthier and more educated portion of the population.
Hoanak	925	1,612	1,962	
Kutubjom	620	1,649	1,462	

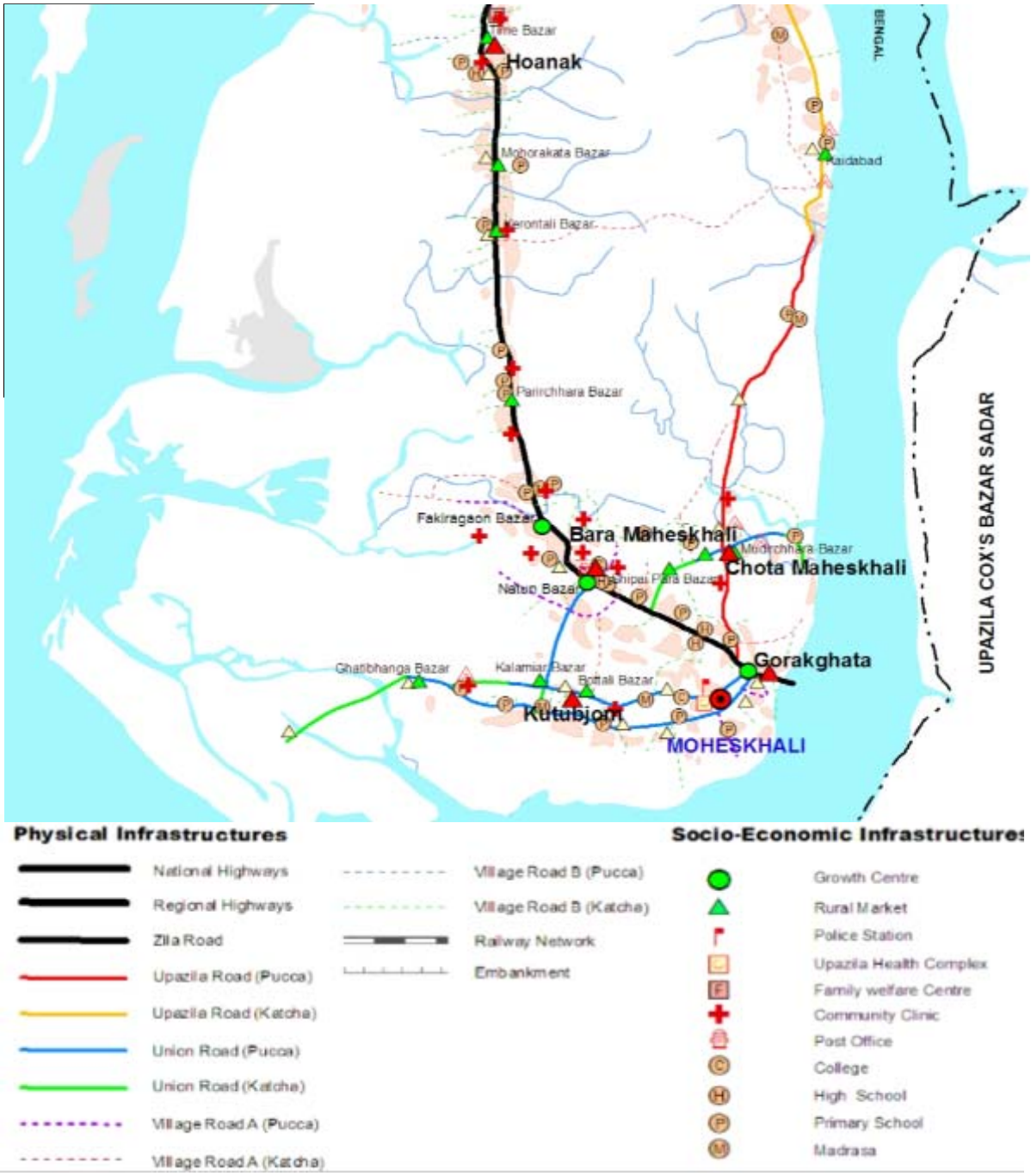
[90] Moheshkhali Disaster Management Plan, 2014.

4.5.15.7 Schools

Moheshkhali has 57 government primary schools, 6 non-government primary schools, 8 non-government lower secondary schools, 15 high schools for boys, 3 high schools for girls, 1 university, 33 Senior Madrasas, and 38 Junior Madrasas.

The location of schools and other social infrastructure is shown in Figure 4-45 below.

Figure 4-45: Location of Schools and Other Social Infrastructure on Southern Moheshkhali Island



Source: Local Government Engineering Department, 2016

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5 Impact Identification and Evaluation

This chapter considers the potential impacts that proposed activities (described in Chapter 2) could have on the existing physical, biological, and socioeconomic environment (described in Chapter 4). Specifically, this chapter describes the following:

5.1 Methodology
5.2 Identification of Potential Impacts
5.3 Evaluation of Potential Impacts
5.4 Data Gaps and Uncertainties

5.1 Methodology

The ESIA Team used a methodology to analyze project impacts that incorporates lessons learned and oil and gas industry best practices from sources such as the International Petroleum Industry Environmental Conservation Association (IPIECA), International Association of Oil and Gas Producers (OGP) and the International Finance Corporation (IFC).

This methodology has been applied consistently by the ESIA Team on projects worldwide and is based on a two-tiered impact assessment process, as shown in Figure 5-1. This methodology identifies and evaluates potential impacts relevant to the proposed project. The steps involved include:

1. Tier 1 Assessment: Review of a wide range of potential impacts and identification ("screening") of those potential impacts that are relevant to the project.
2. Tier 2 Assessment: Evaluation of the impacts identified in Tier 1 based on determination of the unmitigated consequence and likelihood of each consequence occurring. This evaluation results in a rating of the significance of each impact as low, medium or high.
3. Development of mitigation measures for any medium and high level impacts so that all residual impacts (impact after mitigation is applied) are low (see Chapter 6**).**

Further discussion of the methodology for Tier 1 and Tier 2 is presented below.

5.1.1 Tier 1 - Identification of Potential Impacts

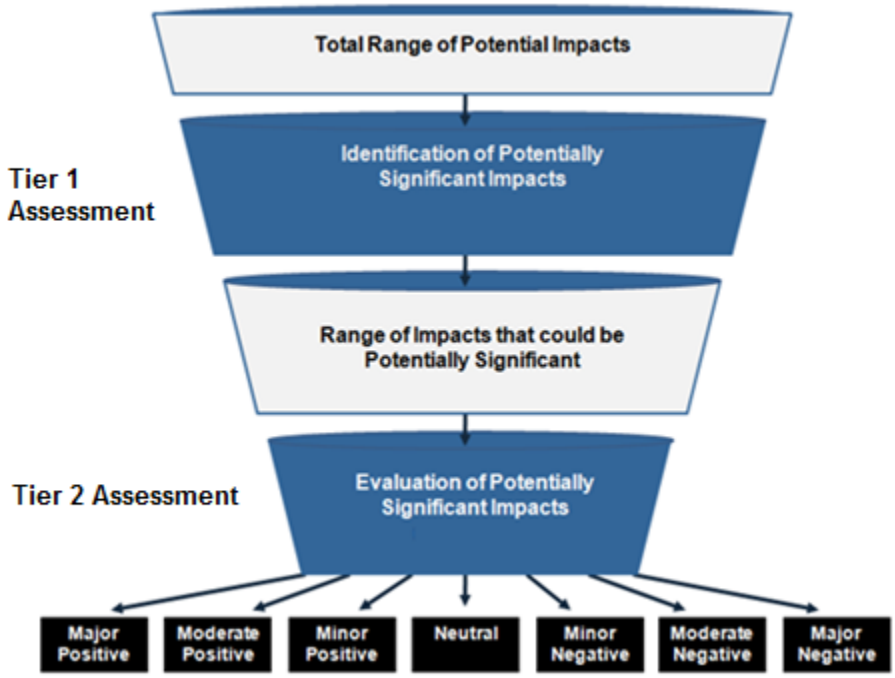
The Tier 1 evaluation was performed through the identification of:

1. Key project activities/operations (e.g., mobilization, construction, etc.)
2. Activities performed in each phase of work (these are considered potential sources of impact, e.g., ballasting, land clearance, etc.)
3. Potential physical, biological, and/or social receptors that could reasonably be affected by the sources of impact (e.g., soils, air, water, flora, fauna, health, economy, etc.)

Criteria-based questions were used for this Tier 1 evaluation, such as:

- Are there sensitive resources relative to a potential impact present in or around the study area (e.g., ecologically sensitive resources)?
- Could the proposed activities reasonably have any influence in altering baseline conditions relative to the potential impact (e.g., could the proposed activities result in any change to socioeconomic conditions in communities along the coast)?
- Could conditions in the affected environment present hazards that could affect project activities or worsen potential impacts (e.g., increasing a risk of water quality or ecological damage from an accidental release)?

Figure 5-1: Impact Assessment Technique Using 2-Tier Significance Criteria



5.1.2 Tier 2 - Evaluation of Potential Impacts

Once the Tier 1 assessment was complete, a series of criteria were used to evaluate the consequence and likelihood of each identified impact.

Based on an evaluation of the nature, intensity, scope, and duration of impact, an overall consequence level was assigned. Criteria used to evaluate the unmitigated consequence of possible impacts are listed in Table 5-1, and criteria used to rate the likelihood of the unmitigated consequence occurring are presented in Table 5-2. The evaluation of potential impacts is summarized in Table 5-3 and each potential impact is described in Section 5.3.

Table 5-1: Impact Consequence Criteria (Unmitigated)

Consequence Level	Criteria
Major (3)	Widespread modification of extraordinary severity, lasting more than one year.
Moderate (2)	Local modification of measurable severity, lasting from a few months to up to one year before recovery; or more widespread modification of lesser severity.
Minor (1)	Localized, relatively isolated change, lasting only a few weeks to a few months before recovery, with no observable residual effects.
Negligible (0)	Little or no change, conditions consistent with background conditions.

Table 5-2: Impact Likelihood Criteria

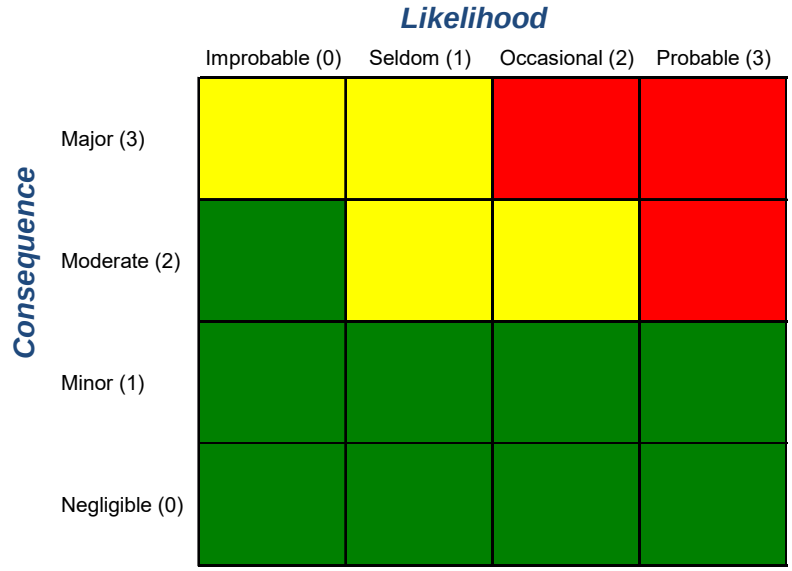
Likelihood Level	Criteria
Probable (3)	The consequence of the impact or event can reasonably be expected to result from project, occurs routinely in similar operations.
Occasional (2)	The consequence of the impact or event has occurred in similar operations, or conditions could allow the impact/event to occur in the program.
Seldom (1)	The consequence of the impact or event has occurred in similar projects, but conditions in this program are unlikely to allow the impact/event to occur.
Improbable (0)	The impact or event is not known to have occurred before.

A matrix (Figure 5-2) was used for qualitative assessment of impacts using the consequence and likelihood criteria presented above. This methodology allows the partitioning of the potential impacts by significance (as high, medium or low), expressed as a function of consequence and likelihood. These categorizations facilitate the identification of the proposed activities that are likely to generate greater impact and the environmental elements that could potentially be most affected. As shown in Figure 5-2:

- The vertical axis represents increasing consequences (negligible to major) in terms of impact
- The horizontal axis represents increasing likelihood (improbable to probable) of the consequence
- Boxes in the matrix represent the significance rating of the impact, increasing from bottom left to top right corners of the matrix

Results of the Tier 2 impact evaluation are presented in 5.3, and environmental management and mitigation requirements are detailed in Chapter 6.

Figure 5-2: Impact Evaluation Matrix



Significance Rating Definition

High (3)		Requires alternative approach/design and mitigation to minimize impact
Medium (2)		Requires mitigation
Low (1)		Proceed with care, apply standard controls but no additional mitigation needed

5.2 Identification of Potential Impacts

5.2.1 Sources of Impact

The phases of the identified for the Project as described in Chapter 2 include:

1. Mobilization
2. Construction and Commissioning
3. Operation
4. Decommissioning
5. Ancillary Activities

Impacts are discussed according to the same phases.

While Decommissioning is presented, no impacts were identified for this phase. After the contract term, ownership of all permanent infrastructure will transfer to the Government of Bangladesh for continued use. The Government of Bangladesh may request the *Excellence* continue service at the terminal, or contract another vessel. If another vessel was selected, all subsea infrastructure would remain, and the Excellence would simply detach from the buoy, undergo repairs and upgrades required to maintain classification, and sail to another location for operation. Assuming first gas in 2018, the *Excellence* would be 28 years old at the end of the 15 year contract term. Excelerate reports vessel fatigue life is 40 years, so with normal upkeep and repairs the *Excellence* would not be decommissioned.

Ancillary activities include cross-cutting activities that will be present during multiple project phases, including support vessel use, port services, and waste management. For efficiency, these impacts are grouped.

Analysis of the work proposed in each of these program phases reveals specific activities that could result in impacts. These activities, referred to as potential "sources of impact", are highlighted in Sections 5.2.1.1 – 5.2.1.4 below.

5.2.1.1 Mobilization (Phase 1)

Only one of the activity associated with mobilization is considered a potential source of impact:

A. Routine discharges

See potential sources of impact included in Ancillary Activities (Phase 5) as these are related to Mobilization and other phases.

5.2.1.1 Construction and Commissioning (Phase 2)

The following activities associated with construction and commissioning are potential sources of impact:

A. Clearance and grading of construction yard and installation of Delivery Point
B. Installation of pipeline, PLEM, riser, and moorings
C. Routine discharges
D. Generation of air emissions
E. Physical presence of FSRU and vessel
F. Enforcement of safety zone and vessel operations
G. Accidental release

Also, see potential sources of impact included in Ancillary Activities (Phase 5).

5.2.1.2 Operation (Phase 3)

The following activities associated with operation are potential sources of impact:

A. Routine discharges
B. Generation of air emissions
C. Physical presence of FSRU and vessels
D. Enforcement of safety zone and vessel operations
E. Job creation
F. Accidental release

Also, see potential sources of impact included in Ancillary Activities (Phase 5).

5.2.1.3 Decommissioning (Phase 4)

Aside from potential sources of impact included in Ancillary Activities (Phase 5), no impacts were identified for this phase.

5.2.1.4 Ancillary Activities (Phase 5)

The following activities associated with ancillary activities are potential sources of impact are:

A. Routine discharges
B. Generation of air emissions
C. Physical presence of vessels
D. Enforcement of safety zone and vessel operations
E. Job creation
F. Accidental release

5.2.2 Potential Impacts

Table 5-3 presents those impacts identified in Tier 1 assessment as possible impacts that could result from the Project activities described in Section 5.2.1.

The impact numbering system in Table 5-3 assigns a unique identifier to each impact. Using the first impact listed as an example, number 1A1, the identifier may be interpreted as follows:

- First number (1) = Project phase (i.e. “mobilization”)
- First letter (A) = Source of potential impact; letters are added sequentially with the addition of sources (i.e. A = “ballasting”)
- Second number (1) = Potential impact; number increases sequentially when there is more than one potential impact associated with the same source (i.e. “Ballasting” might potentially generate two impacts, numbered “1A1” and “1A2”)

Using the methodology described, the consequence and likelihood were identified for each impact listed in Table 5-3 to establish an overall impact rating. This Tier 2 evaluation took into consideration:

- Nature of the impact: an evaluation of the interaction with the impacted receptor (evaluation described for each impact in Section 5.3)
- Intensity: an evaluation of the reversibility of the impact
  - Reversible impacts are temporary and the affected resource (i.e. fauna, water quality, etc.) is expected to return to pre-impact conditions within three to five years
  - Irreversible impacts have permanent affects (i.e. destruction of submerged archaeological resources) that will not return to pre-impact conditions for an extended period of time (>five years), if ever
- Scope: an evaluation of the physical extent of the impact
  - Localized impacts are limited to a small, defined area (i.e. generally within 2 km of the impact source)
  - Dispersed impacts affect widespread areas, the extent of which are potentially unknown (i.e. in the event of a large LNG or diesel spill)
- Duration: an evaluation of the length of the impact
  - Short-term impacts are either non-continuous or last up to approximately six months
  - Medium-term impacts last between approximately six months to approximately two years
  - Long-term impacts last longer than two years
  - Cumulative impact
- Likelihood: an evaluation of how probable the impact is for the proposed activities

In Table 5-3, each potential impact has also been assigned an unmitigated consequence and likelihood “score” or rating according to the Tier 2 assessment, and based on these scores a significance rating has been assigned according to the Impact Evaluation Matrix found in Figure 5-2. Further discussion providing the justification of significance ratings for each impact is included in Section 5.3. All potential impacts with a medium or high significance rating will require mitigation to minimize potential impacts. Mitigation measures for each medium and high level impact are discussed in Chapter 6.

Table 5-3: Summary of Potential Impacts

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Text Ref.	Intensity	Scope	Dura-tion	Overall Consequence Level and Score	Likelihood Level and Score	Significance
Mobilization (Phase 1)										
1A1	Routine discharges	Water	Degradation of water quality from ballast water exchange	5.3.2	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
1A2	Routine discharges	Fauna	Introduction of invasive aquatic species	5.3.2	Irreversible	Dispersed	Long-term	**Major (3)**	**Improbable (0)**	**Low**
Also see Ancillary Activities (Phase 5)										
Construction and Commissioning (Phase 2)										
2A1	Clearance and grading of construction yard and installation of Delivery Point	Soil	Degradation of soils from disruption and compaction	5.3.1.1	Reversible / Irreversible	Localized	Long-term	**Minor (1)**	**Probable (3)**	**Low**
2A2	Clearance and grading of construction yard and installation of Delivery Point	Air	Degradation of air quality from generation of dust	5.3.1.1	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
2A3	Clearance and grading of construction yard and installation of Delivery Point	Flora	Damage to flora from clearance of construction yard[1]	5.3.1.1	Reversible	Localized	Long-term	**Moderate (2)**	**Probable (3)**	**High**

[1] Construction of the Delivery Point will require temporary occupation of approximately 90 x 90 m (8,100 m^2), of which an area of approximately 75 x 70 m (5,250 m^2) are mangroves that will be cleared. An area of approximately 45 x 45 m (2,025 m^2) will be used permanently. While a very small area, significance is considered moderate because the area is within a protected area.

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Text Ref.	Intensity	Scope	Dura-tion	Overall Consequence Level and Score	Likelihood Level and Score	Significance
2A4	Clearance and grading of construction yard and installation of Delivery Point	Fauna	Degradation of habitat and disruption from clearance and physical presence (including light and noise)	5.3.1.1	Reversible	Localized	Medium-term	**Moderate (2)**	**Occasional (2)**	**Medium**
2B1	Installation of pipeline, PLEM, riser, and moorings	Water	Degradation of water quality from increased turbidity, and potential release of nutrients and contaminants into the water column	5.3.1.2	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
2B2	Installation of pipeline, PLEM, riser, and moorings	Fauna	Harm to fauna from degradation of water quality	5.3.1.2	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
2B3	Installation of pipeline, PLEM, riser, and moorings	Fauna	Harm to fauna from disturbance of benthic habitat	5.3.1.2	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
2B4	Installation of pipeline, PLEM, riser, and moorings	Economic / Livelihood	Disruption of economic activity from damage to subsea telecommunications cable	5.3	Reversible	Dispersed	Medium-term	**Major (3)**	**Improbable (0)**	**Low**
2B5	Installation of pipeline, PLEM, riser, and moorings	Cultural Heritage	Damage to archaeological resources	5.3	Irreversible	Dispersed	Long-term	**Moderate (2)**	**Improbable (0)**	**Low**
2C1	Routine discharges	Soil	Degradation of soil quality from discharge of hydrostatic testing water and additives	5.3.2	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
2C2	Routine discharges	Water	Degradation of water quality from discharge of hydrostatic testing water and additives	5.3.2	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
2C3	Routine discharges	Fauna	Disruption of fauna from hydrostatic testing activities and additives	5.3.2	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Text Ref.	Intensity	Scope	Dura-tion	Overall Consequence Level and Score	Likelihood Level and Score	Significance
2D1	Generation of air emissions	Air	Degradation of air quality and increase in greenhouse gas emissions	5.3.3	Reversible	Localized	Short-term	**Minor (1)**	**Probable (3)**	**Low**
2E1	Physical presence of vessels	Fauna	Disruption of habitat from noise and light	5.3.1.3	Reversible	Localized	Long-term	**Minor (1)**	**Probable (3)**	**Low**
2F1	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety zone	5.3.1.4	Reversible	Localized	Short-term	**Moderate (2)**	**Occasional (2)**	**Medium**
2G1	Accidental release	Soil	Degradation in soil quality from accidental release	5.3.4	Reversible	Localized	Long-term	**Moderate (2)**	**Seldom (1)**	**Medium**
2G2	Accidental release	Water	Degradation of water quality from accidental release	5.3.4	Reversible	Localized	Short-term	**Moderate (2)**	**Seldom (1)**	**Medium**
2G3	Accidental release	Fauna	Harm to fauna from accidental release	5.3.4	Reversible	Localized	Short-term	**Major (3)**	**Seldom (1)**	**Medium**
2G4	Accidental release	Economic / Livelihood	Reduction in earnings from loss of fishing grounds and/or harm to ecosystem from accidental release	5.3.4	Reversible	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
Also see Ancillary Activities (Phase 5)										
Operation (Phase 3)										
3A1	Routine discharges	Water	Degradation of water quality from routine discharges (e.g. heating water, cooling water, and deck drainage)	5.3.2	Reversible	Localized	Long-term	**Minor (1)**	**Probable (3)**	**Low**
3A2	Routine discharges	Fauna	Harm to fauna from degradation of water quality from routine discharges	5.3.2	Reversible	Localized	Long-term	**Minor (1)**	**Probable (3)**	**Low**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Text Ref.	Intensity	Scope	Dura-tion	Overall Consequence Level and Score	Likelihood Level and Score	Significance
3B1	Generation of air emissions	Air	Degradation of air quality and increase in greenhouse gas emissions from FSRU operations	5.3.3	Reversible	Dispersed	Long-term	**Moderate (2)**	**Occasional (2)**	**Medium**
3B2	Generation of air emissions	Fauna	Harm to fauna from degradation of air quality	5.3.3	Reversible	Localized	Long-term	**Minor (1)**	**Occasional (2)**	**Low**
3B3	Generation of air emissions	Health	Harm to community health from degradation of air quality	5.3.3	Irreversible	Dispersed	Long-term	**Minor (1)**	**Seldom (1)**	**Low**
3C1	Physical presence of FSRU and vessels	Fauna	Disruption of habitat from noise and light	5.3.1.3	Reversible	Localized	Long-term	**Minor (1)**	**Probable (3)**	**Low**
3C2	Physical presence of FSRU and vessels	Cultural Services	Aesthetic impact of FSRU and Delivery Point	5.3.1.3	Reversible	Localized	Long-term	**Minor (1)**	**Occasional (2)**	**Low**
3D1	Enforcement of safety zone and vessel operations	Fauna	Protection of fish from establishment of safety zone	5.3.1.4	Irreversible	Localized	Long-term	**Minor (1)**	**Probable (3)**	**Low Positive Impact**
3D2	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety zone	5.3.1.4	Irreversible	Localized	Long-term	**Moderate (2)**	**Occasional (2)**	**Medium**
3E1	Job creation	Economic / Livelihood	Increase in economic activity from additional electrical supply, job creation, and generation of revenue for the government	5.3.5	Reversible	Dispersed	Long-term	**Moderate (2)**	**Probable (3)**	**High Positive Impact**
3F1	Accidental release	Air	Degradation of air quality from accidental release	5.3.4	Reversible	Dispersed	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
3F2	Accidental release	Water	Degradation of water quality from accidental release	5.3.4	Reversible	Dispersed	Medium-term	**Minor (1)**	**Seldom (1)**	**Low**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Text Ref.	Intensity	Scope	Dura-tion	Overall Consequence Level and Score	Likelihood Level and Score	Significance
3F3	Accidental release	Fauna	Harm to fauna from accidental release	5.3.4	Reversible	Localized	Medium-term	**Moderate (2)**	**Seldom (1)**	**Medium**
3F4	Accidental release	Health	Harm to human health from accidental release	5.3.4	Reversible	Dispersed	Medium-term	**Moderate (2)**	**Seldom (1)**	**Medium**
3F5	Accidental release	Economic / Livelihood	Damage to community property from accidental release	5.3.4	Reversible	Dispersed	Medium-term	**Minor (1)**	**Seldom (1)**	**Low**
3F6	Accidental release	Economic / Livelihood	Reduction in earnings from loss of fishing grounds and/or harm to ecosystem from accidental release	5.3.4	Reversible	Dispersed	Medium-term	**Minor (1)**	**Seldom (1)**	**Low**
Also see Ancillary Activities (Phase 5)										
Decommissioning (Phase 4)										
None. After the contract term, ownership of all permanent infrastructure will transfer to the Government of Bangladesh for continued use. No decommissioning is required.										
Ancillary Activities (Phase 5)										
5A1	Routine discharges	Water	Degradation of water quality from routine discharges (e.g. deck drainage, grey water, black water, and bilge water)	5.3.2	Reversible	Localized	Long-term	**Minor (1)**	**Probable (3)**	**Low**
5A2	Routine discharges	Fauna	Harm to fauna from routine discharges (e.g. deck drainage, grey water, black water, and bilge water)	5.3.2	Reversible	Localized	Long-term	**Minor (1)**	**Probable (3)**	**Low**
5B1	Generation of air emissions	Air	Degradation of air quality and increase in greenhouse gas emissions from vessel operations	5.3.3	Reversible	Localized	Long-term	**Minor (1)**	**Probable (3)**	**Low**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Text Ref.	Intensity	Scope	Dura-tion	Overall Consequence Level and Score	Likelihood Level and Score	Significance
5C1	Physical presence of vessels	Fauna	Potential damage to marine fauna from contact with hull or propeller	5.3.1.3	Irreversible	Localized	Long-term	**Moderate (2)**	**Seldom (1)**	**Medium**
5D1	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing activities or equipment from vessel operations	5.3.1.4	Reversible	Localized	Short-term	**Minor (1)**	**Occasional (2)**	**Low**
5E1	Job creation	Economic / Livelihood	Local job creation from project activities	5.3.5	Reversible	Dispersed	Long-term	**Negligible (0)**	**Probable (3)**	**Low Positive Impact**
5F1	Accidental release	Soil	Degradation of soil quality from accidental release	5.3.4	Reversible	Localized	Long-term	**Minor (1)**	**Seldom (1)**	**Low**
5F2	Accidental release	Water	Degradation of water quality from accidental release	5.3.4	Reversible	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**
5F3	Accidental release	Fauna	Harm to fauna from accidental release	5.3.4	Reversible	Localized	Medium-term	**Moderate (2)**	**Seldom (1)**	**Medium**
5F4	Accidental release	Economic / Livelihood	Reduction in earnings from loss of fishing grounds and/or harm to ecosystem from accidental release	5.3.4	Reversible	Localized	Short-term	**Minor (1)**	**Seldom (1)**	**Low**

5.3 Evaluation of Potential Impacts

The impact evaluation resulted in assigning a rating of impact consequence (negligible, minor, moderate, major) and likelihood (improbable, seldom, occasional, probable), which together define a significance rating (low, medium, or high) for each identified impact. Any impacts rated as low are considered acceptable and do not require mitigation beyond the operational and environmental controls that are already part of the standard methods used.

Discussion of impacts are grouped into five key categories:
1. Physical Footprint and Presence (Section 5.3.1)
2. Waste Management and Operational Discharges (Section 5.3.2)
3. Air Emissions (Section 5.3.3)
4. Accidental Releases (Section 5.3.4)
5. Positive Benefits (Section 5.3.5)

Associated facilities, cumulative impacts, and trans-boundary impacts are identified in Sections 5.3.6, 5.3.7, and 5.3.8, respectively. Data gaps and uncertainties are discussed in Section 5.4.

The following impacts will no longer be evaluated considering their improbable likelihood:
- Disruption of economic activity from damage to subsea telecommunications cable: The SEA-ME-WE-4 subsea telecommunications cable makes landfall at Cox's Bazar from the south (a branch off the line from Chennai, India to Mallaca Town, Malaysia). As the project site is located northwest of Cox's Bazar, and because the geophysical studies did not identify the subsea cable, the likelihood of the impact occurring is improbable.
- Damage to archaeological resources: While pipeline construction and mooring anchor installation could potentially damage shipwrecks, no such seabed anomalies were identified by the geophysical studies. Therefore, the likelihood of this impact occurring is improbable.

5.3.1 Physical Footprint and Presence

The physical presence of project activities, including construction and operation, could lead to potential impacts, primarily from:
- Clearance and grading of construction yard and installation of Delivery Point
- Installation of pipeline, PLEM, riser, and moorings
- Post trenching
- Physical presence of FSRU and vessels (includes generation of noise, vibration, light, and aesthetic impact)
- Enforcement of safety zone and vessel operations

5.3.1.1 Clearance and Grading of Construction Yard and Installation of Delivery Point

The Delivery Point will consist of permanent onshore valve station to house a mainline valve, pig launcher/receiver facilities, and other controls and safety devices such as the emergency shutdown system, relief valves, and gas and fire detection facilities. The valve station is used to close-off the pipeline in case of emergency, or for conducting routine maintenance, including pigging.

Construction will require temporary occupation of approximately 90 x 90 m (8,100 m^2) located adjacent to the Delivery Point (Figure 5-3). After construction, approximately 75% of the site will be reclaimed, and an area of approximately 45 x 45 m (approximately 2,025 m^2) will be used permanently. Excelerate will primarily be storing materials on barges and thus minimize the area needed for the construction yard. No overland access or roads will be required. All access to the site will be from the sea.

Figure 5-3: Preliminary Delivery Point Layout

Note: approximate extent (engineering on-going) of permanent Delivery Point (Orange) and temporary construction zone (yellow)

Potential impacts to soil, air, flora, and fauna from clearance and grading of construction yard and installation of Delivery Point are discussed below.

Soils

The Delivery Point is located in an area currently comprised of beach, mud, and mangrove. To prepare the site, the land will need to be cleared and leveled. Required equipment will be transported to site via the sea and no roads will be required. Some soil compaction may be required, particularly where the permanent Delivery Point will be located, and use of excavators and other heavy equipment needed for pipeline installation will inadvertently compact soils. Compaction is a process where soils are condensed by reducing the pore spaces between mineral particles and organic matter. Pore spaces are important ecologically, as they allow air and water movement, root growth and water storage in the soil system.[2]

[2] Warren, J. and R. Taylor. 2014. Managing Soil Compaction. Accessed from the Oklahoma State University website: http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-2638/PSS-2244web2014.pdf

Much of the current delivery point becomes temporarily inundated with high tides and seasonal flooding. Sands are difficult to compress because they have relatively large sized particles and little or no structure. Thus, soil compaction is not anticipated to impact the hydrology.

Impacts to soils from clearance and grading will be localized and reversible in areas that will be reclaimed, but irreversible in the footprint of the Permanent Delivery Point. Similarly, impacts will be medium-term in temporary construction areas, but long-term in soils of the permanent Delivery Point. Impacts to soil from disruption and compaction are considered minor, with probable likelihood, resulting in a low significance ranking.

Degradation in soil quality from accidental releases are described in Section 5.3.4.

Air

Clearance and grading will likely result in impacts to air quality from emissions and dust. Air emissions generated from combustion of fossil fuels used for excavators, bull dozers, generators, and other small sources are discussed in Section 5.3.3. Generation of increased dust and airborne particulates caused by grading, filling, removals, and other construction activities may temporarily degrade local air quality. However, such impacts would be reversible, localized, and short-term. Impacts of dust are considered minor, as sand particles are fairly large and do not suspend in the air for long and moisture content of the soils is naturally high, limiting potential dust impacts, and good practice construction techniques will be followed. The likelihood of minor air impacts from dust is considered probable, resulting in a significance ranking of low.

Flora

Installation of the construction yard and Delivery Point will require temporary occupation of approximately 90 x 90 m (8,100 m^2) located adjacent to the Delivery Point, of which an area of approximately 75 x 70 m (5,250 m^2) are mangroves that will be cleared (the rest is beach). Mangroves provide many important ecosystems services, including stabilization of soils, protection from storm surge, habitat for marine and terrestrial fauna, and addition of nutrients to soil and water. [3] Clearance of mangroves will create additional edge habitat, but much of this change would be temporary as mangroves reforested. Further, the clearance would not create an island effect, as there would be sufficient core habitat to allow for natural migration through the current mangrove areas.

As noted in Chapter 4, Sonadia Island is largely reforested, thus the flora species diversity is low. A study by the Bangladesh Forest Department of Kaladia (local name for part of Sonadia Island where the Delivery Point is located) noted the area is dominated by one species, Gray Mangrove (*Avicennia marina)*.[4]

[3] Spalding, M., Kainuma, M., and L. Collins. 2010. *World Atlas of Mangroves*. Washington, D.C.: Earthscan.

[4] Rabbi, G. No date. Habitat Management Plan and Conservation of Threatened Water Birds in Sonadia Island. Accessed from the East Asian-Australasian Flyway Partnership website: http://www.eaaflyway.net/documents/Habitat%20Management%20Plan%20and%20Conservation%20of%20Threaten%20WaterBirds%20in%20Sonadia%20Island.pdf

IUCN notes:

> *"Avicennia marina is a shrub to medium sized tree, 2-5 m tall. This species is found from downstream to intermediate estuarine zones in all intertidal regions... It is shade intolerant with a maximum porewater salinity of 85 ppt. Optimal growth occurs at a salinity of 0-30 ppt…This is a pioneer species on newly formed habitats of mud with a high proportion of sand, but does not seem to grow on pure mud. It is a hardy species in natural conditions and regenerates quickly from coppices, both as individuals and as a species. It is a colonizing species on newly formed mudflats in SE Asia, and has a high tolerance to hypersaline conditions."*[5]

Communication with the Bangladesh Department of Forests (DoF) indicate the mangroves in Kaladia were planted roughly 7 years ago and mangroves can be easily reestablished simply by spreading seeds on the soil surface.

In total, DoF estimates the total area of Mangrove on Sonadia Island is 500 ha (5,000,000 m^2). Thus, clearance of 75 x 70 m (5,250 m^2) for the project is equal to .1 percent of the mangroves of Sonadia. While the mangroves would quickly revegetate, even a small and temporary loss of mangrove in this area is of concern because the Delivery Point is located in a sensitive ecological area. Sonadia is a designated Ecologically Critical Area in Bangladesh and the area has been proposed as a RAMSAR Wetland of International Importance. Thus, impacts to flora from clearance of construction yard are considered moderate, with probable likelihood, resulting in a high significance ranking. Impacts to flora would be reversible in the area of the temporary construction yard, localized, and medium to long-term. Mitigation is required to reduce the risk to an acceptable level.

Fauna

As noted above, Sonadia Island is an important protected area, both nationally and internationally. Sonadia Island is habitat for multiple threatened species, including:

- Spoon-billed Sandpiper (*Calidris pygmaea*), Critically Endangered
- Great Knot, (*Calidris tenuirostris*), Endangered
- Nordmann's Greenshank (*Tringa guttifer*), Endangered
- Green Turtle (Chelonia mydas), Endangered

The three bird species listed above trigger Critical Habitat designation. Rationale for each include:

- Spoon-billed Sandpiper: Estimated population in the wintering areas is between 240 and 400 individuals, of which 26 individuals have recently been recorded on Sonadia Island as winter migrants. This represents between 12.5-7.5 percent of the global population. The median estimate meets Tier 1 threshold for habitat required to sustain ≥ 10 percent of the global population of an IUCN Red-listed CR species.
- Great Knot: The global population is estimated at 292,000 - 295,000. The estimated population wintering in Sonadia is between 400 and 450 individuals. Sonadia Island represents a nationally important concentration of this endangered species.
- Nordmann's Greenshank: The global population is estimated at 500-1,000 individuals. The estimated wintering population of Sonadia Island is 28 individuals. Sonadia Island represents a nationally important concentration of this endangered species.

[5] IUCN. 2010. IUCN Red List: Avicennia marina (Gray Mangrove). Accessed from the IUCN website: http://www.iucnredlist.org/details/178828/0

The Bangladesh Spoon-billed Sandpiper Conservation Project (BSCP) has been conducting monthly water bird surveys during the winter (October – March) in Sonadia since 2009, and monthly (all year) in 2012, 2013, 2014, and 2015. BSCP observation indicate there are four key areas used by waterfowl, as shown in Table 5-4 and Figure 5-5.

Table 5-4: Observed Areas of Critical Habitat on Sonadia Island

Site Name	Habitat Function
Tajiakata	Mudflat (waterfowl forage), high tide roost and staging area
Belekardia	Mudflat (waterfowl forage), high tide roost, and staging area
Kaladia	Mudflat, high tide roost, and staging area
Khorir Char	Mudflat, high tide roost, and staging area

As noted in the table above, mudflats are important habitats on the island for endangered species for forage, roosting, and staging. Mangroves can also be used for roosting, but to a lesser extent.

The Delivery Point is located 700 m (at the closest) from Kaladia mudflat. Clearance of mangroves for construction yard and Delivery Point could degrade the habitat for these species. As shown in Figure 5-4, mangroves near Kaladia mudflats range from dense (photo a) to sparse (photo c). The water birds that utilize mudflats are not interior forest species, and therefore not likely to be deterred by additional edge habitat that will result from clearing of 75 x 70 m (5,250 m^2) of mangrove.

Figure 5-4: Photographs of Various Mangrove Densities near Kaladia Mudflat

Construction activities will create noise and light, which could disrupt these sensitive species. Most noise from the construction activities will be from equipment such as excavators, offshore equipment, and generators. These sounds are considered non-impulsive, as they emit constant and/or cyclical (a period of full power followed by a period of reduced power) sound. While piles will be installed around the valve station to protect infrastructure from large waves and marine debris, and other potential physical impact, the piles will be installed via auger (not driving). Installation of the winch is expected to utilize a buried anchor, but installation of 2-4 anchors which would need to be piled into the sand may be required. Piling is considered impulsive, and is characterized by short duration (generally less than one second), high intensity, abrupt onset, rapid decay, and often rapidly changing spectral composition. Sound levels for typical construction equipment / activities are shown in Table 5-5.

Table 5-5: Sound Levels for Typical Construction Equipment / Activities at 15.25 m (50 ft)

Equipment / Activity	Sound Level (DBA at 15.25 m)
Backhoe	78
Chain saw	84
Compactor	83
Compressor	78
Bull dozer	82
Generator	81

Equipment / Activity	Sound Level (DBA at 15.25 m)
Impact Pile Driver	101

Source: US Department of Transportation, 2015[6]

No physical damage to animal hearing is expected, as birds are expected to maintain distance from the sources, although sound can result in stress responses, flight or flushing responses, changes in foraging, reduction in shorebird populations, changes to habitat usage patterns, and other behavioral reactions.[7] [8] [9] Behavior-based modelling conducted by West et al. predicts that disturbance of shorebirds on wintering grounds can lead to population impacts, and may have greater consequences than permanent habitat loss over smaller areas.[10] Unrestricted disturbance over 50% of an area used by shorebirds was shown by the model to reduce an overwintering population of Eurasian Oystercatchers by up to 20%, and unrestricted disturbance over 10% of the same area reduced the population by up to 8%.

The key factor of disturbance in this case is sound. Sounds naturally attenuate, the extent of which depends on three key factors:

1) Geometric Spreading: sounds from point sources radiate equally in all directions. As the distance from the source is increased more energy is lost to spreading. Sound levels are generally reduced by 6 db for every doubling of distance, without any other losses from atmospheric or surface effects.[11] For example, if a high intensity sound is measured at 101 dB at 15.25 m (sound level of pile driving), it would be expected that they would be reduced to 95 dB by 30.5 m.
2) Atmospheric Effects: atmospheric conditions (e.g. humidity, temperature, wind, and precipitation) influence attenuation of sound. Changes in temperature, humidity and precipitation have little effect on attenuation, relative to other factors.[12] Wind and temperature gradients can "bend" sound, resulting in measured sound levels being very different to those predicted from geometrical spreading and atmospheric absorption considerations alone (differences may be as great as 20 dB).[13]

[6] US Department of Transportation (DOT). 2015. Construction Noise Handbook. Accessed from the DOT website: http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook09.cfm
[7] Ortega, C. 2012. Effects of Noise Pollution on Birds: A Brief Review of Our Knowledge. Ornithological Monographs No. 74, pg(s) 6-22. Accessed from the BIOONE website: http://www.bioone.org/doi/abs/10.1525/om.2012.74.1.6
[8] Pfister, C., Harrington, B.A., and M. Lavine. 1992. The Impact of Human Disturbance on Shorebirds at a Migration Staging Area. Biological Conservation, Volume 60, Issue 2, 1992, Pages 115–126
[9] Burton, N.H.K., Evans, P.R., and M.A. Robinson. 1996. Effects on Shorebird Numbers of Disturbance, the Loss of a Roost Site and its Replacement by an Artificial Island at Hartlepool. Cleveland Biological Conservation, Volume 77, Issues 2–3, 1996, Pages 193–201
[10] West, A.D., Goss-Custard, J.D., Stillman, R.A., Caldow, R.W.G., le V. dit Durell, S.E.A., and S. McGrorty. 2002. Predicting the Impacts of Disturbance on Shorebird Mortality Using a Behaviour-based Model. Biological Conservation, Volume 106, Issue 3, August 2002, Pages 319–328.
[11] Truax, B. Eds. 1999. Handbook for Acoustic Ecology. Inverse Square Law. Accessed from the Simon Fraser University Website: https://www.sfu.ca/sonic-studio/handbook/Inverse-Square_Law.html
[12] Harris, C. 1966. Absorption of Sound in Air Versus Humidity and Temperature. Journal of the Acoustical Society of America, 40, p. 148. Accessed from the Simon Fraser University Website: https://www.sfu.ca/sonic-studio/handbook/Sound_Propagation.html
[13] Ingard, U. 1953. A Review of the Influence of Meteorological Conditions on Sound Propagation. Journal of the Acoustical Society of America, 25, p. 405. Accessed from the Simon Fraser University Website: https://www.sfu.ca/sonic-studio/handbook/Sound_Propagation.html

3) Surface Effects: surface effects can be expected from ground absorption and attenuation from natural barriers. Energy of sound waves are reduced as they reflect off the ground – sandy beaches absorb significantly more sound than do hard smooth surfaces. Interference from reflected sound waves can also reduce sound levels, particularly when both the source and receiver are close to the ground. Trees also will provide a natural barrier and reduce sound levels, although the research on effectiveness of trees is conflicting. Solid barriers provide much more efficient attenuation. The maximum performance of a barrier is limited to about 40 dB, and is most effective when placed close to the source or receiver. [14]

The key factors that will reduce sound levels between the Delivery Point and Kaladia include:

- Distance: the minimum distance is 700 m. Taking into consideration geometric spreading alone, it would be expected that sound levels from the most intense potential sounds (e.g. pile driving) would be reduced from 101 dB at 15.25 m to 71 dB (approximate dB of a shower) at 488 m.
- Height of birds above ground: As the height of the sound sources and birds are both close to the ground, the interference of sound waves reflecting off the ground will reduce sound levels, and sound levels would be further reduced by absorption of the sound by the beach.
- Natural barriers (mangroves): there is a thick mangrove thicket between the Delivery Point and much of Kaladia which will form a natural sound barrier.

It is unclear what atmospheric effects will have on sound attenuation, particularly wind. During the construction season, the winds are predominantly from the north (travel towards Kaladia) which would be expected to increase sound levels downwind of the source.

Sounds will also be generated on construction vessels and the FSRU. The pipeline route travels perpendicular from the Delivery Point westward (away from Kaladia) before turning south. Construction activities offshore are expected to maintain a distance of >2km. The FSRU is located approximately 5 km from areas used by threatened shorebirds. Thus, sound from these sources is expected to be negligible.

Some noise, as well as physical presence, may degrade the value of the habitat to shorebird species and/or cause minor stresses to birds. Impacts from habitat degradation and disruption from clearance and physical presence to fauna are considered moderate, with occasional likelihood, resulting in a medium significance ranking. This impact consequence could also be considered major, but the likelihood of such an impact would be seldom which would also result in an overall medium significance ranking. In either case, mitigation is required to reduce the risk to a more acceptable level.

[14] Aylor, D. Noise Reduction by Vegetation and Ground. Journal of the Acoustical Society of America, 51, p. 197. Accessed from the Simon Fraser University Website: https://www.sfu.ca/sonic-studio/handbook/Sound_Propagation.html

Figure 5-5: Observed Sensitive Sites for Shorebirds in Sonadia Island

Source: BSCP / Acorn International / Google Earth

5.3.1.2 Installation of Pipeline, PLEM, Riser, and Moorings

Installation of subsea infrastructure, including pipeline, PLEM, riser, and moorings, will take place almost entirely offshore. This activity will involve disruption of the sea floor, including sediments which will become suspended in the water column temporarily, and disruption of benthos that may be present in on the seabed. Estimated areas of disturbance are provided in Table 5-6.

Table 5-6: Estimated Area of Seabed Disturbance

Activity	Permanent or Temporary	Estimated Area of Disturbance
Pipeline installation	Temporary	Physical disturbance from pre-trenching, dredging, and jetting: • 500 m x 17 m (8,500 m^2) for pre-trenching • 60 m x 1,787 m (107,220 m^2) for dredging • 10.9 m x 7,048 m (76,823 m^2) for jetting Physical disturbance from sediment deposition*: • >.01 mm: 2.6035 km^2 • >1 mm: 1.019 km^2
Anchor chains and cables	Permanent	• 10 m x 350 m (3,500 m m2)
Buoy	Temporary	• 170 m^2
Mooring anchor installation (suction piles)	Permanent	• 864 m^2
PLEM installation	Permanent	• 3 m x 4 m (12 m^2)

* Based on modeling, see below. Modeling for each scenario were run for different times in the tidal cycle (spring and neap tides), which result in different areal deposition of sediments. Values provided are an average of the results for the different tidal cycles.

The largest areal impacts are expected to result from dredging and jetting. Dredging is required to allow access of the pipe lay barge near shore. Jetting is required to bury the pipe in areas where pre-trenching will not occur (deeper water)

The Suspended Sediment FATE (SSFATE) model was run to assess the short-term behavior of suspended sediment plumes and sedimentation expected to be generated during construction of the pipeline. Modelling results are summarized below and report provided in Appendix D. To ensure that the modeling captured the potential plume and seabed impacts at different stages of the ebb/flood tidal cycle, two scenarios were developed for each construction stage based on start dates of December 1 and December 15 (Table 5-7).

Table 5-7: Sediment Modeling Scenarios

Scenario	Simulation Start Date	Construction Activity	Operating Zone	Feature Length (m)	Total Volume (m^3)	Duration (Days)
1	1-Dec-16	Landfall channel excavation (pre-trenching) by clamshell excavator	500 m seaward of delivery point (0 km - 0.5 km)	500	11,000	3.1
2	15-Dec-16					
3	1-Dec-16	Hydraulic dredging of main approach trench for lay barge access	Landfall channel to 6m depth contour (0.5 km - 2.287 km)	1,786	439,602	18.3
4	15-Dec-16					
5	1-Dec-16	Offshore burial via post-trenching sledge (MASURCA)	Landfall channel to FSRU terminal (0.5 km- 7.548 km)	7,048	69,493	15.0
6	15-Dec-16					

Source: RPS ASA, 2017[15]

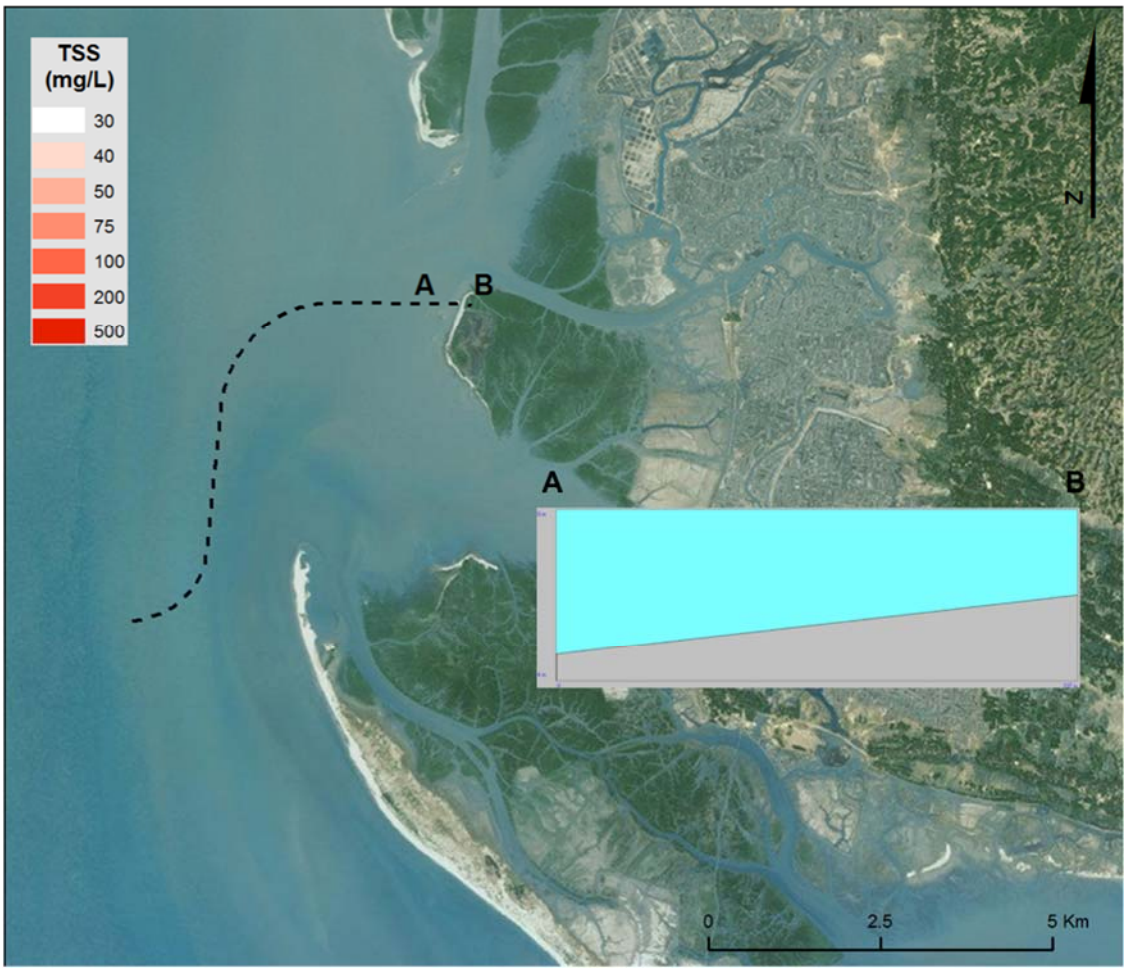
Sediment losses from each activity and burial were represented in the model by characterizing the source strength, vertical distribution, and grain-size distribution for the sediment load. To characterize the sediments that the project would encounter, samples were collected from boreholes and surface grab samples. The grain size distributions developed from these samples were used within the model.

Owing to the high ambient TSS concentrations observed in the offshore waters near the project area, the results presented show areas where the sediment plumes exceed the 30 mg/L concentration threshold - representing approximately 20% of the lowest observed natural TSS for the region.

Suspended sediment concentrations presented in Figure 5-6 through Figure 5-11 show the maximum concentration the model predicts at any time during the activities and at any depth in the water for each simulation. The maximum concentrations predicted are a composite in both space and time; they do not represent any instantaneous snapshot of water column concentrations, but instead show the maximum, time-integrated suspended sediment within the study domain during each scheduled release. The predictive results presented are therefore inherently conservative. Vertical cross-section shown in the figures represent maximum concentrations along the pipeline route (dashed line). Model results are presented for concentrations exceeding 30 mg/L.

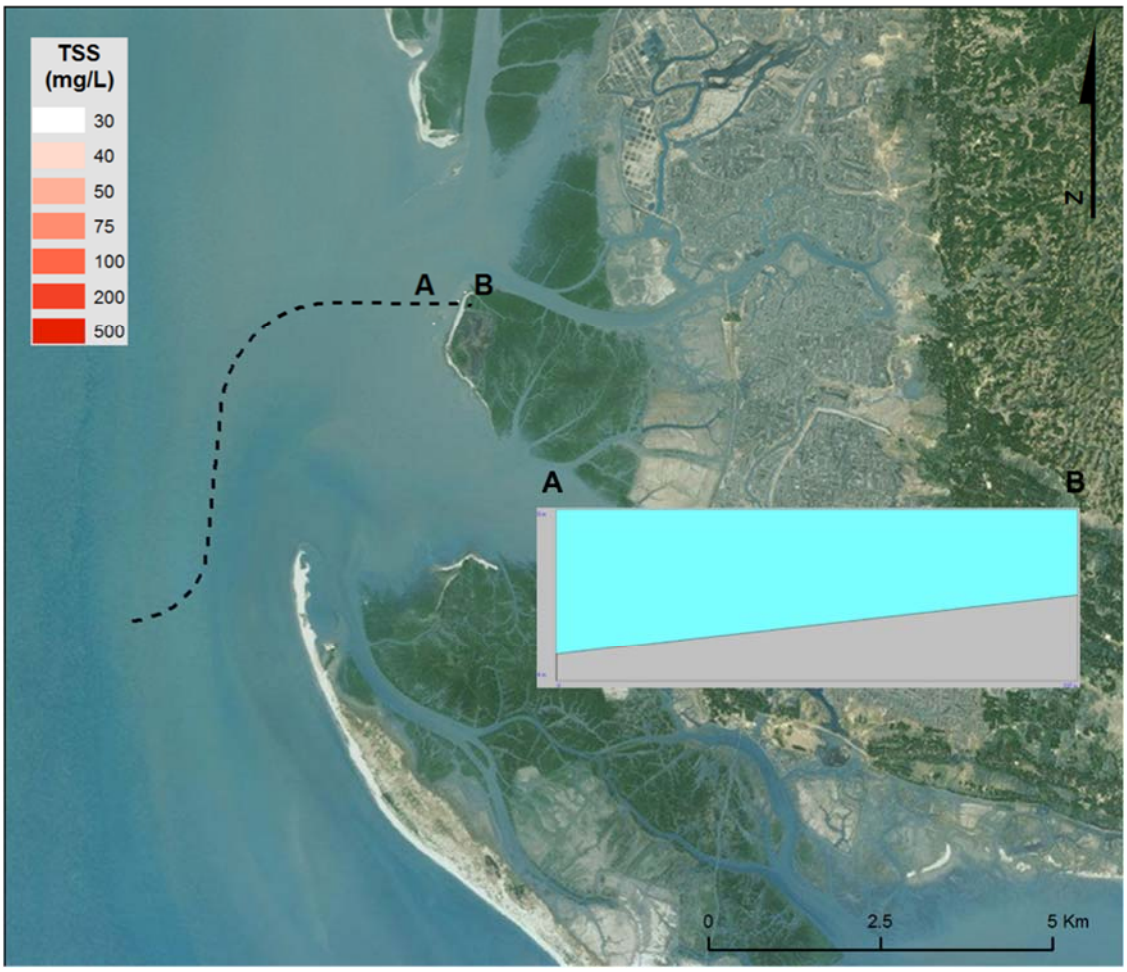
[15] RPS ASA. 2017. Sediment Dispersion Modeling for Post-Trenching at Moheshkhali, Offshore Bangladesh. Unpublished Report.

Figure 5-6: Scenario 1 – Maximum Suspended Sediment Concentration Resulting from Pre-trenching Excavation of the Landfall Trench (Start Date 1 December 2016)



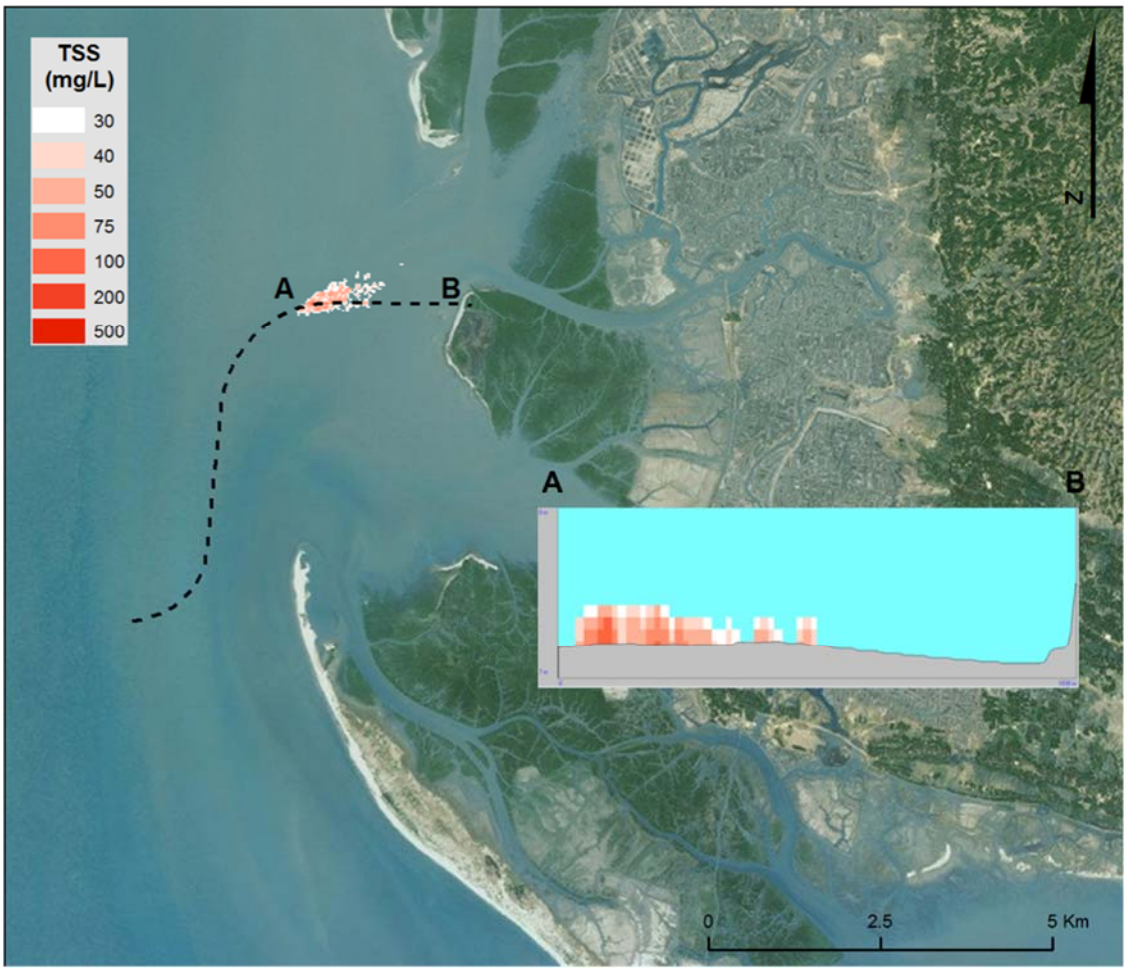
Note: Suspended sediment concentrations at or above 30 mg/L occur rarely during the pre-trenching activities.
Source: RPS ASA, 2017

Figure 5-7: Scenario 2 – Maximum Suspended Sediment Concentration Resulting from Pre-trenching Excavation of the Landfall Trench (Start Date 15 December 2016)



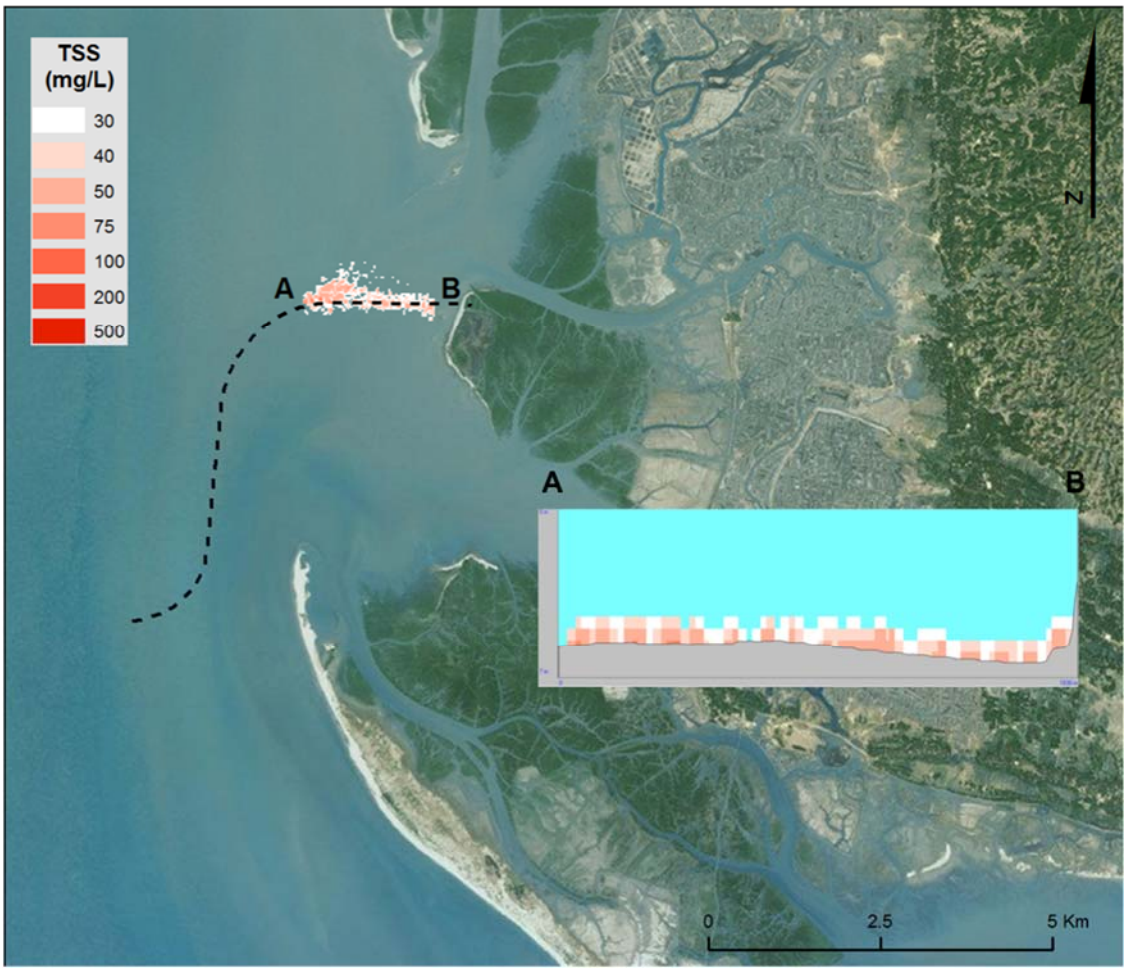
Note: Suspended sediment concentrations at or above 30 mg/L occur rarely during the pre-trenching activities.
Source: RPS ASA, 2017

Figure 5-8: Scenario 3 – Maximum Suspended Sediment Concentration Resulting from Hydraulic Dredging of the Main Approach Trench (Start Date 1 December 2016)



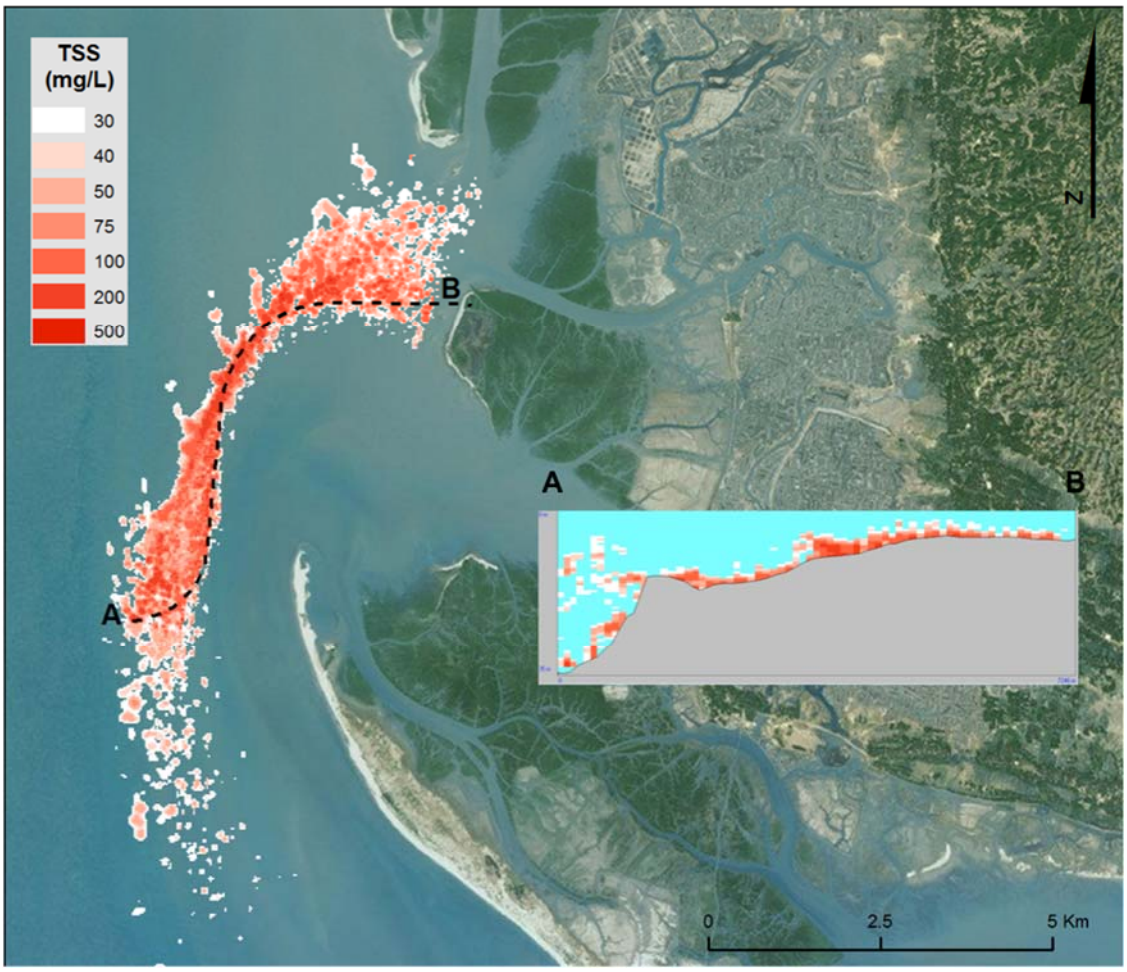
Source: RPS ASA, 2017

Figure 5-9: Scenario 4 – Maximum Suspended Sediment Concentration Resulting from Hydraulic Dredging of the Main Approach Trench (Start Date 15 December 2016)



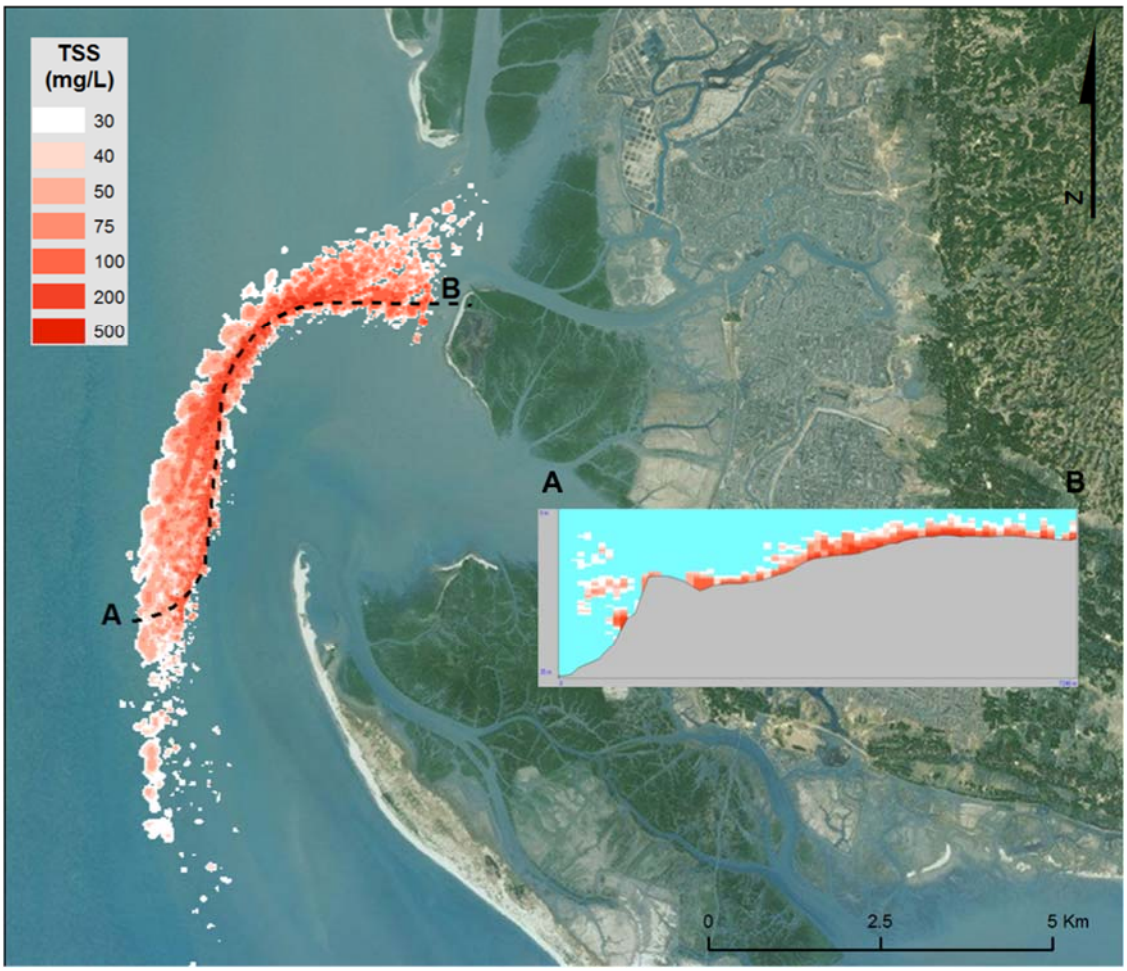
Source: RPS ASA, 2017

Figure 5-10: Scenario 5 – Maximum Suspended Sediment Concentration Resulting from Post-trenching (Start Date 1 December 2016)



Source: RPS ASA, 2017

Figure 5-11: Scenario 6 – Maximum Suspended Sediment Concentration Resulting from Post-trenching (Start Date 15 December 2016)



Source: RPS ASA, 2017

For each simulation, the shape of the plume generally reflects the local circulation and bathymetric features along the pipeline route. Elevated suspended sediment concentrations are predicted to occur on either side of the pipeline routes, reflecting the orientation of the tidal current at the time of the sediment release.

For all scenarios, concentrations at or above the 30 mg/L threshold generally remain within 1 km of the activity, although isolated and short-lived plumes are seen in deeper water, 3 to 5 km from the FSRU terminal point. Table 5-8 summarizes the areal extent of each plume at various concentration thresholds.

Table 5-8: Areas of Total Suspended Sediment Concentration Exceeding Thresholds for Each Model Scenario

Plume concentration (mg/L)	Cumulative Area Exceeding (km^2)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
> 30	0.001	0.002	0.266	0.523	8.273	7.130
> 50	-	-	0.102	0.132	4.823	4.270
> 100	-	-	0.002	0.001	1.953	1.607
> 200	-	-	-	-	0.479	0.386
> 500	-	-	-	-	0.002	0.006

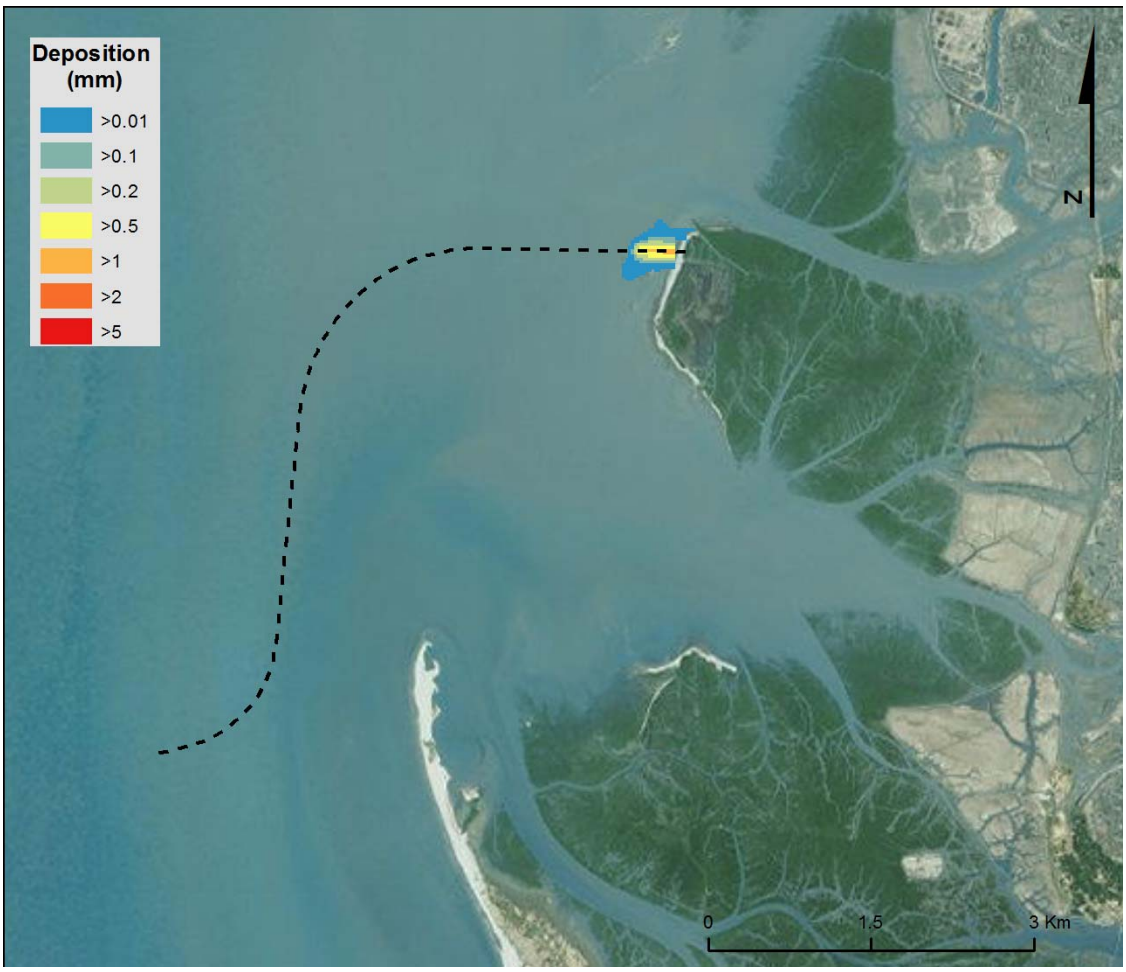
Source: RPS ASA, 2017

The TSS plumes are more elongated (and occur at lower concentrations) near their southern extents, as sediments are generally finer and flow velocities stronger further from the coast.

As shown in the cross-section for each scenario, the sediment plumes typically remain within ~5 m of the seabed. The maximum TSS concentration predicted by the model is 618 mg/L (Scenario 5). For all scenarios, concentrations return to ambient levels within ~12 hours.

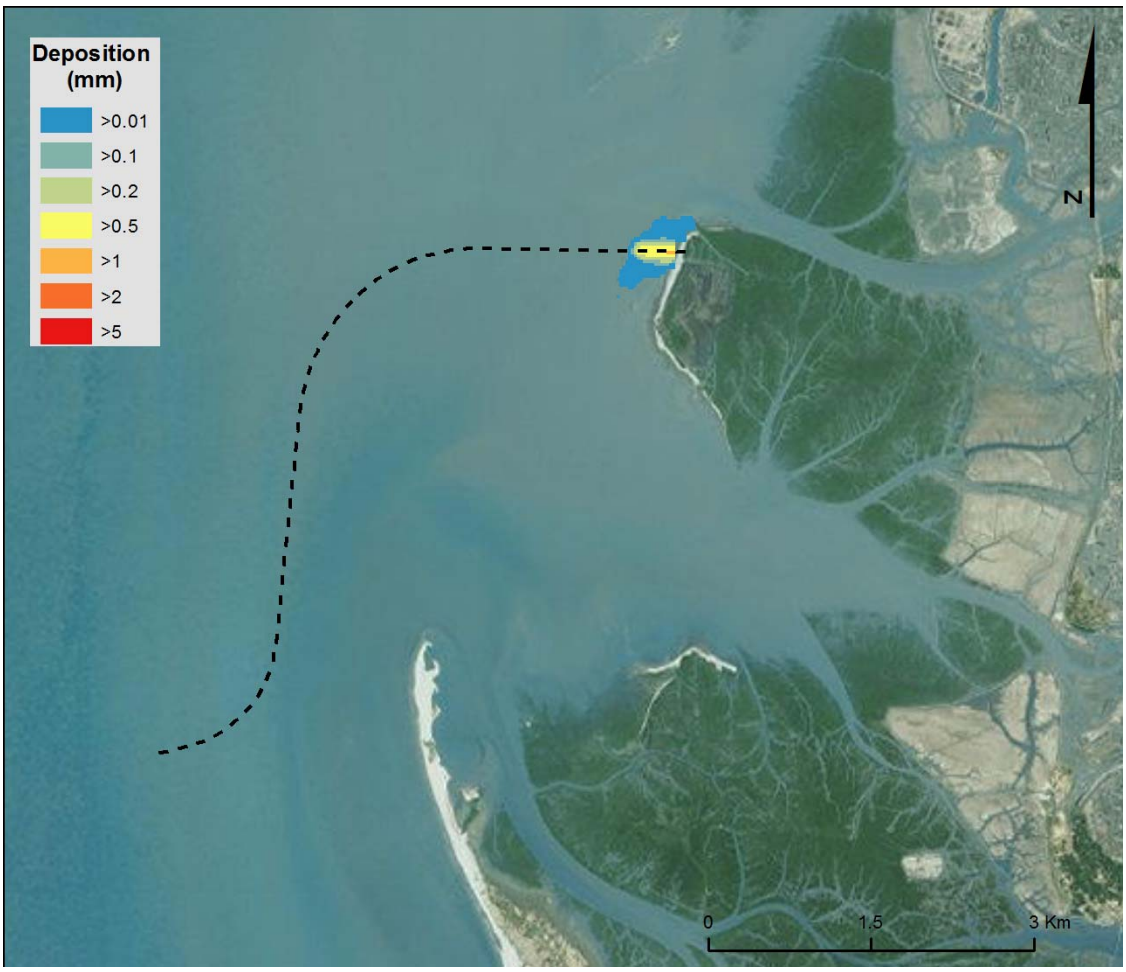
SSFATE was also used to predict deposition on the seabed from re-suspended sediment particles during each stage of construction. Deposit thicknesses were calculated using the mass loading to the seabed, bulk density of solids, and an assumption of no voids (zero porosity). Figure 5-12 through Figure 5-16 show the model-predicted seabed deposition that results from each scenario.

Figure 5-12: Scenario 1 – Extent of Seabed Deposition Resulting from Pre-trenching Excavation of the Landfall Trench (Start Date 1 December 2016)



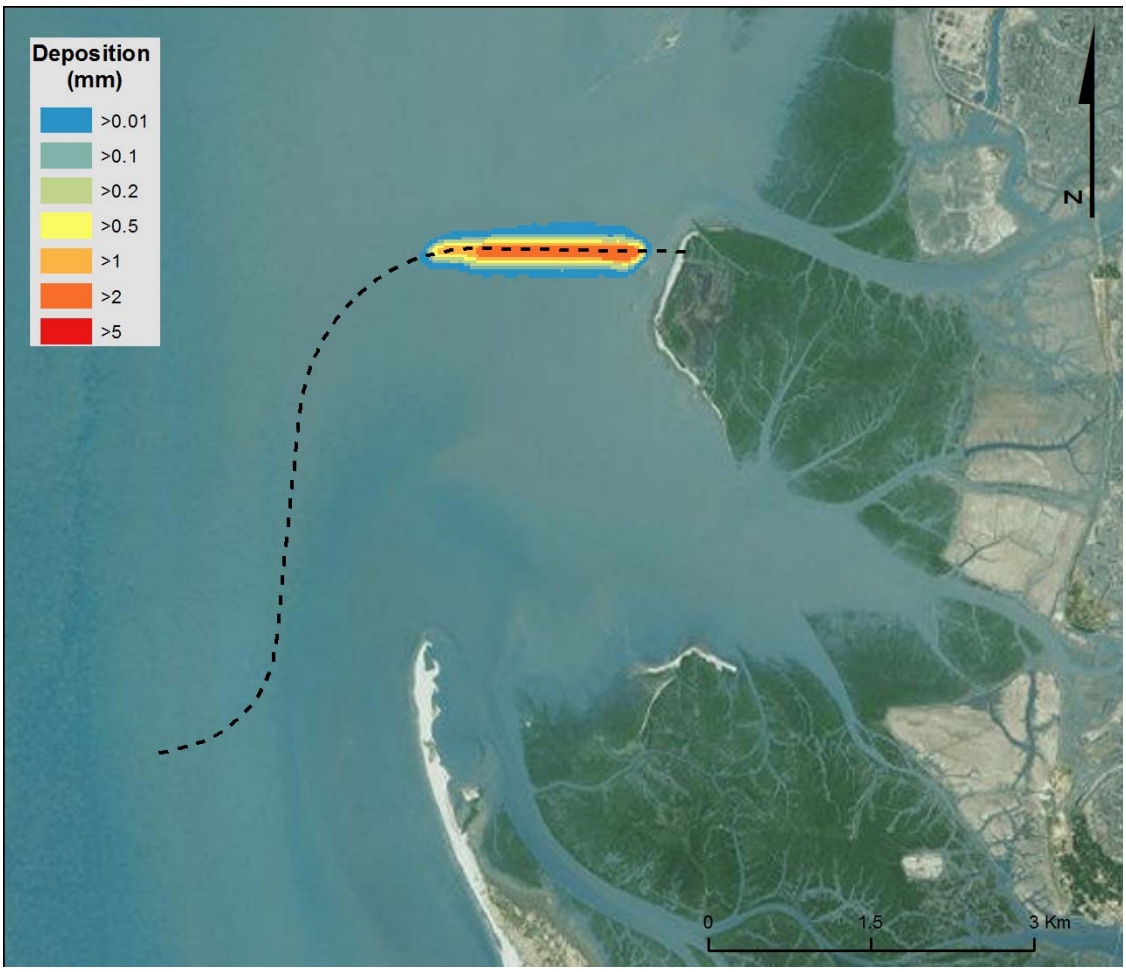
Note: Maximum predicted thickness = 1.19 mm
Source: RPS ASA, 2017

Figure 5-13: Scenario 2 – Extent of Seabed Deposition Resulting from Pre-trenching Excavation of the Landfall Trench (Start Date 15 December 2016)



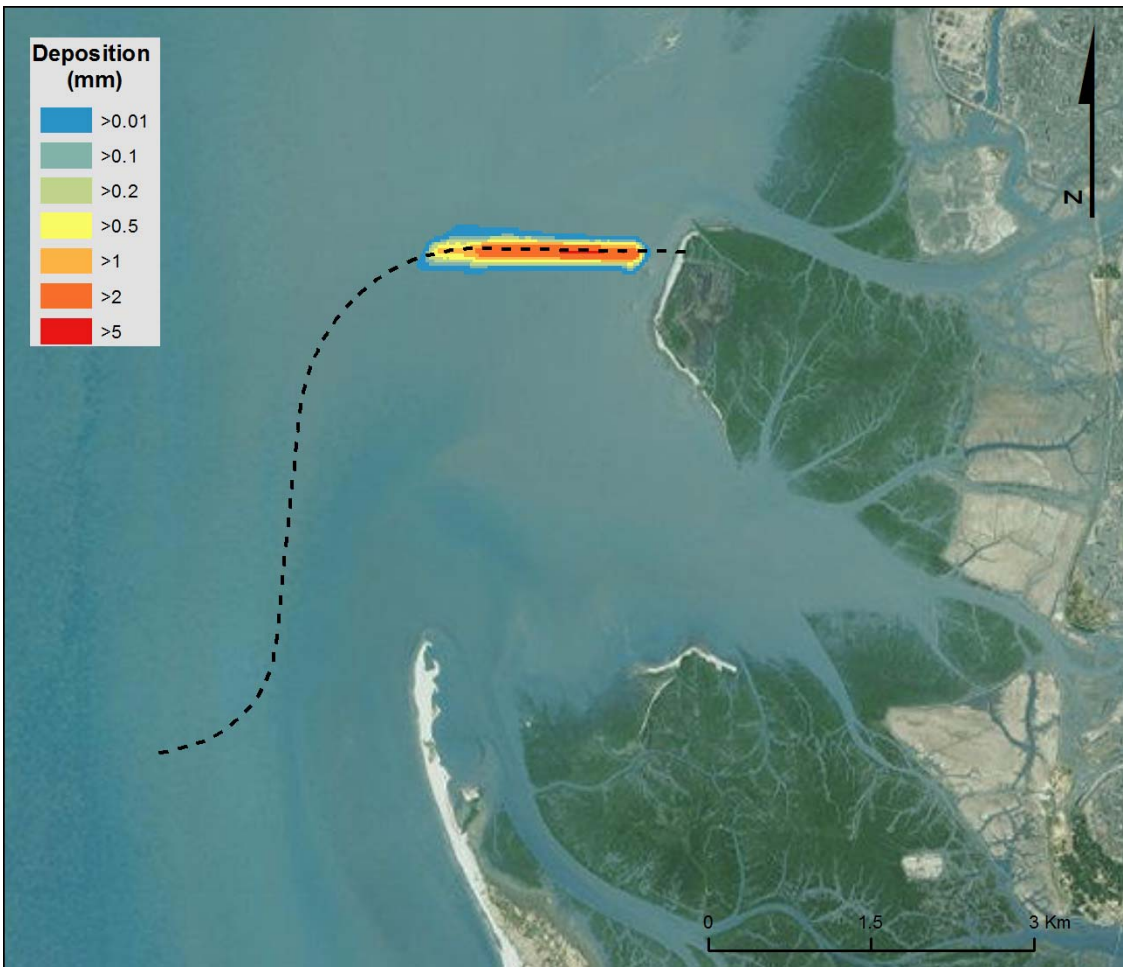
Note: Maximum predicted thickness = 1.07 mm
Source: RPS ASA, 2017

Figure 5-14: Scenario 3 – Extent of Seabed Deposition Resulting from Hydraulic Dredging of the Main Approach Trench (Start Date 1 December 2016)



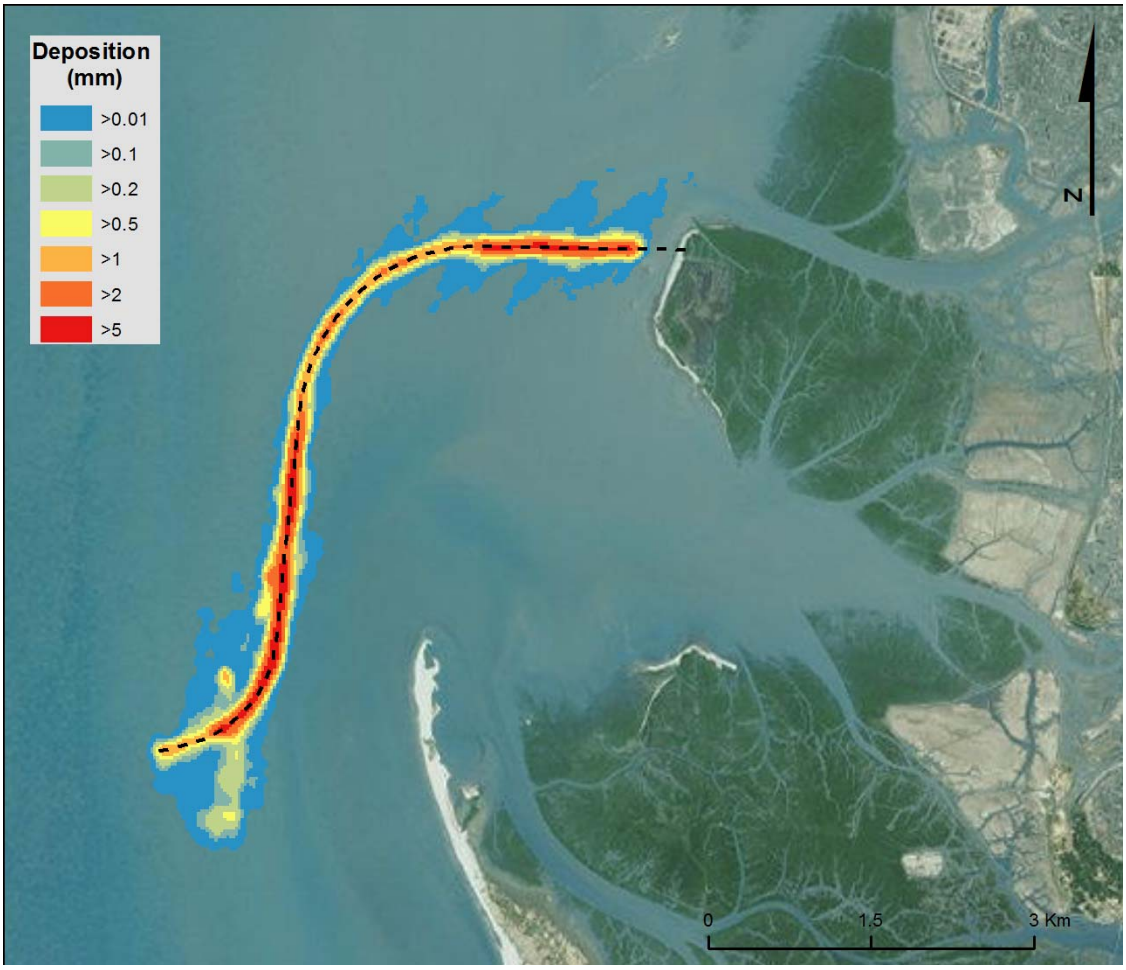
Note: Maximum predicted thickness = 4.57 mm
Source: RPS ASA, 2017

Figure 5-15: Scenario 4 – Extent of Seabed Deposition Resulting from Hydraulic Dredging of the Main Approach Trench (Start Date 15 December 2016)



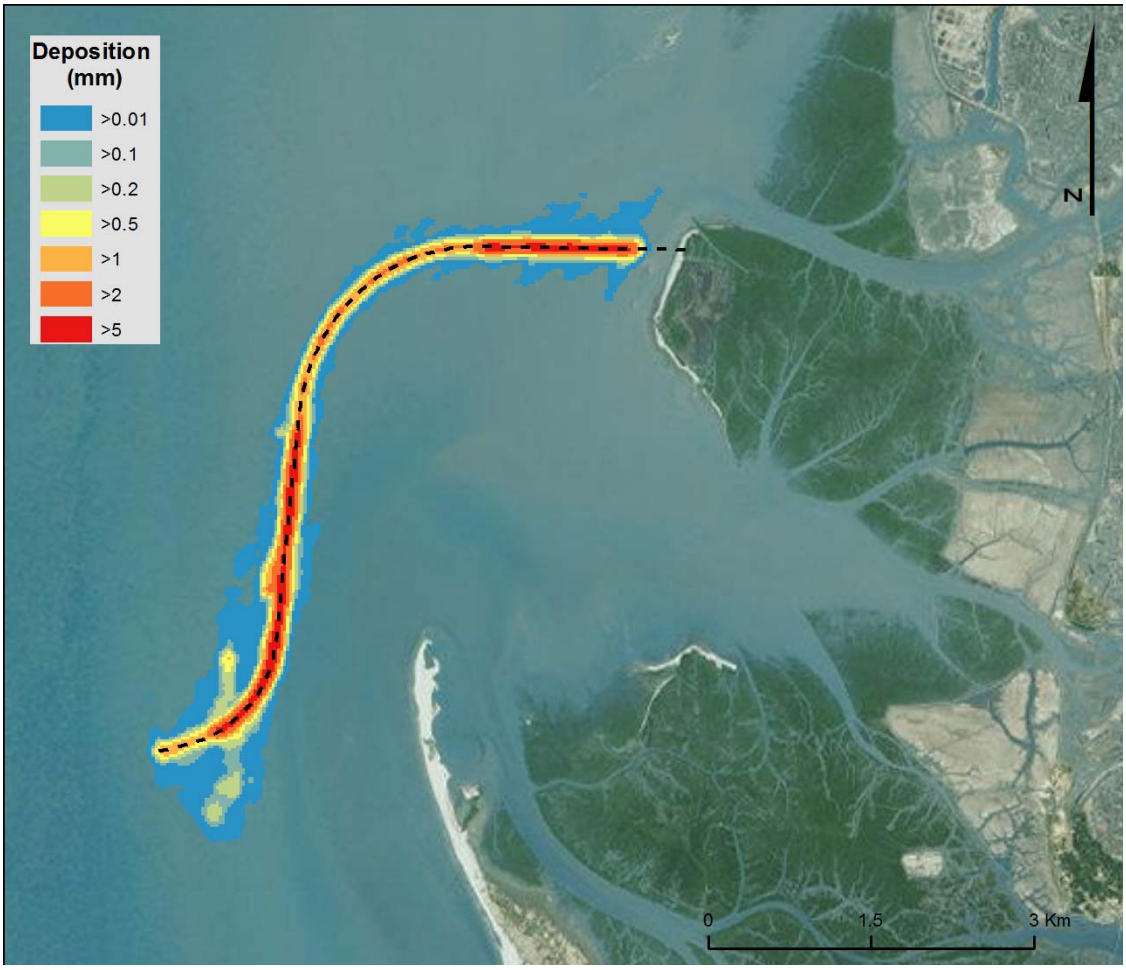
Note: Maximum predicted thickness = 5.13 mm
Source: RPS ASA, 2017

Figure 5-16: Scenario 5 – Extent of Seabed Deposition Resulting from Post-trenching Activities Related to the Subsea Pipeline Installation (Start Date 1 December 2016)



Note: Maximum predicted thickness = 9.58 mm
Source: RPS ASA, 2017

Figure 5-17: Scenario 6 – Extent of Seabed Deposition Resulting from Post-trenching Activities Related to the Subsea Pipeline Installation (Start Date 15 December 2016)



Note: Maximum predicted thickness = 9.84 mm
Source: RPS ASA, 2017

For each activity, deposition is primarily confined to a narrow band extending approximately 200 – 300 m along either side of the trench. A few exceptions are noted for very low sediment loads (<1 mm) that extend up to 1 km from the pipeline location. As with TSS concentrations, deposition patterns are elongated near the FSRU terminal and near the proposed dredging area where the pipe runs perpendicular to the orientation of the tidal current and sediments are dispersed further from source. For all activities, deposition at or above 5 mm is limited to areas within 150 m of the pipeline route. As with the TSS results, the relatively fine-grained sediments near the offshore terminal site result in more prolonged settling of particles and greater dispersion around the construction area. Sediments that remain in suspension and are transported greater than 1 km from the construction zones are ultimately deposited at rates that are undetectable by the SSFATE model.

Table 5-9 summarizes the areal impact of deposition for each scenario.

Table 5-9: Areal Extent of Seabed Accumulation for Each Post Trenching Scenario

Deposition (mm)	Cumulative Area of Deposition (km^2)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
> 0.1	0.074	0.072	0.505	0.444	2.151	1.961
> 1	0.008	0.002	0.235	0.219	0.931	0.922
> 5	-	-	-	0.010	0.212	0.237
> 10	-	-	-	-	-	-

Source: RPS ASA, 2017

Installation of the pipeline, suction piles, buoy, PLEM, and anchor chains and cables will disrupt benthos and benthic habitat, disrupt sediments, and cause a temporary degradation in water quality from suspended sentiments. Potential impacts to water quality and fauna are described below. As the sediment plume is largely contained within the 500 m safety zone, impacts to fishing and shipping are considered limited and will be discussed in Section 5.3.1.4 .

Water

Impacts to water could potentially arise from:

- Degradation of water quality from increased turbidity
- Potential release of nutrients and contaminants into the water column from the disturbed sediments

Installation of subsea infrastructure will increase turbidity and temporarily degrade water quality, particularly as a result of the dredging and post-trenching required to install the pipeline below the seabed. As noted above in Table 5-8, the areas predicted to be impacted in each modeled scenario depend on the concentration of TSS in the plumes and the scenario. TSS is generally high in in the area, with a lowest naturally observed TSS of 150 mg/L. The maximum area exceeding the threshold (20% above lowest naturally observed TSS, 180 mg/l) is 8.273 km^2 during Scenario 5. As the plume concentration increases, the area impacted decreases, such that for Scenarios 1-4 no areas exceed 200 mg/l above the baseline.

Potential impacts to water quality from construction are considered minor considering:

- Concentrations return to ambient levels within ~12 hours
- The extent of the plume at any point in time would be much less than the cumulative total shown above
- Sediment plumes typically remain within ~5 m of the seabed

Impacts to water quality from increased turbidity are considered minor, with probable likelihood, resulting in a significance ranking of low.

Impacts on the water column could also arise from the release of nutrients being released into the water column that would otherwise be trapped in the seabed sediments. The nutrients could favor the development of algal blooms. However, modeling shows that the TSS arising from dredging and post-trenching activities is expected to be very short-lived and limited spatially, so development of algal blooms is unlikely. Impacts to water quality from increase in the nutrient concentration in the water column are considered negligible to minor, with probable likelihood, resulting in a significance ranking of low.

While the dissolution of metals and other inorganics from the TSS into the water column is not favored by anticipated short life of the TSS plume, some amount of dissolution is to be expected. The Environmental Baseline Survey (Appendix L) found concentrations of Nickel in the sediments in some stations was above levels that may cause low level biologic al effects. However, any release of metals to the water would be limited spatially and temporally, and would rapidly disperse with currents. Given the results of the sediment plume modeling, even in the unexpected event the survey identifies contaminants in the sediments to be disturbed, impacts to water quality from any elevated levels of metals or other inorganics that may be present are considered negligible to minor, with probable likelihood, resulting in a significance ranking of low.

Fauna

Impacts to fauna could potentially arise from:

- Physical contact or disturbance during placement/movement of infrastructure on the seabed
- Physical smothering from deposition of sediments on the seabed
- Disturbance from degradation of water quality as a result of sediment suspension in the water column

Geophysical studies confirm the seabed in the project area is entirely soft bottom, made up of 'Silty CLAY with Sand' and 'Silty SAND' (coarser sediments) (Figure 5-18). Prominent 'mega sand ripples' were identified on the western side of the geophysical survey area (approximately 1 nm west of the proposed Terminal Location). The mega ripples were clearly distinguishable in the side scan sonar imagery, as each is approximately 75 m – 145 m distance between adjacent ripple crests and each crest is several meters in height. The habitat value of these for marine fauna are unclear, although it is unlikely these areas will be disturbed. Further, it is believed these ripples resulted from tidal movements, so any disturbance would likely be temporary.

The offshore Environmental Baseline Survey (Appendix L) found that benthic faunal richness was low and no hard bottoms, coral reefs, seagrass beds, chemosynthetic communities, or other sensitive features were identified[16]. Sediment sampling conducted identified low to moderate inter-station variability. Comparison of the sediment metal concentrations against indicative ecological effect thresholds (Effects Range Low - ERLs) showed the majority of metal concentrations were below the values where they would be likely to cause any adverse effects on biota. The only exception was nickel, which was present at concentrations that slightly exceeded the ERL value. All but one of the USA Environmental Protection Agency (EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) concentrations were below detectable limits from all stations. The single detectable PAH was benzo(a)pyrene, which was present at very low levels and would not be expected to have a major detrimental effect on sediment dwelling biotic communities.

Benthic organisms within the footprint of pipeline, PLEM, anchors, buoy and cables could be physically impacted by the disturbance of the sea floor due to physical contact, or by localized and temporary increase in turbidity and sedimentation (causing smothering). As described above, suspended sediments in the water column would quickly (12-24 hours) return to ambient conditions and the plumes would remain within ~5 m of the seabed.

[16] Fugro. 2017. Geotechnical and Environmental Baseline Survey Services Environmental Baseline Survey Report Coast of Moheshkhali Island, Offshore Bangladesh. Unpublished Report.

Deposition is primarily confined to a narrow band extending approximately 200 – 300 m along either side of the trench, and depositional thicknesses at or above 5 mm are limited to areas within 100 m of the pipeline route. The impact would be minor, localized, and short-term on a population level, and benthos will recolonize any areas of direct loss as there will be no degradation of the sediment quality from existing conditions.

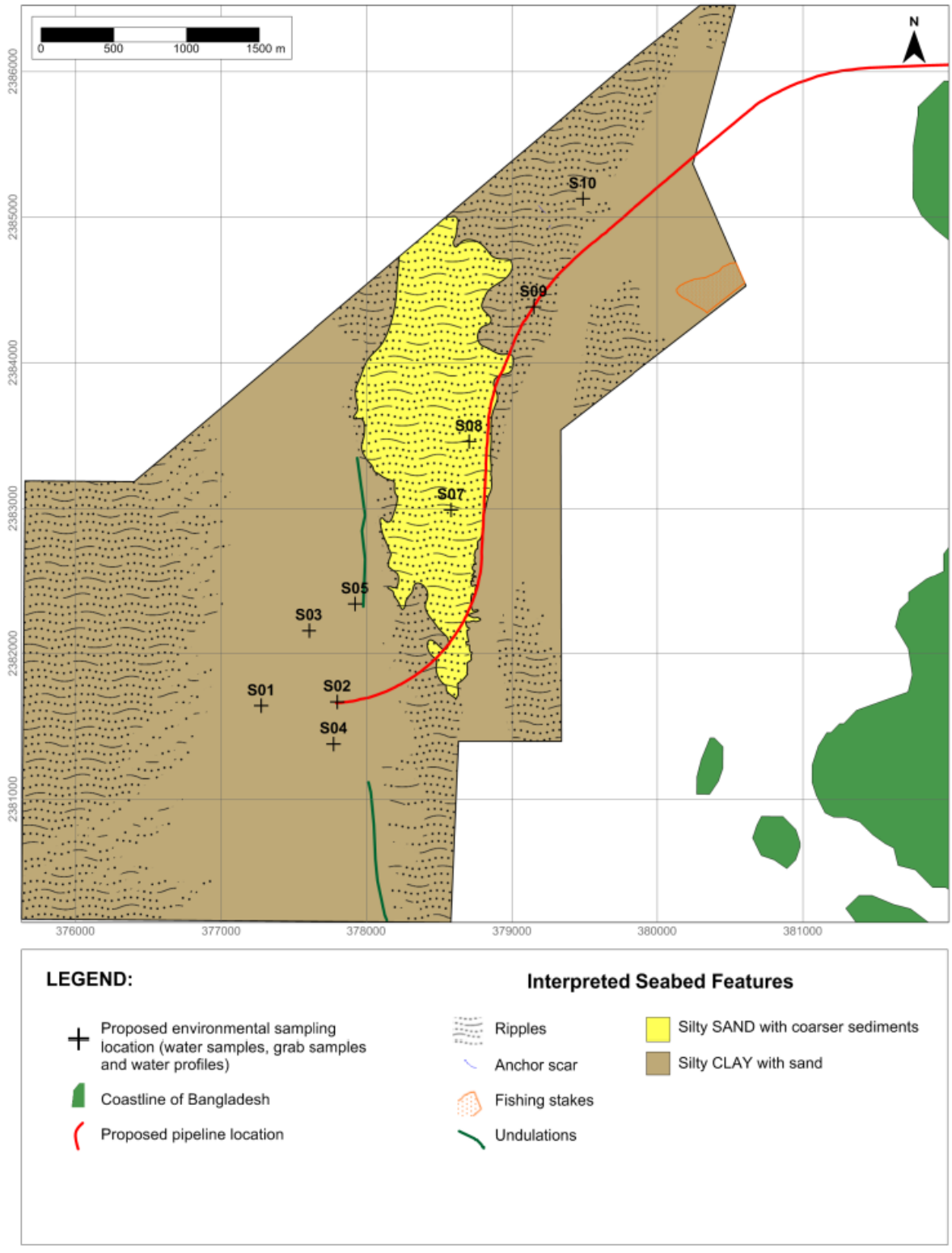
Demersal and pelagic fish species, marine mammals, and sea turtles are mobile and could avoid both physical contact and sediment plumes. Increase in nutrients, metals and other inorganics is expected to be limited, and any impact to these species negligible. While exposure of fauna to nickel in the suspended sediments could harm fauna, the impacts are expected to be limited given the short duration of the sediment plume / time available for dissolution, and relatively low level concentrations.

Pelagic bird species are unlikely to be impacted by installation of the subsea infrastructure, particularly given the sediment plume would be mostly within 5 m on the seabed. Shorebird species, including the Critically Endangered Spoon-billed sandpiper, utilize the mud flats 700 m (at the closest) south of the Delivery Point. While the mudflats contain a similar silty Clay with Sand make up, any potential change in the mudflat conditions (i.e. increase in sediment thickness) could impact the value of the habitat. Harm to a Critically Endangered species would be major; however, modeling indicates the sediment plumes will not impact these areas.

Impacts to fauna from degradation of water quality as a result of sediment suspension in the water column, contact, or disturbance during placement/movement of infrastructure on the seabed, and/or physical smothering from deposition of sediments on the seabed are considered minor, with a probable likelihood, resulting in a significance ranking of low.

Discussion of subsea noise is presented in Section 5.3.1.3 .

Figure 5-18: Seabed Features



Source: Fugro, 2017

5.3.1.3 Physical Presence of FSRU and Vessels

The FSRU and support vessels will create light and noise, and transiting vessels could potentially strike wildlife. The vessel will also be located 2.4 km from shore, and will be visible with the naked eye from Sonadia Island. Sonadia Island is a protected area, and the presence of the FSRU and construction activities could degrade the viewshed from some stakeholder perspectives. Potential impacts from the physical presence of the FSRU and support vessels on wildlife and stakeholders (cultural services) are described below.

Fauna – Noise

Potential impacts of sound generated by onshore clearance and grading are discussed in Section 5.3.1.1 . Potential impacts described in this section relate to offshore activities.

Underwater noise during the construction phase will be produced primarily by the supply vessels. In addition, the use of equipment (e.g. cranes, winches, and stingers), construction activities (e.g. welding), and living activities (e.g. lights and cooking) on the vessels and on the barges would require generators, which create their own level of noise, a small fraction of which is transferred into the water column. Thrusters used by dynamically positioned vessels will be the dominant source of underwater sound during construction activities. The thrusters are operated intermittently as needed to get vessels into position during anchoring and construction. The barges, which would be the largest vessels used during pipeline construction, do not have engines and are towed by tugs.

Sound generated during operation by the FSRU will primarily include regasification, offloading, and vessel thrusters. Sounds will be transmitted into the air directly from mechanical equipment located on or near the deck of the vessel and into the water, primarily by energy transmitted through the ship's hull, or via thrusters in the water. Underwater sound may also be generated by the riser, PLEM, and/or pipeline.

The Environmental Impact Statement for the Northeast Gateway, an LNG import Terminal using Excelerate FSRUs and similar buoy technology noted[17]:

- Vessel noises, caused by engine and noises of on board operating machinery, generally fall in the frequency range of 5 to 2,000 Hz, with highest intensities below 100 Hz
- Pipeline construction activities, such as post-lay jetting, create broadband sounds; the strongest are below 10 Hz but frequencies can reach as high as 500 Hz
- Broadband source levels for construction vessels range from approximately 160 to 180 dB re 1 µPA at 1 meter.
- Operation of the FSRU would result in broadband sounds at a maximum of 123 dB
- Only sound energy at approximately 3.5 kHz and higher would be outside the existing ambient range
- All sound energy at 100 m distance would fall below 120 dB for continuous noise
- By 500 m all sound energy would be within the existing ambient range

No offshore pile driving or blasting (the loudest of marine construction activities) is proposed for construction of Project facilities.

[17] Environmental Resources Management. 2006. USCG Final Environmental Impact Statement and MEPA Final Environmental Impact Report. Accessed from the NOAA website: http://www.nmfs.noaa.gov/pr/pdfs/permits/neg_eis2006.pdf

Possible effects from subsea sound include: physical effects (hearing impairment), behavioral effects (displacement, avoidance, tolerance), and masking, depending on the frequency range and sound pressure level experienced at the receptor (e.g. marine mammal, sea turtle or fish).

Marine mammals are considered the most sensitive of marine fauna to noise; however, marine mammals in the project area are largely limited to occasional dolphins (e.g. Irrawaddy dolphin). Further, sound generated from construction and operation are expected to be below sound pressure levels required to cause permanent physical harm to marine mammals.

Impacts to other mobile species, such as fish and sea turtles, are expected to be limited as they have the ability to swim away if the sound level is disturbing. Such movements would be short lived, as they are expected to return to the affected areas once the disturbance has ceased. No noticeable effects on plankton, benthic invertebrates, or birds are expected.

The level of noise generated from construction activities, FSRU operation, and vessel engines may cause minor behavioral changes, such as increased surfacing and avoidance of the area near the sound source. Masking may occur within 500 m of the activities, which could have minor impacts to species that rely on echolocation for communication, navigation, and finding food. However, impacts to sea life from noise is considered minor, with a probably likelihood, resulting in a significance ranking of low. Such impacts would be reversible, localized, and long-term.

Fauna – Light

Construction and normal operations will be carried out on a continuous 24-hour basis, requiring adequate work space lighting for a safe work environment during night operations. The lighting will occur at a location where there ordinarily is no light at night, except perhaps for the temporary movement of fishing and other vessels. The new source of light from project activities could attract both airborne and seaborne wildlife, including sea turtles and sea birds.[18]

Seabirds can be attracted to light on offshore structures at night. Offshore structures offer a resting place for migrating birds and a food source from an increase in marine life attracted by underwater structures and discharges. However, offshore structures may also pose hazards to seabirds as they may become injured by flying into vertical structures, or ingest materials.[19] [18] Pelagic sea birds are most at risk from structures at sea, but there are no threatened pelagic species noted. While light from the construction activities at the Delivery Point could disrupt roosting birds at night, as discussed above, light from the FSRU and vessels is not expected to disrupt threatened species present.

Other marine fauna (fish, sea turtles, etc.) may be attracted by light in the water and though the proximity to vessels and equipment poses a potential physical hazard, there is less significant concern for impact to these species.

[18] Russell, R.W. 2005. Interactions between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico: Final Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-009. 348 pp.

[19] Wiese, Francis K, Motevecchi, W.A., Davoren, G.K., Huettmann, F., Diamond, A.W., Linke, J. Seabirds at Risk around Offshore Oil Platforms in the North-west Atlantic. Marine Pollution Bulletin Vol. 42, No 12, pp 1283-1290, Great Britain, 2001.

Olive Ridley and Green sea turtles are reported to nest on beaches 2.4 km east of the FSRU location. Sea turtles hatchlings emerge at nightfall and instinctively move towards the brightest horizon when on the surface. While lighting from hotels and onshore sources have been reported to disrupt sea turtle hatchling navigation to the sea, this is not a concern for the proposed project, as the source of light will be in the ocean and would attract hatchings to the sea per normal behavior. [20]

Harm to fauna from light is considered minor, with probable likelihood, resulting in a significance ranking of low. The impact would be reversible (unless resulting in mortality of an individual), localized and long-term. The consequence of loss of a single individual of a threatened species could also be considered moderate to major (e.g. for Spoon-billed Sandpiper), however the likelihood of such an occurrence is improbable, leading to the same, low, significance ranking.

Fauna – Contact with Hull or Propeller

Increased traffic from support vessels could increase the probability of collisions between vessel hulls and/or propellers and marine mammals or sea turtles occurring in the area. Two ships operating in close proximity (e.g. FSRU and LNG carrier) induce hydrodynamic forces on each other that can lead to collisions. These forces increase with ship speed and size. Some studies have indicated that whales, when exposed to the hydrodynamic forces of large ships, may be drawn into the path, thus colliding with the ship[21]. Stranding data for the U.S. Gulf and Atlantic Coasts, Puerto Rico, and the U.S. Virgin Islands show that about 9% of living and dead stranded sea turtles had boat strike injuries.[22] Vessel speed has been shown to be directly related to marine mammal collisions, and Silber et al. (2010) note that most vessel collisions occur at speeds over 14 knots.

These collisions could cause major wounds and/or be fatal.[23] [24] [25] [26] Debilitating injuries may have negative effects on a population through impairment of reproductive output. Dolphins and sea turtle species are known to inhabit Bangladesh's waters. While infrequent near the FSRU, dolphins are more common near the Sangu River, just south of Chittagong.

The consequence of vessel strike is considered moderate to major, especially if vessel strike led to death of a threatened species, with seldom likelihood. In either case, the result is an impact of medium level significance, requiring mitigation to reduce the risk to an acceptable level. The impact would be irreversible, localized, and long-term.

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[20] Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. In: Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, FL: CRC Press. Pp. 387-409.

[21] Silber, G.K., Slutsky, J., and S. Bettridge. 2010. Hydrodynamics of a Ship/whale Collision. Journal of Experimental Marine Biology and Ecology 391 (2010) 10–19.

[22] Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. In: Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, FL: CRC Press. Pp. 387-409.

[23] Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between Ships and Whales. Marine Mammal Science 17:35-75.

[24] Kraus, S.D. 1990. Rates and Potential Causes of Mortality in North Atlantic Right Whales (Eubalaena glacialis). Marine Mammal Science 6:278-291.

[25] Waring, G.T., D.L. Palka, K.D. Mullin, J.H.W. Hain, L.J. Hansen, and K.D. Bisack. 1997. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 1996. NOAA Tech. Memo. NMFS-NE-114.

[26] Jensen, A. and G.K. Silber. 2004. Large Whale Ship Strike Database. Accessed from the NOAA website: http://www.fisheries.noaa.gov/pr/pdfs/shipstrike/lwssdata.pdf

Cultural Services
While Sonadia Island is a designated Ecologically Critical Area, it is only accessible by boat. Further, Cox's Bazar, the only nearby port, lacks infrastructure (i.e. docks and service providers) to facilitate significant expansion of tourism to the area. Despite these challenges, approximately 30 to 50 visitors travel to Sonadia Island each year.[27] Most of the visitors are wildlife photographers, and travel in small groups of three to five.

Construction activities and terminal operations may disturb Sonadia Island visitors from sound and/or change in the landscape aesthetics. Construction activities nearshore will be limited in duration (~6 months) and 700 m from the nearest key wildlife photography location. Once in operation the FSRU and support vessels will be visible on the horizon. However, other vessels of similar size (e.g. cargo tankers) are common in the region. The consequence is therefore considered minor, and likelihood occasional, resulting in a significance ranking of low. Such impacts would be reversible, localized, and long-term.

5.3.1.4 Enforcement of Safety Zone and Vessel Operations
In accordance with international safety practices, a safety zone will be established around the construction vessels (temporary) and FSRU (permanent). Excelerate is currently evaluating terminal design and reviewing navigability study results to determine the final size of the zone, but discussions with the Chittagong Port Authority and Department of Explosives by the ESIA team suggest the zones will include 500 m radius around the FSRU for small vessels (i.e. fishing boats) and 1,000 m radius for large vessels (i.e. cargo tankers). The purpose of the safety zone is to allow unencumbered operation of the terminal (i.e. vessel maneuvering), protection of the terminal from accidental or intentional harm (i.e. vessel collision and hull breach), and protection of public safety (e.g. from vessel collision). Marine vessels transporting personnel and supplies to and from the terminal site will also result in a small increase to vessel traffic near the supply base. It is expected that Chittagong Port will be used as a supply base, as Cox's Bazar does not have the infrastructure, nor water depth, to accommodate large vessels. Chittagong is the largest seaport in Bangladesh and in 2014 handled 2,566 vessels.[28]

Enforcement of the zones will impact other sea users, most notably fishing and shipping. While there is a direct boat service from Cox's Bazar to Moheshkhali Island, this route only traverses the Moheshkhali Channel and does not intersect with project activities. No other ocean transportation services were identified.

Potential impacts to shipping and fishing from safety zone and vessel operations described below.

Shipping
Excelerate commissioned a Waterway Suitability Assessment and Navigation Study to assist in the determination of suitability of this area for mooring an FSRU, and the mooring / un-mooring of the shuttle LNG carriers.[29] The study noted, "Due the remote location of the project site, it was difficult to determine the vessel traffic patterns, sizes, and types of vessels

[27] Personal communication with Sayam Chowdhury, Assistant coordinator of the Spoon-billed Sandpiper Task Force.
[28] Chittagong Port Authority. 2016. Accessed from the CPA website: http://cpa.gov.bd/
[29] Maritime Institute of Technology and Graduate Studies. 2016. Bangladesh Gateway Navigation Study & Simulation Study. Unpublished Report.

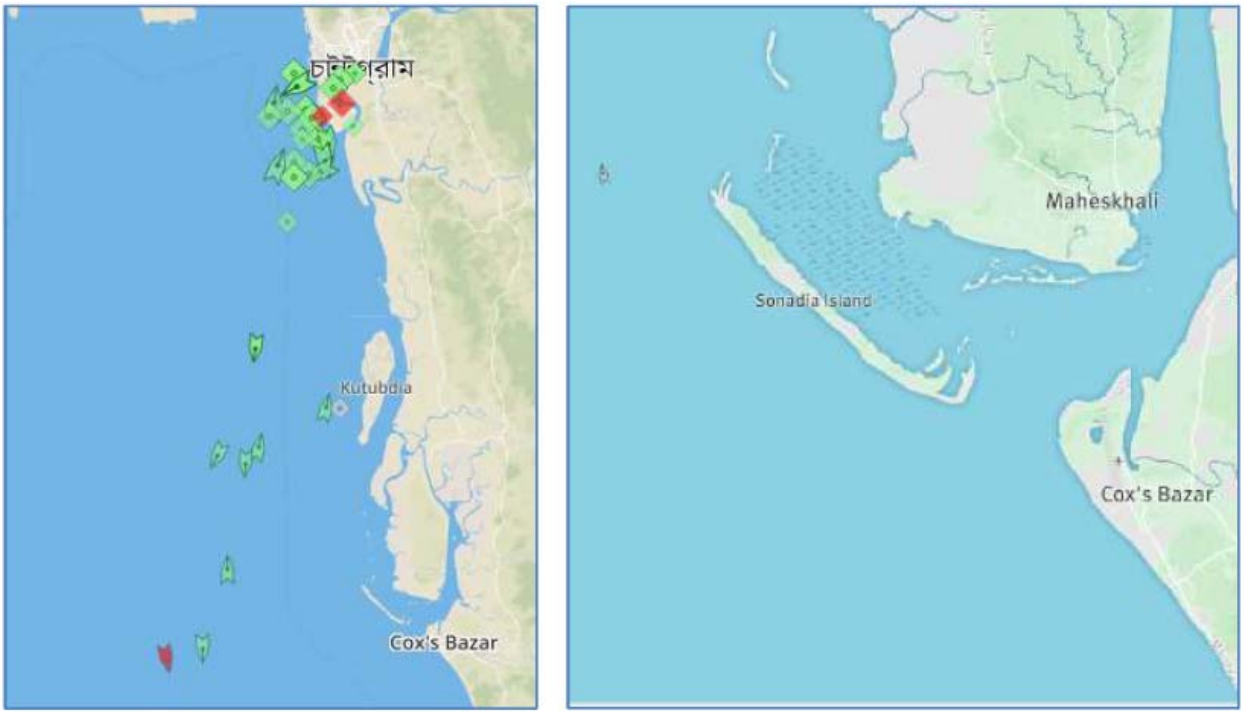
that regularly transit near the site and surrounding area. There is no clear transit corridor to Chittagong depicted on the relevant nautical chart (British Admiralty Chart 90) or mentioned in the British Admiralty Sailing Directions."

Correspondence with a local pilot established:

- Maritime traffic near the project area includes many fishing boats
- Local cargo ships do not transit near the project area
- Ocean going vessels, "mother ships", occasionally pass through the project area; however, they are not following the route as per BA Chart 84 (Approaches to Chittagong)[30].
- Normally all ocean-going ships arriving and leaving from Chittagong and Kutubdia do not anchorage in the project area

In addition to the local captain's guidance, Automatic Identification System (AIS) vessel traffic was monitored for 30 days using Marinetraffic.com. Figure 5-19 shows a representative screenshot of the AIS traffic near the site. In general, the vessels stayed at least 30 km west of the site. However, on a few occasions vessels did get within 3 km of the site, as shown in Figure 5-19.

Figure 5-19: Representative Vessel Traffic



Note: Figure on left from August 4, 2016 – 2:20 pm and figure on right from August 24, 2016 - 10 am. Typical traffic on left, and sporadic ship passing near project area on right.
Source: Maritime Institute of Technology and Graduate Studies, 2016[29]

The location of the terminal site will require minor alteration of vessel routes, but only to an added distance of up to 1,000 m. All vessels will follow the international industry practices for notifying mariners and port authorities, establishing a safety zone, using markings and lighting,

[30] The referenced correspondence indicates that contrary to the Navigation Study observation, there is some indication of a defined approach route to Chittagong.

and observing marine navigation rules. Potential impacts to shipping are considered minor, with occasional frequency, resulting in a significance ranking of low. Such impacts would be reversible, localized, and long-term.

Fishing

In Bangladesh, waters less than 40 m depth are reserved for artisanal fishing. As the FSRU will be located in approximately 30 m of water, no industrial fishing will be impacted and no sport fishing charters were identified. Interviews with fisheries officers at Upazila level indicated that as many as 35,000 Moheshkhali fishermen work in the Bay of Bengal (including registered and unregistered fishermen). The 2015 Bangladesh Marine Fisheries Capacity Building Project found that there are 222 mechanized boats owned by 168 fishermen in the Moheshkhali Upazila. Boat size vary in length from 9.15 m to 45 m, and in engine horsepower from 12 to 75 HP. In 2007, marine fisheries accounted for 19.4% of the total fisheries production (2.56 million tons), of which 93.4 % were from artisanal fisheries.[31] Catch per unit effort has declined from 650 kg/ day/ boat in 2001-2002 to under 100 kg/ day/ boat in 2005-2006.

Communications with fisheries officers, fishery association manager, and local pilot suggest the FSRU location is used regularly by artisanal fishermen. The geophysical study team also identified a number of fishing vessels anchored near Sonadia Island and fixed bamboo fishing gear at the edge of the intertidal zone, both adjacent to the proposed terminal location. Fishing is an important source of income and protein for artisanal fishermen, and enforcement of the safety zone is likely to displace fishing activity from 1.785 km^2. Fishing vessels will be able to pass between the FSRU safety zone and the coast. Vessels without motors and smaller mechanized boats are restricted to the Moheshkhali Channel due to high seas, and will not be impacted by the safety zone. Vessels utilizing areas near the FSRU are large, and capable of traveling to other suitable areas without much additional time/effort. Example vessels observed at port on Moheshkhali Island are shown in Figure 5-20. Further, not all of the registered mechanized boats of Moheshkhali are expected to fish near the project area (Moheshkhali Island has numerous ports and is approximately 60 km in length). If 50% of the mechanized vessels of Moheshkhali are capable of fishing in the open ocean and, of those, 70% may occasionally utilize the area to be closed as a result of the safety zone, then ~78 vessels may be impacted by the safety zone.

[31] Hussain, M.G., Hoq, M.E., Emran, M., and M. Asaduzaman. N.D. Marine & Coastal Fisheries Resources, Activities and Development in Bangladesh: Relevance to BOBLME Project. Accessed from: http://iwlearn.net/iw-projects/1252/reports/IWS-09%20Country%20Report%20-%20Bangladesh.pdf

Figure 5-20: Vessels Observed at Port on Moheshkhali Island

Source: Acorn International, 2016

The artisanal fishing sector utilizes powered and unpowered traditional boats, using gill nets (57.7 percent of catch), set bag nets (29.0 percent), trammel net (2.5 percent), long lines (6.0 percent), and other fishing gear (4.8 percent).[32] Some of these gear, long lines in particular, may be damaged by vessel operations.

Damage to nets and/or loss of productivity could result in a moderate impact to artisanal fishing communities, as fishing is a key source of income and protein, and the likelihood of a moderate impact is considered occasional, resulting in a significance ranking of medium. Potential impacts to fishing from safety zone and/or accidental damage to gear would be reversible, localized, and long-term. Mitigation is required to reduce the significance of the impact.

5.3.2 Waste Management and Operational Discharges

The project will generate wastes and operational discharges throughout the life of the project.

Non-hazardous and hazardous wastes routinely generated at LNG facilities include general office and packaging wastes, waste oils, oil contaminated rags, hydraulic fluids, used batteries, empty paint cans, waste chemicals and used chemical containers, used filters, oily sludge from oil water separators, scrap metals, and medical waste, among others. All wastes will be stored, transported, and disposed of appropriately, per a Waste Management Plan(s) that will be developed for the project.

During international transit to Bangladesh, ballast water will be exchanged in international waters over 200 nautical miles from the shore in accordance with IMO requirements to prevent the introduction of non-native species to Bangladeshi waters. Ballast will also be required during normal operations. To maintain operational trim when LNG and other materials are loaded to

[32] FAO. 2007. Fishery Country Profile: Bangladesh.

the *Excellence*, ambient seawater will be pumped into dedicated ballast tanks as necessary. The *Excellence* has dedicated ballast tanks which are not used to store other liquids, so the water they contain cannot be contaminated with oil or chemicals. No biocide or other additives will be needed for ballasting.

Following installation of the pipeline it will be filled with sea water for hydrostatic testing. This operation will require a one-time use of approximately 1,550 m^3 water. No corrosion inhibitors, dyes or other additives to the hydrotest water are anticipated, and the water will not be heated or cooled for the test. However, if the pipeline is flooded for an extended period, up to 282 L of dye (PRESERVAN 2140) and 1,410 L of corrosion inhibitor (PRESERVAN 650) will be added to the sea water (inhibited sea water). After completion, the sea water will be tested and treated to applicable standards, then discharged to the ocean. The pipe used for the project will be new steel and lined with epoxy paint. Typically, hydrostatic test water will pick up some iron oxide (rust) from new pipeline, depending on the total time the water remains in the pipeline. The quantity is likely to be fairly small and may give the discharge water a slightly red color. The water may also pick up some sand or dirt left over from the installation. Up to 10 m^3 of MEG will be used to dewater the pipeline between pigs. Most of the MEG will be contained within the pipeline for the life of the project, but any excess residue would be captured in the pig trap and brought to the surface for proper disposal.

Seawater for the firewater system will be sourced through two firewater pump intakes located in the fore and aft sections of the FSRU. This system will be used only in an emergency and during monthly system tests.

Clean rain water and wash waters will be allowed to drain to sea through sea scuppers. Stormwater that collects near equipment that could release hydrocarbons and other chemicals would be collected with curbs and gutters and routed to a holding tank, brought to shore, and disposed of at an approved facility.

Wastewater from machinery spaces will pass through an oily water separator and collected in a bilge water tank. Oily bilge water will be transferred for disposal at an appropriate onshore facility.

Vessels will be equipped with sewage treatment units that meet MARPOL requirements and have sufficient capacity to service the expected crew. Disposal of sanitary waste will comply with MARPOL requirements. Treated grey water will be discharged.

Food waste will be generated by the project during construction and operation. Management of food wastes will comply with MARPOL requirements.

Sea water will be used as cooling water for condensers and fresh water cooling system. Cooling water from condensers will be discharged at a maximum rate of 4,000 m^3/hour from a subsea port at 5-10^o C warmer than the ambient ocean temperature. Cooling water from freshwater cooling system will be discharged at a maximum rate of 940 m^3/hour from a subsea port at 6.5^o C warmer than the ambient ocean temperature. Cooling water from freshwater generator will be discharged at a maximum rate of 42 m^3/hour from a subsea port at 22.5^o C warmer than the ambient ocean temperature.

LNG will be vaporized using open-loop shell-and-tube vaporizers. Approximately 215,800 m^3 of sea water will be used per day during the vaporization process to heat LNG at a sendout rate of 500 MMSCFD. The cooled sea water will be discharged to sea at a maximum rate of 9,000

m^3/hr from two subsea vaporizer ports (one per side of vessel). Heating water will be -9° C when discharged compared to ambient ocean temperature.

To quantify potential impacts of discharges on water quality, thermal discharge modeling was conducted (summarized below and full report included in Appendix E). The FRSU has multiple thermal discharges, both cold and warm, which originate from different process streams and are discharged at different locations. An overview of the discharges with respect to temperature differential is provided in Table 5-10. The FRSU takes in seawater and runs it through the regasification system which extracts energy from the seawater in order to raise the temperature of the liquefied natural gas such that it promotes a phase change to gas vapor. This process reduces the water temperature which is then discharged back in to the receiving water, resulting in a cold water thermal plume within the receiving water. Similarly, the FRSU takes in water for use in cooling various process streams which result in discharges with elevated temperatures or a warm water thermal plume within the receiving waters.

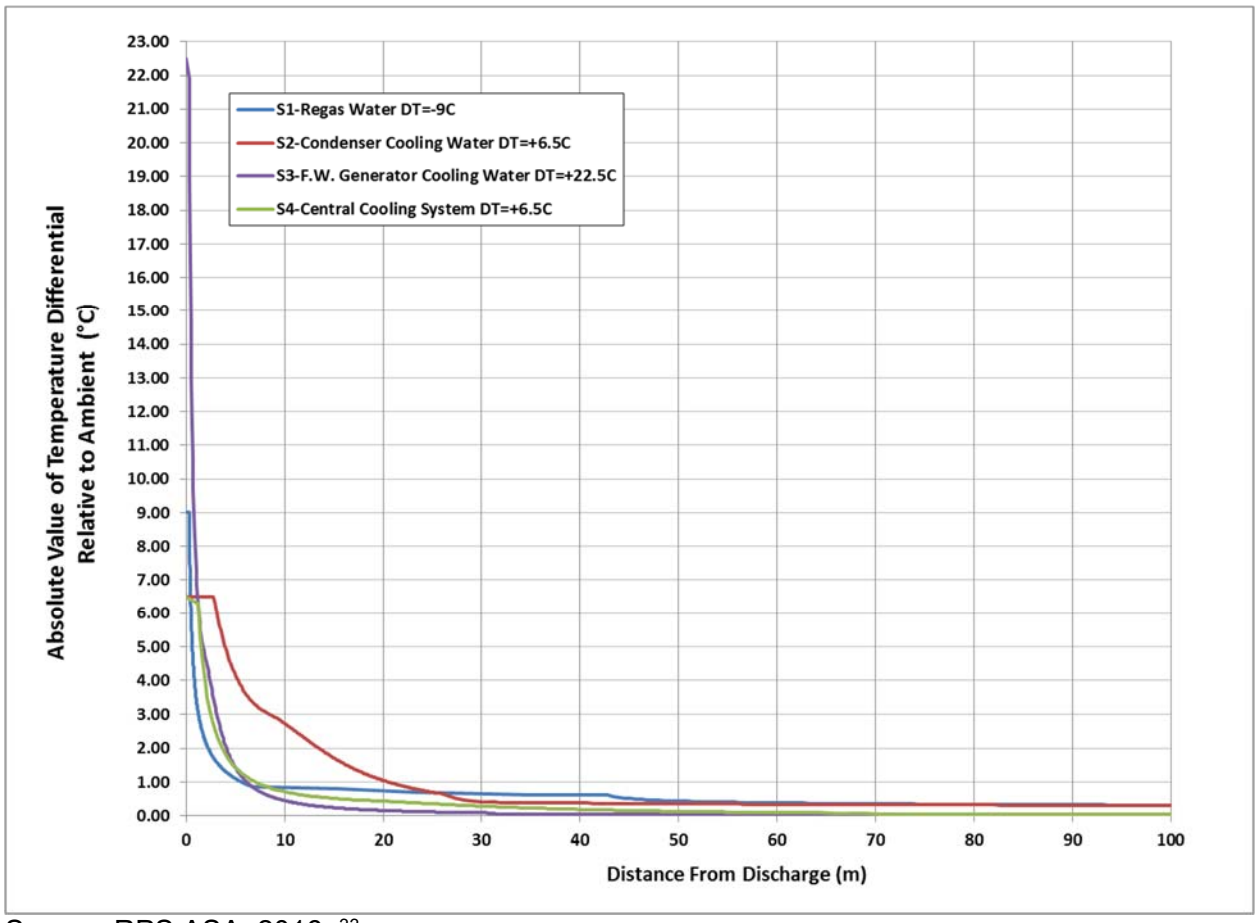
The thermal plume is the resulting plume or region of water within the receiving water that has modified temperature due to the discharge; the size of a thermal plume depends on the temperature differential of interest by which it is defined (e.g. >1 °C above background). Results of the modeling were used to compare against World Bank EHS Guidelines which state that in lieu of an established mixing zone that the plume must not result in a change in water temperature of more than 3 °C relative to ambient for an extent greater than 100 m from the discharge.

Table 5-10: Summary of Thermal Discharge Parameters

Parameter	Units	Value			
Scenario ID		S1	S2	S3	S4
Scenario Description		Heating water used in regasification process	Main condenser cooling water	F.W. generator cooling water	Central cooling system
# of Instances		2	1	1	1
Location		Port & Starboard	Port	Starboard	Port
Water Depth at Discharge	**m**	36	36	36	36
Discharge Depth	**m**	10.6	7.38	7.99	8.42
Warm/Cold Discharges		Cold	Warm	Warm	Warm
Discharge Pipe Description		600A	1400A	125A	400A
Discharge Pipe Outer Diameter	**in**	24	56	5.53	16
Discharge Inner Diameter	**in**	23.25	55.25	5.014	15.25
Discharge Orientation		90 deg downward	45 deg downward	45 deg downward	90 deg downward
Discharge Flow	**m^3/hr**	4,500	4,000	42	940
Discharge Initial Temperature Differential	**°C**	-9	+6.5	+22.5	+6.5
Required Dilution to Reduce to 3C above Ambient		3	3	8	3

Plume modeling of the thermal discharge within the receiving waters was performed using the CORMIX model. Results of the modeling are shown in Figure 5-21.

Figure 5-21: Thermal Plume Temperature Differential Relative to Ambient as a Function of Distance from Discharge



Source: RPS ASA, 2016a[33]

Potential impacts to water and fauna from waste management and operational discharges are described below. Impacts of accidental release of waste described in Section 5.3.4.

Soils

During pre-commissioning the pipeline will be filled with sea water for hydrostatic testing. No corrosion inhibitors, dyes or other additives to the hydrotest water are anticipated, and the water will not be heated or cooled for the test. However, if the pipeline is flooded for an extended period, up to 282 L of dye (PRESERVAN 2140) and 1,410 L of corrosion inhibitor (PRESERVAN 650) will be added to the sea water (inhibited sea water). Prior to hydrotesting, four pigs will be run through the pipeline from the PLEM to the beach. In between the first pigs will be sea water, and after the last pig either sea water or inhibited sea water (not anticipated). In either case, liquids from the pipeline would be tested to ensure compliance with applicable standards. Fluids will then either be treated and discharged, or sent to a disposal facility.

[33] RPS ASA. 2016a. LNG Regasification Thermal Discharges Modeling, Bangladesh. Unpublished Report.

Discharge of fluids may result in disruption of soils, discoloration, and or contamination if spilled. Additional pigs will be run after the hydrotesting, but from the beach to the FSRU so the risk of potential impact from these activities is low. Potential impact of hydrostatic test water to soil quality is considered moderate, but the likelihood of a moderate impact is seldom. Such an impact would be reversible, localized, and short-term. This represents a significance ranking of medium, requiring mitigation to reduce the risk to an acceptable level.

Water

During transit to Bangladesh, ballast water will be exchanged by the FSRU, support vessels, and LNG carriers in international waters over 200 nautical miles from shore in accordance with IMO requirements. Ballast will also be required during normal operations to maintain operational trim when LNG and other materials are loaded to the *Excellence*. Ballast water will not contain oil, chemicals, biocides or other additives. Potential impacts of ballast water discharge to water quality are considered negligible to minor, with a probable likelihood, resulting in a significance ranking of low. Such impacts would be reversible, localized, and short-term.

Following installation of the pipeline it will be filled with sea water for hydrostatic testing. This operation will require a one-time use of approximately 1,550 m^3 of water. No corrosion inhibitors, dyes or other additives to the hydrotest water are anticipated, and the water will not be heated or cooled for the test. However, if the pipeline is flooded for an extended period, up to 282 L of dye (PRESERVAN 2140) and 1,410 L of corrosion inhibitor (PRESERVAN 650) will be added to the sea water (inhibited sea water). In addition, up to 10 m^3 of MEG will be used to dewater the pipeline between pigs. Most of the MEG will be contained within the pipeline for the life of the project, but any excess residue would be captured in the pig trap and brought to the surface for proper disposal. Hydrotest water will be tested and treated (if required) to meet applicable standards prior to discharge. The location of discharge has not yet been determined. Discharge of hydrostatic test water and/or MEG may cause minor discoloration (from rust and/or dye), increased turbidity, and minor change in ocean temperature, and introduce chemicals to the environment. However, potential impacts of these discharges to water quality is considered minor to moderate, reversible, localized and short-term. While the likelihood of discharge of fluids is probable, the likelihood that discharge of fluids will result in a moderate impact is considered seldom. This represents a significance ranking of medium, requiring mitigation to reduce the risk level to an acceptable level.

As noted above, all discharges will comply with MARPOL and other IMO requirements. Food waste, sewage, and oily waters will not be discharged from the FSRU, nor support vessels unless in transit to Chittagong and distance from shore limits, per MARPOL, are met. Discharge of food waste and sewage to sea from supply vessels may cause a localized increase in the biological oxygen demand in the receiving surface waters. The discharge of these waste streams will introduce relatively small amounts of nutrients and organic material to well-mixed, well-oxygenated surface ocean waters resulting in a minor contribution to local marine productivity and possibly attracting some opportunist feeders. The sewage and domestic wastewater discharge may contain a low level of residual chlorine from the sewage treatment facility on the support vessels. Oily waters from the FSRU will be shipped to shore for disposal, and oily waters from support vessels will only be discharged if waters contain less than 15 PPM of oil content and vessels are in route to the supply base. The volume and nature of discharge from drains and bilges will be small scale given the limited volumes discharged, the depth of water offshore, and the capacity for dilution and dispersion. Discharge of food, sewage, and oily waters could result in minor degradation of water quality. Potential impacts would be reversible,

localized and long-term (over life of project), with a probable likelihood, resulting in a significance ranking of low.

Operation of the FSRU will result in discharge of cooled water used during vaporization, and warmed water from main condenser cooling, forward generator cooling water, and central cooling system. These discharges will cause a localized change in water temperature. These changes will be reversible and long term. As noted above, temperature of thermal plumes in the ocean are predicted to return to 3 degrees Celsius of ambient water temperature (World Bank EHS guideline) within 10 m of discharge and within 1 degree Celsius of ambient water temperature within 50 m. Impacts to water quality from thermal discharges are considered minor, with probable likelihood, resulting in a significance ranking of low.

The Marine Growth Preventative System (MGPS) will self-generated sodium hypochlorite in the sea chests (~0.5ppm solution) for the purpose of marine biofouling control. No corrosion inhibitors or other chemicals will be added. The MGPS system complies with IMO regulations, and impacts to water quality are expected to be negligible.

The normal water use of the FSRU will be up to approximately 420,500 m^3/day. World Bank EHS Guidelines require water intake to be less than one percent of tidal excursion volume, when located within an estuary. As the FSRU is located approximately 2 km from shore and not in an estuary, this limit does not apply. Hydrostatic testing will require a one-time use of approximately 1,550 m^3 of sea water. While the intake for this water will likely be at the FSRU offshore, the intake locations have not yet been defined. In the unlikely event the intake is located nearshore, the volume required would fall substantially below the 1 percent limit. The estuary, bounded by the Kaladia to the south and Khorir Char to the north, has a surface area of approximately 2,400,000 m^2 and an average tidal height of 1.5 m, thus the average tidal excursion volume is approximately 3,600,000 m^3. Intake required for hydrotesting represents .04% of this volume.

Fauna

Intake of ballast water can also include bacteria, microbes, small invertebrates, eggs, cysts, and larvae of various species. When ballast waters are exchanged according to IMO rules, these species will have a negligible impact to the marine environment. However, if ships fail to follow the rules and exchange foreign ballast water near shore, the transferred species may survive to establish a reproductive population in the host environment, becoming invasive, out-competing native species, and becoming pests. In some cases, invasive aquatic species from ballast water exchange can have a major impact to ecosystems. Such an impact would be irreversible, dispersed, and long term. However, the likelihood of this impact occurring is improbable, given the standard practices[34] that will be followed, thus resulting in a significance ranking of low.

Sea water required for cooling, ballast, vaporization and other uses on the FSRU will be extracted from the ocean via the high and low sea chests. The total open area for the high and low sea chests is approximately 18.12 m^2. Under normal water use capacity, the calculated through-screen velocity of water entering the sea chests is approximately 0.14 m/sec, below the World Bank EHS guideline value of 0.5 ft/sec (.1524 m/sec). Mesh size on grates of the sea chests are 2.21 cm slots. The water intake rate and mesh will mitigate fish, turtles and other

[34] As noted in Chapter 6, Excelerate will comply with IMO expectations for ballast water and sediment management, including requirements of the International Convention for the Control and Management of Ships' Ballast Water and Sediments Convention and IMO's Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens.

large fauna from entrainment, but will not act to abate entrainment of planktonic organisms. Plankton entrained in the sea chests will die from the Marine Growth Preventative System (MGPS) which generates sodium hypochlorite (~0.5ppm) in the sea chests to control biofouling. Potential impacts of sea water intake on fauna is considered minor, reversible (on the landscape level, localized and short-term. The likelihood of a minor impact occurring is probable, resulting in a significance ranking of low.

Discharge of hydrostatic test waters may have a minor impact to water quality from discoloration (from rust), increased turbidity, and small change in ocean. However, the Delivery Point is located close to sensitive shoreline species habitat and discharge of test waters uncontrolled may degrade these habitats. Therefore, potential impacts of hydrostatic test water to fauna is considered moderate, reversible, localized, and short-term. The likelihood of a moderate impact occurring is seldom, resulting in a significance ranking of medium. Mitigation is required to reduce the risk to a more acceptable level.

All routine discharges will comply with MARPOL and other IMO requirements, but may result in minor degradation of water quality. Similarly, discharge of operational discharges related to FSRU operation will result in minor changes in ocean temperature within 50 m of discharge location. These discharges may locally harm plankton that is sensitive to water quality and unable to move from the discharge stream, although other wildlife is unlikely to be affected. Discharge of food may have a minor positive impact on wildlife by providing additional nutrients, although this impact is considered negligible. Impacts to fauna from discharge of food, sewage, oily waters, and operational discharges are considered minor, with probable likelihood, resulting in a significance ranking of low. Potential impacts would be reversible, localized, and long-term (over life of project).

5.3.3 Air Emissions

During construction, air emissions will be generated from supply vessels, excavators, bull dozers, generators, and other small sources. These emissions will be temporary and considered negligible, so were not included in the emissions inventory. However, there is potential that these small sources could result in excess emissions (e.g., black smoke, white smoke, sulfur dioxide) if equipment in not properly maintained. No overland access or roads will be required. All access to the site will be from the sea.

The principal air pollutant emissions sources on the FSRU, the *Excellence*, are the two main boilers and the diesel generator. A smaller emergency generator also contributes to the vessel's emissions. However, because under normal conditions it is run only for testing, its contribution to the total emissions is considered to be negligible. The vessel also has an incinerator on board, but the operating plan is to remove all waste from the vessel and not use the incinerator. Therefore, it is not considered to be a source of emissions.

For the purposes of conducting the base case air pollutant emissions inventory during operations, we have assumed that the FSRU is operating continuously at its contracted sendout rate of 500 MMSCFD. In this mode of operation, the diesel generator is not required. Therefore, all of the emission sources are assumed to come from the two boilers used for regasification. With both boilers operating, the required load is less than 36 percent on each of them to meet the contracted gas sendout required.

The emissions inventory for the FSRU is summarized in Table 5-11. The two air pollutants of greatest concern, nitrogen oxides and sulfur oxides, are included in this table. Nitrogen oxides are the result of the combustion of the natural gas and liquid fuels. Sulfur oxides result almost

entirely from the liquid fuels combustion. Particulate matter emissions will also occur from the combustion of liquid fuels but are not included in the table because the emissions levels are less than one-tenth of those of sulfur oxides.

Annual emissions are based on the continuous operation of the emission sources except the emergency generator, which is assumed to be run for two hours per month for testing. The grams per second emission rates shown in the table for each source are the instantaneous emissions for the indicated load, while the tonne/year figures are the total emission for the indicated load and the indicated operating hours per year.

Table 5-11: FSRU Operating Air Pollutant Emissions: 500 MMSCFD Sendout

Source	Rating	Load	Operating hours/year	Fuel Consumption	SO_x		NO_x	
					g/sec	tonne/yr	g/sec	tonne/yr
Boiler 1	71 MWth	35.8%*	8760	1511 kg NG/hr	0.031	0.99	1.95	61.6
Boiler 2	71 MWth	35.8%	8760	1511 kg NG/hr	0.031	0.99	1.95	61.6
Emergency Generator**	500 kWe	100%	24	93 kg Diesel/hr	0.78	0.07	1.68	0.15

* Two boilers are run at 35.8% rather than one at 71.6% because Excelerate has contractual obligations regarding redundancy and performance. Running both in parallel also assists in boil off gas management, safety of operations in the event of boiler failure, and reduction of emissions (even if only one boiler is in use, the other would need to be kept running using HFO).
**Fueled with MDO or MGO having a maximum sulfur content of 1.5%. SOx emissions are based on 1.5% S.

The NOx emissions for the boilers shown in Table 5-11 are based on a measured NO_x flue gas concentration of 157 ppm (dry).

The sendout from the FSRU may at times exceed the contracted sendout rate of 500 MMSCFD. The amount of time it exceeds this rate, and the amount by which it exceeds it, depends on the demand for natural gas. For the purposes of conducting an alternative emissions inventory, we have assumed that it may operate up to 10 percent of the year at a sendout rate of 600 MMSCFD.

When the FSRU operates at sendout rates greater than 500 MMSCFD, continuous operation of the diesel generator is required. The emissions that occur during this sendout rate are summarized in Table 5-12. The tonnes per year figures as based on 876 hours per year of operation at the higher sendout rate.

Table 5-12: Excellence FSRU Operating Air Pollutant Emissions: 600 MMSCFD Sendout

Source	Rating	Load	Operating hours/year	Fuel Consumption	SOx		NOx	
					g/sec	tonne/yr	g/sec	tonne/yr
Boiler 1	71 MWth	36.8%	876	1553 kg NG/hr	0.032	0.10	2.01	6.33
Boiler 2	71 MWth	36.8%	876	1553 kg NG/hr	0.032	0.10	2.01	6.33
Diesel Generator*	3650 kWe	30%	876	252 kg Diesel/hr	2.10	6.61	3.68	11.6

*Fueled with MDO or MGO having a maximum sulfur content of 1.5%. SOx emissions are based on 1.5% S.

As shown in Table 5-12, while operating, the diesel generator is the largest source of both NOx and SOx emissions. The latter would be expected since the fuel oil burned by the generator is assumed to have a sulfur content of 1.5 percent, while the natural gas consumed in the boilers contains negligible sulfur.

The NO_x concentrations in the boiler flue gas are the same in Table 5-12 as in Table 5-11, 157 ppm. The diesel NO_x emissions are based on an emission factor for 12.1 g/kW-hr.[35] This is equivalent to 1560 mg/Nm^3 in the exhaust gas.

Combining the results in Table 5-11 and Table 5-12 for the scenario in which the FSRU operates 90 percent of the year at 500 MMSCFD and 10 percent of the year at 600 MMSCFD results in its having total emissions annual NO_x emissions of 135 tonnes per year and total annual SO_x emissions of 8.6 tonnes.

During the time that the FSRU is being filled with LNG, additional emissions will come from the LNG carrier. These emissions will result from the LNG carriers operating its boilers at partial load during the LNG unloading process.

LNG carriers are expected to arrive at the FSRU once per week, and to take two days to unload. This amounts to 2,503 hours of operation annually. While these operations are not part of the terminal itself, they will occur along with and adjacent to the terminal. The emissions resulting from a typical LNG carrier are shown in Table 5-13. The figures in this table are based on carrier operating at partial load burning natural gas with the emission rates per unit of fuel consumption equivalent to those of the FSRU.

Table 5-13: LNG Carriers Operating Air Pollutant Emissions

Source	Rating	Load	Operating hours/year	Fuel Consumption	SOx		NOx	
					g/sec	tonne/yr	g/sec	tonne/yr
Boiler 1	50 MWth	55.5%	2503	1652 kg NG/hr	0.034	0.30	2.11	19.0
Boiler 2	50 MWth	55.5%	2503	1652 kg NG/hr	0.034	0.30	2.11	19.0

[35] The vessel was constructed in accordance with MARPOL 73/78. The diesel emissions for NO_x are based on that standard: - 45.0 x n(-0.2) g/kW-hr for 130 ≤ n < 2000 rpm where n is the rpm of the engine. The engine manufacturer uses a nominal rpm of 720 for rating purposes, so the limit was evaluated on that basis. The resulting limit is 12.1 g/kW-hr.

Carbon Dioxide emissions associated with the principal FSRU combustion sources are shown in Table 5-14. Total annual CO_2 emissions are slightly below 75,000 tonnes per year. These emissions are based on the FSRU operating 90 percent of the year at a sendout rate of 500 MMSCFD and 10 percent of the year at a sendout rate of 600 MMSCFD. Emissions from the LNG carrier are not included in this table because greenhouse gas emissions are not of concern for local air quality and the accounting of the LNG carriers' emissions would be the responsibility of the owners or operators of the carriers.

Table 5-14: FSRU Annual Carbon Dioxide Emissions

Source	Operating hours/year	Annual Fuel Consumption, tonnes	Annual CO_2 Emissions, tonnes
Boiler 1	8760*	13,270 (Natural Gas)	37,026
Boiler 2	8760*	13,270 (Natural Gas)	37,026
Diesel Generator*	876	220.5 (Fuel Oil)	702
Total Emissions			74,754

*10 percent of these hours at a sendout rate of 600 MMSCFD, 90 percent at 500 MMSCFD

To assess the local impacts of the emissions air dispersion modeling was employed. The U.S. Environmental Protection Agency's AERMOD dispersion model was used for this purpose. AERMOD is widely used in the U.S. for predicting ambient concentrations from point sources of emissions. It is an accepted model for demonstrating compliance with ambient air quality standards. The most recent version of the model, AERMOD (v15181), was used for this modeling analysis.

The AERMOD model is designed to use hourly surface meteorological data for wind speed and direction, as well as upper air meteorological data, as inputs for calculating ambient concentrations. Such data were not available for the site of this assessment. Therefore, the model was run using screening meteorological data in order to determine the worst-case, one-hour concentrations of air pollutants in the area of the planned terminal. The screening level meteorological data were generated using the U.S. EPA AERSCREEN model. The resulting meteorological files were then used as inputs to AERMOD.

Using AERMOD in this way allowed the two vessel boilers and single diesel generator be modeled simultaneously. Typically, the peak concentration as a function of distance from the stack is determined without regard to direction as part of a screening analysis. In this case, the vessel dimensions were included in the modeling to account for wake effects on the predicted concentrations. Peak concentrations were then determined at 100 meter intervals out to three kilometers using a polar grid system with calculations made at every 10 degrees, from 10 to 360 degrees around the origin.

The mooring system for the FSRU allows the vessel to rotate in response to strong wind and current conditions that occur during storms. Under normal conditions, however, the orientation of the FSUR is fixed with the bow pointed towards 212.5 degrees. This orientation was used for presenting the results of the air dispersion modeling, with the mooring point designated as the center of the polar grid for the modeled concentrations.

Emission rates for the boilers and diesel engine were described in the previous section. Other emission source parameters used for the modeling are listed in Table 5-15. All of these parameters were taken from design drawings for the vessels or were supplied by Excelerate Energy.

Table 5-15: Emission Source Characteristics

	FSRU Boiler	FSRU Diesel Generator	LNG Carrier Boiler
Number of Units	2	1	2
Stack Height, meters above deck	22.8	23.6	22.8
Deck Height, meters above water	14.3	14.3	14.3
Stack Diameter, meters	1.4	0.7	1.3
Stack Outlet Orientation	45 degrees	45 degrees	45 degrees
Stack Gas Temperature, C	158	350	160
Vessel Length, meters	227		227
Vessel width, meters m	43.4		43.4

The results of the air dispersion modeling are shown in Appendix F. Annual concentrations of SO_2 were not plotted, as the concentrations are negligible (<5 percent of the allowable concentrations near the shoreline in all scenarios, see Table 5-17).

The modeled concentrations of NO_x are summarized in Table 5-16. These concentrations are presented for the location 2 km east of the terminal near the coastline, which is 2.4 km east. The results are given for annual average. The Bangladesh standard for NO_x is 100 ug/m^3 annual average concentration.

Table 5-16: Peak Annual NO_x Concentrations 2 km East of FSRU

Scenario	Annual Concentration
	ug/m^3
FSRU @ 500 MMSCFD Sendout	8.3
FSRU @ 600 MMSCFD Sendout	9.0*
FSRU @ 500 MMSCFD Sendout with LNG carriers Unloading	10.8**
FSRU @ 600 MMSCFD Sendout with LNG carriers Unloading	11.3-11.6***

*Weighted average based on 90 percent operation at 500 MMSCFD sendout and 10 percent at 600 MMSCFD sendout
**Weighted average based on one LNG delivery per week lasting 48 hours.
***Concentration depends upon the fraction of the time LNG unloading occurs during operation of the FSRU at the greater sendout rate.

In all cases, the modeled concentrations are below the guideline value.

It should be noted, however, that the figures in Table 5-16 are conservative values, as screening level assessments are meant to provide conservatively high concentration values.

Conversely, it should also be noted that greater concentrations will occur closer to emission sources. These concentrations are shown on the concentration plots (Appendix F). Because these locations are over open water, they are not used for comparison purposes.

The other pollutant of potential concern from the terminal is sulfur dioxide. The modelled concentrations of SO_2 are summarized in Table 5-17. These concentrations are presented for the location 2 km due east of the terminal near the coastline, which is 2.4 km east. The results are given for two averaging times: the 24-hour average value and the annual average value. The Bangladesh standards for SO_2 are 365 ug/m^3 for a 24-hour average and 80 ug/m^3 annual average.

Table 5-17: Peak 24-hour and Annual SO_2 Concentrations 2 km East of FSRU

Scenario	24-hour Concentration	Annual Concentration
	ug/m^3	ug/m^3
FSRU @ 500 MMSCFD Sendout	0.80	0.13
FSRU @ 600 MMSCFD Sendout	26	4.4
FSRU @ 500 MMSCFD Sendout with LNG carriers Unloading	1.7	0.27
FSRU @ 600 MMSCFD Sendout with LNG carriers Unloading	27	4.5

For the modeled location, the results indicate that SO_2 concentrations will increase negligibly in the scenarios in which the vessels are burning only natural gas. This result is expected since natural gas contains very little sulfur.

In no cases do the SO_2 concentrations exceed the Bangladesh standards. The SO_2 concentration is based on a fuel sulfur content of 1.5 percent. If diesel fuel having a lower sulfur content of were used, the ambient concentrations of SO_2 would be reduced proportionately.

5.3.3.1 Predicted Effects of Air Emission

Generation of air emissions could potential result in the following impacts:

- Degradation of air quality and greenhouse gas emissions
- Harm to fauna from degradation of air quality
- Harm to human health from degradation of air quality

Air

No ambient air quality data is available for the offshore terminal location. However, site reconnaissance and review of previous studies (e.g. original EIA and Sonadia Port Feasibility Study) suggest the air quality in the area is good. Sources of air pollutants in this rural coastal area are limited to emissions from fishing and other boats offshore, smoke from cooking fires, and limited vehicle traffic in the central and eastern parts of Moheshkhali Island. The original EIA classified the area as “Residential and Rural (Category 3)”, per the Bangladesh Environmental Conservation Rules (ECR), 1997.

While ambient air quality standards are included for Residential and Rural areas, as well as others, in ECR 1997, a World Bank funded Air Quality Management Project (AQMP) implemented by the DoE during 2000-2007 noted “the air quality standards set under the ECR 1997 do not specify monitoring methods and frequency, averaging times, compliance requirements and other necessary factors. Moreover, in these standards, thoracic coarse and fine particulate matter (PM_{10} and $PM_{2.5}$, respectively) were not included.”[36] This program led to the revision of the ambient air quality standards of Bangladesh in July 2005. The new standards are provided in Table 5-18.

[36] MoE. ND. Recommendations Regarding Revisions to the Bangladesh National Ambient Air Quality Standards. Accessed from the CASE website: http://case.doe.gov.bd/file_zone/feedback/Revision%20of%20National%20Ambient%20Air%20Quality%20Standard.pdf

Table 5-18: Applicable Ambient Air Quality Standards

Pollutant	Averaging Time	Bangladesh Standard (ug/m^3)
CO	8-hour	10,000
	1-Hour	40,000
Pb	Annual	.5
NO_x	Annual	100
TSP	8-hour	200
PM_{10}	Annual	50
	24-hour	150
$PM_{2.5}$	Annual	15
	24-hour	65
O_3	1-hour	235
	8-hour	157
SO_2	Annual	80
	24-Hour	365

The ECR 1997 also include a series of emissions limits for point sources. Consultation with DoE for this ESIA confirmed these standards are for onshore activities and will not apply to this project. In such cases, ECR 1997 defer to World Bank EHS Guidelines. The applicable World Bank Industry Sector Guidelines for Shipping apply, and these guidelines defer to IMO requirements under MARPOL 73/78 Annex VI. As noted above, the Excellence was constructed in accordance with MARPOL 73/78 and compliance with Annex VI requirements are included in vessel classification.

During construction, air emissions will be generated from supply vessels, excavators, bull dozers, generators, and other small sources. These emissions will be temporary and considered negligible, so were not included in the emissions inventory. However, there is potential that these small sources could result in excess emissions (e.g., black smoke, white smoke, sulfur dioxide) if equipment in not properly maintained.

During operation, key emissions sources include the FSRU and LNG carriers. As described above, ambient air quality near the shoreline is well below the Bangladesh standards.

NO_x and SO_x interact with water, oxygen and other chemicals in the atmosphere to form acid rain. Acid rain can change the pH and nutrient content of surface waters, impacting water quality and wildlife. [37] Acid rain can also directly impact plant life by harming foliage or impacting soil quality (i.e. change in pH or leaching of minerals and nutrients from the soil). Increases in particulates from NO_x and SO_x can also increase haze.[38] [39] Impacts from degradation of air quality to fauna and human health are described below.

Air emissions during construction are reversible, localized, and short term, and are considered minor with a likelihood of probable, resulting in a significance ranking of low. Operational

[37] US EPA. 2016. Acid Rain. Accessed from the US EPA website: https://www.epa.gov/acidrain
[38] US EPA. 2016. Sulfur Dioxide (SO2) Pollution. Accessed from the US EPA website: https://www.epa.gov/so2-pollution
[39] US EPA. 2016. Nitrogen Dioxide (NO2) Pollution. Accessed from the US EPA website: https://www.epa.gov/no2-pollution

emissions do not exceed relevant standards and would be considered low on their own. However, as discussed in Section 5.3.7.1 the cumulative impact of this project and other planned projects could be considered moderate, with an occasional likelihood, resulting in a significance ranking of medium. Impacts would be reversible, dispersed, and long-term. Mitigation is required to reduce the significance of this impact.

In addition to traditional air pollutants, CO^2, a greenhouse gas, will also be generated. Potential cumulative impacts of CO_2 are addressed in Section 5.3.7.1 .

Fauna

Fauna can be exposed to degradation in air quality from direct inhalation, ingestion of particles in food or water, and/or absorption through the skin. Impacts of degradation of air quality to animals are similar to those experienced by humans. [40] SO_x and NO_2 primarily affect the respiratory system and the effects depend on the type of pollutant involved, the duration and time of exposure, and the amount taken up by the animal. Acid rain from high levels SO_x and NO_2 can result in surface water acidification and a decline in, and loss of, fish and amphibian populations.

Air emissions from construction will be intermittent and mobile, and are expected to have a negligible impact to fauna. Air pollutant concentrations during operations are expected to be below Bangladesh ambient air quality guidelines onshore where animals (especially birds) congregate. Potential deposition of pollutants through rain or particles would be dispersed, and impacts likely limited. The impacts to fauna from air emissions can be considered minor with an occasional likelihood, resulting in a low impact significance ranking. Impacts would be reversible, localized, and long-term.

Health

Air pollution can harm human health once pollutants reach certain concentrations. Short term health effects of poor air quality can include[41] [42]:

- Irritation of the eyes, nose, and throat
- Wheezing, coughing, chest tightness, and breathing difficulties
- Worsening of existing lung and heart problems, such as asthma
- Increased risk of heart attack

Long-term exposure to air pollution can cause cancer and damage to the immune, neurological, reproductive, and respiratory systems, and in extreme cases, death. The nearest community is greater than 6 km from the FSRU. Under no scenario were emission concentrations above Bangladesh ambient air quality thresholds at these communities. Fishermen or visitors to Sonadia Island are also unlikely to be exposed to emissions concentrations above Bangladesh ambient air quality thresholds. The consequence of potential impacts to human health from degradation of air quality is considered minor, with a seldom likelihood, resulting in a significance rating of low. This impact would be irreversible, dispersed, and long term.

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[40] Newman, J.R., Schreiber, R.K., and E. Novakova. 1992. Air Pollution Effects on Terrestrial and Aquatic Animals in Tingey, D.T, eds. *Air Pollution Effects on Biodiversity* (pp 177-233). New York, New York: Springer Science+Business Media.

[41] WHO. 2016. Ambient (Outdoor) Air Quality and Health Factsheet. Accessed from the WHO website: http://www.who.int/mediacentre/factsheets/fs313/en/

[42] Massachusetts Department of Environmental Protection. 2016. Toxic Air Pollutants. Accessed from the Mass DEP website: http://www.mass.gov/eea/agencies/massdep/air/quality/toxic-air-pollutants.html

5.3.4 Accidental Releases

Potential impacts from accidental releases were identified in each phase of the Project with examples including:

- Release of LNG
- Release of natural gas (after regasification, from pipeline)
- Release of diesel fuel, e.g., from a fuel tank or from a hose during fuel transfer
- Release of materials used in routine maintenance of vessels and equipment, e.g., lubricants, paints, etc.
- Release of solid waste

It is also possible that natural gas at ambient temperature could be released from the offshore pipeline conveying product from the FSRU to the onshore pipeline delivery point. However, any potential environmental impact of such a release would be very low because the product is naturally occurring gases, and the likelihood that the pipeline could rupture or otherwise fail with the built-in controls in place (see Chapter 2) is also very low.

This section begins with consideration of the predicted effects of any of the four accidental releases referenced above. Following those considerations, the section turns to an evaluation of potential impacts of LNG, diesel or other hazardous liquids to environmental receptors of particular concern.

5.3.4.1 Predicted Effects of Accidental Releases

LNG

LNG is an odorless gas that is transported as a liquid stored at a very cold temperature (-260ºF or -162ºC) and ambient air pressure. The gas consists primarily (>95%) of methane, with the remainder consisting of ethane, propane and other natural gas constituents. It is stored in "cryogenic" tanks and transfer lines that maintain the low temperatures so that it is contained under controlled conditions.

Accidental releases would only occur if there were a failure of these conditions, such as a rupture in a tank or transfer line. The likelihood of such an accidental release is extremely low, as referenced in the statistics presented in the Environmental Impact Assessment prepared by the US Coast Guard for the Northeast Gateway Energy Bridge Liquefied Natural Gas Deepwater Port[43].

> More than 80,000 LNG carrier voyages have taken place, covering more than 100 million miles (161 million km) while loaded, with no major accidents, safety problems, recorded fatalities to vessel crew, or the general public, or recorded fires on deck or within cargo areas. Out of the greater than 80,000 shipments of LNG since 1964, 8 marine incidents worldwide have resulted in LNG spills. These spills have resulted in some damage to the carrier, but no LNG fires have occurred (Sandia, 2004). The most significant damage resulting from LNG leakage involved a deck or plating fracture from cryogenic embrittlement (CH-IV International, 2002). An additional 11 incidents involved a vessel collision, a vessel running aground, or vessel fracture due to high seas deflection stresses. However, none of these 11 incidents resulted in a spill of LNG (CH-IV International, 2002).

[43] US Coast Guard. Environmental Impact Assessment prepared by the US Coast Guard for the Northeast Gateway Energy Bridge Liquefied Natural Gas Deepwater Port. November 2006.

In the very unlikely event that LNG were to be released to the environment during Project operations, it would quickly vaporize and either evaporate or, if under unlikely circumstances ignited, burn or under even more unlikely circumstances, explode. In any case, the LNG would not disperse as a liquid in the environment, so all release scenarios would result in dispersion of the released product in gaseous form. This could happen under the following scenarios:

- Evaporation – in which an accidental LNG would escape to the air as a vapor and disperse as a gas. Due to its density as a liquid in cryogenic storage, released LNG might initially settle to the surface of the sea water surrounding the FSRU. If this occurs, the ambient temperature of the air and sea water would typically cause the released LNG to evaporate and disperse as airborne vapor.
- Combustion – In rare circumstances, released LNG could come into contact with a spark or flame, which could ignite the flammable gas, causing a fire. This could occur, for example if released LNG vapor were to pool on the water surface or be captured in a contained area prior to warming to a gaseous state ("Vapor pooling") and simultaneously encounter an ignition source.
- Explosion – In an even more rare circumstance, it is possible that a large amount of LNG settling quickly to the sea surface while still at a very low temperature could expand extremely quickly upon coming in contact with the ambient temperature sea surface and explode (in a reaction called "rapid phase transition") prior to evaporation as a gas.

Given that any accidental release would be most likely evaporate, modeling was performed to predict the effects of how evaporated LNG would disperse in the air. The findings of this modeling are summarized later in this section and presented in detail in Appendix G. Potential impacts of the very unlikely combustion or explosion scenarios are discussed later in this chapter with respect to specific environmental receptors.

Natural Gas

The FSRU will re-gasify the LNG in a controlled process (See Chapter 2) and transfer it via a new seafloor pipeline to the existing Petrobangla gas pipeline Delivery Point. Failure of the pipeline due to a rupture of the pipeline itself (due, for example, to corrosion, subsidence or damage from a dragged anchor) or of the valve at the Delivery Point could cause a release of the natural gas to the environment.

Diesel

Diesel will be stored in tanks onboard the FSRU as a back-up source of fuel for the generators needed to operate equipment. The amount of diesel needed is minimal because under normal circumstances the generators will be fueled by natural gas. For the purpose of evaluating impacts, an assumption is made that no more than 18.9 m^3 of diesel fuel will be stored on the vessel at any one time. It is possible that the LNG carriers may carry diesel as a fuel for their generators. Based on these conditions, the worst realistic case scenario for a diesel spill from the Project operation would be an 18.9 m^3 spill to the sea surface adjacent to either the FSRU or connected LNG carriers. It is not considered realistic that both vessel's diesel tanks could rupture simultaneously. Adding to the extreme unlikelihood of even an 18.9 m^3 diesel spill is the fact that any diesel would be stored in tanks that are surrounded by bunding for secondary containment.

Diesel is a very light oil (low viscosity) that, if accidentally released, would quickly spread into thin sheens.[44] Spilled diesel would then quickly evaporate, much in less than 24 hours, and/or disperse into the water column by wave action.[45] Diesel dispersed in the water column would biodegrade quickly. Rough seas and high temperatures of the location would increase the rate of natural evaporation and dispersion. Due to the low viscosity, diesel fuel tends not to emulsify like more persistent hydrocarbons (i.e. crude oil). Wind and currents in the region predominantly travel to the north or south, depending on tidal and seasonal factors, away from the sensitive shorelines and Critical Habitat. Diesel is not very adhesive; therefore, would not adhere strongly to sediments or shoreline habitats. Given these qualities, and that support vessels and the FSRU will have oil spill response equipment available, none of the diesel would be expected to reach the shoreline. The great majority of any diesel released would quickly evaporate, with only a small amount becoming entrained in the water column.

Diesel will also likely be used to power equipment in the construction and on-going maintenance of facilities at the Delivery Point. The amount of diesel that would be stored in the construction yard during construction is not yet determined, but would not be expected to exceed 3.79 m^3 at any one time. Diesel storage on shore would be in a tank situated within a bunded containment area covered with an impervious liner and protected with guardrails or pylons to prevent accidental damage from vehicles. Any diesel oil that might somehow spill outside of the containment area into the sandy / silty soil would collect on the soil surface and seep into the upper layers of soil, requiring remediation.

Other Potentially Hazardous Liquids

Small amounts of hazardous liquids will likely be stored on the FSRU as needed for on-going operation and maintenance. This will typically include:

- Lubricating or hydraulic oil (stored in drums or tote tanks in quantities of generally not more than 1.89 m^3)
- Solvents for cleaning (stored in sealed containers in quantities generally not more than .19 m^3 -.39 m^3)
- Paint (stored in sealed containers in quantities generally not more than .19 m^3)

As with diesel fuel, all of these liquids will be stored and refilled in bunded areas with secondary containment on the interior of the vessel.

The specific properties of the oil, solvents, and paints will dictate how quickly any such material would evaporate, disperse, or sink if accidentally released to the sea around the FSRU. In any case, the volume discharged to the sea in the very unlikely event of an accidental release would be small under any realistic release scenario.

Small quantities (generally less than 1.14 – 1.51 m^3 in aggregate) of lubricating oil as well as potentially solvents and other maintenance fluids will likely be stored and used at the construction yard to maintain construction equipment during construction, and at the Delivery Point to maintain the valve and pigging station during on-going operations. As described in relation to diesel fuel above, these fluids will be stored and normally used within bunded and

[44] National Research Council [USA]. 2003. Oil in the Sea III: Inputs, Fates, and Effects. The National Academies Press: Washington D.C.
[45] ITOPF. 2014. Fate of Marine Oil Spills. Accessed from the ITOPF website: http://www.itopf.com/knowledge-resources/documents-guides/document/tip-2-fate-of-marine-oil-spills/

impervious areas. Any releases outside bunded areas would permeate the top layer of soils and need to be remediated.

Solid Waste
Solid wastes include items such as paper, cardboard, wood, plastic and glass containers, junk equipment, used drums, filters, used oil and air filters, lumber and packing materials, spent batteries, light bulbs, cables, rags, etc. These wastes can be categorized further into recyclable materials, non-recyclable materials, and special wastes. Special wastes include materials that require special handling, such as containers used to store chemicals or lubricants, batteries, or medical wastes. All wastes will be packaged and transported to appropriate waste management companies for proper disposal or recycling.

Wastes that must be disposed onshore will be temporarily stored at the shorebase, prior to transport to an approved facility for proper disposal.

Accidental release of solid waste is possible from improper storage, transport, or disposal. Items released to the beach could be retrieved and disposed of properly, Items released to sea that sink would likely be deposited on the seafloor and be unable to retrieve. Items that float could be retrieved and deposited in the appropriate container. Strict procedures for waste management will be followed, and each vessel will have the IMO required Garbage Management Plan. Therefore any accidental release of solid waste would likely be limited.

5.3.4.2 Potential Impacts from Accidental Releases
Potential impacts to water quality and marine life from an accidental release could vary in intensity depending on the species impacted and nature of the release as discussed below.

- Degradation of Water Quality from Accidental Release
- Degradation to Air Quality from Accidental Release
- Harm to Fauna from Accidental Release
- Harm to Soil from Accidental Release (on-shore)
- Harm to Humans (Workers and Public) and Property from Accidental Release

Water Quality
In the marine environment, impacts to water quality can lead to adverse effects to marine life, as discussed further below. Marine organisms may be exposed to contaminants in water through direct contact or ingestion. Over longer periods decreased water quality may impact habitat, leading to larger-scale population-level or ecosystem impacts.[46] Various materials behave differently in the environment. A release of LNG to the water is unlikely to have any measurable impact on water quality because it will almost immediately evaporate or combust. Instead, the effects of an LNG release on the environment is discussed in terms of impacts to air quality below.

In the very unlikely event of a rupture in the seafloor pipeline planned to convey natural gas from the FSRU to the Delivery Point, a plume of gas that would rise to the sea surface and be released to atmosphere once exposed to the sea surface. Controlled studies of impacts to fish

[46] Population-level effects would be effects that cause a measurable decrease in species population within a study area. Examples could be an acute event causing multiple fatalities, or chronic event where the species' reproductive systems/abilities are impacted by exposure to toxins. An ecosystem level impact would be greater scale affecting multiple habitats and species.

from continuous exposure to seafloor natural gas releases have found that such exposure (i.e., continuous exposure over 4-5 days or exposure to a major gas blow-out) can cause pathological effects to exposed individuals[47]. However, in the case of the Project, any release from the pipeline would be short term (in any case less than one hour, as a ruptured pipeline would be shut in as pressure changes are detected) and mobile marine life would move away from the gas plume.

An accidental release of diesel, other hazardous liquids, or solid waste could, however, cause localized[48] water quality impacts. As noted, diesel is lighter and has a higher volatility than crude or fuel oil (neither of which will be stored nor produced as part of the Project), and thus tend to evaporate faster than such oils. Other contaminants (e.g., additives to lubricating oil or chemicals found in solvents or paint) have low volatility and thus are less likely to evaporate and slower to decay; these materials may persist for a longer period in the seawater surrounding the FSRU if spilled.

Air Quality

Computer-based dispersion models were run to predict the potential path that released LNG vapor would most likely to take if it were to be accidentally released to the environment – either to the water surface or to the air, from the proposed FSRU terminal. A number of different release and meteorological scenarios were considered in the modeling to predict the distance from the FSRU that the plume of evaporated gas would disperse to below the lowest concentrations at which the vapor could explode (the "Lower Explosive Limit", or LEL) if ignited. The modeling is important in oil spill response planning to help ensure that the necessary resources are in place to protect the environment in the event of an accidental release.

As a summary of the modeling results, Table 5-19 and Figure 5-22 show the distance to LEL in the event of either a release of LNG to water (from "Evaporating Pool") or directly to air ("From Vapor Release").[49] The dispersion of LNG from an accidental release to water is predicted to disperse much further from the FSRU before dispersing to less than LEL concentrations than would a release directly to the air (from a rupture/hole in a tank or transfer line or valve, for example). Only in 4 of the 24 modeled scenarios would the evaporating LNG from a release to the water be predicted to reach a distance of up to 1,200 meters from the FSRU before falling below LEL concentrations, and the maximum predicted distance under any scenario would be 2,450 meters. Because the FSRU is expected to located 2.4 km offshore (west of the shoreline), and given that predominant wind directions are either to the north (in the wet season) or to the south (in the winter), the modeling predicts that any LNG release would fall to below the lowest explosive levels well before it could reach shore.

The explosivity level of vaporized LNG is important to understanding potential environmental impacts both because of the potential environmental damage resulting from a fire and as an indicator of the gaseous constituents (principally methane) that are naturally occurring yet at a higher concentration in the vapor cloud than in ambient air conditions. Prior to dispersing to below LEL levels, the vapor cloud could in a very unlikely scenario be ignited, burn and generate heat and potential direct damage to fauna in the direct vicinity of a fire or explosion (see below). The constituents of LNG vapor are naturally occurring gases which will have no unusual effect on ambient air quality other than a localized increase in the concentration of

[47] See, for example, discussion in Patten, Stanislav. "Gas Impact on Fish and Other Marine Organisms" accessed at http://www.offshore-environment.com/gasimpact.html on 15 November 2016.
[48] Limited because of the limited quantities of these liquids to be stored on the FSRU.
[49] RPS ASA. 2016b. LNG Atmospheric Dispersion Modeling, Bangladesh. Unpublished Report.

gaseous carbon in the air surrounding the FSRU and a contribution of greenhouse gas (GHG) to the environment.

A release of LNG vapor, which consists of >95% methane, would emit a strong GHG to the atmosphere. If LNG were to be released and ignited, the combustion would convert the emission to carbon dioxide, which is a much less potent GHG. According to USEPA guidance[50] on GHG and their global warming potential, "Methane (CH_4) is estimated to have a global warming potential (GWP) of 28–36 [times that of CO2] over 100 years. CH_4 emitted today lasts about a decade on average, which is much less time than CO2. But CH_4 also absorbs much more energy than CO2. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. The CH_4 GWP also accounts for some indirect effects, such as the fact that CH_4 is a precursor to ozone, and ozone is itself a GHG." Section 5.3.3 regarding air emissions provides further discussion of this dispersed-scale air quality impact.

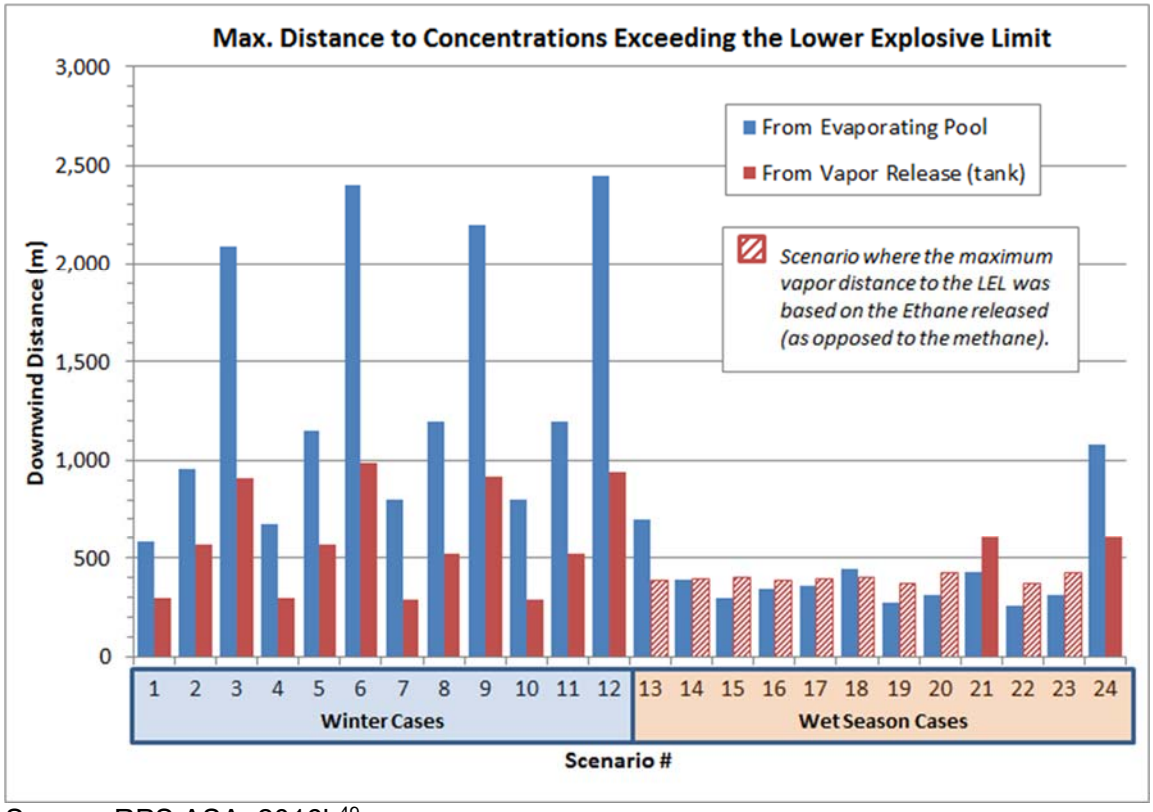
Table 5-19: Predicted Maximum Distance of Dispersion to Lower Explosive Limit Concentrations of Evaporated LNG in the Event of an Accidental Release from the FSRU

Scenario	Maximum Distance to LEL (m)		Scenario	Maximum Distance to LEL (m)	
	From Evaporating Pool	From Vapor Release		From Evaporating Pool	From Vapor Release
1	580	300	13	700	390
2	960	570	14	390	400
3	2,090	910	15	300	410
4	680	300	16	340	390
5	1,150	570	17	360	400
6	2,400	990	18	440	410
7	800	290	19	270	380
8	1,200	520	20	310	430
9	2,200	920	21	430	610
10	800	290	22	260	380
11	1,200	520	23	310	430
12	2,450	940	24	1,080	610

Source: RPS ASA, 2016b[49]

[50] See https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

Figure 5-22: Predicted Maximum Distance of Dispersion to Lower Explosive Limit Concentrations of Evaporated LNG in the Event of an Accidental Release from the FSRU



Source: RPS ASA, 2016b[49]

Fauna

As described in relation to water quality impacts, a release of LNG to the sea surround the FSRU would have very little if any chemical/degradation impact to aquatic life, whether it be to nekton (fish and marine mammals, for example), plankton, or benthos (marine life living on or within the seafloor sediments). As noted above, however, an LNG vapor release could under very unlikely conditions ignite while at the sea surface prior to dispersing below LEL concentrations and cause a fire or explosion that would cause direct, fatal damage to any fish or other marine life that might be in the direct vicinity of such a fire or explosion.

With regard to a spill of diesel or other hazardous liquid, aquatic life can be adversely impacted by contact with and ingestion of toxins from such a release. US EPA has stated that fish: "may come into direct contact and contaminate their gills; the water column may contain toxic and volatile components of oil that may be absorbed by their eggs, larvae, and juvenile stages; and they may eat contaminated food. Fish which are exposed to oil may suffer from changes in heart and respiratory rate, enlarged livers, reduced growth, fin erosion, a variety of biochemical and cellular changes, and reproductive and behavioral responses."[51] The level of impact considered in this type of impact would be much less likely to occur in response to a diesel spill (the worst likely case oil spill scenario for this Project) than for a crude oil spill from an offshore oil production activity, for example.

[51] United States Environmental Protection Agency (US EPA), Office of Emergency and Remedial Response, Oil Program Center. 1999. Understanding Oil Spills and Oil Spill Response. Retrieved from the US EPA website: http://www.epa.gov/oem/docs/oil/edu/oilspill_book/chap5.pdf

The critical habitat that exists for Spoon-billed Sandpiper , Great Knot, and Nordmann's Greenshank along the shore facing the offshore terminal deserve special attention in considering potential impacts to fauna from an accidental release by the project operations. The endangered and critically endangered species that inhabit this shoreline depend on very specific, limited habitat requirements, and (particularly in the case of the Critically Endangered Spoon-billed Sandpiper), even a modest alteration of those habitat conditions could cause a lasting, negative impact to the species populations. However, based on the modeling and analysis presented above, the only potentially credible scenario in which an accidental release of LNG or hazardous liquid from the project could impact such habitat would be if the gas delivery pipeline were to be somehow breached and ignited at a point on the beach, causing a fire on the beach. In such a case, individual animals could be harmed or killed if in direct contact with the fire, and vegetation on dry ground in the vicinity of such a fire could be burned and temporarily destroy or deteriorate nesting, feeding or other habitat conditions. A spill of diesel from vessel collision or from onshore construction activities could potential effect sensitive shorelines which are habitat for endangered species. The part of Sonadia known as Kaladia is at most risk, given its proximity to the Delivery Point. Such a spill could directly impact sensitive species themselves, or indirectly if food sources (i.e. invertebrates) or habitat (i.e. mudflats) were harmed for an extended period.

Soil

Any accidental spill of diesel fuel, lubricating oil or other hazardous liquid that might occur outside of a bunded and impervious containment area at the construction yard or Delivery Point would cause chemical and biological degradation of the impacted soil as well as the fauna and flora associated with the impacted soil area. The amount of hazardous liquid that would be used outside of a containment area would be very low. Such activities might include maintenance or fueling of individual vehicles/pieces of mechanized equipment, which would involve the use of <.19 m^3 of liquid at any one time, and typically much less. A spill of .19 m^3 might impact up to a maximum of 100 square meters of soil surface (=0.01ha) and permeate up to 1 meter below the surface, resulting in a volume of 100 cubic meters of contaminated soil, more if the spill were to flow over the surface to the intertidal zone or a waterway. As noted the vegetation (typically mangroves) and benthic organisms that inhabit the affected soil would also be impacted, resulting in diminished growth or death of species in the impacted area.

Humans and Property

An LNG vapor fire or explosion could potentially harm workers on the FRSU either through direct exposure to the explosion or fire, exposure to thermal radiation and heat from a fire, inhalation of smoke from a fire. Likewise, workers conducting maintenance activities at or near the delivery point could be harmed by a fire if there were a rupture of the line near where they are working and the escaping gas finds an ignition source.

An LNG fire or explosion could also damage the FSRU, its equipment or the pipeline. As described previously, the likelihood of such an event is very low (there are no recorded incidents of this having occurred.) Direct impact of a fire or explosion to the public is even more unlikely, because a safety zone will be maintained around the FSRU and because there are no residences or areas actively used by the public in the vicinity of the on-shore portion of the pipeline near and at the delivery point.

More likely, though still a low likelihood event, would be the potential for cryogenic LNG to spill from a vessel on the FSRU, and make contact with a worker or material on the vessel. Human

contact with the extremely cold LNG liquid prior to its rapid warming and vaporizing could cause very severe burns (frost bite) to the skin, potentially causing loss of the use of contacted parts of the body or infection. Contact of this liquid with metal or other objects could compromise the integrity of such material, potentially to the point of causing the contacted materials to weaken or break.

5.3.5 Positive Benefits

Positive impacts identified include potential benefit to biodiversity from enforcement of the safety zone and economic activities that will result from the project. These benefits are described below.

5.3.5.1 Biodiversity

No fishing will be allowed within the safety zone. Prohibition of fishing could potentially result in a positive impact to biodiversity, as it essentially creates a small marine protected area and sanctuary for fish. While the area is small (~79 ha), the vessel and subsea infrastructure will provide new subsea structure (i.e. habitat). Offshore oil and gas infrastructure are known to be good habitat for fish.[52] Establishment of safety zones may have a have a minor positive impact on biodiversity with a probable likelihood, resulting in a low significance. Potential impacts would be irreversible, localized, and long-term (over life of project).

5.3.5.2 Economic Benefits

The Project is not expected to result in many permanent jobs in Bangladesh, directly. Given the complex nature of construction and operation activities, highly specialized and experienced workers are needed to ensure timely, well communicated, and safe completion of activities. Local activities to support the project in Bangladesh are expected to be limited to the temporary housing of off-duty workers in area hotels and transport of workers through local airport. In addition, the project may create an additional temporary need for dock services and provision of food and materials, thereby creating a few additional jobs.

The most significant benefit of the project relate to the indirect impacts that will result from economic growth likely to result from additional gas supply. The country currently faces natural gas shortages of approximately 500-650 MMSCFD and these shortages have caused disruption in industrial production, particularly in the clothing, ceramics, fabrics, and steel industries. [53] [54] Thus, the gas delivered by the project would fill a majority of the shortage, although it is unclear if the shortage is in the Chittagong region. In either case, the project will support the production of significant additional electricity in Bangladesh. Reliable long-term availability of natural gas is critical to the development of competitive industry in the country, economic growth, and well-being of the people of Bangladesh (40.1% of whom still have no access to electricity).[55]

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[52] Claisse, J.T., Pondella, D.J., Love, M., Zahn, L.A., Williams, C.M., Williams, J.P., and A.S.. Bull. 2014. Oil Platforms Off California are among the Most Productive Marine Fish Habitats Globally. PNAS, October 28, 2014. Vol. 111, no. 43.

[53] Rasel, A.R. 2015. 'Gas crisis in Chittagong to go in 2 years'. Dhaka Tribune, 11 October 2015. Accessed form the Dhaka Tribune website: http://archive.dhakatribune.com/bangladesh/2015/oct/11/gas-crisis-chittagong-go-2-years

[54] Daily Star. 2016. '124 garment factories hit by gas shortage' Daily Star, 15 May 2016. Accessed from the Daily Star website: http://www.thedailystar.net/business/124-garment-factories-hit-gas-shortage-1224082

[55] World Bank. 2016. 'Access to electricity (% of population)'. Accessed from the World Bank website: http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS

Positive impacts from the project will also result from limited direct job creation. The consequence of this impact is negligible and likelihood probable, resulting in an impact significance of low. Indirectly, however, the project will create economic growth and improve the well-being of many people. This impact consequence can be considered moderate with a probable likelihood, resulting in an impact significance ranking of high.

5.3.6 Associated Facilities

Moheshkhali Floating LNG will tie-in to a pipeline owned and operated by the Bangladesh Gas Transmission Company Limited (GTCL), a subsidiary of Bangladesh Oil, Gas & Mineral Corporation (Petrobangla). While the gas pipeline is being advanced by a separate developer under separate contracts and financing, it is considered an "associated facility" by the IFC Performance Standards as the primary purpose of the pipeline is, at present, to receive and transport gas from Moheshkhali Floating LNG and the project would not be viable without it.

In order to gather data to help characterize potential environmental and social impacts from the completed construction of the pipeline, known as the Anowara - Moheshkhali pipeline (GTCL pipeline), and to evaluate what (if any) risk those impacts may pose to the Project, Excelerate commissioned BETS Consulting Services Ltd. (BETS), a Bangladesh consultancy, to conduct a brief survey of the pipeline route.

At the time of the signing of the Terminal Use Agreement[56] in July of 2016, GTCL had completed 88 of the 89.4 km total length of the pipeline, of which the entire pipeline is buried. When the field team from BETS visited sites along the completed right of way (RoW) in December 2016 the pipeline construction activities had been completed, with the exception of final activities at one river crossing. At the time of the ESIA completion, all pipeline construction is believed completed.

The survey (Appendix H) included:

- Coordinating with Petrobangla and gathering information on project status, pipeline location, contractors used, and mitigation and management measures implemented
- Gathering information from the Deputy Commissioner's offices in Chittagong and Cox's Bazar on compensation records and status
- Driving the pipeline route to the extent feasible, particularly areas near communities and of environmental sensitivity (i.e. through mangroves, forested areas, and river crossings and riparian areas)
- Conducting limited interviews with project affected stakeholders
- Documenting findings with photographs and mapping

5.3.6.1 Location and Setting

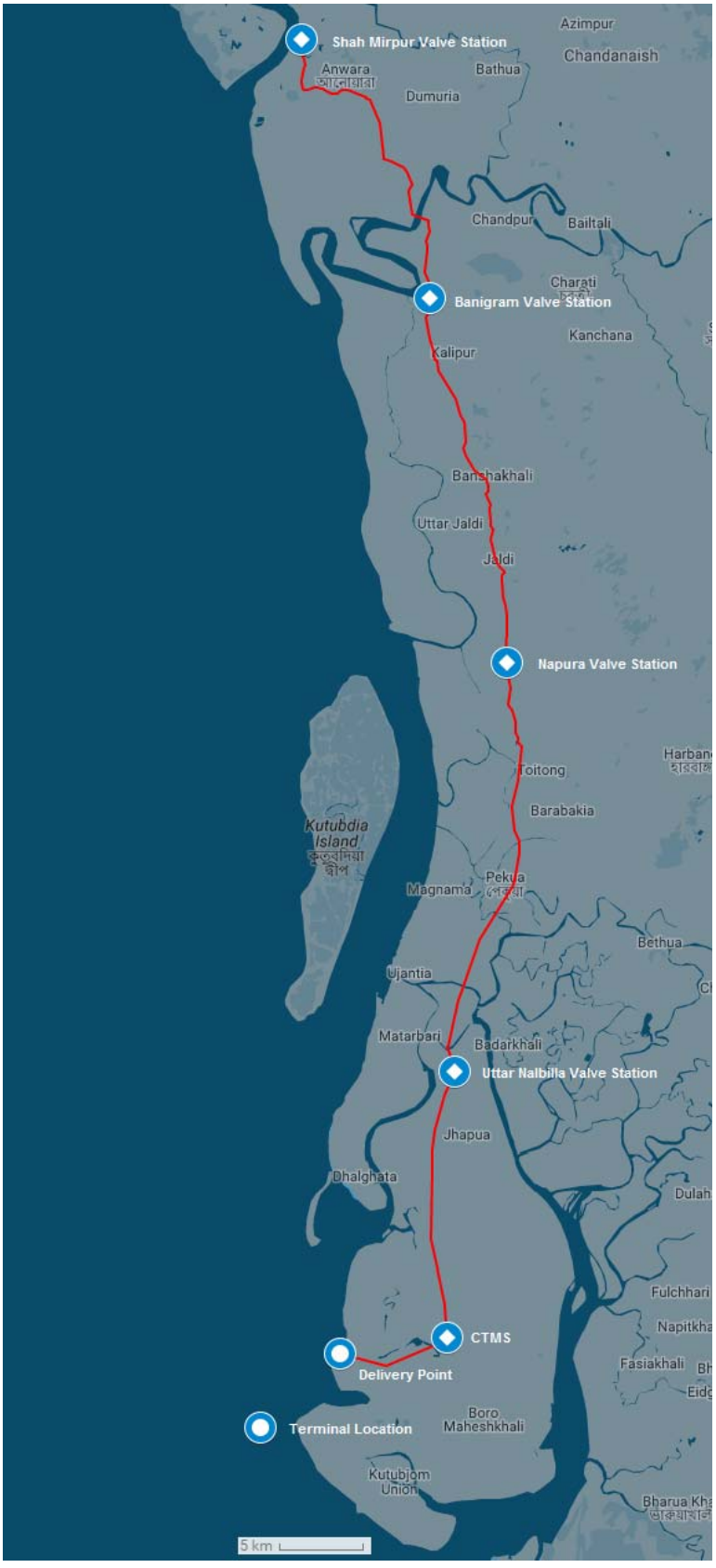
The location of the pipeline route is shown in Figure 5-23.

The pipeline route RoW from the Delivery Point travels eastward through the Sonadia Island ECA for approximately 3.5 km, of which 2.3 km are mangroves and the remaining are abandoned salt pans. Sonadia Island ECA is considered Critical Habitat under IFC Performance Standard 6. The pipeline then turns northward to Anowara through active aquaculture, agriculture, and limited forested areas. Approximately 26 km of the RoW in the south are artificial ponds used for salt and shrimp farming and is not populated. After construction, agricultural activities can take place within the RoW, although no trees can be planted. There will not be any permanent disruption of economic activities. The remaining pipeline route in the

[56] The TUA was agreed between Excelerate Energy Limited Bangladesh and Petrobangla

north (approximately 60.5 km) becomes more populated and is scattered with trees along river edges and near homesteads. However, the pipeline route largely avoids physical impacts to homes and property. The pipeline route crossed a number of rivers and streams.

Figure 5-23: Pipeline Route



5.3.6.2 Assessment of Pipeline Construction Impacts

Physical Environment

The field survey conducted by BETS indicates that the environmental impacts of the pipeline construction project are characterized as “moderate” at present, based on the evaluation presented in Table 5-20. However, the construction activities were not fully completed during the field visit. The contractors will need to apply restoration practices consistent with good international industry practice (GIIP)[57], to ensure that the impacts can be reduced to a lower level over time, particularly at water crossings. The “moderate” impact categorization is based on the observations noted in the following table.

Table 5-20: Physical Environment Impact Characterization

Resource Observed	Evidence of Impact Observed	Conse-quence	Likeli-hood	Impact Category
Soils	Soils not yet stabilized after backfilling of some areas, including along water courses, presenting a risk of significant erosion and loss of topsoil. Not widespread but intense in localized areas of impact.	Minor	Probable	Low
Hydrology and Water Quality	Trenching not backfilled, side cast spoils and bentonite piles not removed, and sites not restored to previous grading in some areas, including along and near water courses. This could result in sedimentation of rivers and (occasionally) alter drainage and cause associated mid to long term impacts in residential areas, agricultural fields and wildlife/fishery habitat.	Moderate	Occasional	Medium
Vegetation	No evidence of revegetation along disturbed surfaces at time of field survey, though natural mangrove regeneration has begun to take effect naturally in areas where mangroves were disturbed. Some mangrove die off due to side-cast or eroded sand deposition, which could (occasionally) cause longer term impacts to vegetative communities and dependent habitat.	Moderate	Occasional	Medium
Protected Areas and Critical Habitat	Approximately 3.5 km of the pipeline route are within the Sonadia Island Environmentally Critical Area which is considered Critical Habitat under IFC Performance Standard 6. The pipeline RoW	Moderate	Probable	High

[57] See in particular the IFC’s EHS Guidelines for Gas Distribution Systems, (http://www.ifc.org/wps/wcm/connect/9c6e3d0048855ade8754d76a6515bb18/Final+-+Gas+Distribution+Systems.pdf?MOD=AJPERES) and the IFC General EHS Guidelines

Resource Observed	Evidence of Impact Observed	Conse-quence	Likeli-hood	Impact Category
	(23 m) required clearance of .053 km2 of mangroves within the protected area, as well as .023 km2 of mud flats that were previously used as salt pans and shrimp ponds.			

Social Environment

The field survey conducted by BETS indicates that the social impacts of the pipeline construction project are characterized as “low” to “moderate” overall at present and as with the environmental impacts these can be reduced to a lower level over time with proper restoration. The “moderate” impact categorization is based on the observations noted in Table 5-23.

Of particular importance to the level of social impact observed from the pipeline construction is the very limited amount of resettlement that appears to have been required. Observations and interviews with land holders during the field survey and a review of the satellite imagery showing the pipeline route suggest that only one household was permanently displaced, and the number of other properties that were impacted to the point of requiring compensation was less than envisioned in the original EIA, developed in 2012 by BETS. A summary of the information provided by Deputy Commissioners on amount and status of compensation provided is shown in Table 5-21 and Table 5-22. These findings are lower than the original pipeline impact assessment which estimated 2,670 households (approximately 11,287 people) would be economically displaced by the project, including 4 families losing land and homes, and one stakeholder losing business infrastructure. A Resettlement Action Plan (RAP) was envisioned by BETS and mentioned in the original EIA, as a key mitigation element that would ensure appropriate communication, compensation, and restoration of livelihoods as appropriate. However, no RAP was produced, although the local legal framework (Acquisition and Requisition of Immovable Property Ordinance, 1982) appears to have been followed, led by the Deputy Commissioners.

The data provided by Deputy Commissioners is incomplete. Some data was provided on the number of stakeholders impacted in Chittagong District and no data was provided for number of stakeholders impacted in Cox’s Bazar District. In order to estimate the number of households and stakeholders impacted (to compare to the data provided in the original EIA) in the Chittagong district, the ESIA team took an average number of impacted stakeholders per ha from Case Number 20/2011-12 and Case Number 12/2014-15 and normalized for area of land acquired and average household size[58]. Using this methodology, the Chittagong district impacts 4.13 households/ha (20.7 people/ha) for a total of 461 households (2,308 people).

Unfortunately, no data was provided on the number of people impacted in Cox’s Bazar cases, nor was the total area of each case reported. In order to estimate the number of households and people affected in the Cox’s Bazar District, the ESIA team took the total number of stakeholders impacted in Chittagong (2,308) and normalized for population densities, length of pipeline in

[58] According to the 2011 census, the average household size in the Chittagong Division is 5.01.

each district, and average household size.[59] Using this methodology, the Cox's Bazar District impacts 293 households (1,470 people).

Based on the above methodology, approximately 754 households (3,778 individuals) were impacted by the pipeline construction. There are flaws to this methodology, most notably the area of requisition is adjacent to the area of acquisition, and therefore the same landowners are most likely double counted in most instances. If one was to assume only 25% of land required temporarily (requisition land), the total number of stakeholders affected would drop to 530 households (2,654 individuals). While the approach described is imperfect, it provides an estimate from which the ESIA team can assess the impacts and risks. Further, more clarity will be provided as the processes advance.

This is a linear project with a RoW 23 m wide. Thus, the RoW may only represent small percentages of each individual's land holdings, and, given farming is allowed after construction, the impacts are largely temporary. While restoration of berms and farm land by contractors may not occur, these impacts could be addressed by farmers if needed (i.e. manually fixing berms with shovels and/or grading land with rakes).

[59] According to the 2011 census, the population density of Chittagong District was 1,400 people/km^2, the population density of Cox's Bazar District was 920/km^2, and the average household size in the Chittagong Division is 5.01. Approximately 45.4 km of the pipeline was in Chittagong District and 44 km of the pipeline is located in Cox's Bazar District.

Table 5-21: Status of Compensation in Anwara, Bashkhali & Patiya Upazila, Chittagong District

Sl. No.	Land Acquisition Case Number	Acquisition / handed over / Requisitioned Land (ha)	Land Compensation (BDT)	Compensation for infrastructure damage (BDT)	Trees /crop compensation (BDT)	Total compensation plus 50% (BDT)	No. of People Compensated	Compensated Amount (BDT)	Remarks
1	20/2011-12 (acquisition)	36.0063	264,136,988	21,760,668	4,645,629	435,814,927	737	201,546,536	Compensation process on-going - 46% complete.
2	21/2011-12 (requisition)	66.1422					1,369 (estimated by ESIA team)		Case work on-going
3	12/2014-15 (acquisition)	0.9765	34,605,828	1,372,764	125,600	54,156,288	30	20,403,739	Compensation process on-going – 38% complete.
4	02/2015-16 (Handover)	5.6490	22,164,977	261,445	384,976	34,217,097	Owned by government , so ESIA Team assumes no people impacted	27,459,433	Deposition of Khash Land - 80% complete
5	07/2015-2016 (acquisition)	2.0780	80,495,816	889,143		122,077,439	43 (estimated by ESIA team)		Compensation disbursement not yet started
6	08/2015-16 (requisition)	6.2081					129 (estimated by ESIA team)		Case work on-going

Notes:

- Acquisition/handed over/ Requisitioned Land (Acre):
  - Acquisition of land is the purchase of land.
  - Handed over of land is to exchange of land ownership from one government body to another. Particularly khash (govt. land) land needs to exchange.
  - Requisition of land is the temporary acquisition of land.
- Land compensation: Compensation made for the land acquisition/requisition/handover.
- Compensation for infrastructure damage: Compensation made for building, roads, power supplies etc.
- Trees/crop compensation: Compensation made for tree cutting, damage of crop etc.
- Total compensation plus 50% (BDT) includes compensation for the land, infrastructure, trees/crop damages times 1.5 the real calculated damage.
- No. of Compensated People: Total number of peoples who are compensated.
- Compensated Amount: The amount of money has already been compensated by the DC office.
- Estimated no of people compensated are based on a rate of 20.7 people impacted per ha

Source: BETS

Table 5-22: Status of Compensation in Brief of Moheshkhali Upazila, Cox's Bazar District

Sl. No.	L.A. Case No.	Compensation of Land including Additional 50% (BDT)	Compensation of Infrastructure including Additional 50% (BDT)	Compensation of Crop / trees including Additional 50% (BDT)	Total Cost including Administrative Cost (BDT)	No. of People Compensated	Remarks
1	01/2012-13 (acquisition)	147,138,654	10,295,863	1,009,148	170,326,940	1,470 combined (estimated by ESIA team)	Handed over possession to GTCL on 16/02/2016 after disbursement of compensation
2	01(1)/2012-13 (requisition)	-	54,047,221	39,395,228	100,450,632		Handed over possession to GTCL on 16/02/2016 after disbursement of compensation

Source: BETS

Table 5-23: Social Impact Characterization

Resource Observed	Evidence of Impact Observed	Conse-quence	Likeli-hood	Impact Category
Land Use (Displacement and Resettlement)	In contrast to the original EIA predictions, it appears impacts were limited (destruction followed by due compensation for 1 structure). While no RAP was produced, it also seems that significant displacement was avoided, the project followed the compensation process required by local law (see Chapter 3), and the stakeholder whose house was demolished was satisfied by the compensation provided.	Minor	Probable	Low
Land Use (Compensation in cases of Displacement or Land Use Impact)	Pipeline construction is all but complete; compensation for land access and impacts is lagging. Based on the conservative methodology, the ESIA team estimates 1,820 out of 3,778 (48%) have been provided compensation and it is unlikely that all will be ultimately compensated. According to BETS, the manner in which compensation is progressing is typical. There are challenges with land registration; communication is hampered by illiteracy among land occupants, and compensation rates below current market. While affected people do have legal remedy, the cost of pursuing claims in court are prohibitively high relative to compensation amounts. Field interviews indicate that stakeholders are generally satisfied with the access and compensation process being followed, but the interview results may be suspect given that some indicated satisfaction even without knowing if their compensation would be received. At highest risk are unregistered tenants, who may lack the resources to pursue compensation claims. The number of tenant farmers affected is not known. Some affected people decided not to pursue compensation, given the small value of their claims (for temporary loss of agricultural land) and cost of pursuing remedy (e.g. travel expenses), see	Moderate	Occasional	Medium

Resource Observed	Evidence of Impact Observed	Conse-quence	Likeli-hood	Impact Category
	interview with Mohammad Idris Badsha on page 10 of the BETS report). See discussion of land tenure challenges in Section 3.2.3.2.			
Agriculture	Aside from loss of trees, it appears that agricultural impacts are generally temporary, as crops are now being cultivated on the RoW for the most part. Some of the more significant hydrologic changes left in place after construction (disturbance of agricultural berms on pond edges) could change drainage to agricultural areas over time and cause mid to longer term decline in the productivity of or access to these areas for farming. However, it is BETS' opinion that disturbance to berms can be remedied by farmers which leads to the low impact significance.	Minor	Occasional	Low
Human Rights - Labor	BETS indicate that the 7 contractors hired to complete the pipeline hired skilled labor locally, and paid per daily market rates. There is no indication of underage workers being employed.	Minor	Probable	Low
Worker and Community Health and Safety	It appears that contractors were uneven in their ability to provide safe working conditions. Workers were working without personal protective equipment and dangerous equipment was found without adequate safeguards in populated areas (in one case an electrical generator left unfenced in a residential area), raising concerns for the health and safety of both workers and the public (communities) along the RoW.	Moderate	Occasional	Medium

5.3.7 Cumulative Impacts

The ESIA team evaluated the potential cumulative environmental and social impacts that could result from the proposed project activities in combination with current actions and reasonably expected future developments in the area.

Bangladesh Power Development Board intends to develop up to 5,000 ha on Moheshkhali Island for a multi-plant power complex with total generation capacity up to 9,000 MW and deep

sea port.[60] [61] However, reports of the planned development range in capacity and design, and it is unclear if the projects are feasible. Current projects nearing the construction stage include:

1. **Matarbari Coal Fired Power Plant (1200 MW)**: Coal Power Generation Company of Bangladesh Limited (CPGCBL) intends to build the power plant and associated facilities, including: jetty and coal handling facilities for coal import, coal storage, township development, rural electrification, and construction of transmission facilities and roads. The project has received environmental approval and financing (by JICA), and an MOU for implementation was signed between CPGCBL and Sembcorp of Singapore. The Matarbari coal fired power plant will be located approximately 18 km north of the Terminal Location on the Island of Moheshkhali. For additional detail, visit: http://www.cpgcbl.gov.bd/

2. **Single Point Crude Offloading Mooring**: The single point mooring being developed by Eastern Refinery Limited (ERL) will be located offshore the west side of Moheshkhali Island, approximately 11 km north of the FSRU. The project will include installation of a single point mooring, two 36" pipelines, and tank farm. Crude offloaded will be transferred from the tank farm to the ERL refinery in Chittagong. The project will accommodate offloading of tankers up to 120,000 DWT.

3. **500 MMSCFD FSRU**: In addition to the proposed FSRU being developed by Excelerate, Summit LNG Terminal Company recently signed an agreement with Petrobangla to develop an FSRU offshore the west side of Moheshkhali.[62] The project would have a similar design to Excelerate's project and would include installation of FSRU and related infrastructure required to supply 500 MMSCFD/day of gas to the grid. The location of the FSRU is not yet known, but likely to be within a few km of the Excelerate FSRU.

A feasibility study for deep sea port conducted in 2009 selected Sonadia Island, less than 5 km from the FSRU, as the preferred site. However, it is unclear if this project will proceed.

Other potential projects include an onshore LNG terminal on Moheshkhali Island (1,000 MMSCFD).

Cumulative effects identified from project activities and reasonable foreseeable other activities in the region could include degradation of local air quality and increase in global greenhouse gas emissions, increased pressure on threatened species, and increase marine vessel traffic.

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[60] Bangladesh Power Development Board (BPDB). 2012. Final Report on Consulting Services on Coal Sourcing, Transportation and Handling of (2x660) MW Coal Based Thermal Power Plants Each at Chittagong and Khulna, and 8320 MW LNG and Coal Based at Maheshkhali. Accessed from the Bangladesh – India Friendship Power Company Limited Website: http://bifpcl.com/new/wp-content/uploads/2014/06/EIA-Report-Volume-V.pdf

[61] BPDB. 2014. Expression of Interest for consultancy services. Accessed from the BPDP website: http://www.bpdb.gov.bd/download/maheshkhali9000MW/EOI%20Notice_%20Maheshkhali%209000%20MW%20Power%20Plant.pdf

[62] Offshore-technology.com. 2017. "Summit Group to develop $500m LNG terminal in offshore Bangladesh". January 5, 2017. Accessed from the Offshore-technology.com website: http://www.offshore-technology.com/news/newssummit-group-to-develop-500m-lng-terminal-in-bangladeshs-offshore-island-5709753

5.3.7.1 Impacts of Air Emissions

As noted above, there are a number projects that are likely to be developed in the project area in the near future. It is also possible that additional projects will also developed in the project area over the 15-year lifespan of the project, as the government would like to see Moheshkhali Island become an energy and industrial hub.[63] All of Moheshkhali Island, including the project area, can be considered the same airshed, thus should be considered together from a cumulative impact assessment perspective.

These projects will have a negative impact on air quality, which could secondarily affect human health and wildlife.

No ambient air quality data is available for the areas offshore Moheshkhali. However, site reconnaissance and review of previous studies (e.g. original EIA and Sonadia Port Feasibility Study) suggest the air quality in the area is good. Sources of air pollutants in this rural coastal area are limited to emissions from fishing and other boats offshore, smoke from cooking fires, and limited vehicle traffic in the central and eastern parts of Moheshkhali Island.

Air emissions from Moheshkhali floating LNG construction will be temporary and are considered negligible. During operation, key emissions sources include the FSRU and LNG carriers. As described above, project emissions are not expected to result in exceedances of Bangladesh ambient air quality standards at the shoreline (2.4 km east). The project point source emissions also meet applicable World Bank Industry Sector Guidelines for Shipping.

In view of the uncertainties and data gaps in project information it is challenging to assess the cumulative impacts on air quality from the potential developments in the project area, but given the scale of the developments the impacts could be considered significant. However, there are many actors involved and Excelerate has little ability to influence the other projects.

In cases where there is a significant risk for cumulative impacts, but a developer has limited leverage over the solution, IFC's Good Practice Handbook on Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets requires the developer to, "…be accountable only for the design and implementation of mitigation measures commensurate with the magnitude and significance of its contribution to the cumulative impacts. However, individual sponsors should use their best efforts to engage other developers, governments, and other stakeholders in acknowledging the cumulative impacts and risks and in designing coherent management strategies to mitigate them."

Therefore, mitigation measures are required to mitigate this risk. As noted in Section 5.3.3, the significance of degradation of air quality impact was raised from low to medium as a result of the cumulative impact concern. Mitigation to address cumulative impacts to air quality will be addressed in Chapter 6.

The project will also contribute to global greenhouse gas emissions, as the project will generate approximately 75,000 tons of CO_2 emissions annually. IFC performance standards require reporting all projects with emissions over 25,000 annually, thus this requirement is triggered. In 2012, Bangladesh's total CO_2 equivalent emissions were 190 million metric tons ($MtCO_2$).[64] The

[63] Personal communication with Deputy Commissioner of Cox's Bazar district.

[64] USAID. 2012. Greenhouse Gas Emission in Bangladesh. Accessed from the climatelinks.org website: https://www.climatelinks.org/sites/default/files/asset/document/GHG%20Emissions%20Factsheet%20Bangladesh_4-28-16_edited_rev08-18-2016_Clean.pdf

project with will therefore represent .0395 percent of the total emissions in Bangladesh. As the alternative sources of electricity planned in Bangladesh are coal, the Project is an environmentally preferred option.

5.3.7.2 Pressure on Threatened Species

Sonadia Island is habitat for numerous threatened and endangered species, and is key habitat for the Critically Endangered Spoon-billed Sandpiper. Spoon-billed Sandpiper habitat destruction is suspected to be a key factor leading to species declines.[65] Project activities, particularly construction of the delivery point, may disrupt sensitive species. As noted above, additional mitigation is required to manage these impacts. The impacts described above are temporary, and after construction the on-going impacts to sensitive species is expected to be negligible. The project will conduct long-term monitoring of biodiversity on Sonadia Island, which will monitor any potential changes and make a positive contribution to the knowledge base and future conservation actions.

Thus, while the project may have a short term, limited impact to sensitive species, the overall impact from the project is expected to be positive.

Construction of the deep-water port at Sonadia would have significant long term impacts on sensitive species. However, the proposed project would not worsen these impacts.

5.3.7.3 Increase Marine Vessel Traffic

The project is expected to increase marine traffic between the FSRU and Chittagong Port. Project related vessel traffic would be negligible relative to all other marine traffic. The increase in traffic could lead to disruption of fishing activities, although project related fishing impacts will be mitigated, thus the long-term cumulative impact to fishing is considered negligible.

The project will also require port services and use of supporting industries, such as waste management providers. Chittagong is the largest port in Bangladesh, and discussions with the Chittagong Port Authority did not identify any capacity constraints. The impact of project related activities at port would likely result in net economic benefit and limited environmental and social impacts.

5.3.8 Trans-boundary Impacts

The FSRU is located more than 100 km north of the nearest national maritime boundary (with Myanmar). Under a worst case LNG spill, the maximum extent of the liquid and vapor emissions is 2.5 km. LNG Carriers will travel from international ports to the FSRU to support the project, but potential impacts of LNG Carriers are considered negligible, as standard procedures for ballast water management will be implemented. Wastes from the project are expected to be shipped to approved waste disposal facilities in Chittagong, so no transboundary impacts are anticipated from waste disposal.

Project activities and potential impacts are limited to near the FSRU and Delivery Point, thus no trans-boundary impacts are expected.

[65] IUCN. 2013. IUCN Redlist: Calidris pygmaea. Accessed from the IUCN website: http://www.iucnredlist.org/details/22693452/0

5.4 Data Gaps and Uncertainties

Relevant uncertainties and gaps identified include:

- Ambient air quality: No baseline air quality monitoring was conducted as part of the original ESIA, and it was not feasible to conduct air quality monitoring in the schedule permitted to develop this ESIA. Site reconnaissance and review of existing studies indicate that sources of air pollutants in this rural coastal area are limited to emissions from fishing and other boats offshore, smoke from cooking fires, and limited vehicle traffic in the central and eastern parts of Moheshkhali Island. As the project 1) is located offshore, 2) adjacent areas are fairly remote and industrial activity limited, and 3) the predominant wind is from the south (open ocean), it is likely that the air shed is considered 'non-degraded'.
- Distribution and abundance of sensitive fauna: the key sensitive species in the project area are 1) shorebirds, and 2) sea turtles. Chapter 4 provides historical records for both shorebirds and sea turtles, but only shorebird data is current. The most recent data for sea turtles is from 2010 and should be updated and tracked as part of the Biodiversity Monitoring and Evaluation Plan. However, the information from 2005 – 2010 indicates a steady nesting trend and clear indication of species present and provides sufficient understanding to evaluate the potential impacts. Occurrence of marine mammal species in the project area are expected to be limited based on secondary data sources. Observations by the BSCP indicate dolphins are the most common marine mammals, but even these are rare. No marine mammals were observed during the roughly one month geotechnical and geophysical survey.
- Distribution and abundance of fish: Detailed secondary data on demersal and pelagic fish species are provided in Chapter 4, but no fish survey was conducted. It is unlikely that a short term fish survey would be either representative or complete, thus would not likely add additional value to the impact assessment.
- Flora survey: the original EIA team conduct a rapid site appraisal for the onshore footprint that included a qualitative evaluation of flora at the site. Details of a robust and scientific flora survey conducted by Bangladesh Forest Department of Sonadia Island are included in Chapter 4. As the onshore footprint is limited, no additional site survey was conducted for this ESIA.

None of these gaps represented a considered great enough impediment to prevent a reasonable evaluation of potential project impacts or development of appropriate mitigation measures to address the potential impacts identified for the project.

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6 Mitigation and Management

6.1 Introduction

The impact evaluation presented in Chapter 5 identified impacts with low, medium, and high level pre-mitigation significance rankings associated with the proposed Moheshkhali Floating LNG project. The impacts with low level significance ratings are considered not to require further mitigation beyond the application of standard industry controls, while the impacts with medium and high level significance ratings are considered to require further mitigation to bring the overall significance to a low level.

Before introducing the proposed mitigation measures for the Project, an overview of the Excelerate environmental and social management structure is presented, as well as a discussion of some of the key management practices that will be in place.

6.2 Environmental and Social Management Structure

Excelerate will maintain overall responsibility for environmental and social management, but day-to-day implementation of controls and mitigation will largely be the responsibility of the engineering, procurement, and construction (EPC) contractor, Geocean Entrepose (Geocean), operations and maintenance (O&M) contractor, EXMAR Ship Management (ESM), and ports services contractor, Svitzer. Stakeholder concerns will be managed by Excelerate throughout the project. No shore-leave is foreseen and in-transit accommodation will be strictly limited.

A brief description of each company is provided below.

6.2.1 Excelerate Energy

Formed in 2003, Excelerate is the pioneer and market leader in innovative floating LNG solutions. They provide integrated services along the entire LNG value chain with an objective of delivering rapid-to-market and reliable LNG solutions. Excelerate is the operator of the largest fleet of FSRUs in the industry with over $3 billion in assets, including nine FSRUs and one LNG carrier.

The Excelerate Environmental Policy is provided in Figure 6-1. Excelerate has a long-standing relationship with ESM and will ensure all contractors manage environmental and social issues according to contract requirements and good international industry practice.

Excelerate is ISO 9001 certified.

Figure 6-1: Environmental Policy

excelerate energy®	Environmental Policy			
Prepared by: MJT	Approved by: RAB	Revision No.: Revision 0	Issue Date: 15 Sep 2016	Page 1 of 1

A core value for Excelerate Energy, L.P. is our continuing commitment to the environment throughout all of our business operations. We value and expect excellence in our environmental performance, and firmly believe that the energy solutions we provide will help improve the environment. We require that our businesses and facilities are operated and maintained in a manner that ensures the stewardship of the environment in which we operate.

Environmental Policy

Our commitment to excellent environmental performance and personal accountability for that performance is communicated throughout all levels of the organization, and we take a variety of measures to ensure that message reaches every employee.

Objectives

Environmental Objectives:

- ADVISE each manager, supervisor, employee and contractor of his or her responsibilities with regards to the environment and to ensure performance measurements.
- COMPLY fully with all applicable laws and regulations.
- DESIGN and operate facilities worldwide using the practices necessary to protect human health and the environment.
- ASSESS environmental risks before starting a new activity or developing a new facility/site.
- PROVIDE training to protect our employees and the environment.
- PARTICIPATE in proactive efforts to improve technology laws and regulations.
- PROVIDE professional staff to support environmental activities.
- MONITOR and report performance for continuous improvement.

Excelerate Energy places the same emphasis on achieving industry-leading environmental performance that we place on achieving outstanding productivity, cost control, and earnings. To ensure we maintain our focus, environmental performance is a key factor in the overall assessment of the Company performance.

At Excelerate Energy, L.P. we believe outstanding business performance and outstanding environmental performance must go hand in hand.

Rob Bryngelson CEO

6.2.2 Geocean

Geocean is a marine contractor based in Marseille, France, with 30 years of experience worldwide and a specialization in turnkey solutions for the offshore oil and gas industry. Geocean operates a fleet of specialized vessels and equipment (e.g. submarine excavators and lay barges), able to work in the most severe conditions reliably and safely.

The company is ISO 9001 certified and dedicated to integrity of its operations and services. It strives to complete projects in strict observance of the value of human life and company ethics.

6.2.3 ESM

ESM, based in Belgium, is a maritime and offshore asset management business. It provides crew, commissioning services, operational management, and maintenance services for FSRUs, vessels specialized in performing ship-to-ship transfers of LNG, and other offshore units. Excelerate and ESM have worked together since 2003, and ESM is the technical manager for all of Excelerate's FSRUs worldwide.

ESM has the following certifications:

- ISO 29001 – quality management system for product and service supply organizations for the petroleum, petrochemical and natural gas industries
- ISO 14001 – environment management system
- ISO 9001 – quality management system
- OHSAS 18001 – occupational health and safety management system

6.2.4 Svitzer

Svitzer, a Maersk Group Company, is based in Denmark has been in operation since 1833. With a fleet of 430 vessels, Svitzer provides service in three areas: 1) harbor towage, 2) terminal towage, and 3) salvage and emergency response. Svitzer has highlighted that it is dedicated to deliver the highest degree of safety in operations, ensuring safe, reliable, and efficient operations. The company is implementing a new safety management system that complies with OVMSA (Offshore Vessel Management and Self-Assessment), a code that incorporates best practices from other standards, including: OHSAS 18001, ISO 9001, ISO 14001, ISM Code, UK HSE, and AMSA.

6.2.5 Roles and Responsibilities

Roles and responsibilities of key staff responsible for environmental and social management for construction are described in Table 6-1 and for operation described in Table 6-2.

Table 6-1: Roles and Responsibilities during Construction

Staff	Roles and Responsibilities
Senior Manager of Environmental Permitting (Houston based)	The Senior Manager of Environmental Permitting will lead the following activities: • Permitting and IFC Compliance • HSE and Security management • Stakeholder engagement through construction • Management of Government Authorizations Register • Coordination with Biodiversity Lead (External) • Liaison with Houston based team • Hand-over to HSE Compliance Coordinator

Staff	Roles and Responsibilities
Construction Manager (Chittagong based)	The Construction Manager will lead the following activities: • Onsite HSE Supervision • Liaison with subcontractor HSE representatives
HSE In-country Representative (Chittagong based)	The HSE In-country Representative will lead the following activities: • Monitoring of HSE compliance • Draft reporting, including biodiversity • Liaison with subcontractor HSE Representatives • Stakeholder engagement and grievance management
Vice President of Government, Environmental and Regulatory Affairs (Houston based)	Vice President of Government, Environmental and Regulatory Affairs will lead the following activities: • Setting environmental and social policies • Ensuring compliance with environmental and social policies
Geocean HSE Representative	The HSE Representative will lead the following activities: • On site management • HSE monitoring and reporting • Internal auditing
Biodiversity Lead (External)	While Excelerate will maintain responsibility for managing biodiversity, it will engage local specialists from the Bangladesh Spoon-billed Sandpiper Conservation Project (BSCP) to support implementation of the Biodiversity Action Plan (BAP), including monitoring. BSCP was included on the ESIA team, and will be involved with developing the BAP. During construction, the Biodiversity Lead will conduct monitoring and report findings to the HSE In-country Representative. Following an adaptive management approach, the Biodiversity Lead will bring any biodiversity related concerns to the Senior Manager of Environmental Permitting who will coordinate any changes to the BAP.

Table 6-2: Roles and Responsibilities during Operations

Staff	Roles and Responsibilities
HSE Compliance Coordinator (Houston based)	The HSE Compliance Coordinator will lead the following activities: • Final QA/QC of environmental and social related reports • Liaison with Houston based team • Auditing program • Management of Government Authorizations Register • Management of Biodiversity-related concerns • Ensuring compliance of vessel certifications and classification
HSSE In-country Representative (Chittagong based)	The HSSE In-country Representative will lead the following activities: • Monitoring of HSE compliance • Coordinate and monitor security arrangements • Draft reporting, including biodiversity • Liaison with subcontractor HSE Representatives • Stakeholder engagement and grievance management

Staff	Roles and Responsibilities
Vice President of Government, Environmental and Regulatory Affairs (Houston based)	Vice President of Government, Environmental and Regulatory Affairs will lead the following activities: • Setting environmental and social policies • Ensuring compliance with environmental and social policies
ESM HSE Representative (Antwerp based)	The HSE Representative will lead the following activities: • HSE monitoring and reporting • Internal auditing
Svitzer HSE Representative	The HSE Representative will lead the following activities: • HSE monitoring and reporting • Internal auditing
Biodiversity Lead (External)	As with construction, Excelerate will engage local specialists from the BSCP to support implementation of the Biodiversity Action Plan (BAP). The Biodiversity Lead will lead biodiversity monitoring and reporting, according to the Biodiversity Monitoring and Evaluation Plan (BMEP) that will be developed as part of the BAP. During operation, the Biodiversity Lead will conduct monitoring and report findings to the HSE In-country Representative. Following an adaptive management approach, the Biodiversity Lead will bring any biodiversity related concerns to the HSE Compliance Coordinator who will coordinate any changes to the BAP.

6.2.5.1 Management of Stakeholder Engagement and Grievance Management

Management of stakeholder concerns is paramount to project success. Excelerate will implement a Stakeholder Engagement Plan (SEP) (Section 6.3.9) and Grievance Mechanism (6.3.10) to ensure strategic, proactive stakeholder communication, and that stakeholders have a non-judicial option for seeking remedy from project related impacts and concerns.

Proactive Stakeholder Engagement

Prior to and during construction, proactive stakeholder engagement with government officials will be led by Senior Manager of Environmental Permitting and supported by the HSE In-country Representative. The Senior Manager of Environmental Permitting is based in Houston but will travel to Bangladesh for stakeholder engagement as needed (frequency and purpose of visits to be determined in the SEP). The HSE In-country Representative will assist in setting up meetings and conduct as-needed follow-up if the Senior Manager of Environmental Permitting is not in-country. The HSE In-country Representative will speak local languages and be available to respond to stakeholder requests for information. Responses will be coordinated with the Senior Manager of Environmental Permitting.

It is envisioned that the level of effort required for stakeholder engagement will drop considerably after commissioning. During operations, the HSE In-country Representative will lead on-going stakeholder engagement, following the strategy defined in the SEP. They will also maintain the SEP as needed, in consultation with appropriate Excelerate Staff.

Grievance Management
The grievance mechanism will be developed prior to construction, and stakeholders will be informed how to access the grievance mechanism by the Senior Manager of Environmental Permitting during pre-construction stakeholder engagement program.

During construction, Senior Manager of Environmental Permitting will be responsible for managing the grievance process, but they will be supported by HSE In-country Representative and others as required. HSE In-country Representative will likely play a key role in registering the grievances and communicating back to complainants.

Given the nature of the project and activities, it is envisioned that most of the grievances (if any) will result from fishermen (i.e. enforcement of safety zone or damage to fishing gear from vessels). Fishermen attempting to enter the safety zone will be advised of the purpose of the safety zone and access points for additional information or to log a complaint/grievance. Methods for communicating with stakeholders and process for lodging complaints will take into consideration language, literacy, accessibility, and other factors.

Any stakeholder attempting to access the site via land (unlikely) will also be advised how to contact the company for additional information or to log a complaint/grievance.

Awareness training on the roles and responsibilities of external and subcontractor staff will be provided.

6.3 Environmental and Social Management Requirements

As noted above, Excelerate will maintain overall responsibility for environmental and social performance, but the EPC, O&M, and port services contractors will also apply their own procedures and management systems. As part of its routine practices, Excelerate will monitor the project and all contractor activities for compliance with its Environmental Policy and contractual requirements.

The ESMP is a framework document, but additional actions that will be performed for this project to manage environmental and social risks, identified below and in Table 6-3:

- Basis of Design and Compliance with IMO requirements
- Development of a Security Plan
- Development of an Emergency Response Plan
- Development of an Oil Spill Response Plan
- Development of a Waste Management Plan
- Development of a Health and Safety Plan
- Development of a Biodiversity Action Plan with Biodiversity Monitoring and Evaluation Plan
- Development of a Hydrotest Water Disposal Plan
- Development of a Stakeholder Engagement Plan
- Development of a Grievance Mechanism
- Limitations to Project Site Access
- Program for Inspection and Maintenance
- EHS Bridging Process with Contractors

Table 6-3: Environmental and Social Management Plans/Programs

Plan/Program	Responsibility		
	Construction	Operations	Port Services
Basis of Design and Compliance with IMO requirements	Vessel owners will ensure each maintains Classification and has up to date certifications		
Development of a Security Plan	N/A	ESM	N/A
Development of an Emergency Response Plan	Geocean	ESM	Svitzer
Development of an Oil Spill Response Plan	Geocean	ESM	Each vessel will have a Shipboard Oil Pollution Emergency Plan, per MARPOL 73/78
Development of a Waste Management Plan	Geocean	ESM	Each vessel will have a Garbage Management Plan, per MARPOL 73/78
Development of a Health and Safety Plan	Geocean	ESM	Svitzer
Development of a Biodiversity Action Plan	Excelerate[1]	Excelerate	Excelerate
Development of a Hydrotest Water Disposal Plan	Geocean	N/A	N/A
Development of a Stakeholder Engagement Plan	Excelerate	Excelerate	Excelerate
Development of a Grievance Mechanism	Excelerate	Excelerate	Excelerate
Limitations to Project Site Access	Svitzer	Svitzer	Svitzer
Program for Inspection and Maintenance	Geocean	ESM	Svitzer
EHS Bridging Process with Contractors	Excelerate	Excelerate	Excelerate

These activities are discussed below.

[1] While Excelerate will maintain responsibility, biodiversity management will involve external specialists from BSCP.

6.3.1 Basis of Design and Compliance with IMO Requirements

Application of design standards form the foundation of environmental protection, and codify standard controls for managing potential impacts. The *Excellence* is classed with Bureau Veritas which certifies the vessel was constructed and is maintained in accordance with Class rules, and that the vessel meets good engineering practices, and relevant design and safety standards.

The FSRU and support vessels will be required to meet IMO standards for safety and security, including those shown in Table 6-4.

Excelerate's vessels also maintain a complete set of up to date certificates including those below related to the IMO environmental Codes and Resolutions:

- Certificate of Classification
- International Anti-fouling System Certificate
- Cargo Ship Safety Construction Certificate
- Certificate of Compliance-Safety Management System
- International Air Pollution Prevention Certificate
- International Oil Pollution Prevention Certificate
- International Sewage Pollution Prevention Certificate
- Ship Sanitation Control
- International Energy Efficiency Certificate

Table 6-4: IMO and MARPOL Design Requirements

Design Requirement	Description
Double Hull Construction	The FSRU and LNG carriers would be constructed with an outer and inner hull to provide protection against collisions and resultant cargo loss.
Separation of Cargo Holds and Piping Systems	IGC code requires the structural separation of cargo holds from other spaces, as well as separation of cargo piping from other piping systems. Amongst other things, this helps keep cargo leaks away from potential ignition sources and keeps cargo from inadvertently being pumped through the wrong pipes.
Accessibility for Inspection Access	IGC code requires that a tank be constructed so that at least one side is visible and accessible to inspectors. This allows proper periodic inspection of the tank for integrity and signs of corrosion or stress.
Leak Detectors in Hold Spaces	IGC code requires that gas detectors and low temperature sensors be placed in a cargo hold in order to identify potential cargo leakage. An alarm sounds if either is detected and appropriate repairs and precautions can be undertaken.
Tank Requirements for Cargo Containment	ICG code requires that a tank be constructed with materials that can withstand the temperatures involved so as to properly contain the cargo, and have adequate relief valve systems to avoid over pressurization.
Structural Analysis	IGC code requires structural analysis of the cargo containment system and specifies individual tank stress limitations.
Secondary Containment and Thermal Management	IGC code requires partial secondary containment to contain leaks and prevent contact of cryogenic liquid with the inner hull. This prevents thermal stress. In addition, insulation in conjunction with a primary and backup heating system must be installed that would keep the cargo from exceeding the thermal limitations of the material selected for the inner hull should the leak prevention system fail.
Tank Construction and Testing Requirements	IGC codes address standards for workmanship, quality, and testing of tanks under construction. Each tank on the FSRU will have had its welds non-destructively tested, and have had a pressure test to insure integrity before cargo is pumped aboard.
Isolation, Construction and Testing Requirements for Piping and Pressure Vessels	IGC code specifies piping thickness, leak testing, pressure testing, isolation requirements, welding requirements and many other aspects of pressure vessel, and piping design and construction. This insures the integrity of these systems before any cargo is brought aboard.
Emergency Shutdown Valves and Shutdown Systems	IGC code requires remote control shutdown systems for ceasing of cargo and vapor transfer in an emergency. This system must have the ability to be activated from at least two locations on board the FSRU and will also be automatically activated in the event of a cargo fire.
Pressure Venting Systems	IGC code specifies that appropriate venting of the cargo be installed to keep the cargo under the design pressure of the tank and keep relief valves from having to

Design Requirement	Description
	operate. The FSRU will use some of this gas for fueling the boilers, and will add the rest to the gasified product being pumped to shore.
Vacuum Protection Systems	IGC code requires the installation of relief valves that would prevent under pressurization of cargo tanks in the event that cargo was pumped out without adequately providing for vapor return. The FSRU will have sufficient vapor return capacity to keep the pressures at appropriate levels, however this system will prevent under pressurization should this system fail to be actuated or fail to work properly.
Fire Protection Systems	IGC code requires that LNG carriers have a saltwater fire main system for fighting fires throughout the ship, and fixed dry chemical and CO_2 systems for cargo areas and compressor rooms, respectively.
Cargo Tank Instrumentation	IGC code requires that each cargo tank be outfitted with an integrated instrumentation/alarm system that notifies the crew of possible leaks via gas detection and temperature sensors; and tank liquid levels, temperatures and pressures. These systems, as well as the pressure relief systems mentioned above, provide many-layered protection against cargo release either through equipment malfunction or human error.
Additional Gas Detection Systems	IGC code also requires gas detection systems and alarms in spaces where cargo is located, including compressor spaces, spaces where fuel gas is located, and other spaces likely to contain gasified cargo. Venting systems for certain spaces and portable gas detectors are also required.

6.3.2 Security Plan

In compliance with IMO's International Ship and Port Facilities Security Code (ISPS) Code, Excelerate will implement a number of preventative measures to secure the FSRU and other vessels. The Security Plan is the key requirement, and will address:

- Access control for people, goods and material
- Monitoring and alerting vessels that approach or enter the security zone
- Identifying risks and measures to deter terrorist activity
- Internal and external notification requirements and responses in the event of a perceived threat or attack
- Designating a Security Officer
- Providing identification means for personnel
- Security training requirements
- Emergency procedures such as evacuation
- Special operations procedures (re-manning, refueling, diving, support vessel operations and logistical concerns)
- Recordkeeping for maintenance
- Tests and operations outlined in the operations manual

ESM will be responsible for developing and implementing the FSRU security plan.

6.3.3 Emergency Response Plan

Excelerate and/or its subcontractors will develop an Emergency Response Plan (ERP) to respond in a safe, rapid, effective, and efficient manner to potential incidents that might result

from project activities. Emergency response operations are designed to directly address all emergency situations and their consequences, and establish command and control over the incident scene, ensure the safety of responders, develop plans of action, and facilitate communications.

Emergency situations to be addressed in the ERP will include:
- Spills (diesel, chemical spills, etc.)
- Fire and/or explosion
- Personnel (injuries, fatalities, missing person, etc.)
- Evacuations
- Natural disasters (hurricane, earthquake, etc.)
- Transportation – personnel or equipment (vessel collision, etc.)
- Security (kidnap/extortion, piracy, etc.)
- Media/public relations (could result from any of the incidents above)

The ERP will include:
- Response Procedures
- Key Contacts (within and outside of Excelerate)
- Notification Procedures
- Medical Evacuation Plan (MEDEVAC)

It is likely that each subcontractor will have their own specific ERPs, but it will be the responsibility of Excelerate to ensure all scenarios are covered and each subcontract is working together in the event of an incident (as necessary).

6.3.4 Oil Spill Response Plan

The term Oil Spill Response Plan (OSRP) is used generically here, but the requirement could be met with similar plans, such as Shipboard Oil Pollution Emergency Plans, Oil Spill Contingency Plans or other. As with the ERP, it is likely that each subcontractor will have its own plan(s) to respond in the event of a spill. Excelerate will ensure the company and its subcontractors are adequately prepared for a spill of fuel or other hydrocarbon from the FSRU, support vessels, and onshore activities.

6.3.5 Waste Management Plan

Excelerate will ensure that all wastes for the project are properly managed in accordance with applicable laws and regulations, company policies, and international standards relevant to the offshore oil and gas industry. Having a Waste Management Plan (WMP) in place will help prevent accidental release of wastes by presenting safe handling, storage and disposal methods for each waste generated during Project activities.

The WMP will include:
- Description of the types of wastes that will be generated
- Waste minimization opportunities
- Waste management methods
- Recordkeeping practices, including manifest and waste tracking forms

As with above, each subcontractor may have their own WMP, or similar (e.g. Garbage Management Plan), but Excelerate will ensure all wastes are managed following applicable standards.

6.3.6 Health and Safety Plan

Offshore oil and gas activities pose health and safety risks to employees, contractors and the public. Excelerate will ensure each subcontractor develops a Health and Safety Plan (HSP) to manage health and safety concerns specific to the Project. The HSP(s) will include:

- Identification of health and safety hazards
- Measures to minimize hazards to workers
- Risk categorization
- EHS procedures, training and other controls and risk reduction measures (e.g. personal protective equipment, training, management programs, etc.) to protect workers and the public.

The HSP(s) will be kept on site (and/or on vessels). The implementation of the HSP(s) will mitigate or minimize health and safety impacts by ensuring that workers understand hazards specific to the project and how they can prevent incidents from occurring.

6.3.7 Biodiversity Action Plan

The Delivery Point is located within an area defined as Critical Habitat according to IFC Performance Standard 6. In order to provide a clear set of actions and responsibilities to minimize and mitigate potential impacts to biodiversity for the project, deliver net gains for Critical Habitat values, and to define required monitoring and evaluation, a Biodiversity Action Plan (BAP) will be developed. The BAP will include a Biodiversity Monitoring and Evaluation Plan (BMEP) and cover all phases of the project. Development of the plan and monitoring activities will include integration of specialist experts that have been studying key biodiversity features in the project area of influence for over 10 years. The BAP will also include suggested actions to support long term protection of the area.

This will be managed by Excelerate, but BSCP will help develop the plan and take part in on-going monitoring and evaluation. Biodiversity specialists involved in this project also lead global Spoon-Billed Sandpiper conservation efforts in consultation with and supported by Birdlife International, Wildfowl and Wetland Trust (WWT), Wetlands International, and other global conservation organizations.

6.3.8 Hydrotest Water Disposal Plan

It is likely that hydrotest water will need to be discharged into the sea. In such cases, the World Bank Group EHS guidelines require a Hydrotest Water Disposal Plan to be developed. The Plan will include points of discharge, rate of discharge, chemical use and dispersion, testing requirements, environmental risk, and monitoring.

This plan will be developed and managed by Geocean.

6.3.9 Stakeholder Engagement Plan

Chapter 7 of this ESIA describes the strategy, objectives, completed activities, and plans for public consultation and engagement in support of the Moheshkhali Floating LNG project. The chapter also includes a description of regulatory requirements for engagement, as well as stakeholder analysis.

As described, Excelerate envisions conducting additional engagement, including:

- Pre-construction engagement to update parties that expressed interest during previous consultation and by holding structured, public sessions in areas of project influence

- Ongoing engagement during construction and operations to maintain relationships and ensure public avenues for communication

To supplement the information provided in Chapter 7, Excelerate will develop tools for maintaining stakeholder relationships and communications, including a stakeholder register and stakeholder engagement tracker. These will be “live” documents, updated throughout the project to incorporate lessons learned as well as new findings from research and other activities. These tools will be designed to guide Excelerate’s efforts on all external engagements, provide key information on engagement objectives, include details on methodology and communication means/tools, start and end dates for communities/areas visited, meeting information, expected attendees, language requirements, etc.

6.3.10 Grievance Mechanism

An important element of successful stakeholder engagement is having a system or mechanism in place to capture and respond to grievances from the public during the project. IFC requires that such mechanisms be established so that local residents and other potentially affected stakeholders can communicate their grievances and receive assurance that they will be addressed in a consistent and transparent manner. Excelerate will implement a grievance management system to resolve all grievances following industry standard practices. This system will establish a positive avenue for the company to interact directly with stakeholders and build positive relationships.

This will be managed by Excelerate.

6.3.11 Limitations to Project Site Access

The FSRU is considered a vessel with restricted manoeuvrability under Convention on the International Regulations for Preventing Collisions at Sea (COLREGs), rules established by the IMO. Under these rules, other vessels are required to give way and pass at safe distances to the ship. Fishing vessels and other vessels may pass near the operations area. A safety zone will be established to protect the health and safety of members of the public and maintain vessel security. Members of the local fishing communities will be informed in advance of the project.

Excelerate has already engaged with Port Authorities, other agencies, local government officials, fishing agencies, and fishing association leaders to advise them of this safety zone. The FSRU captain and/or support vessels will monitor nearby vessel movements and provide warnings by radio and other means (including deploying a support vessel) to notify and redirect other vessels if needed.

These limitations will help to mitigate potential impacts to the public, specifically to fishermen and other vessel operators moving near the FSRU and construction activities.

6.3.12 Program for Inspection and Maintenance and Standard Operating Procedures

During the project, there will be daily maintenance inspections and equipment will be maintained in good order. Standard procedures for refuelling, handling and managing wastes and monitoring discharges will be followed to ensure protection of the environment. A good maintenance program will help ensure that accidents do not occur.

6.3.13 EHS Bridging Process with Contractors

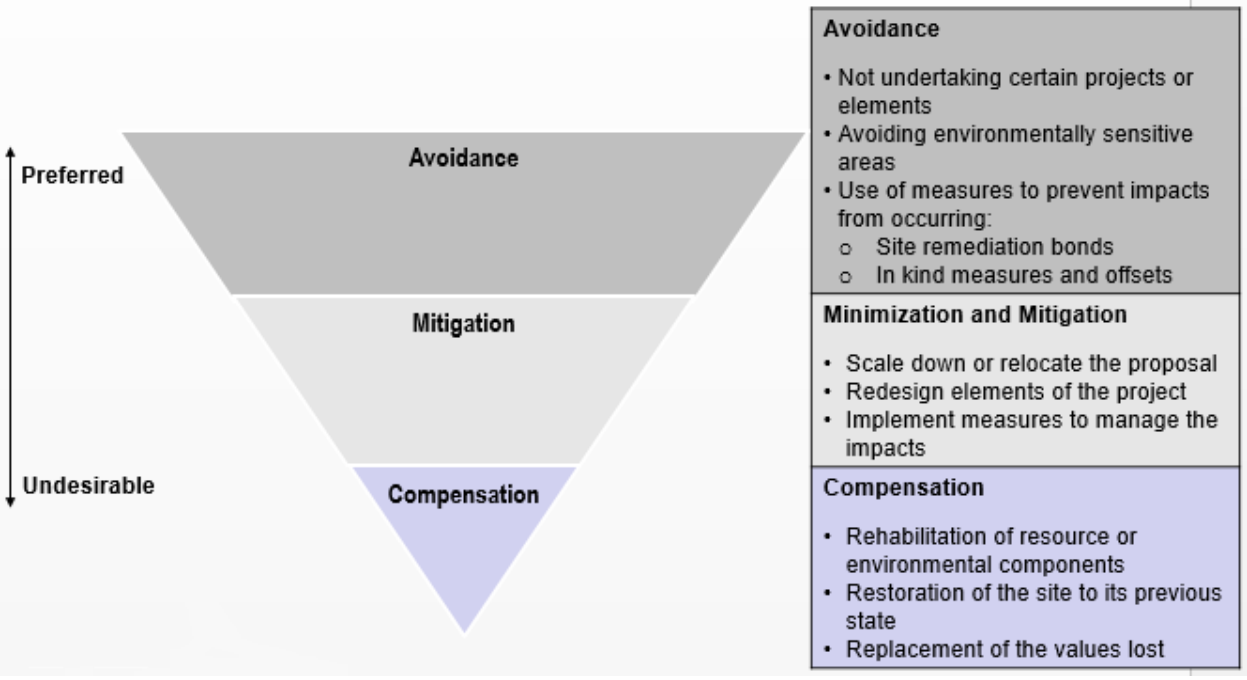
As noted above, Excelerate will rely on its subcontractors for many aspects of environmental and social performance. Excelerate will perform a bridging analysis to evaluate adequacy of subcontractor plans and procedures, and to ensure all aspects of the project are covered (i.e. no gaps between subcontractor activities).

Excelerate will integrate the main results of the bridging analysis into a bridging document and, together with the subcontractors, will use this document to help ensure each will operate according to its own requirements as well as the requirements of this ESIA. The training, procedures and implementation of plans described will help ensure that the subcontractors will perform actions that will mitigate or help to minimize potential project impacts. Excelerate will conduct regular monitoring of contractor performance to ensure compliance with ESMP and other plans, and environmental and social clauses will be added to subcontracts. Excelerate will be responsible for any contractor-related non-compliances, so will ensure the appropriate incentives and penalties are in place to support good contractor performance.

6.4 Controls and Mitigation Measures

One of the key purposes of impact assessment is to ensure mitigation measures are defined and implemented to manage significant impacts. Excelerate will implement a mitigation hierarchy (Figure 6-2) seeking to first avoid potential impacts. If avoidance is not possible, Excelerate will minimize potential impacts through design alternatives and/or implementation of standard controls and mitigation. Where residual impacts are above an acceptable level, compensation and/or offsets will be provided.

Figure 6-2: Mitigation Hierarchy



Source: Acorn International

As described in the ESIA methodology presented in Chapter 5, mitigation is required for potential impacts with pre-mitigation rankings of either high or medium to reduce the residual

impact to low. There were 16 potential impacts identified for the project that were ranked as high to medium level prior to mitigation.

The mitigation measures recommended are based on the ESIA team's experience on similar operations worldwide and international guidance documents such as those prepared by IPIECA and World Bank Group. Additional considerations for developing mitigation measures were made based on the concerns of stakeholders expressed during the stakeholder engagement process.

After developing mitigation measures, the impacts were re-evaluated to determine the "residual risk", or the risk remaining after the mitigation measures are put into place.

While low level impacts do not require mitigation, Table 6-5 summarizes standard controls that will be implemented to ensure the impacts are minimized. A matrix of proposed mitigation measures for medium and high ranked impacts, and residual impacts after application of mitigation measures, is presented in Table 6-6. The Project's Environmental and Social Management Plan (ESMP) is presented in Table 6-7 and provides a tool for implementing recommended mitigation measures. The ESMP is a framework document that ties in a number of activity/impact specific management plans (e.g. ERP and WMP). Summaries of key management plans required are provided in Section 6.3.

Table 6-5: Standard Controls

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
Mobilization (Phase 1)					
1A1	Routine discharges	Water	Degradation of water quality from ballast water exchange	**Low**	• Comply with IMO requirements for Ballast Water management • Basis of Design and compliance with IMO
1A2	Routine discharges	Fauna	Introduction of invasive aquatic species	**Low**	• Comply with IMO requirements for Ballast Water management • Basis of Design and compliance with IMO
Also see Ancillary Activities (Phase 5)					
Construction and Commissioning (Phase 2)					
2A1	Clearance and grading of construction yard and installation of Delivery Point	Soil	Degradation of soils from disruption and compaction	Low	• Install appropriate onshore erosion and sediment control measures (e.g. silt fences) to prevent sediment from moving off site and causing excessive turbidity in water bodies, as needed • Minimize heavy machinery use • Cover open stockpiles of construction materials prior to rain events • Restore disturbed areas as soon as possible after work is complete • Maintain good housekeeping
2A2	Clearance and grading of construction yard and installation of Delivery Point	Air	Degradation of air quality from generation of dust	**Low**	• Minimize dust from material handling sources, including storage piles, by using covers or increasing moisture content • Use dust suppression techniques such as applying water to minimize dust from vehicle movements • Maintain good housekeeping (keep surfaces clean)
2A3	Clearance and grading of construction yard and installation of Delivery Point	Flora	Damage to flora from clearance of construction yard	**High**	• See proposed mitigation measures listed in Table 6-6 • Prohibit logging, foraging and any other damaging activity to flora outside of project activities

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
2A4	Clearance and grading of construction yard and installation of Delivery Point	Fauna	Degradation of habitat and disruption from clearance and physical presence (including light and noise)	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Prohibit hunting and fishing by workers • Minimize use of lighting to avoid disturbing wildlife • Minimize number of personnel allowed onshore • Maintain regular communication with bird specialists on progress and monitoring results • Identify peak time (during day/night) for bird activity and aim to avoid/minimize impacts (e.g. reduced team size, low noise activity periods)
2B1	Installation of pipeline (including post-trenching), PLEM, riser, and moorings	Water	Degradation of water quality from increased turbidity, and potential release of nutrients and contaminants into the water column	**Low**	• Ensure sediments to be disturbed are not contaminated • Limit activities that disturb sediments to the extent possible • Place excavated material on up-current side of trench • Excavation methods should be selected to minimize suspension of sediments, minimize destruction of benthic habitat, increase accuracy of operation, and minimize impacts to identified onshore sensitive sites • Use techniques to minimize adverse impacts on aquatic life from the re-suspension of sediments • Monitor trenching to evaluate effectiveness of impact prevention strategies / actions
2B2	Installation of pipeline (including post-trenching), PLEM, riser, and moorings	Fauna	Harm to fauna from degradation of water quality	**Low**	• Ensure sediments to be disturbed are not contaminated • Limit activities that disturb sediments to the extent possible • Place excavated material on up-current side of trench • Excavation methods should be selected to minimize suspension of sediments, minimize destruction of benthic habitat, increase accuracy of operation, and minimize impacts to identified onshore sensitive sites • Use techniques to minimize adverse impacts on aquatic life from the re-suspension of sediments • Monitor trenching to evaluate effectiveness of impact prevention strategies / actions

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
2B3	Installation of pipeline (including post-trenching), PLEM, riser, and moorings	Fauna	Harm to fauna from disturbance of benthic habitat	**Low**	• Ensure sediments to be disturbed are not contaminated • Limit activities that disturb sediments to the extent possible • Identify and avoid sensitive sea floor features • Place excavated material on up-current side of trench • Excavation methods should be selected to minimize suspension of sediments, minimize destruction of benthic habitat, increase accuracy of operation, and minimize impacts to identified onshore sensitive sites • Use techniques to minimize adverse impacts on aquatic life from the re-suspension of sediments • Monitor trenching to evaluate effectiveness of impact prevention strategies / actions
2B4	Installation of pipeline (including post-trenching), PLEM, riser, and moorings	Economic / Livelihood	Disruption of economic activity from damage to subsea telecommunications cable	**Low**	• Conduct geophysical study to identify presence of telecommunications cables and, if present, avoid
2B5	Installation of pipeline (including post-trenching), PLEM, riser, and moorings	Cultural Heritage	Damage to archaeological resources	**Low**	• Conduct geophysical study to identify presence of archaeological resources and, if present, avoid
2C1	Routine discharges	Soil	Degradation of soil quality from discharge of hydrostatic testing water and additives	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Use the same water for multiple tests • Reduce the need for chemicals by minimizing the time that test water remains in the equipment or pipeline • Carefully select chemical additives in terms of dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential • Send offshore pipeline hydrotest water to onshore facilities for treatment and disposal, where practical

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
2C2	Routine discharges	Water	Degradation of water quality from discharge of hydrostatic testing water and additives	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Minimize the volume of hydrotest water offshore by testing equipment at an onshore site prior to loading the equipment onto the offshore facilities, if feasible • Use the same water for multiple tests, if feasible • Reduce the need for chemicals by minimizing the time that test water remains in the equipment or pipeline • Carefully select chemical additives in terms of dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential • Send offshore pipeline hydrotest water to onshore facilities for treatment and disposal, where practical
2C3	Routine discharges	Fauna	Disruption of fauna from hydrostatic testing activities and additives	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Minimize the volume of hydrotest water offshore by testing equipment at an onshore site prior to loading the equipment onto the offshore facilities, if feasible • Use the same water for multiple tests, if feasible • Reduce the need for chemicals by minimizing the time that test water remains in the equipment or pipeline • Carefully select chemical additives in terms of dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential • Send offshore pipeline hydrotest water to onshore facilities for treatment and disposal, where practical
2D1	Generation of air emissions	Air	Degradation of air quality and increase in greenhouse gas emissions	**Low**	• Prohibit burning of wastes • Conduct routine maintenance of equipment and machinery • Limit idling of equipment
2E1	Physical presence of vessels	Fauna	Disruption of habitat from noise and light	**Low**	• Conduct routine maintenance of vessel engines and equipment • Maintain safe limits from shore • No anchoring near sensitive areas
2F1	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety zone	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Avoid areas used by fishing, to the extent practical • Follow standard practices for vessel navigation and safety (e.g. SOLAS) • Liaise with appropriate authorities so notice to mariners and other notifications are accurate and timely

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
2G1	Accidental release	Soil	Degradation in soil quality from accidental release	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Maintain good housekeeping • Avoid use of hazardous materials to the extent possible • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements • Use engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard • Implement management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures • Analyse potential spill and release scenarios using available industry statistics on spills and accidents where available • Analyse potential for uncontrolled reactions such as fire and explosions • Analyse potential consequences of spills based on the physical geographical characteristics of the project site, including aspects such as its distance to settlements, water resources, and other environmentally sensitive areas • Conduct training and drills as part of emergency preparedness response training

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
2G2	Accidental release	Water	Degradation of water quality from accidental release	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Maintain good housekeeping • Avoid use of hazardous materials to the extent possible • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements • Use engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard • Implement management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures • Analyse potential spill and release scenarios using available industry statistics on spills and accidents where available • Analyse potential for uncontrolled reactions such as fire and explosions • Analyse potential consequences of spills based on the physical geographical characteristics of the project site, including aspects such as its distance to settlements, water resources, and other environmentally sensitive areas • Conduct training and drills as part of emergency preparedness response training

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
2G3	Accidental release	Fauna	Harm to fauna from accidental release	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Maintain good housekeeping • Avoid use of hazardous materials to the extent possible • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements • Use engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard • Implement management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures • Analyse potential spill and release scenarios using available industry statistics on spills and accidents where available • Analyse potential for uncontrolled reactions such as fire and explosions • Analyse potential consequences of spills based on the physical geographical characteristics of the project site, including aspects such as its distance to settlements, water resources, and other environmentally sensitive areas • Conduct training and drills as part of emergency preparedness response training

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
2G4	Accidental release	Economic / Livelihood	Reduction in earnings from loss of fishing grounds and/or harm to ecosystem from accidental release	**Low**	• Maintain good housekeeping • Avoid use of hazardous materials to the extent possible • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements • Use engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard • Implement management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures • Analyse potential spill and release scenarios using available industry statistics on spills and accidents where available • Analyse potential for uncontrolled reactions such as fire and explosions • Analyse potential consequences of spills based on the physical geographical characteristics of the project site, including aspects such as its distance to settlements, water resources, and other environmentally sensitive areas • Conduct training and drills as part of emergency preparedness response training In addition, the following mitigation measures proposed for other impacts will further reduce the risk of this impact: • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • Develop and maintain a Stakeholder Engagement Plan • Develop and implement a Grievance Mechanism
Also see Ancillary Activities (Phase 5)					
Operation (Phase 3)					
3A1	Routine discharges	Water	Degradation of water quality from routine discharges (e.g. heating water, cooling water, and deck drainage)	**Low**	• Basis of Design and compliance with IMO requirements • Implement an inspection and maintenance program

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
3A2	Routine discharges	Fauna	Harm to fauna from degradation of water quality from routine discharges	**Low**	• Basis of Design and compliance with IMO requirements • Implement an inspection and maintenance program
3B1	Generation of air emissions	Air	Degradation of air quality and increase in greenhouse gas emissions from FSRU operations	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Basis of Design and compliance with IMO requirements
3B2	Generation of air emissions	Fauna	Harm to fauna from degradation of air quality	**Low**	• Basis of Design and compliance with IMO requirements • Implement an inspection and maintenance program The following mitigation measures proposed for other impacts will further reduce the risk of this impact: • Use diesel fuel with less than .5 percent sulfur for auxiliary generators • Develop and implement an Emissions and Air Quality Monitoring Program
3B3	Generation of air emissions	Health	Harm to community health from degradation of air quality	**Low**	• Basis of Design and compliance with IMO requirements • Implement an inspection and maintenance program The following mitigation measures proposed for other impacts will further reduce the risk of this impact: • Use diesel fuel with less than .5 percent sulfur for auxiliary generators • Develop and implement an Emissions and Air Quality Monitoring Program
3C1	Physical presence of FSRU and vessels	Fauna	Disruption of habitat from noise and light	**Low**	• Conduct routine maintenance of vessel engines and equipment • Maintain safe limits from shore
3C2	Physical presence of FSRU and vessels	Cultural Services	Aesthetic impact of FSRU and Delivery Point	**Low**	• Maintain safe limits from shore

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
3D1	Enforcement of safety zone and vessel operations	Fauna	Protection of fish from establishment of safety zone	**Low** **Positive Impact**	N/A
3D2	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety zone	**Medium**	• See proposed mitigation measures listed in Table 6-6 • Avoid areas used by fishing, to the extent practical • Follow standard practices for vessel navigation and safety (e.g. SOLAS) • Liaise with appropriate authorities so notice to mariners and other notifications are accurate and timely
3E1	Job creation	Economic / Livelihood	Increase in economic activity from additional electrical supply, job creation, and generation of revenue for the government	**High** **Positive Impact**	N/A
3F1	Accidental release	Air	Degradation of air quality from accidental release	**Low**	• Implement an inspection and maintenance program • Use engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard In addition, the following mitigation measures proposed for other impacts will further reduce the risk of this impact: • Develop and implement an Emissions and Air Quality Monitoring Program
3F2	Accidental release	Water	Degradation of water quality from accidental release	**Low**	• Implement an inspection and maintenance program • Maintain good housekeeping • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements In addition, the following mitigation measures proposed for other impacts will further reduce the risk of this impact: • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
3F3	Accidental release	Fauna	Harm to fauna from accidental release	**Medium**	• Implement an inspection and maintenance program • Maintain good housekeeping • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements • See proposed mitigation measures listed in Table 6-6
3F4	Accidental release	Health	Harm to human health from accidental release	**Medium**	• Implement an inspection and maintenance program • Maintain good housekeeping • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements • See proposed mitigation measures listed in Table 6-6

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
3F5	Accidental release	Economic / Livelihood	Damage to community property from accidental release	**Low**	• Maintain good housekeeping • Avoid use of hazardous materials to the extent possible • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements • Use engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard • Implement management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures • Analyse potential spill and release scenarios using available industry statistics on spills and accidents where available • Analyse potential for uncontrolled reactions such as fire and explosions • Analyse potential consequences of spills based on the physical geographical characteristics of the project site, including aspects such as its distance to settlements, water resources, and other environmentally sensitive areas • Conduct training and drills as part of emergency preparedness response training In addition, the following mitigation measures proposed for other impacts will further reduce the risk of this impact: • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • Develop and maintain a Stakeholder Engagement Plan • Develop and implement a Grievance Mechanism

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
3F6	Accidental release	Economic / Livelihood	Reduction in earnings from loss of fishing grounds and/or harm to ecosystem from accidental release	**Low**	• Maintain good housekeeping • Avoid use of hazardous materials to the extent possible • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements • Use engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard • Implement management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures • Analyse potential spill and release scenarios using available industry statistics on spills and accidents where available • Analyse potential for uncontrolled reactions such as fire and explosions • Analyse potential consequences of spills based on the physical geographical characteristics of the project site, including aspects such as its distance to settlements, water resources, and other environmentally sensitive areas • Conduct training and drills as part of emergency preparedness response training In addition, the following mitigation measures proposed for other impacts will further reduce the risk of this impact: • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • Develop and maintain a Stakeholder Engagement Plan • Develop and implement a Grievance Mechanism
Also see Ancillary Activities (Phase 5)					
Decommissioning (Phase 4)					
None. After the contract term, ownership of all permanent infrastructure will transfer to the Government of Bangladesh for continued use. No decommissioning is required.					

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
Ancillary Activities (Phase 5)					
5A1	Routine discharges	Water	Degradation of water quality from routine discharges (e.g. deck drainage, grey water, black water, and bilge water)	**Low**	• Basis of Design and compliance with IMO requirements • Implement an inspection and maintenance program
5A2	Routine discharges	Fauna	Harm to fauna from routine discharges (e.g. deck drainage, grey water, black water, and bilge water)	**Low**	• Basis of Design and compliance with IMO requirements • Implement an inspection and maintenance program
5B1	Generation of air emissions	Air	Degradation of air quality and increase in greenhouse gas emissions from vessel operations	**Low**	• Implement an inspection and maintenance program • Maintain emissions of NOx and SOx within the limits established by international regulations • Comply with limits to Sulphur content in fuels • Navigate port access areas at partial power, achieving full power only after leaving the port area
5C1	Physical presence of vessels	Fauna	Potential damage to marine fauna from contact with hull or propeller	**Medium**	• See proposed mitigation measures listed in Table 6-6
5D1	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing activities or equipment from vessel operations	**Low**	• Adhere to rules of navigation, particularly in the various channels where space may be limited In addition, the following mitigation measures proposed for other impacts will further reduce the risk of this impact: • Develop and maintain a Stakeholder Engagement Plan • Develop and implement a Grievance Mechanism
5E1	Job creation	Economic / Livelihood	Local job creation from project activities	**Low** **Positive Impact**	N/A

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Control(s)
5F1	Accidental release	Soil	Degradation of soil quality from accidental release	**Low**	• Adhere to rules of navigation, particularly in the various channels where space may be limited • Implement an inspection and maintenance program • Maintain good housekeeping • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements • Vessel audits In addition, the following mitigation measures proposed for other impacts will further reduce the risk of this impact: • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP
5F2	Accidental release	Water	Degradation of water quality from accidental release	**Low**	• Adhere to rules of navigation, particularly in the various channels where space may be limited • Implement an inspection and maintenance program • Maintain good housekeeping • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements
5F3	Accidental release	Fauna	Harm to fauna from accidental release	**Medium**	• See proposed mitigation measures listed in Table 6-6
5F4	Accidental release	Economic / Livelihood	Reduction in earnings from loss of fishing grounds and/or harm to ecosystem from accidental release	**Low**	• Adhere to rules of navigation, particularly in the various channels where space may be limited • Implement an inspection and maintenance program • Maintain good housekeeping • Ensure hazardous materials are labelled and stored in sealed containers with secondary containment of adequate volume to prevent the discharge of spills and debris • Store hazardous materials in designated areas with appropriate signage and protection from the elements

Table 6-6: Recommended Mitigation Measures for Impacts with Medium and High Significance

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Measures	Residual Impact
Mobilization (Phase 1)						
No medium or high level impacts identified. See Ancillary Activities (Phase 5)						
Construction and Commissioning (Phase 2)						
2A3	Clearance and grading of construction yard and installation of Delivery Point	Flora	Damage to flora from clearance of construction yard	**High**	• Develop and implement a BAP • Develop and implement a Site Rehabilitation Plan • Minimize the footprint of temporary and permanent areas required on land and avoid areas with established mangroves to the extent possible • Prior to clearance document locations and area of mangroves to be cleared and ensure No Net Loss of mangrove area after rehabilitation • Support conservation efforts of Sonadia Island • Conduct long term monitoring of Critical Habitat values • See standard controls listed in Table 6-5	**Low**
2A4	Clearance and grading of construction yard and installation of Delivery Point	Fauna	Degradation of habitat and disruption from clearance and physical presence (including light and noise)	**Medium**	• Develop and implement a BAP • Install sound barriers between construction yard and sensitive sites • Develop clear restricted areas/buffer zones for contractors and staff to avoid disturbance to bird sites (700m away) • Conduct monitoring of bird behavior by specialists during construction to ensure mitigation measures are sufficient and allow for adaptive management • Support conservation efforts to obtain net positive benefit to Critical Habitat values (e.g. training to communities, beach patrols, and/or other initiatives) • See standard controls listed in Table 6-5	**Low**
2C1	Routine discharges	Soil	Degradation of soil quality from discharge of hydrostatic testing water and additives	**Medium**	• Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring • Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones • See standard controls listed in Table 6-5	**Low**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Measures	Residual Impact
2C2	Routine discharges	Water	Degradation of water quality from discharge of hydrostatic testing water and additives	**Medium**	• Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring • Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones • See standard controls listed in Table 6-5	**Low**
2C3	Routine discharges	Fauna	Disruption of fauna from hydrostatic testing activities and additives	**Medium**	• Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring • Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones • See standard controls listed in Table 6-5	**Low**
2F1	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety zone	**Medium**	• Develop and maintain a Stakeholder Engagement Plan • Develop and implement a Grievance Mechanism • See standard controls listed in Table 6-5	**Low**
2G1	Accidental release	Soil	Degradation in soil quality from accidental release	**Medium**	• Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • See standard controls listed in Table 6-5	**Low**
2G2	Accidental release	Water	Degradation of water quality from accidental release	**Medium**	• Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • See standard controls listed in Table 6-5	**Low**
2G3	Accidental release	Fauna	Harm to fauna from accidental release	**Medium**	• Develop and implement a BAP • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • See standard controls listed in Table 6-5	**Low**
Also see Ancillary Activities (Phase 5)						

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Measures	Residual Impact
Operation (Phase 3)						
3B1	Generation of air emissions	Air	Degradation of air quality and increase in greenhouse gas emissions from FSRU operations	**Medium**	• Use diesel fuel with less than .5 percent Sulfur for auxiliary generators • Develop and implement an Emissions and Air Quality Monitoring Program • See standard controls listed in Table 6-5	**Low**
3D1	Enforcement of safety zone and vessel operations	Economic / Livelihood	Disruption of fishing and marine traffic from safety zone	**Medium**	• Develop and maintain a Stakeholder Engagement Plan • Develop and implement a Grievance Mechanism • See standard controls listed in Table 6-5	**Low**
3F3	Accidental release	Fauna	Harm to fauna from accidental release	**Medium**	• Develop and implement a BAP • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • Conduct long term monitoring of Critical Habitat values • See standard controls listed in Table 6-5	**Low**
3F4	Accidental release	Health	Harm to human health from accidental release	**Medium**	• Develop and implement a BAP • Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • Develop a HSP • Conduct long term monitoring of Critical Habitat values • See standard controls listed in Table 6-5	**Low**
Also see Ancillary Activities (Phase 5)						
Decommissioning (Phase 4)						
No medium or high level impacts identified						
Ancillary Activities (Phase 5)						
5C1	Physical presence of vessels	Fauna	Potential damage to marine fauna from contact with hull or propeller	**Medium**	• Support vessels should maintain a safe distance from marine mammals and sea turtles. If seen, reduce vessel speed and maintain the following distances: o 50 m from dolphins, porpoises, and sea turtles o 100 m from whales • See standard controls listed in Table 6-5	**Low**

Impact Identification	Activity/ Source of Potential Impact	Affected Resource	Nature of Potential Impact	Significance	Mitigation Measures	Residual Impact
5F3	Accidental release	Fauna	Harm to fauna from accidental release	**Medium**	• Develop and implement an ERP • Develop and Implement an OSRP • Develop and implement a WMP • Conduct long term monitoring of Critical Habitat values • See standard controls listed in Table 6-5	**Low**

6.5 Environmental and Social Management Plan

Excelerate will follow an ESMP (Table 6-7) to ensure that mitigation measures presented in Table 6-6 are properly implemented. For ease of use, the ESMP has been prepared in a table format so that it can be a stand-alone document and easily kept on board Project vessels.

For each mitigation measure identified in Table 6-6, the ESMP presents:

- Schedule of implementation
- Monitoring requirements
- Training requirements
- Responsibilities
- Reporting requirements
- Cost of implementation

The ESMP below has been prepared based on available information, but should be maintained as a “live” document as project engineering and design are finalized. Excelerate will review the ESMP and identify any modifications that may be needed throughout the project lifecycle.

Excelerate will be the “owner” of the ESMP and responsible for ensuring that the mitigation measures in the ESMP are properly implemented. Geocean, ESM and Svitzer staff will have day-to-day responsibility for implementing many of the mitigation measures.

Table 6-7: Environmental and Social Management Plan

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
Mobilization (Phase 1)							
No medium or high level impacts identified. See Ancillary Activities (Phase 5)							
Construction and Commissioning (Phase 2)							
2A3	Develop and implement a BAP	Throughout construction and commissioning	To be determined in plan. Long term monitoring required per IFC Performance Standard 6.	Awareness training to Geocean and Excelerate staff	Excelerate Senior Manager of Environmental Permitting	Monthly reports	$50,000
	Develop and implement a Site Rehabilitation Plan	Develop prior to construction and implement as soon as practical. Complete rehabilitation prior to operations.	Completion review and annually until vegetation is established	None	Excelerate Construction Manager	Site Rehabilitation Completion Report	$50,000
	Minimize the footprint of temporary and permanent areas required on land and avoid areas with established mangroves to the extent possible	Integrate into engineering and design, and implement throughout construction	Review siting prior to land clearance and confirm location is according to design	None	Excelerate Construction Manager	Monthly reports	No additional cost
	Prior to clearance document locations and area of mangroves to be cleared and ensure No Net Loss of mangrove area after rehabilitation	Document mangrove coverage before construction and monitor rehabilitation of site during operations	Document mangrove coverage before construction and monitor rehabilitation of site during operations	Awareness training to Geocean	Excelerate Construction Manager	Monthly Report Site Rehabilitation Completion Report	No additional cost
	Support conservation efforts of Sonadia Island	Throughout lifetime of project	Conduct monitoring of Critical Habitat values and activities conducted	To be determined in BAP	Excelerate Senior Manager of Environmental Permitting	To be determined in BAP	$1,000 per year

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
2A3	Conduct long term monitoring of Critical Habitat values	Throughout lifetime of project	To be determined in BAP	To be determined in BAP	Excelerate Senior Manager of Environmental Permitting	To be determined in BAP	$2,500 / month
2A4	Develop and implement a BAP	See 2A3 above					
	Install sound barriers between construction yard and sensitive sites	At outset of construction	Ensure installation before significant activity takes place onshore	Discuss with Geocean team prior to mobilization to ensure appropriate design	Excelerate Construction Manager	Monthly report	$5,000
	Develop clear restricted areas/buffer zones for contractors and staff to avoid disturbance to bird sites (700m away).	Include in engineering and apply throughout construction	On-going monitoring and enforcement of the restricted areas	Install signs on site and provide awareness training to any staff working onshore	Excelerate Construction Manager	Monthly reports	No additional cost
	Conduct monitoring of bird behavior by specialists during construction to ensure mitigation measures are sufficient and allow for adaptive management	Throughout construction	Conduct monitoring of bird behavior (frequency to be determined in BAP)	Ensure monitor is able to evaluate bird behavior	Excelerate Senior Manager of Environmental Permitting	Reports of species counts and notes of upset behaviour	Included in 2A3
	Support conservation efforts to obtain net positive benefit to Critical Habitat values (e.g. training to communities, beach patrols, and/or other initiatives)	Throughout lifetime of project	Conduct monitoring of Critical Habitat values and activities conducted	To be determined in BAP	Excelerate Senior Manager of Environmental Permitting	To be determined in BAP	$1,000 per year

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
2C1	Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring	Develop prior to construction and implement during hydrotesting	To be determined in plan. At a minimum, testing of hydrotest water must be completed prior to discharge, and location and rate if discharge must be recorded.	Awareness training to Geocean and Excelerate staff	Excelerate Construction Manager	Hydrotest water test results Monthly reports	$20,000
	Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones	During construction	Location and rate if discharge must be recorded	Awareness training to Geocean and Excelerate staff	Excelerate Construction Manager	Monthly reports	No additional cost
2C2	Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring	See 2C1 above					
	Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones	See 2C1 above					
2C3	Develop and implement a Hydrotest Water Disposal Plan that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and monitoring	See 2C1 above					
	Prohibit discharge of hydrotest waters in shorebird exclusion/buffer zones	See 2C1 above					

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
2F1	Develop and maintain a Stakeholder Engagement Plan	Develop plan prior to construction and implement throughout construction and commissioning	Track interactions with fishermen and other vessels entering the safety exclusion zone	Awareness training to Excelerate, Geocean and Svitzer staff on protocol for managing interactions with other vessels	Excelerate Senior Manager of Environmental Permitting	Stakeholder engagement tracker and meeting minutes Monthly reports	$25,000
	Develop and implement a Grievance Mechanism	Develop grievance mechanism (incl. procedure) prior to construction and implement throughout construction and commissioning	Track interactions with fishermen and other vessels entering the safety exclusion zone Track grievances	Awareness training to Excelerate, Geocean, and Svitzer staff on protocol for managing interactions with other vessels Communication with Bangladesh Navy on protocol for grievance mechanism	Excelerate Senior Manager of Environmental Permitting	Grievance tracker Monthly reports	$10,000
2G1	Develop and implement an ERP	Develop plan prior to construction and implement throughout construction and commissioning	Review records of training Conduct at least one drill during construction	Awareness training to Excelerate, Geocean and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate Senior Manager of Environmental Permitting	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	$50,000

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
2G1	Develop and Implement an OSRP	Develop plan prior to construction and implement throughout construction and commissioning	Review records of training Conduct at least one drill during construction	Awareness training to Excelerate, Geocean and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate Senior Manager of Environmental Permitting	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	$20,000 plus shared cost of ERP drill
	Develop and implement a WMP	Develop plan prior to construction and implement throughout construction and commissioning	Track waste volumes generated and chain of custody through ultimate disposal at licensed facility	Awareness training to Excelerate, Geocean and Svitzer staff on plan	Excelerate Senior Manager of Environmental Permitting	Waste manifests Transfer of custody forms Monthly reports	$20,000
2G2	Develop and implement an Emergency Response Plan	See 2G1 above					
	Develop and Implement an Oil Spill Response Plan	See 2G1 above					
	Develop and implement a Waste Management Plan	See 2G1 above					
2G3	Develop and implement a Biodiversity Management Plan	See 2A3 above					
	Develop and implement an Emergency Response Plan	See 2G1 above					
	Develop and Implement an Oil Spill Response Plan	See 2G1 above					
	Develop and implement a Waste Management Plan	See 2G1 above					

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
Also see Ancillary Activities (Phase 5)							
Operation (Phase 3)							
3B1	Use diesel fuel with less than .5 percent Sulfur for auxiliary generators	Throughout operations	Test fuel prior to acceptance to ensure Sulfur is within limits	Awareness training to Exmar and Excelerate staff	Excelerate HSE Compliance Coordinator	Bunker delivery notes Quarterly Reports	Market rates
	Develop and implement an Emissions and Air Quality Monitoring Program	Throughout operations	Continuous	Awareness training to Exmar and Excelerate staff	Excelerate HSE Compliance Coordinator	Quarterly Reports Annual Emissions and Air Quality Monitoring Report	$100,000 per year
3D2	Develop and maintain a Stakeholder Engagement Plan	Update plan prior to operation and implement throughout operations	Track interactions with fishermen and other vessels entering the safety exclusion zone	Awareness training to Excelerate, Exmar, and Svitzer staff on protocol for managing interactions with other vessels	Excelerate HSE Compliance Coordinator	Stakeholder engagement tracker and meeting minutes Monthly reports	$50,000

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
3D2	Develop and implement a Grievance Mechanism	Update grievance mechanism (incl. procedure) prior to operations and implement throughout operations	Track interactions with fishermen and other vessels entering the safety exclusion zone Track grievances	Awareness training to Excelerate, Exmar, and Svitzer staff on protocol for managing interactions with other vessels Communication with Bangladesh Navy on protocol for grievance mechanism	Excelerate HSE Compliance Coordinator	Grievance tracker Monthly reports	$25,000
3F3	Develop and implement a BAP	Throughout operations	To be determined in plan. Long term monitoring required per IFC Performance Standard 6.	Awareness training to Exmar, and Excelerate staff	Excelerate HSE Compliance Coordinator	Annual Monitoring Reports	$25,000 per year
	Develop and implement an ERP	Update plan prior to operations and implement throughout operations	Review records of training Conduct at least one drill annually	Awareness training to Excelerate, Exmar, and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate HSE Compliance Coordinator	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	$5,000

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
3F3	Develop and Implement an OSRP	Update plan prior to operations and implement throughout operations	Review records of training Conduct at least one drill during annually	Awareness training to Excelerate, Exmar, and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate HSE Compliance Coordinator	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	$5,000 plus $10,000 annually for drills
	Develop and implement a WMP	Update plan prior to operations and implement throughout operations	Track waste volumes generated and chain of custody through ultimate disposal at licensed facility	Awareness training to Excelerate, Exmar, and Svitzer staff on plan	Excelerate HSE Compliance Coordinator	Waste manifests Transfer of custody forms Monthly reports	$5,000 per year
	Conduct long term monitoring of Critical Habitat values	See 2A3 above					
3F4	Develop and implement a BAP	See 3F3 above					
	Develop and implement an ERP	See 3F3 above					
	Develop and Implement an OSRP	See 3F3 above					
	Develop and implement a WMP	See 3F3 above					
	Develop a HSP	Develop prior to construction and update prior to operations. Implement throughout the project lifecycle.	To be defined in plan. At a minimum, should include monitoring of training records, and tracking of incidents and near misses.	HSE induction training for Excelerate, Exmar and Svitzer staff	Excelerate HSE Compliance Coordinator	Records of training Monthly reports	$20,000 plus 10,000 per year

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
3F4	Conduct long term monitoring of Critical Habitat values	See 2A3 above					
Also see Ancillary Activities (Phase 5)							
Decommissioning (Phase 4)							
No medium or high level impacts identified							
Ancillary Activities (Phase 5)							
5C1	Support vessels should maintain a safe distance from marine mammals and sea turtles If seen, reduce vessel speed and maintain the following distances: • 50 m from dolphins, porpoises, and sea turtles • 100 m from whales	During entire project lifecycle	Track sightings of marine mammals and sea turtles in all vessels	Awareness training to Geocean, Exmar, and Svitzer staff	Excelerate Senior Manager of Environmental Permitting (during construction) and Excelerate HSE Compliance Coordinator (during operations)	Monthly reports	No additional cost
5F3	Develop and implement an ERP	During entire project lifecycle	Review records of training Conduct at least one drill annually	Awareness training to Excelerate, Geocean, Exmar, and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate Senior Manager of Environmental Permitting (during construction) and Excelerate HSE Compliance Coordinator (during operations)	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	Costs estimated in specific project phases above

Impact Identification	Mitigation Practice	When to Apply	Monitoring	Training Required	Responsible Party	Reporting	Approximate Cost to Implement Mitigation Measure
5F3	Develop and Implement an OSRP	During entire project lifecycle	Review records of training Conduct at least one drill during annually	Awareness training to Excelerate, Geocean, Exmar, and Svitzer staff on plan Coordinate with local officials where applicable	Excelerate Senior Manager of Environmental Permitting (during construction) and Excelerate HSE Compliance Coordinator (during operations)	Training records Stakeholder engagement tracker and meeting minutes Monthly reports	Costs estimated in specific project phases above
	Develop and implement a WMP	During entire project lifecycle	Track waste volumes generated and chain of custody through ultimate disposal at licensed facility	Awareness training to Excelerate, Geocean, Exmar, and Svitzer staff on plan	Excelerate Senior Manager of Environmental Permitting (during construction) and Excelerate HSE Compliance Coordinator (operations)	Waste manifests Transfer of custody forms Monthly reports	Costs estimated in specific project phases above
	Conduct long term monitoring of Critical Habitat values	See 2A3 above					

6.6 Mitigation Relative to the Associated Facilities

As noted in Chapter 5, the recent BETS field survey reveals low to in some cases moderate environmental and social impacts of the associated GTCL pipeline construction. Timely application of appropriate surface restoration (soil, drainage, and vegetation) and compensation practices could reduce all of these impacts to a low level.

If the required site restoration practices are not properly applied, or the compensation practices are not properly completed quickly, however, the impacts could remain moderate. Based on this possibility, it is recommended that Excelerate take the following actions to mitigate this risk:

1) Develop a specific communication protocol which will consist of periodic formal communications with the downstream operator to ensure the Anowara-Moheshkhali Pipeline is being operated and maintained appropriately, including where available the review of Petrobangla/ GTCL Anowara-Moheshkhali Pipeline monitoring reports
2) Continuously monitor the operating pressure, temperature and flowrate of the subsea pipeline from the FSRU and in the event of any anomalies, immediately notify the downstream operator
3) Subject to host national approvals, undertake two additional Associated Facility pipeline surveys, once during the first quarter of project construction and once during the final quarter of project construction, to be undertaken in a manner that compliments the Project ESIA Associated Facility pipeline survey
4) To the extent feasible, document report and facilitate the resolution of any identified stakeholder grievances or anomalies to Petrobangla/ GTCL and appropriate local government authorities.

6.7 Training

In addition to the training requirements indicated in the ESMP, training requirements of vessel crews of vessels are specified in the IMO STCW Convention. A wide variety of training is required, including: marine firefighting, water survival, spill response and clean-up, emergency medical procedures, hazardous materials procedures, confined space entry, and training on operational procedures.

Training requirements are also indicated in individual subcontractor management systems. For example, training for local vessel operators in the BAP, ERP, OSRP and other mitigation requirements will be needed at the start of construction and periodically throughout operations.

6.8 Compliance

To ensure compliance with applicable standards Excelerate maintains an Authorizations Register that complies all legal, regulatory, and financial commitments (including, for example, permit conditions, and financial covenants). Excelerate designates staff to maintain the register, and has engaged local council to advise on any changes required based (e.g. in the event a new law is promulgated).

6.9 Auditing

Beyond the routine inspection and monitoring activities conducted, audits will be carried out internally by Excelerate to ensure compliance with regulatory requirements as well as their own EHS standards and policies. Audits will also cover the subcontractor self-reported monitoring and inspection activities. The audit shall be performed by qualified staff and the results shall be communicated to Excelerate executive management.

The audits will include a review of compliance with the requirements of the ESMP and include, at minimum, the following:

- Completeness of EHS documentation, including planning documents and inspection records;
- Conformance with monitoring requirements;
- Remedial actions required to address any non-compliances; and
- Training activities and record keeping.

6.10 External Reporting

Excelerate will submit environmental monitoring reports to IFC after disbursement, at a frequency to be agreed upon by IFC and Excelerate (e.g. quarterly during construction and annually over the lifetime of the project). In the event of non-compliance to any environmental or social covenant in the loan agreements or any unanticipated impacts, Excelerate will prepare a corrective action plan describing the process and actions that will be undertaken to ensure compliance.

Per the conditions of the Environmental Clearance Certificate, Excelerate will submit an Environmental Performance Report at the end of construction to DOE Cox's Bazar District office and Dhaka office. Similarly, Excelerate will submit quarterly Environmental Monitoring Reports to DOE Cox's Bazar District office and Dhaka office.

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7 Public Consultation

7.1 Introduction

This chapter describes the strategy, objectives, completed activities and plans for public consultation and engagement in support of the Moheshkhali Floating LNG project ("Project"), to be located offshore the Island of Moheshkhali and Northwest of Cox's Bazar, Bangladesh.

In addition to reviewing requirements in Bangladesh for consultation and engagement, the document also details previous consultation activities undertaken, objectives, and approaches for stakeholder identification, consultation, and engagement, and future planned activity in support of active communication with stakeholders about the Moheshkhali floating LNG import terminal.

7.2 Consultation Regulations and Requirements

There are no legal requirements in Bangladesh for public consultation or information disclosure during the permitting process. However, sector specific guidelines suggest public participation as a part of impact assessment study and recognize the need to consider socio-cultural, physical, and biological impacts. According the EIA guidelines for industries, opportunities for the public to participate are under the discretion of the Director General of the Department of Environment.

The environmental approval process in Bangladesh is shown below in Figure 7-1.

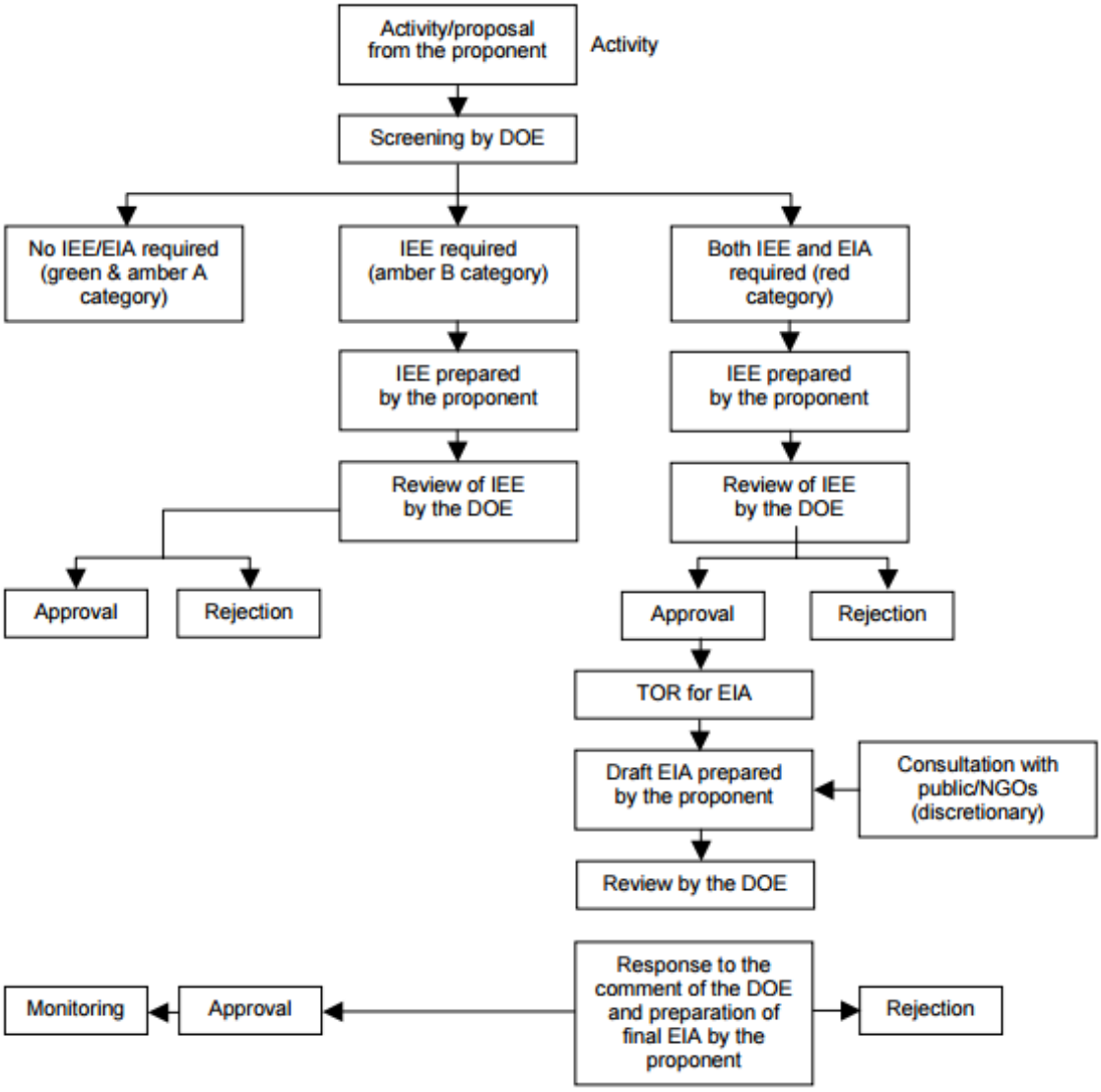
While public consultation is not required, it is recognized as a good industry practice[1] and a key contributor to social license to operate. For this reason, the Project is pursuing a multi-tiered consultation strategy which is detailed below.

7.3 Stakeholder Analysis

The Moheshkhali Floating LNG Project has a broad range of stakeholders, at the national, regional, and local level. By using stakeholder analysis (see Figure 7-2, mapping criteria below), the Project identified priority groups and individuals for engagement.

[1] Consultation and engagement is also a critical component of the IFC's Performance Standards on Environmental and Social Sustainability.

Figure 7-1: Flowchart of Environmental Approval Process in Bangladesh



Source: Ahammed and Harvey, 2004[2]

[2] Ahammed, R., and N. Harvey. 2004. Evaluation of environmental impact assessment procedures and practice in Bangladesh. Impact Assessment and Project Appraisal, 22:1, 63-78, DOI: 10.3152/147154604781766102

Figure 7-2: Mapping Criteria

Stakeholder Mapping Criteria		
Criteria		**Detailed description**
Interest Criteria	Interest in Project	Stakeholder has an interest in (i) the execution of project activities or (ii) the project's environmental, social, economic, cultural impacts, risks and activities
	Geography	The location of the stakeholder or its activities are within the Study Area (*based on ESIA, baseline studies and other background information*)
	Issues and Topics	Stakeholder is closely associated with one or more of region's key social, economic, cultural or environmental issues or considerations, including:
		- Tourism
		- Salt production
		- Artisanal, commercial and recreational fishing
		- Sensitive ecosystems
		- Workforce development
		- Human rights
		- Vulnerable groups, including women, children, elderly, ethnic groups, etc.
Influence Criteria	Hard influence	a legal and/or documented commitment - regulatory, contractual, etc. – associated with this stakeholder
	Soft influence	Building positive relations with the stakeholder is likely to contribute to overall project success. Or, conversely, stakeholder has led successful media campaigns that delay or inhibit large industrial/ development /commercial projects or has rallied community support for its causes.
	Networks	The stakeholder is well networked with relevant:
		- NGOs, community-led groups
		- key government entities
		- media
		- other well-recognized stakeholder groups

Stakeholders include representatives of the government—public agencies responsible for regulatory oversight—as well as interested members of civil society and the general public for whom project development may present potential impacts. Key government actors are listed below.

7.3.1 Ministry Representatives

Key Ministries with oversight over Moheshkhali Floating LNG include:

- The Ministry of Energy;
- Ministry of Shipping (and Chittagong Port Authority);
- Ministry of Environment and Forests;
- Ministry of Power, Energy and Mineral Resources.

At the regional/local level, and in the capital, representatives of these ministries issue project approvals, no objection certifications (NOCs), and clearance certifications prior to commencement of construction.

7.3.2 Agencies and Departments

The following agencies and departments provide key approvals and as such as are important stakeholders:

- The Bangladesh Energy Regulatory Commission;
- Department of Shipping;
- Department of Environment;
- Department of Forests;
- Department of Explosives;
- Bangladesh Inland Water Transport Authority.

7.3.3 Military

Several branches of the Bangladesh Military are also involved in aspects of the Floating LNG project, including:

- The Bangladesh Air Force;
- The Navy;
- The Coast Guard.

These stakeholders also issue approvals, and facilitate the safe and cooperate use of port, marine and other resources.

7.3.4 Regional and Local government

As regional and local government representatives, these stakeholders also issue approvals.

- The District Commissioner (Chittagong);
- Deputy Commissioner (Cox's Bazar);
- Union Parishad (Chairman and other officers) and
- Upazila administrators

A regulatory EIA has been completed and approved for the Project. Approval was preceded by extensive consultation, information sharing, and collaboration with the above government stakeholders. This current Public Consultation Plan includes review of previous meetings, as well as plans for update meetings with these groups and stakeholders; details are provided below.

7.3.5 NGOs and Civil Society

Previous and current / planned consultation activities have also focused on NGOs and civil society organizations, as well as local communities. The 'area of influence' for the Project includes the offshore footprint[3] of the floating storage and regasification unit (FSRU), the physical footprint of temporary onshore areas needed during construction, the areas used within the port, transportation corridor, and office spaces.

[3] Including safety zone and vessel maneuvering zones

7.3.6 Local Communities

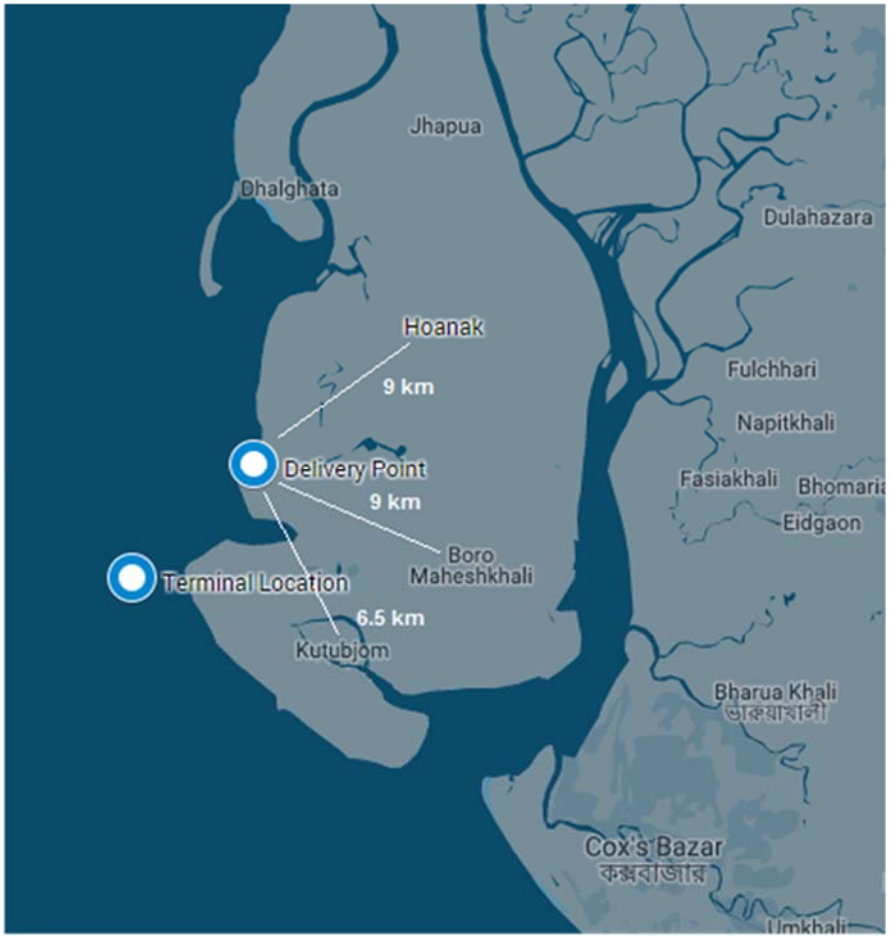
Within this geographic scope, the communities that live within, or utilize the area for economic activities may experience impacts from project construction and operations; as such they are important stakeholders.

Within the Cox's Bazaar District lies the Moheshkhali Upazila, and within this Upazila are three Union Council jurisdictions – Boro Moheshkhali, Hoanak, and Kutubjom– that are inhabited by people who live within 5-10 km of the Project Delivery Point (Figure 7-3).

Boro Moheshkhali consists of 29 villages, Hoanak includes 27 villages, and Kutubjom has 24 villages. The proposed Delivery Point is about 9 km from village Boro-Dale (within Boro Moheshkhali Union) and about 9 km from village Panirchara (within Hoanak Union). 4 Kutubjom union, and its villages are situated approximately 6.5 km from the Delivery Point.

The people living in these villages are also important stakeholders and will be consulted and updated prior to construction, as part of this Public Consultation Plan.

Figure 7-3: Village Locations and Stakeholders



[4] Field observation made during a 2012 visit by BETS.

7.4 Consultation Phases, Objectives and Approaches

This Public Consultation Plan, including strategy and objectives, builds on on-going and previous communication and engagement activity pursued since 2012. These activities are briefly reviewed below; additional detail is provided in Appendices. Public consultation and stakeholder engagement regarding the FSRU is being conducted in five (5) phases. These phases are:

Phase 1: Original EIA Consultation: 2012 – 2015

Phase 2: Post EIA – Engagement (Defining LTO (permits, NOCs, et al). August 2016

Phase 3: Engagement for Mitigation Planning / SLTO. October 2016

Phase 4: Pre-Construction Engagement (feedback mechanism, safety, et al.) Tbd/ 2H 2017.

Phase 5: Project Engagement: during Construction, early Operations. Tbd. 1Q 2018 forward.

7.4.1 Engagement and Consultation: 2016 - 2017 Objectives

The primary objectives of the public consultation process are to:

1. Ensure transparency and involvement of stakeholders in assessing and managing the potential environmental, socioeconomic, and health impacts of the project.
2. Help manage risks, concerns and expectations through on-going dialogue with stakeholders.
3. Improve decision-making, and build understanding by actively involving key project stakeholders in two-way communication. Through this process, the project will better understand the concerns and expectations of stakeholders, and the opportunities to increase project value to the local community.

To achieve these objectives, the Project consultation strategy includes:

- Reviewing the successes and lessons from previous consultation activities in Bangladesh and the project area
- Assembling information to presents stakeholders with a useful update to that shared during earlier project engagement
- Ensuring that stakeholders at the national, regional and local level have access to Project information and are able to raise questions and offer input
- Building upon the established stakeholder relationships to ensure that the Project has appropriate mechanisms in place to inform and receive feedback from stakeholders throughout construction and operation of the terminal

7.4.2 Methodology and Approaches

Public consultation and disclosure of information about the proposed Floating LNG Project has and will continue to take place through:

- Presentation of information about the Project
- Recording of stakeholder comments
- Interviews with key stakeholders
- Informal and formal focused group meetings

The consultation process is being conducted at several levels. The first level includes government ministries at respective provincial and district offices. The second level involved civil society stakeholders, private organizations, and local communities organized in groups. Current

plans follow this approach in order to re-establish and broaden local relationships and update stakeholders on project progress and next steps.

7.5 Completed Consultation and Disclosure

Consultation and Engagement in support of the FSRU has included successful completion of Phases 1-3; these are detailed below.

7.5.1 Phase 1: Original EIA Consultation.

In 2012, BETS Consulting implemented a consultation program based on preliminary examination of the FSRU's likely site, and area(s) of influence. Both key informant interviews and public/group meetings were undertaken as an input to the environmental assessment process. Between January and May 2012, consultation sessions focused on creating dialogue about potential positive and negative project impacts, as well as compiling the basic socioeconomic profile of community members in the immediate vicinity of the planned project.

Consulted stakeholders included:

- Petrobangla and GTCL
- The Upazila Nirbahi Officer (UNO) – Moheshkhali
- Deputy Commissioner - Cox's Bazar
- Local cultural organizations
- Local business and labor representatives (ferry and other boat pilots; salt cultivators, et al)
- Local Police
- Navy and Coast Guard
- Interested community members

Among the comments and concerns raised were the following:

- The extent to which agricultural activities, salt farming, and shrimp cultivation might be impacted
- Amount of compensation to be made available to affected people
- Possibility of noise, air and water pollution affecting communities and wildlife
- Potential for local content in the construction of the FSRU project

See Appendix I for more detail regarding phase 1 consultation.

7.5.2 Phase 2: Post-EIA Engagement

As noted above, an EIA has been completed and approved for the Moheshkhali Floating LNG Project. The impact assessment process included public consultation (undertaken in 2011-2012). Following completion of the impact assessment process, the project received Environmental Clearance. Consultation continued after award of Environmental Clearance, to ensure stakeholder awareness, support, and input.

Petrobangla has an established program of stakeholder involvement in Cox's Bazar. The goal for the Project is to build upon the work already undertaken, and to develop a strategy that continues to provide opportunities for all stakeholders to actively contribute throughout Project development.

One of the ways this can be achieved is through this ESIA process. In order to develop the strategy for consultation and disclosure a number of steps were followed, each of which is described below:

1. Likely stakeholders in the Project were identified and their interests in the project assessed;
2. The stakeholder involvement already undertaken by the Operator was reviewed and analyzed as to the level of success and, based on this, methods were developed for increasing involvement and for facilitating active participation in the process; and
3. The consultation program was implemented:
    - Pre-ESIA consultation;
    - ESIA scoping consultation;
    - ESIA draft document disclosure consultation;
    - Post ESIA project consultation;
    - Programme for on-going consultation defined.

Figure 7-4 below illustrates the process.

In 2016, as part of this impact assessment updating process, scoping study engagement activity commenced with a simple stakeholder mapping exercise which listed key stakeholders and characterized their level of interest in the LNG project.

Stakeholder mapping was followed by a scoping trip in Bangladesh that included meetings with government officials and other key stakeholders. Results of these meetings are detailed below

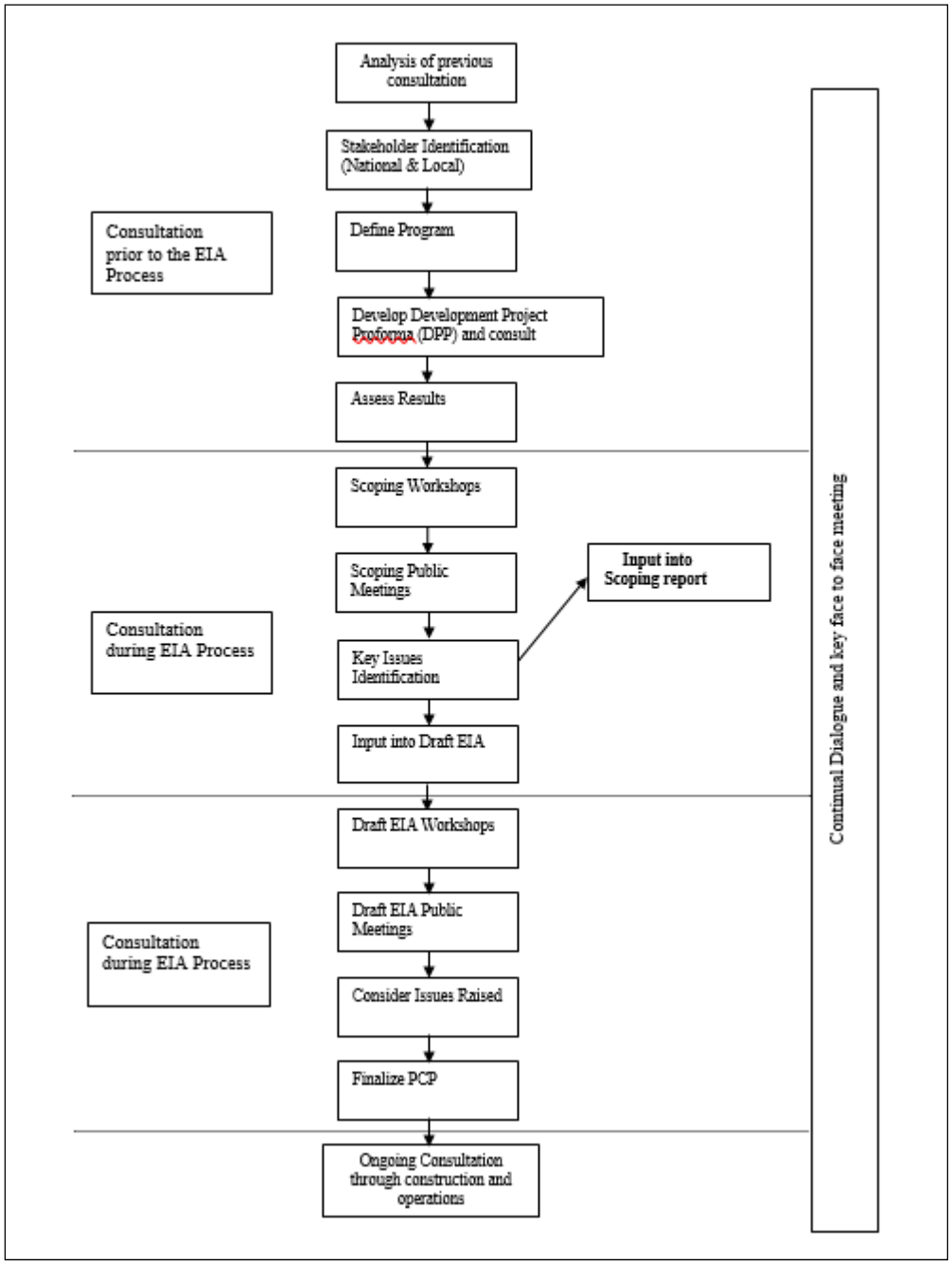
A first set of update consultation meetings took place in August 2016. The government and quasi-government departmental meetings were held in at the offices of Petrobangla as well as Provincial and District offices. As detailed in Appendix I, consultation with local stakeholders built upon questionnaires and survey results to focus public dialogue on key issues of concerns. Follow up consultation returned to these issues, and additionally revisited the details of construction and operations, in order to update interested stakeholders in how technical aspects of the Project had progressed.

In Dhaka, the engagement team met with members of Petrobangla, GTCL, the Ministry of Environment and Forests, the Department of Environment, the Ministry of Shipping and the Energy and Mineral Resources Division.

In Cox's Bazar, meeting attendees included the Deputy Commissioner of Cox's Bazar, the Department of Environment, the UNO of Moheshkhali, the Union Chairman, members of the Upazila administration, and the Forestry Division.

These meetings focused on updating these stakeholders regarding progress of the Moheshkhali Floating LNG project, sharing relevant news about other projects and developments in Moheshkhali, and discussing and answering questions about upcoming activities. No concerns were noted during these sessions. Summary meeting minutes for Phase 2 consultation can be found in Appendix J.

Figure 7-4: EIA Public Consultation - Bangladesh



7.5.3 Phase 3: Engagement for Mitigation Planning

In October 2016, members of the Project team traveled to Bangladesh for stakeholder consultation meetings organized in Dhaka, Chittagong, Cox's Bazar, and Moheshkhali.

In Dhaka, the engagement team met with members of Petrobangla, the Department of Environment, the Department of Forests, the Department of Fisheries, the Department of Explosives, the Bangladesh Energy Regulatory Commission, the office of Natural Resource Management, the Coast Guard, and environmental NGOs including the IUCN.

Chittagong consultation included meetings with the Port Authority (Chittagong), Chittagong University, Department of Explosives, and representatives of the Coast Guard.

In Cox's Bazar, meetings were held with the Deputy Commissioner of Cox's Bazar, as well as local representatives of the Departments of Environment, Forests, and Fisheries.

Moheshkhali engagement and consultation focused on local government representatives (the Upazila Nirbahi Officer, Union Parishad Chairmen) as well as fishing associations and local civil society groups, as well as limited groups of local village representatives closest to the Project tie-in site.

The overarching focus of these consultation and engagement sessions was updating these Project stakeholders regarding progress of the Moheshkhali Floating LNG project, sharing relevant news about other projects and developments in Moheshkhali, and discussing and answering questions about upcoming activities. More details can be found in Appendix K.

7.6 Engagement and Consultation Plans: 2017 - 2018

Planned future consultation and engagement activities will focus on preparing host communities prior to construction mobilization. With a focus on safety, impact management, and establishing/maintaining open lines of communication, phase 4 and phase 5 activities are outlined below.

7.6.1 Phase 4: Pre-Construction Engagement

The Project plans to pursue final, pre-construction mobilization consultation by re-engaging and updating parties that expressed interest during previous consultation and by holding structured, public sessions in areas of project influence.

In the 2 months immediately prior to construction, phase 4 engagement activity will focus on ensuring that stakeholders are cognizant and comfortable regarding Project plans and are aware of how to communicate with Floating LNG representatives should need arise. These consultation activities will focus on multiple stakeholder 'layers' and locations:

- At the national level, update engagement with government and other representatives as needed
- Regional consultation and updates: meetings will be arranged with the Port authority and Coast Guard regarding security, spill response, and other aspects of maritime safety
- Regional and local: closer to the Delivery Point, the Project will update the Deputy Commissioner, Cox's Bazar; the UNO Moheshkhali, Union Chairmen, the Chief Inspector (police), and in the 3 nearby unions, interested village residents.

Additionally, Table 7-1 below lists those individuals who will receive follow-up consultation based on previous engagement and demonstrated interest.

Table 7-1: Local Engagement - Interested Parties

Name	Organization/Profession	Address
Md. Giash Uddin	Village Conservation Group Sonadia ECA	Sonadia Pochimpara village, Moheshkali Island
Md. Azizul	Local Villager	Tajiakata Village, Moheshkali Island
Mohammad Jafor Alam	Chairman	Boro Moheskhali
Mohammad Abul Kalam	UP Member Ward No. 1	Boro Moheshkhali
Md. Faridul Alam Son of Late Osman Goni	Salt Cultivator	Panichara Bazar
Md. Zafor Alam Son of Late Kala Mia	Salt Cultivator	Borodail

As noted above, the Project will host public community meetings in the villages closest to the tie-in site. These villages were previously visited in the initial round of meetings, and during mitigation planning consultation. As in previous rounds of consultation, the selection of guiding questions (Figure 7-5) will again be used as a means of ensuring that public discussions touch upon community level concerns.

Figure 7-5: Consultation Questions

1. What is your view about the proposed project?
2. Who may benefit from the project (income and occupational groups)?
3. Approximately how many households by type?
4. Who may be affected by the project (income and occupational groups)? Approximately how many households by type?
5. Is there any small/ marginal group who may be affected?
6. Is there any Adibashi/ ethnic minority who may be affected?
7. What affect will the proposed project have on the community of women?
8. What are the problems that may arise due to implementation of the project?
9. How to overcome / what are the steps to be taken to overcome problems?
10. What are the supports that the proposed project authority or implementation authority may get from them?
11. Who are the people likely to oppose that project?
12. What are their concerns? How to overcome that?
13. What are the problems that may occur after implementation of the project?
14. What are the effects of the project likely to be on local community?
15. What types of effects may be there to the project from the community side?
16. Are there any trees or gardens or cemetery with religious or cultural or heritage significance nearby? If so where (distance approximately in meter).
17. Are there any environmentally significant areas (i.e. ecologically critical area, protected forest, sanctuary etc.) nearby or within the project? If so where (distance approximately in meter).
18. Will construction and operation of the project affect your working life?
19. What potential environmental problems we should pay attention to?
20. Do you as a local representative/officials/resident/worker have any specific observation on the environmental changes and impacts that may take place?
21. Do you have any suggestions to reduce such environmental impacts?
22. Do you have any other suggestions or ideas?
23. Any other point that may come up during discussion or they want to add or share?

7.7 Phase 5: Project Engagement – Construction and Operations

As the Floating LNG Project moves forward, the consultation focus will be on maintaining relationships and ensuring public avenues for communication. These include:

- Reviewing of stakeholder comments during the ESIA update consultation, to validate whether planned mitigation measures adequately address stakeholder concerns.
- Establishment of a Grievance Mechanism that allows for the collection and response to concerns and feedback from community members and stakeholders in the Project's area of influence,
- Designing and implementing a Construction and Operations Engagement Plan that builds on the rounds of public consultation and disclosure activity to ensure that stakeholders remain aware of Project-related environmental and social performance, safety considerations, and means to provide feedback and resolve any concerns.

7.8 Grievance Mechanism

An important element of successful stakeholder engagement is having a system in place to capture and respond to grievances from the public throughout the life of the project. The International Association of Oil and Gas Producers (OGP) and International Petroleum Industry Environmental Conservation Association (IPIECA) advise that such mechanisms should be established so that local residents and other potentially affected stakeholders can be assured that their grievances are received and addressed in a consistent and transparent manner. OGP suggests that grievance mechanisms can help to establish a positive avenue for a company to interact directly with stakeholders and build positive relationships.

The project grievance mechanism (GM) will a key means for addressing concerns raised by local stakeholders, including the fishing community, with regard to impacts and mitigation. If any unanticipated negative impacts occur that can be clearly demonstrated as a result of the Project, stakeholders will be able to submit their concern to Excelerate Energy through the GM, and are ensured of a response through this process. The Project team will evaluate each grievance submitted on a case-by-case basis to determine if the request for compensation is valid.

The GM will be rolled out in advance of the start-up of the project so that stakeholders and residents know in advance how to contact a company representative, and so that the company can ensure that the appropriate resources are available to address any grievances that are raised. The GM will be part of an overall engagement strategy that includes the following elements:

- Excelerate will maintain correspondence with appropriate government agencies and be available to answer any questions or provide additional information upon request
- Excelerate will commit to providing timely and transparent responses to each question or concern received in a manner that is free of intimidation, and to keep records of all grievances received as well as responses given.
- All grievances will be responded to, in accordance with the preferred method of communication specified by the complainant, if contact details of the complainant are provided.
- Individuals who submit their comments or grievances have the right to request that their name be kept confidential.
- Excelerate will ensure that Project contractors are prepared to manage grievances consistent with Excelerate's system.
- Excelerate will keep a grievance log (including those received and addressed by the Contractor), based on which grievance management reports will be produced.

Excelerate is currently developing the complete GM procedure with its subcontractors.

At all times, complainants should be able to seek legal remedies in accordance with the laws and regulations of Bangladesh.

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Appendix A: Project Environmental Clearance Certificate

Government of the People's Republic of Bangladesh
Department of Environment
www.doe-bd.org
Head Office, Paribesh Bhaban
E-16 Agargaon, Dhaka-1207

Memo No : DoE/Clearance/5117/2011/250 Date: 07/01/2016

Subject: Environmental Clearance for Offshore LNG Floating Storage and Regasification Unit (FSRU) Terminal Permanently Moored at Island/Finger Jetty Activities Project at Maheshkhali Area under Cox's Bazar District.

Ref: 1) Your Application dated 31/03/2013, 16/09/2015 and 20/12/2015.

With reference to the above, the Department of Environment (DOE) is pleased to award the Environmental Clearance along with Environmental Impact Assessment (EIA) Approval in favor of Offshore LNG Floating Storage and Regasification Unit (FSRU) Terminal Permanently Moored at Island/Finger Jetty Activities Project at Maheshkhali Area under Cox's Bazar District subject to fulfilling the following terms and conditions.

1. The activity under Offshore LNG Floating Storage and Regasification Unit (FSRU) Terminal Permanently Moored at Island/Finger Jetty Activities Project shall not result in the loss of containment of any materials that would affect health or will have damaging impact on the environment or natural resources.
2. Activities must be carried out in a competent manner. This includes:
   a) the processing, handling, movement and storage of materials and substances used to carry out the activity; and
   (b) the treatment, storage, processing, reprocessing, transport and disposal of waste generated by the activity.
3. All plant and equipment installed at the premises or used in connection with the licensed activity:
   (a) must be maintained in a proper and efficient condition; and
   (b) must be operated in a proper and efficient manner.
4. During the construction period, an emergency response system has to be put in place with proper emergency equipment and manpower. With this respect, an appropriate safety orientation has to be given to relevant employees, contractors, visitors and alike.
5. Proper and adequate on-site precautionary and safety measures shall have to be taken so that any untoward accident could be avoided.
   To address any untoward fire, blow-out or other emergencies, the project authority shall provide training to the local people (e.g. fishermen) working/living within 1 km radius of the project site.
7. Oil Spill response Plan shall have to be meticulously implemented. In case of any oil spill, continued monitoring shall be ensured till completion of its recovery/disposal.
8. Full and adequate utilization of the system for mitigation of pollution and environmental damage as well as that for treatment of wastes shall be ensured.
9. A fully functional fire fighting equipment shall be kept on site through out the project period.
10. In order to control noise pollution, vehicles & equipment shall be maintained regularly; working during sensitive hours and locating machinery close to sensitive receptor shall be avoided.
11. Construction material should be properly disposed off after the construction work is over.
12. Comprehensive Environmental Performance report, upon completion of the construction activities shall have to be submitted to both the DOE Cox's Bazar District Office and Head office describing actual intervention and rehabilitation at the project site.
13. Stringent control measures and procedures to be adopted to avoid gas leakage during storage and transmission activities.
14. The Environmental Management Plan included in the EIA report shall strictly be implemented and kept functioning on a continuous basis.
15. All the required mitigation measures along with the emergency response plan suggested in the EIA report is to be strictly implemented and kept operative/functioning on a continuous basis.

16. No solid waste can be burnt in the project area. An environment friendly solid waste management should be in place during whole the period of the project in the field.
17. Proper and adequate on-site precautionary measures and safety measures shall be ensured so that no habitat of any flora and fauna would be demolished or destructed.
18. As described in the report environmental monitoring should be strictly followed and monitoring report should be shared with DOE on quarterly basis to ensure the environmental management properly.
19. At the time of commissioning of the FSRU and Gas Transmission Pipeline utmost precautionary measures should be taken to reduce the possibility of accident.
20. In case of any emergency, the following information shall immediately be reported to Cox's Bazar District Office and Headquarters of the Department of Environment(DOE) simultaneously
    a) Nature of incident (fire, accident, etc.)
    b)Personnel affected (injured, missing, fatalities, etc.)
    c) Emergency support available and its location (standby transport, medical facilities, etc.)
    d)Weather conditions
    e) Current operations (abandoning the site, fire fighting, etc.)
21. All pollution incidents shall be reported immediately to the Cox's Bazar District Office, Chittagong Regional Office and Headquarters in Dhaka of the Department of Environment.
22. Environmental Monitoring Report shall be submitted on a quarterly basis to both the DOE offices including actual intervention and the rehabilitation, mitigation and treatment options adopted at the project site.
23. All parameters of effluent, gaseous emission, noise, solid waste, hazardous waste, etc. shall be within the limits in the Environment Conservation Rules (ECR) 1997. In case of non-coverage of ECR 1997 the World Bank Environment, Health and Safety Guideline shall be adhered to.
24. No activity of cutting/razing/dressing of hill or hilly land is endorsed under this clearance without due permission/clearance of the concerned authority of the Government of Bangladesh.
25. Appropriate permission would be required to obtain from the forest department in favor of cutting/felling of any plant/tree/sapling forested by any individual or government before doing such type of activity.
26. Appropriate permission/NOC would be required to obtain from BIWTA before starting the project activity.
27. The project authority shall extend active cooperation to DOE officials to facilitate their visit to the site as and when necessary.
28. This clearance is valid only for the Offshore LNG Floating Storage and Regasification Unit (FSRU) Terminal Permanently Moored at Island/Finger Jetty Activities Project as figured out in the EIA report submitted to this department.
29. Violation of any of the above conditions shall render this clearance void.
30. This Environmental Clearance is valid for one year from the date of issuance and the project authority shall apply for renewal to the Cox's Bazar District Office with a copy to the Head Office of DOE at least 30 days ahead of expiry.

07.01.2016

(Syed Nazmul Ahsan)
Director (Environmental Clearance, c.c)

General Manager (Planning)
Gas Transmission Company Limited (GTCL)
Red Crescent Borak Tower (Level-2, 6 & 8)
71-72, Old Elephant Road, Eskaton, Ramna, Dhaka-1000.

Copy Forwarded to :

1) Private Secretary to the Hon'ble Secretary, Ministry of Environment and Forests, Bangladesh Secretariat, Dhaka.
2) Director, Department of Environment, Chittagong Regional Office, Chittagong.
3) Deputy Director/Office in-charge, Department of Environment,
4) Assistant Director, Office of the Director General, Department of Environment, Head Office, Dhaka.

Appendix B: List of Flora and Fauna from Original EIA

List of fauna in Bangladesh covered under CITES appendices I and II							
Class	Order	Family	Appendix I		Appendix II		English Name
			Genus	Species	Genus	Species	
MAMMALIA	PRIMATES	Cercopitibecidae	Semnopitbecus	entellus			Commom Langur *
		"	Traccypitbecus	pileatus			Capped Langur *
		Hylobatidae	Hylobates	boolock			Hoolock Gibbon *
	PHOLIDOTA	Maindae			Mains spp		Pangolin *
	LAGOMORPHA	Leporidae	Caprolagus	bispidus			Hispid Hare
	RODENTIA	Sciuridae			Ratufa spp		Squirrel *
	CETACEA	Platanistidae	Platanista spp				River Dolphin *
		Delpbinidae	Sousa spp				Indo-Pacific humpback *
		Pbocoenidae	Neopbocaena	pbocaenoides			Fineless Porpoise *
		Balaenopteridae	Balaenoptena	muculus			Blue Whale
	CARNIVORA	Canidae			Canis	Anpus	Wolf
		"			Cuon	Alpinus	Dhole *
		Ursidae	Helardos	malayanus			Sun Bear
		"	Melursus	ursinus			Sloth Bear
		"	Ursus	tbibetanus			Black Bear
		Mustelidae	Lutra	lutra			Common Otter *
		"			Aonyx	cinerea	Small-Clawed Otter *
		"			Lutra	perspicillata	Smooth Coated Otter *
		Felidae	Pardofelis	marmorata			Golden Cat
		"	Prionailrrus	bengalensis			Leopard Cat
		"	Neofelis	nebulosa			Clouded Leopardd *
		"			Felis	cbaus	Jungle Cat *
		"			Felis	viverrnus	Fishing Cat *
		"	Pantbera	pardus e.w			Cheeta
		"	Panthera	tigris			Bengal Tiger
	PROBOSCIDEA	Elephantidae	Elepbas	maximus			Asain Elephant *
	PERISSSODACTYLA	Rbinocerotidae			Rbinoceros	Unicornis e.w	Asiatic One homed Rhinoceros
		"			Dedermocerus	sumatrensis e. w	Tow homed Rhinoceros

P. e = **Possibly Extinct**
e. w = Extinct in Wild in Bangladesh

*** = all aesteric market species have been reported from eastern coastal region.**

List of fauna in Bangladesh covered under CITES appendices I and II							
Class	**Order**	**Family**	**Appendix I**		**Appendix II**		**English Name**
			Genus	**Species**	**Genus**	**Species**	
	ARTIODACTYLA	Cervidae	Cervus	duvaucelii			Swamp Deer
		"	Axis	porcinus			Hog Deer
		Bovidae	Bos	gaurus			Gaur
		"	Nacmorbedus	sumatraensis			Goat Antelope *
AVES	PELECANIFORMES	Pelecanidae	Pelecanus	crispus			Dalmatian pelican
	CICONIFORMES	Ciconiidae	Cicconia	boyciana			Oriental strock
		Threskironithidae			Platalea	Leucordia	Spoon bill *
	ANSERIFORMES	Anatidae	Carina	scutulata			White winged duck
		"	Rbodonessa	caryopbyllacea p.e			Pick-headed duck
		"			Anas	formosa	Baikal Teal
		"			Sarkidiomis	melanotos	Comb Duck
	FALCONIFORMES	Cathartidae	Vultur	grypbus			Griffon Vulture
		Ccaipitridae	Aquila	beliaca			Immperial Eagle
		"	Haliaeetus	leucocephalus			Pallas's Sea-Eagle
		Falconidae	Falco	jugger			Falcon
		"	Falco	peregrinus			Peregrine Falcon *
		Phasianidae	Syrmaticus	bumiae			Humes Pheasantt
		"			Pavo	muticus p.e	Green Peafowl
		"			Polyplectrron	bicalaratum	Grey Peacock Pheasant
	GRUIFORMES	Gruidae			Grus	antigone	Surus Crane
		"			Antbropodies	uirgo	Demosile Crane
	CHARADIIFORMES	Scolopacidae	Tringa	guttifer			Nordman's Greenshank *
	CORACIIFORMES	Bucerotidae	Aceros	nipalensis			Fufous-necked Hombill
		"	Buceros	bicomis	Anthracoceros spp.		Great Hombill
	PASSERIFORMES	Pittidae			Pitta	nympba	Pitta
REPTTILIA	TESTUDINATA	Emydidae	Batagur	baska			Batagur
		"	Geoclemys	bamiltoni			Spotted Pond Turtle
		"	Melanochelys	tricarinata	Testudinidae spp. *		Tricarinet Hill Turtle *

P. e = **Possibly Extinct**
e. W = **Extinct in Wild in Bangladesh**

List of fauna in Bangladesh covered under CITES appendices I and II							
Class	**Order**	**Family**	**Appendix I**		**Appendix II**		**English Name**
			Genus	**Species**	**Genus**	**Species**	
		Testudinidae			Indotestudo	elongata	Elongated Tortoise
		"			Manouria	emys	Anian Giant Tortoise
		Cheloniidae	Caretta	caretta			Loggerhead Turtle *
		"	Chelonia	mydass			Green Turtle *
		"	Eretmocbelys	imbricata			Hawksbill Turtle *
REPTILIA	TESTUDINATA	Cheloniidae	Lepidocbelys	olivacea			Olive Ridley Turtle *
		Dermochelyidae	Dermochelys	coriacea			Leatherback Turtle
		Trionycbidae			Lissemys	punctata	Brahminy flap shell Turtle *
		"	Aspideretes	gangeticus			Indian Softshell Turtule
		"	Aspideretes	nigricans			Black Soft-shell Turtule
		"	Aspideretes	hurun			Indian Peacock Soft-shell Turtle
	CROCODYLIA	Crocodylidae	Crocodylus	palustris e.w			Mugger
		"	crocodylus	porosus			Estuarine Corcodile
		Gavialidae	Gavialis	gangeticus			Gharial
	SAURIA	Varanidae	Varanus	bengalensis			Black Monitor *
		"	Varanus	flavescenss			Yellow Monitor
		"			Varanus	salvator	Water Monitor *
	SERPENTES	Boidae	Python	molurus			Indian Python *
		"			Pytbon	reticulatus	Reticulated Python
		"			Boa	constrictor	Sand Boa
		Colubridae			Ptyas	mucosus	Rat Snake *
					Elacbistodon	westermanni	Indian Egg-eating snake
		Elapidae			Naja	naJa	Indian cobra
		"			Opbiopbagus	bannab	King Cobra *
AMPHIBIA	ANURA	Ranidae			Rana	bexadactyla	Green Frog *
		"			Rana	tigerina	Indian Bull Frog *
ANNELIDA	HIRUDINOIDEA	Hirudinidae			Hirudo	medicinalis	Leech

P. e = Possibly Extinct
e. w = Extinct in Wild in Bangladesh

Wildlife of Eastern Coastal Region of Bangladesh, including the Hill forests species

No.	Scientific Name	Common Name
	MAMMALS	
1	*Order - Insectivora* *Suncus murinus*	Grey Mask Shrew
2	*Order - Chiroptera* *Pteropus giganteus*	Flying Fox
3	*Rousenttus leschenaulli*	Fulvous Fruit Bat
4	*Cynopterus spninx*	Shortnosed Fruit Bat
5	*Rhinopome hardwickei*	Lesser Rat-tailed Bat
6	*Megaderma lyra*	False vampire
7	*Pipistrellus corromandra*	Pipistrelle
8	*Hesperoptenus tickelli*	Tickell's Bat
9	*Scotophilus temminki*	Lesser Yellow Bat
10	*Order - Primate* *Macaca mulatta* *Macaca fasicularis Hylobates hoolock* *Traccypithecus pileatus Macaca assamensis*	Rhesus Macaque Crabeating Macaque - Ex. Hoolock Gibbon Capped Langer Assamere macaque
11	*Order – Carnivora* *Canis aureus*	Jackal
12	*Vulpes bengalensis*	Bengal Fox
13	*Lutra perspicillata*	Smooth Indian Otter
14	*Aonyx cinerea*	Clawless Otter
15	*Viverra zibetha*	Large civet
16	*Viverricula indica*	Small Civet
17	*Paradoxurus harmaphroditus*	Palm Civet
18	*Herpestes auropunctatus*	Small Mongoose
19	*H. edwardsi*	Common Mongoose
20	*Panthera tigris*	Bengal Tiger - Ex
21	*Filis bengalensis*	Leopard Cat
22	*Felis viverrina*	Fishing Cat
23	*Felis chaus*	Jungle Cat

No.	Scientific Name	Common Name
	Order - Artiodactyla	
24.	*Muntiacus muntiac*	Barking Deer
25.	*Sus scrofa*	Wild Boar
26.	*Order - Lagomorpha* *Lepus nigricollis*	Rufoustailed hare
27.	*Order - Rodentia* *Funumbulus pennauti*	Fivestripped Palm Squirre
28.	*Bandicota bengalensis*	Lesser Bandicoot
29.	*B. indica*	Bandicoot Rat
30.	*Mus booduga*	Indian Porcupine
31.	*M. musculus*	House Mouse
32.	*Rattus rattus*	Common House Rat
33.	*Hystrix indica*	Indian Porcupine
34.	*Order - Cetacea* *Orcaella brevirostris*	Irrawaddy Dolphin
35.	*Neophocaena phocaenoides*	Little Porpoise
36.	*Stenella malayana*	Malay Dolphin
37.	*Platanista gangetica*	Ganges River Dolphin
38.	*Delphinus delphis*	Common Dolphin
39.	*Sotelea plumbea*	Plumbeous Dolphin
	Birds	
	Family - Prodicipedidae	
40.	*Podiceps ruficollis*	Little Grebe
	Family - Polecanidae	
41.	*Pelecanus philippensis*	Spotbilled Pelican
42.	*P. onocrotalus*	White/Rose Pelican
	Family - Phalacrocoracidae	
43.	*Phalacrocorax carbo*	Large Cormorant
44.	*P. niger*	Little cormorant
45.	*Anhinga rufa*	Darter
	Family - Ardeidae	
46.	*Ardea goliath*	Giant Heron
47.	*A. cinerea*	Grey Heron
48.	*A. purpurea*	Purple Heron
49.	*A. imperialis*	Great Whitebellied Heron
50.	*Butorides striatus*	Little Green Heron
51.	*Ardeoal grayii*	Pond Heron

No.	Scientific Name	Common Name
52.	*Bubulcus ibis*	Cattle egret
53.	*Egretta alba*	Large egret
54.	*Egretta internedia*	Intermediate Egret
55.	*Egretta garzetta*	Little egret
56.	*Nycticorax nycticorax*	Night Heron
57.	*ixobroychus cinnamomeus*	Chestuat Bittern
58.	*I. Sinensis*	Yellow Bittern
59.	*Dupetor jlavicollis*	Black Bitten
60.	*Gorsachius melanopterus*	Tiger Bittern
61.	*Family - Ciconiidae* *Ibis leucocephalus*	Painted stork
62.	*Anastomus oscitans*	Openbill Stork
63.	*Ciconia ciconia*	White Stork
64.	*Ciconia episcopus*	Whitenecked stork - Ex
65.	*Leptoptilos javanicus*	Lesser Adjutant
66.	*L.dubius*	Greater Adjutant - Ex
67.	*Xenorhynchus oscitans*	Blacknecked Stork
68.	*Family - Threskiornithidae* *Threkiornis melanocephala*	White Ibis
69.	*Platelea leu cordia*	Spoonbill
70.	*Family - Anatidae* *Anser isdicus*	Barheaded Goose
71.	*anser*	Grey Lag Goose
72.	*Dendrocygna javanica*	Lesser Whistling Teal
73.	*Anas penelope*	Wigeon
74.	*A. crecca*	Common Teal
75.	*A. clypeata*	Shoveller
76.	*A. acuta*	Pintail
77.	*A. Platyrhynchos*	Mallard
78.	*A. strepers*	Gadwall
79.	*A querquedula*	Gargancy
80.	*Aythya fuligula*	Tufted Duck
81.	*A nyroca*	Whiteeyed Pochard
82.	*A·ferina*	Common Pochard
83.	*Tedorna ferruginea*	Brahminy Duck
84.	*Nettapus coromandelianus*	Cotton Teal
85.	*Netta rufina*	Redcrested Pochard
86.	*Family - Pandionidae* *Pandion haliaetus*	Osprey

No.	Scientific Name	Common Name
87.	*Family Accipitridae* *Elanus caeruleus*	Blackwinged Kite
88.	*Milvus migrans*	Pariah Kite
89.	*Haliasterindus*	Brahminy Kite
90.	*Accipter badius*	Shikra
91.	*A.nisus*	Sparrow Hawk
92.	*A. Triviagatus*	Crested Goshawk
93.	*Butaster teesa*	Whiteeyed Buzzard
94.	*Pernis ptilorhynchus*	Honey Buzzard
95.	*Spizaetus limnetus*	Changeable Hawk
96.	*Buteo rufinus*	Longlegged Buzzard
97.	*B.buteo*	Buzzard
98.	*Hiraaetus pennatus*	Booted Hawk Eagle
99.	*Aquila rapax*	Tawny Eagle
100.	*A. clanga*	Greater Spotted Eagle
101.	*A. pomarina*	Lesser Spotted Eagle
102.	*Ictinaetus malayensis*	Black Eagle - Ex
103.	*Haliaeetus leueogaster*	Whitebellied Sea Eagle
104.	*H. leucoryphus*	Pallas's Fishing Eagle
105.	*Icthyophaga icthyaetus*	Greyheaded Fishing Eagle
106.	*Gyps bengalensis*	Whitebacked Vulture
107.	*Circus macrourus*	Pale Harrier
108.	*C. melanoleucos*	Pied harrier
109.	*C. aeruginosus*	Marsh harrier
110.	*Spilornis cheela*	Crested Serpent Eagle
111.	*Family - Falconidae* *Falco peregrinus*	Shaheen Falcon
112.	*F. chiquera*	Redheaded Merlin
113.	*F. serverus*	Oriental Hobby
114.	*Family - Phesianidae* *Francolinus Gularis*	Swamp Partridge
115.	*Gallus gallus*	Red Jungle Fowl
116.	*Family - Rallidae* *Rallus aquaticus*	Water Rail
117.	*Amourornis fuscus*	Ruddy Crake
118.	*A. phoenicurus*	Whitebreasted water Hen
119.	*Gallicrex cinerea*	Water Cock
120.	*Gallinula chloropus*	Moorhen
121.	*Fulica atra*	Coot
122.	*Porphyrio porphyrio*	Purple Moorhen

No.	Scientific Name	Common Name
	Family - Jacanidae	Bronzewinged Jacana
123.	*Metapidius indicus*	Pheasantlailed Jacana
124.	*Hydrophasianus chirurgus*	
	Family - Haematopodidae	
125.	*Haematopus ostralegus*	Oystercatcher
	Family - Charadriidae	
126.	*Vanellus cinereus*	Greyheaded Lapwing
127.	*V. spinosus*	Spurwinged Lapwing
128.	*V. indicus*	Redwattled Lapwing
129.	*V. malabaricus*	Yellowwattled Lapwing
130.	*Pluvialis spuatorola*	Grey Plover
13l.	*P. dominica*	Eastern Golden Plover
132.	*Charadrius placidus*	Longbilled Ringed Plover
133.	*C. mongolus*	Mongolian Plover
134.	*C. leschenaulti*	Large Sand Plover
135.	*C .alexandrinus*	Kentish Plover
136.	*C .dublus*	Little Ringed Plover
137.	*C. hiaticula*	Ringed Plover
138.	*Numeneus phaeopus*	Eastern Whimbrel
139.	*N. arpuata*	Curlew
140.	*Limosa limosa*	Blacktailed Godwit
14l.	*Tringa glareola*	Wood Sandpiper
142.	*T. erythropus*	Spotted Redshank
143.	*T. terek*	Terek Sandpiper
144.	*T. totanus*	Common Redshank
145.	*T. nebularia*	Green Shank
146.	*T. ochropus*	Green Sandpiper
147.	*T. hypoleucos*	Common Sandpiper
148.	*T. stagnatilis*	Marsh Sandpiper
149.	*Limnodromus semipalmetus*	Asian Dowitcher
150.	*Arenaria inter pres*	Turnstone
15l.	*Capella gallinago*	Fantail Snipe
152.	*Capella stenura*	Pintail Snipe
153.	*Calidris alpinus*	Dunlin
154.	*C. minutus*	Little Stint
155.	*C. temmincki*	Temminck's Stint
156.	*C. tenuirostris*	Eastern Knot
157.	*C. alfa*	Sanderling
158.	*C. testaceus*	Curlew
159.	*Philomachus pygnax*	Sandpiper
160.	*Stercoraxius parasiticus*	Parasitic Skua

No.	Scientific Name	Common Name
	Family - Rostratulidae	
161.	*Rostratula bengalensis*	Painted Snipe
	Family - Reeurvirostridae	
162.	*Haemantopus haemantopus*	Blackwinged Stilt
163.	*Recurvirostra avosetta*	Avocet
	Family - Burhinidae	
164.	*Burhinus oedicnemus*	Thick Knee
	Family - Glareolidae	
165.	*Glareola lactea*	Small Pratincle
	Family - Laridae	
166.	*Larus argentatus*	Herring Gull
167.	*L. burnnicephalus*	Brownheaded Gull
168.	*L. ridibundus*	Blackheaded Gull
169.	*L. icthyaetus*	Great Blackheaded Gull
170.	*Chlidonias hybrida*	Whiskered Tern
171.	*Gelochelidon nilotica*	Gullbilled Tern
172.	*Sterna bergii*	Largecrested Tern
173.	*S. acuticauda*	Whi tewinged Black Tern
174.	*S. bengalensis*	Lesser Crested Tern
175.	*S albifrons*	Little Tern
176.	*S. aurentia*	River Tern
177.	*S. hirundo*	Common Tern
178.	*Hydroprogne caspia*	Caspian Tern
179.	*Rynchops albicollis*	Indian Skimmer
	Family - Columbidae	
180.	*Treron phoenicoptera*	Yellowfooted Green Pigeon
181.	*T curvirostra*	Thickbilled Green Pigeon
182.	*Tpompadora*	Greyfronted Green Pigeon
183.	*Ducula aenea*	Green Imperial Pigeon
184.	*Columba livia*	Blue Roack Pigeon
185.	*Streptopelia decaocto*	Ring Dove
186.	*S. tranquibarica*	Red Turtle Dove
187.	*S. chinensis*	Spotted Dove
188.	*S. orientalis*	Rufous Turtle Dove
189.	*Chaleophaps indica*	Emarald Dove
	Family - Psittacidae	
190.	*Psittacula krameri*	Roseringed Parkeet
191.	*P. finschi*	Slatheaded Parakeet
192	*P. roseata*	B1ossomheaded Parakeet

No.	Scientific Name	Common Name
	Family - Cuculidae	
193.	*Clamator coromandus*	Red winged Crested Cuckoo
194.	*C. jacobinus*	Pied Crested Cuckoo
195.	*Cuculus micropterus*	Indian Cuckoo
196.	*C. varius*	Brain Fever Bird
197.	*Cacomantis merulinus*	Plaintive Cuckoo
198.	*C. sonneratii*	Banded Bay Cuckoo
199.	*C. merulinus querulus*	Banded Bay Cuckoo
200.	*Eudynamys scolopaeea*	Koel
20l.	*Rhopodytis tristis*	Large greenbilled Malkoha
202.	*Taccoca lescenaulti*	Sirkeer Cuckoo
203.	*Contropus sinensis*	Crow Pheasant
204.	*S. toulou*	Lesser Coucal
	Family - Strigidae	
205.	*Tyto alba*	Barn Owl
206.	*Otus scops*	Scops Owl
207.	*0. bakkamoena*	Collard Scops Owl
208.	*Bubo nipalensis*	Forest Eagle Owl
209.	*B. zeylonensis*	Brown Fish Owl
210.	*B. bubo*	Great Horn Owl
21l.	*B·flavipes*	Tawny Fish Owl
212.	*Athena brama*	Spotted Owlet
213.	*Ninox xcutulata*	Brown Hawk Owl
214.	*Asio flammeus*	Shorteared Owl
	Family - Caprimulgidae	
215.	*Caprimulgus indicus*	Jungle Night jar
216.	*C. macrurus*	Longtailed Night jar
217.	*C. affinis*	Franklin's Night jar
	Family - Apodidae	
218.	*Cypsiurus parvus*	Palm Swift
	Family - Alcedinidae	
219.	*Ceryle rudis*	Lesser Pied Kingfisher
220.	*Alcedo athis*	Common Kingfisher
221.	*Pelargopsis amauroptera*	Brownwinged Kingfisher
222.	*P. capensis*	Storkbilled Kingfisher
223.	*Halcyon coromandra*	Ruddy Kingfisher
224.	*H. smyrnensis*	Whitebreasted Kingfisher
225.	*H. pileata*	Blackcapped Kingfisher
226.	*H. chloris*	Whitecollared Kingfisher

No.	Scientific Name	Common Name
	Family - Meropidae	
227.	*Merops orientalis*	Green Bee-eater
	Family - Coraciidae	
228.	*Coracias bengalensis*	Roller
	Family - Upupidae	
229.	*Upupa epos*	Hoopoe
	Family - Capitonidae	
230.	*Megalaima lineata*	Lineated Barbet
231.	*M. haemacephala*	Coppersmith Barbet
	Family - Picidae	
232.	*Junx torquilla*	Wryneck
233.	*Pic us flavinucha*	Large Yellow naped Woodpecker
234.	*P. myrmecophoneus*	Little Scaly bellied Green Woodpecker
235.	*Dinophum benghalense*	Lesser Goldenbacked Woodpecker
236.	*Picoides macie*	Fulvousbreasted Pied Woodpecker
237.	*P. mahrattensis*	Yellow fronted Pied Woodpecker
238.	*P. nanus*	Pigmy Woodpecker
239.	*Chrysocaptes lucidus*	Larger Goldenbacked Woodpecker
240.	*Micropternus brachyurus*	Rufous Woodpecker
	Family - Alaudidae	
241.	*Mirafra assamica*	Asian Bush Lark
242.	*Alauda gulgula*	Eastern Skylark
	Family - Hirundinidae	
243.	*Riparia poludicola*	Plain Sand Martin
244.	*Hirundo rustica*	Common Swallow
245.	*H. daurica*	RedrumpedlStriated swallow
246.	*H. smithi*	Wire/Longtailed Swallow
247.	*Delichon nipalensis*	House Martin
	Family - Laniidae	
248.	*Lanius vittatus*	Baybacked shrike
249.	*L. schach*	Blackheaded shrike
250.	*L. cristatus*	Brown Shrike
	Family - Oriolidae	
251.	*Oriolus xanthornus*	Blackheaded oriole

No.	Scientific Name	Common Name
	Family - Dicruridae	
252.	*Dicrurus adsimilis*	Black Drongo
253.	*D. luecophaeus*	Ashy Drongo
254.	*D. aeneus*	Bronzed Drongo
255.	*D. hotentotus*	Hairy Crested Drongo
256.	*D. paradiseus*	Greater Racket tailed Drongo
	Family - Artamidae	
257.	*Artamus fuscus*	Ashy Swallow Drongo
	Family - Sturnidae	
258.	*Aplonis panayensis*	Glassy Starling
259.	*Sturnus malabaricus*	Greyheaded Straling
260.	*S. vulgaricus*	Starling
261.	*S. contra*	Pied Myna
262.	*Acrodortheres tristis*	Common Myna
263.	*A·fuscus*	Jungle Myna
264.	*A. gingingianus*	Bank Myna
	Family - Corvidae	
265.	*Dendrocitta vagabunda*	Rufous Tree-Pie
266.	*Corvus splendens*	House Crow
267.	*C. macrorhynchos*	Jungle Crow
	Family - Campephagidae	
268.	*Tephrodornis pondicerianus*	Common Wood shrike
269.	*Coracina melaschistos*	Small Grey Cuckoo Shrike
270.	*C. novaehallandiae*	Large Cuckoo Shrike
271.	*S. melanoptera*	Balckheaded Cuckoo Shrike
272.	*Pericrocotus cinnamomeus*	Small Minivet
273.	*P·flammeus*	Scarlet Minivet
274.	*P. erythropygius*	White Bellied Minivet
	Family - Irenidae	
275.	*Aegithina tiphia*	Common lara
276.	*Chloropsis*	Goldfronted Chloropsis
277.	*C. cochinchinensis*	Bluewinged Chloropsis
278.	*C. hardwickii*	Orangebellied Chloropsis
	Family - Phcnonotidae	
279.	*Pycnonotus jocosus*	Redwhiskered Bulbul
280.	*P. cafer*	Redvented Bulbul
281.	*P. melanicterus*	Blackheaded Yellow Bulbul

No.	Scientific Name	Common Name
	Family - Muscicapidae	
282.	*Trichastoma aabotti*	Abbot's Babbler
283.	*Pellorneum palustri*	Marsh Spotter Bablar
284.	*P. ruficeps*	Spotted Babblar
285.	*Turtoides striatus*	Jungle Babblar
286.	*Aleipe poioicphela*	Quaker Babblar
287.	*Muscicapa parva*	Redbreasted Flycatcher
288.	*M. rubeculoides*	Bluethroated Flycathcer
289.	*M. thalassina*	Verditer Flycatcher
290.	*Rhipidura albicollis*	Blacknaped Flycatcher
291.	*Culicicoapa ceylonensis*	Greyheaded Flycatcher
292.	*Monarcha azurea*	Blacknaped Flycatcher
293.	*Cisticola juncidis*	Streaked Fantail Warbler
294.	*C axilis*	Fantail Warbler
295.	*Prinia hodgsoni*	Franklin Wren Warbler
296.	*P. subflava*	Plain Longtail Warbler
297	*P. socialis*	Ashy Wren Warbler
298.	*Orthotomus sutoris*	Tailor Bird
299.	*Acrocephalus agricola*	Paddy Field Warbler
300.	*A. orientalis*	Eastern Great Reed Warbler
301.	*A. stentorius*	Great Reed Warbler
302.	*A. dumetorum*	Blyth's Reed Warbler
303	*Terpsiphone paradisi*	Paradise Flycatcher
304.	*Bradypterus luteoventris*	Brown Bush Warbler
305.	*Phylloscopus affinis*	Tickl's Leaf Warbler
306.	*P·fuscatus*	Dusky Leaf Warbler
307.	*Erithaeus svecicus*	Bluethroat
308.	*Copsychus saularis*	Magpie Robin
309.	*C. S. erimelas*	Magpie Robin
310.	*Phoenicurus ochruros*	Black redstart
311.	*Suxicola caprata*	Pied Bush Chat
312.	*S. torquata*	Stone Chat
313.	*Suxicoloides fulicata*	Robin
314.	*Monticola solitarius*	Blue Rock Thrush
315.	*Zoothera citrin a*	Orangeheaded Thrush
316.	*Turdus ruficollis*	Redthroated Thrush
317.	*Pachycephala cinerea*	Mangrove Whistler
318.	*P. grisola*	Mangrove Whistler
	Family - Paridee	
319.	*Parus major*	Grey Tit
	Family - Sittidae	
320.	*Sitta castanea*	Chestnutbellied Nutlatch
321.	*S. frontalis*	Velvetfronted Nuthatch

No.	Scientific Name	Common Name
	Family - Motacillidae	
322.	*Anthus novaeseelandiae*	Paddyfield Pipit
323.	*A. hodgsoni*	Indian Tree Pipit
324.	*Motacilla flava*	Yellow Wagtail
325.	*M. citreola*	Yellowheaded Wagtail
326.	*M. alba*	Pied Wagtail
327.	*M. madaraspatensis*	Large Pied Wagtail
328.	*M. cinerea*	Grey Wagtail
	Family _ Dicaeidae	
329.	*Dicaeum crythrorhynchos*	Tiekell's Flowerpeeker
330.	*D. cruentatum*	Searletbaeked Flowerpeeker
331.	*D. agile*	Thiekbilled Flowerpeeker
332.	*D. trigonostigma*	Orangebellied Flowerpeeker
	Family - Certhiidae	
333.	*Certhia himalayana*	Tree Creeper
	Family - Nectariniidae	
334.	*Nectarinea zeylonica*	Purplerumped Sun bird
335.	*N. asiatica*	Purple Sundbird
	Family - Zosteropidae	
336.	*Xosterops palpebrosa*	White-eye
	Family - Ploceidae	
337	*Passer domesticus*	House Sparrow
338.	*Ploceus rutilans*	Common Tree Sparrow
339.	*P. philippinus*	Baya
340.	*Pm manyar*	Streaked Weaver Bird
341.	*Lonchura malabaria*	Whitethroated Munia
342.	*L. striata*	Whitebaeked Munia
343.	*L. punctulal*	Spotted Munia
	Family - Fringilidae	
344.	*Melophus lathami*	Crested Bunting

No.	Scientific Name	Common Name
	Reptiles	
	Turtles and Tortoises	
345.	*Kachuga tecta*	Roofed Turtle
346.	*Melanchelys tricarinata*	Threekeeled Land Tortoise
347.	*Morenia petersi*	Yellow Turtle
348.	*Lissemys punctata*	Spotted FlapShell
349	*Pelochelys bibroni*	Bibron's SoftShell
350.	*Chitra indica*	Asiatic SoftShell
351.	*Geoclemys hamiltoni*	Black Pond Turtle
352.	*Trionyx gangeticus*	Ganges SoftShell
353.	*T. hurum*	Peacock SoftShell
354.	*Chelonia mydas*	Green Turtle
355.	*Caretta caretta*	Loggerhead Turtle
356.	*Lepidochelys olivacea*	Olive Ridley Turtle
357.	*Eretmochelys imbricata*	Hawksbill Turtle
	Lizards and Skinks	
358.	*Hamidactylus brooki*	House Lizard
359.	*H. jlaviviridis*	Common House Lizard
360.	*H. frenatees*	Mouse Gecko
361.	*Gecko gecko*	Wall Lizard
362.	*Caloes versicolor*	Garden Lizard
363.	*Mabuya carinata*	Common Skink
364.	*Varanus bengalensis*	Bengal/Grey Lizard
365.	*V. salvator*	Water Monitor Lizard
	Snakes	
366.	*Typhlina porrectus*	Slender Worm Snake
367.	*T bramina*	Common/Brahminy Worm Snake
368.	*Python molorus*	Rock Python
369.	*Eryx conlous*	Common Sand Boa
370.	*Lycodon aulicus*	Common Wolf Snake
371.	*Amphiesma stolata*	Stripped Keelback
372.	*Xenochrophis piscator*	Checkered Keelback
373.	*X cerasogaster*	Darkbellied Marsh Snake
374.	*Atretium schistosuri*	Olive Keelback
375.	*Acrochordus granulatus*	File/Wart Snake

No.	Scientific Name	Common Name
376.	*Ptyas mucosus*	Rat Snake
377.	*Dendrelaphis tristis*	Common Bronzeback Tree Snake
378.	*Ahaetulla nasutus*	Common Vine Snake
379.	*Enhydris enhydris*	Common Smooth Water Snake
380.	*Cerberus rhynchops*	Dogfaced Water Snake
381.	*Gerardia prevostiana*	Glossy Marsh Snake
382.	*Fordonia leucobalia*	Whitebellied Mangrove Snake
383.	*Praesecutata viparina*	Sea Snake
384.	*Bungarus cczeruleus*	Common Krait
385.	*Bungarusfasciatus*	Banded Krait
386.	*Naja naja*	Monocellate Bengal Cobra
387.	*Ophiop/zagus hannah*	King Cobra
388.	*Enhydrina sehistosa*	Hooknosed Sea Snake
389.	*Hydrophis nigrocinctus*	Blackheaded Sea Snake
390.	*Hydrophis obscurus*	Estuarine Sea Snake
391.	*H. caerulescens*	Malacca sea Snake
392.	*Microcephalophis gracilis*	Common Narrowheaded Sea Snake
393.	*M. cantons*	Cantor's narrowheaded Sea Snake
394.	*Trimeresurus ervihrurus*	Spot tailed Pit Viper
	Crocodilian	
395.	*Crocoth'Ius porosus*	Estuarine Crocodile – Ex
	Amphibia	
	Faznily – Bufonidae	
396.	*Bufo melanostictus*	Common Toad
	Pam – Microhylidae	
	Microhyla ornata	Ornate Microhylid
	Family – Ranidae	
397.	*Rana hexadactvla*	Green Frog
398.	*Rana cyanophlictis*	Skipper Frog
399.	*Rana tigexina*	Bull Frog
400.	*Rana limnocharis*	Cricket From
401.	*Rana tytilery*	Titlers frog
	Family – Klacophoridae	
402.	*Rhacophorus maculatus*	Tree Frog

Source: FRMP, 1997 and NCS-IP-1997

List of Plants of Study Area

TREES

Botanical Name	Local Name
Albizia procera	Korai
Antidesma ghaesembilla	Khudijam
Anisoptera scaphula	Boilam
Aphanamixis polystachya	Pithraj
Artocarpus chaplasha	Chapalish
Bombax insiginis	Banshimul
Bursera serrata	
Callicarpa arborea	Barmala
Cassia fistula	Sonalu
Chickrassia vellutine	Chikrass
Ardisia solanacea	B anj am
Dehaasia kurzii	Madan mostok
Dipteroccarpus turbinatus	Guardian
Elaeocarpus robustus	Jalpai
Ficus hispida	Dumur
Ficus sp.	
Glochidion multiloculare	Paniaturi
Glycosmis arborea	Datmajan
Macrange peltata	Bura
Maesa indica	
Phyllanthus reticulatus	Sheori
Pterospermum acerifolium	Moos
Pterospermum semisaggitaturn	Laona assar
Quercus spicata	
Microcos paniculata	Assar
Syzygium cumini	Kalo jam
Trema orientalis	Jiban
Trevesia palmata	
Zizzyphus oenoplea	Banboroi
Ricinus communis	Verenda
Swintonia jloribanda	Civit

TREES

Botanical Name	Local Name
Achyranthus aspera	Apang
Adenostemma lavenia	
Alpinia nigra	Tara
Amaranthus spinosus	Kantanotey
Amaranthus viridis	Notey
Begonia sp.	
Borreria erecta	
Borreria articularis	
Centella asiatica	Thankuni
Centranthera hispida	
Cleome viscosa	Haldey hurhury
Colocassia sp.	Kachu
Commelina difJusa	
Commelina erecta	
Corchorus sp.	
Croton bonplandianus	Boncroton
Curculigo recurva	Bidripata
Cyanotis cristata	
Erechites	
Etlingera loroglossa	
Hedyotis scandens	
hedychium thyrciflorum	
Lepidagathis incurva	
Leucas sp.	Shetoron
Lindernia ciliata	
Lindernia indica	
Ludwigia hyssopifolia	
Mimosa pudica	Lazzabati
Murdannia nudiflora	
Musa ornata	Ramkola
Ocimum canum	
Hedyotis corymbosa	
Ophiorrhiza mangus	
Osbeckia chinensis	
Peperomia pellucida	
Phrynium pubenrva	
Polygonum hydropiper	Panimorich
Ruellia tuberosa	
Scoparia dulsis	Ban dhaney
Stachytarpheta indica	
Torenia asiatica	
Spilanthes culva	
Vernonia cicerea	

SHRUBS AND UNDERSHRUBS

Botanical Name	Local Name
Cassia sophera	Kalakusunda
Cassia tora	Chakunda
Centranthera hispida	Shomraj
Clerodendrum nutans	Malibong
Clerodendrum viscosum	
Crotalaria pallida	Jhanjhani
Desmodium alatum	
Desmodium gyrans	Gorachand
Crotalaria ferruginea	
Glycosmis sp.	
Glochidion sp.	
Hyptis suaveolens	Tokma
Lantana camara var. aculeata	Guagandha
Ocimum basilicum var. purpurescens	
Leea crispa	Kukura
melastoma malabathricum	Phutki
Mussaenda corymbosa	Shilchauri
Premna esculanta	Lalna
Osbeckia sp.	
Rhynchotechum ellipticum var. hookerii	
Solanum torvum	Phuti begun
Sarchochalamys pulcherrima	Murichia
Sida acuta	Kureta
Sida cordata	Pithberal
Sesbania sp.	
Triumfetta rhomboidea	Banokra
Tephrosia purpurea	Bannil
Uraria hamosa	
Urena lobata	Banokra
Urena lobata subsp. sinuala	Kunjira
Pavetta sp.	
Zanthoxylum rhetsa	
Calotropis gigantea	Akanda
Eupatorum odorata	Assam lata

CLIMBERS AND TWINERS

Botanical Name	Local Name
Agryrea argentea	
Derris trifoliata	
Dioscorea bellophylla	Alulata
Dioscorea bulbifera	
Dioscorea oppositifolia	
Dioscorea pentaphylla	
Dioscorea wallichii	
Vitis pentagona	
Dioscorea sp.	
Ipomoea pes-caprae	
Mikania cordata	
Momordica dioica	
Mucuna pruriens	Shimlata
Passiflora foetida	
Passiflora sp.	
Smilax glabra	Kumari lata
Smilax zeylanica	Kumari lata
Trichosanthes sp.	
Thunbergia grandiflora	Banslata
Vitis repens	

Source: FRMP, 1997

Common occurring and commercially important Pelagic and Demancal fin fishes and shell fishes of Marine Environment

Family	Species (Scientific name)	English name	Local Name
1. Aridae	*Arius sp.*	Cat fish	Kata machh
2. Bagridae	*Mvstus gulio*	Bagrid Cat fish	Nuna Tengua/guilla*
3. Centropomidae	*LatesCalcarifer*	Gaint sea perch/cock-up	BhetkilKoral machh
4. Cynogbonidae	*Cv no gloss us lingua*	Cynoglossus bilineatus	Kukurjib
5. Cy noglonidae	*Cynoglossus bilineatno*	Fourline tongue sole	Kukurjib
6. Drepanidae	*Drepane longimanna*	Sickle fish	Paun Machh
7. Ephippidae	*Ephippus orbis*	Spade fish	Hatir Kasn
8. Genedae	*Gerres filamentosus*	Whip fin maojarra / Silver – biddies	DomMachh
9. Gerredae	*Pentaprionu Longimanus*	Long fill mojarra / Silver – biddies	Jagiri
10. Harpadontidae	*Harvadon Nehereus*	Bombay duck	Loitha machh*
11. Lactariidae	*Lactarius lactarrus*	False Trevally	Sadha machh
12. Lutianidae	*Lutianus Johni*	Tohn's/Red snapper	Ranga Choukya
13. "	*Latianus Sanguineus*	Blood Sanpper	Ranga Choukya
14. "	*Lutianus malabaricus*	Malabar red snapper	Ranja Choukya
15. Leiognathidae	*Leiogenathnus brevirostris*	Shortnore pond fish	Taka Chanda*
16. Menidae	*Menemaculata*	Moon fish	Chan Chanda *
17. Mullidae	*Upeneus sulphu reus*	Goat fish	Sonali bata*
18. Mugilidae	*Liza tade*	Tade grey mullet	Gool bata*
19. "	*LizaSubviridis*	Green back grey mullet	Panda
20. Mugilidae	*Valamergil Speigleri*	sheigler's grey mullet	Fhena Khaiya
21. Mugilidae	*Mugil aphalus*	Flathead grey mullet	Khorul bata*
22. Nemipteridae	*Nemipterus Japonicus*	Japanese thread fin bream	Rupban
23. Pangaridae	*Pangasius Pangasius*	Fatty Catfish	------
24. Pomadasyidae	*Pomadasys hasta*	Lined Silver grunta	Datina*
25. Pomadasyidae	*Pomadasys maculatus*	Blotched grunter	Gutidatina

Family	Species (Scientific name)	English name	Local Name
26. Polynemidae	*Polvnemus indicus*	Indian Salman	Lakhua*
27. Polynemidae	*Polvnemuss Paradiscus*	Paradise thread fin	Tapsi*
28. Poljnemidae	*Eleutheronema tetradactylam*	Four finger thread fin	Thailla
29. Platycephalidae	*Fplatycevhabes indicus*	Flat-head fish	Murbaila
30. Priacanthidae	*Pracanthus tavenus*	Purple-Spotted big-eye	Pari machh
31. Prettodidae	*Psettodes erumei*	Indian halibat	Samudra Sarboti
32. Rachycentridae	*Rachvcentron Canadus*	Cobia	Raja Gajar
33. Synodontidae	*Sausida tumbil*	Greater Lizard fish	Achila
34. Sillaginidae	*Sillage domina*	Lady fish	Tolar dandi
35. Sciaenidae	*Otolithoides Pama*	Pama Croaker	Lambu
36. Scianidae	*Otolithes Maculatus*	Croaker	Gotipoa
37. "	*Otolithes Cuvieri*	Lesser tiger foothed croakor	Poa
38. "	*Protonibea diacanthus*	Spotted Croker	Kalapoa
39. "	*lohnius arqentates*	Silver Pennah Croker	Lalpoa
40. Sparidae	*Argyrops Spinifer*	Long spine Sea bream	Lal datina
41. Sphyracridae	*Sphvraena Forsteri*	Forster's barracuda	Dharkuta
42. Signnidae	*Siganus javus*	Streaked spinefoot	------
43. Stromatedae	*Pampus Chinensis*	Chinese pomfret	Rup Chanda**
44. "	*Pompus argentcus*	Silver pomfret	Foli Chanda**
45. Tricuhicuridae	*Leptuvacanthus Sabala*	HairtaiVRibbon fish	Chhuri Machh
46. Thera ponidaee	*Therapar jarbua*	Therapon perch	Barguni
47. Engraulidae	*setipinna taty*	Hair fin anchovy	Teilla phasa
48. "	*Thryssa mystax*	Moustached thryssa	Phasa*
49. "	*Coilia dussunicsi*	Ponited tail ancovy	Olua
50. Clupeidae	*Escualosa thoracata*	White Sardine	Hichiri Machh*
51. "	*Ilisha filigera*	Big eye Dish	Choukya*

Family	Species (Scientific name)	English name	Local Name
52. Clupcidae	*Hilsa ilisha*	Hilsa Shad	Ilish / Hilsa * *
53. "	*Saridinella fimbriata*	Fringe-Scale Sardine	Takhia
54. Chirocentridae	*Chrocentnus dorab*	Walf heming	Karatichela
55. Carangidae	*Parastromateus niger*	Black Pomfret	Hail Chanda * *
56. "	*Scomberoides Commersonianus*	Talang Queen fish	Chapa Kori
57. "	*Selar boops*	Oxeye Scad	Moori / Salar
58. "	*Megalaspis Cordvla*	hardtali Scad	Kauwa
59. "	*Carangoides malabaridus*	Malabar Cavalla	Malabar Mori
60. "	*Alepesd;eddaba*	Djeddaba Crevalle	Moori
61. "	*Seriolina nigrotasciate*	Black-banded trevally	-------
62. Scombridae	*Euthynnus afjinis*	Eastern little tuna	Born mattiya*
63. "	*Sards Orienthlis*	Striped bonito	Bony mattya**
64. "	*Thunnus Obesus*	Big-eye tuna	Born mattya**
65. Scornbridae	*A uxix rochei*	Bullet tuna	Born Maittya*
66. "	*Scomberomorus guttatus*	Indopacific King Mackeul	MittyaiSurarnari*
67. "	*Scomberomonus Commerson*	Narrow barrid Spanish rnakerel	Surma Machh*
68. "	*Rastvelliger Kanagurta*	Indian Mackerel	Charnpa*
69. Carcharhinidae	*Scoliodon Sorrakowah*	Dog fish	Thatte Hangar ^
70. "	*Scoliodons Walbeehmii*	Milk Shank	Karnot/Hangor ^
71. Dasyatidae	*Himantura Uarnak*	Sting ray	Haush
72. Rhynihobatidae	*Rhychobatus d;eddensis*	Skate	Pitarnbui
73. Rhinobatidae	*Rhinobaton grasulatus*	Skate	Pitarnbui
74. Sphyrpiclae	*Sphyrna Bochii*	Hammir headed shenk	Haturi Hangor ^

* Commercially important species

** Most commercially important species

^ Consumed by the tribal people. Some times the fins and other parts of the body of these Sharks are exported for preparing various foods such as soup.

Freshwater and Brackishwater Shrimp
Family = PALAEMONIDAE

1. *Macrobrachium rosenbergii* (De Man)
2. *Macrobrachium malcolmsonii* (H. Milne Edward)
3. *Macrobrachium villosimanus* Tiwari
4. *Macrobrachium birmaniscus* (Schenkel)
5. *Macrobracltium rude* (Heller)
6. *Macrobrachium dyanus* (Henderson)
7. *Macrobrachium dolichodactylus* (Hilgendrof)
8. *Macrobrachium mirabilie* Kemp
9. *Macrobracltium laalarrei* (H. Mine Edwards)
10. *Macrobracltium idella* Heller
11. *Macrobracltium kempi* (Tiwari)
12. *Macrobrachium lancesteri* De Man
13. *Macrobrachium superbum* De Man
14. *Macrobrachium palaemonoides* De Man
15. *Leander (Expalaemon) styliferus* (H. Milne Edwards)
16. *Palaemon (Nematopalaemon) tenuipes* (Henderson)
17. *Palaemon (Exopalaemon)* modestus Heller
18. *Palaemon (N) kamajuliensis* Khan, Fincham & Mahmood
19. *Palaemon (Palaender)* serrifer Stimpson
20. *Palaemon (Palaender) sommelinkii* (De Man)
21. *Leal1drites celebensis* (De Man)
22. *Leptocarpus potamiscus* (Kemp)
23. *Leptocarpus fluminicola* (Kemp)

Brackish water and Marine Shrimp

Family = ALPHEIDAE

24. *Alphaeus euphorosynae* De Man
25. *Alphaeus trimiziae* Kazmi

Family = PENAEIDAE

26. *Penaeus monodon* Fabricius
27. *Penaeus semisulctus* De man
28. *Penaeus indicus* H. Milne Edwards
29. *Penaeus japonicus* Bate
30. *Penaeus merguiensis* De Man
31. *Penaeus penicillatus* Alcock
32. *Penaeus orientalis* Kishinouye
33. *Penaeus canaliculatus* Oliver

34. ***Metapenaeus monoceros*** (Fabricius)
35. ***Metapenaeus brevicornis*** H. Milne Edwards
36. ***Metapenaeus spinulatus*** (Kubo)
37. ***Metapenaeus stridulans*** (Alcock)
38. ***Metapenaeus lysianassa*** (De Man)
39. ***Matapenaeus affinis*** (H. Milne Edwards)
40. ***Parapenaeopsis sculptilis*** (Heller)
41. ***Parapenaeopsis hardwickil*** (Miers)
42. ***Parapenaeopsis coromandalica*** (Alcock)
43. ***Parapenaeopsis uncta*** (Alcock)
44. ***Parapenaeopsis cornuitamaxxillipide*** Alcock
45. ***Parapenaeopsis stylifera*** (H. Milne Edwards)
46. ***Silencer subauda*** Kubo
47. ***Solenocara melautho*** De Man
48. ***Solenocera indica*** Nataraj
49. ***Solenocera haxtil*** Wood Mason
50. ***Trachypenaeus curvirostris*** (Stimp son)
51. ***Metapenaeopsis andamanesis*** Wood Mason

Marine Shrimp

Family = PANDALIDAE

52. ***Plesionika martia*** H. Milne Edwards
53. ***Heterocarpus gibbosus*** Bata
54. ***Heterocarpus woodmasoni*** Alcock
55. ***Hippolysmata (Hippolysmata) vittala*** Kemp
56. ***Latreustes mucronatus*** Stimpson
57. ***Acetes indicus*** H. Milne Edwards
58. ***Acetes erythraeus*** Nobili
59. ***Acetes japonicus*** Kishinouye

Commercially Important Marine & Coastal Shrimps

60. Penaeus monodon
61. Penaeus indicus
62. Metapenacus mmocerous
63. Metapenalus dobsoni
64. Meta penaeus breviconnis

Source: 1. Chingri: Bangladesher Chingri Utpadon O Chash, Shahdat Ali, August, 1992, Page: 21-24

2. Bangladesh Fisheries Development Corporation.

Appendix C: Critical Habitat Assessment

Moheshkhali Floating Liquefied Natural Gas (LNG) Import Terminal Development, Bangladesh

Critical Habitat Assessment, Moheshkhali, Cox's Bazar

Prepared for:

excelerate energy®

Performed by:

Acorn INTERNATIONAL

with

ArcCona Consulting

February 2017

Moheshkhali Floating Liquefied Natural Gas (LNG) Import Terminal Development, Bangladesh

Critical Habitat Assessment, Moheshkhali, Cox's Bazar

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Cover Photograph: AcrCona Consulting, 2016

Executive Summary

On July 18, 2016, Excelerate Energy Bangladesh, Ltd. (Excelerate), Bangladesh Oil, Gas & Mineral Corporation (Petrobangla), and the Government of Bangladesh executed the Terminal Use Agreement (TUA) and the Implementation Agreement (IA) for the construction and operation of Bangladesh's first LNG import terminal – Moheshkhali Floating LNG (the "project" or the "terminal"). Moheshkhali Floating LNG will be located offshore the Island of Moheshkhali in southeast Bangladesh.

Excelerate is seeking financing from International Finance Corporation (IFC), thus IFC's Performance Standards on Environmental and Social Sustainability (Performance Standards) apply.

As part of the project's risk and impact assessment process, scoping identified that the onshore component of the project was located in a sensitive area which includes habitat for threatened species, including the Critically Endangered Spoon-billed Sandpiper (*Calidris pygmea*).

Based on the requirements of IFC Performance Standard 6, this report provides an assessment of potential Critical Habitat distribution relative to Moheshkali Floating LNG project in Moheshkhali, Cox's Bazar, Bangladesh.

Biodiversity features were screened based on the quantitative thresholds required by the Critical Habitat determination criteria described in IFC Performance Standard 6. These criteria include:

Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species
Criterion 2: Endemic and/or restricted-range species
Criterion 3: Migratory and/or congregatory species
Criterion 4: Highly threatened and/or unique ecosystems
Criterion 5: Key evolutionary processes

Critical Habitat is present in the study area. Critical Habitat triggers, biodiversity values present, rationale, and Critical Habitat deamination are described in Table 0-1.

Table 0-1: Critical Habitat Summary

Critical Habitat Trigger	Biodiversity Value	Rationale	Critical Habitat
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species, and Criterion 3: Migratory and/or congregatory species	Spoon-billed Sandpiper *(Calidris pygmaea)*	· Habitat required to sustain ≥ 10 percent of the global population of an IUCN Red-listed CR species. · Meets BirdLife International's Criterion A4i for congregations and Ramsar Criteria 6 for Identifying Wetlands of International	Critical Habitat, Tier 1

Critical Habitat Trigger	Biodiversity Value	Rationale	Critical Habitat
		Importance	
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species	Great Knot (*Calidris tenuirostris)*	· Represents nationally important concentrations of an EN species.	Critical Habitat, Tier 2
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species, and Criterion 3: Migratory and/or congregatory species	Nordmann's Greenshank (*Tringa guttifer)*	· Represents nationally important concentrations of an EN species. · Meets BirdLife International's Criterion A4i for congregations and Ramsar Criteria 6 for Identifying Wetlands of International Importance	Critical Habitat, Tier 2

In addition, Sonadia Island is nationally protected and internationally recognized as a key biodiversity area (Important Bird Area and proposed Ramsar wetland).

In order to define management actions, a robust process was used to map the distribution of Modified, Natural, and Critical habitats. This process included comparing three data sets:

1. Desktop land cover data
2. Areas defined by Bangladesh Spoon-billed Conservation Program (BSCP) as habitat for endangered shorebirds, based on long-term monitoring
3. Satellite color infrared imagery

Modified and Natural habitats based on desktop land cover data are provided in Figure 0-1.

The BSCP has been conducting monthly water bird surveys during the winter (October – March) in Sonadia since 2009, and monthly (all year) in 2012, 2013, 2014, and 2015. Our team included two members of the BSCP, and long term monitoring data was used to support this report. BSCP observations indicate there are four key areas used by waterfowl, as shown in Table 0-2 and Figure 0-2.

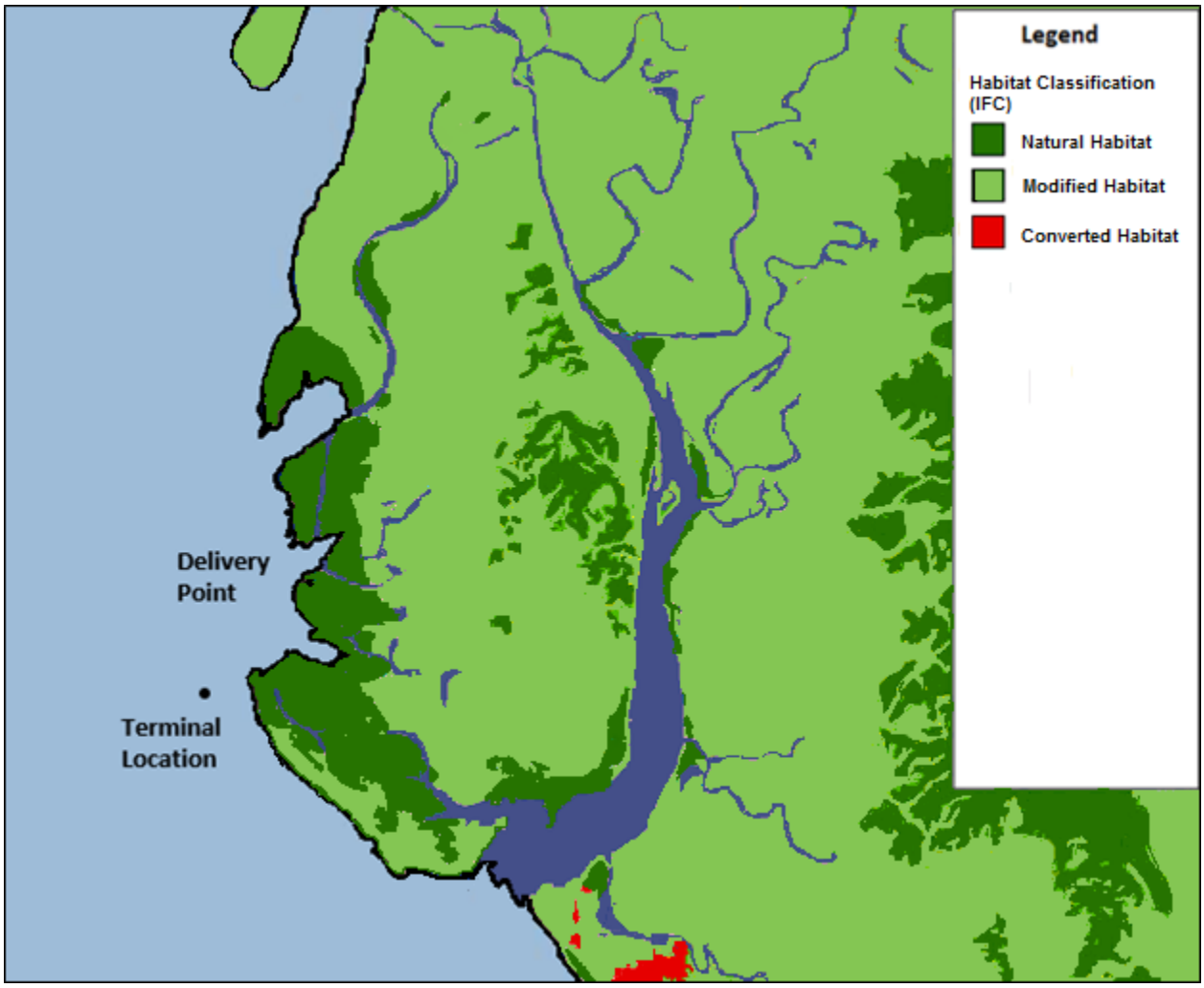
An image classification process utilizing ESRI's ArcGIS spatial analyst extensions was used to refine the habitat classifications. The final output of the GIS mapping is shown in Figure 0-3 and areas defined as Critical Habitat shown in Figure 0-4.

While the Delivery Point is close (700 m) to sensitive mudflats, this ecosystem is resilient and quick to recover from disturbance. However, the area is Tier 1 Critical Habitat and a detailed Biodiversity Action Plan (with Biodiversity Monitoring and Evaluation Plan) will be required to manage the potential impacts to biodiversity values present.

Table 0-2: Observed Key Biodiversity Areas on Sonadia Island

Site Name	Habitat Function
Tajiakata	Mudflat (waterfowl forage) and high tide roost
Belekardia	Mudflat (waterfowl forage), high tide roost and sea turtle nesting beach
Kaladia	Mudflat and high tide roost
Khorir Char	Mudflat and high tide roost

Figure 0-1: Map of Natural and Modified Habitat



Source: Acorn International / ICIMOD. 2016[7]

Figure 0-2: Observed Areas of Critical Habitat in Sonadia Island

Source: Acorn International / Google Earth

Figure 0-3: GIS Based Sensitivity Map

Source: Acorn International

Figure 0-4: Discrete Management Unit Considered Critical Habitat (Light Orange Shading) and Sensitive Sites for Critical Habitat Values within DMU (Dark Orange Shading)

Source: Acorn International, BSCP, Google Earth

1 Introduction

1.1 Project Overview

On July 18, 2016, Excelerate Energy Bangladesh, Ltd. (Excelerate), Bangladesh Oil, Gas & Mineral Corporation (Petrobangla), and the Government of Bangladesh executed the Terminal Use Agreement (TUA) and the Implementation Agreement (IA) for the construction and operation of Bangladesh's first LNG import terminal – Moheshkhali Floating LNG (the "project" or the "terminal"). Moheshkhali Floating LNG will be located offshore the Island of Moheshkhali in southeast Bangladesh (Figure 1-1).

Figure 1-1: Project Location

Source: ESRI / Acorn International

The terminal would include the provision of one of Excelerate's existing floating storage and regasification units (FSRU), the Excellence, and the installation of a turret loading buoy anchored offshore, flexible riser, pipeline end manifold (PLEM), and 7 km subsea pipeline with final tie-in connection at the Delivery Point (the battery limit with the existing onshore pipeline).

Coordinates for the proposed terminal location and Delivery Point are shown in Table 1-1.

Table 1-1: Coordinates of Key Project Components

Point Name	Northing	Easting
Proposed Terminal Location (Subject to Change)	21° 32' 04.00"N	91° 49' 07.00"E
Delivery Point (Proposed)	21° 34' 22.74" N	91° 51' 46.83" E

Construction will require temporary occupation of approximately 90 x 90 m (8,100 m^2) located adjacent to the Delivery Point, of which an area of approximately 75 x 70 m (5,250 m^2) are mangroves that will be cleared. Excelerate will primarily be storing materials on barges and thus minimizing the area needed for the construction yard. After construction, approximately 75% of the site will be reclaimed, and an area of approximately 45 x 45 m (2,025 m^2) will be used permanently.

Excelerate will also rent office and port space, and employ port service vessels during construction and operation. Office and port activities will likely be based in Chittagong, although potential activities out of Cox's Bazar may be required.

The FSRU will have 138,000 cubic meters of LNG storage capacity and a base regasification capacity of 500 million standard cubic feet (MMSCFD) per day. LNG carriers will deliver LNG to the terminal approximately every 5 days at rated send-out of 500 MMSCFD. LNG will be vaporized using open-loop shell-and-tube vaporizers.

1.2 Need for Critical Habitat Assessment

Excelerate is seeking financing from International Finance Corporation (IFC), thus IFC's Performance Standards on Environmental and Social Sustainability (Performance Standards) apply.

As part of the project's risk and impact assessment process, scoping identified that the onshore component of the project was located in a sensitive area including habitat for threatened species, including the Critically Endangered Spoon-billed Sandpiper (*Calidris pygmea*).

IFC Performance Standard 6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources aims to:

- Protect and conserve biodiversity
- Maintain the benefits from ecosystem services (see Box 1)
- Promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities

IFC is guided by the Convention on Biological Diversity, which defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems." [1]

In order to clarify the requirements of IFC Performance Standard 6, a Critical Habitat Assessment is required. The main objectives of the Critical Habitat Assessment are to:

- Make a determination on whether Critical Habitat is triggered for the landscape in which the project is located

[1] International Finance Corporation. 2012. Performance Standards on Environmental and Social Sustainability.

- Obtain an understanding of the set of “biodiversity values”, if any, that trigger Critical Habitat status for the landscape in which the project is located
- Define potential Critical Habitat

This Critical Habitat Assessment will also inform the ongoing Environmental Impact Assessment (EIA) and form the basis of a stand-alone Biodiversity Action Plan, if required.

Box 1: Definition of Ecosystem Services

Ecosystem services is a term used to describe the benefits humans derive from the natural world. The Millennium Ecosystem Assessment grouped these benefits into four types of services: provisioning, regulating, cultural, and supporting services. Examples of each type of service are shown below.

Source: Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC

1.3 Critical Habitat Assessment Team

The Critical Habitat Assessment Team is presented in Table 1-2 and Curricula Vitae (CV) for regional experts are provided in Appendix A.

Table 1-2: Critical Habitat Assessment Team

Name	Areas of Expertise	Nationality	Assigned Position
Atma Khalsa	Wildlife and fisheries conservation; ESIA; IFC Performance Standards	USA	Project Manager
Dean Slocum	ESIA; IFC Performance Standards; ESIA	USA	Project Director
Dr. Christoph Zöckler	Ornithology; conservation biology; wetland ecology	UK	Biodiversity Specialist
Sayam Chowdhury	Ornithology; conservation biology; wetland ecology	Bangladesh	Biodiversity Specialist
Andrew Buchman	Anthropology; stakeholder engagement; political science	USA	Social Specialist
Patrick Bond	GIS and remote sensing	USA	GIS Specialist

2 Methodology

As defined by IFC, the process used to develop this Critical Habitat Assessment included:

1. Study area description and mapping
2. Initial literature review and stakeholder consultation
3. In-field data collection and verification of available information
4. Discrete Management Unit description and mapping
5. Critical habitat determination

In addition to the process for conducting Critical Habitat Assessment described in the IFC Performance Standard 6 Guidance Notes (GN) and IFC's Critical Habitat Assessment Terms of Reference, the methodology used was guided by Stefan, et al., 2013.[2]

2.1 Study Area Description and Mapping

IFC Performance Standard 6 Guidance Notes (GN) 55-57 define Critical Habitat. In order to identify the biodiversity values that could potentially trigger Critical Habitat criteria, a broad landscape and seascape analysis was conducted to obtain an understanding of the relative importance of the project site and the surrounding areas. This analysis included identification of, inter alia:

- Threatened and endangered species in the region
- Sensitive and/or biodiverse ecosystems
- Nationally protected areas
- Internationally recognized areas of biodiversity importance

[2] Stefan, C.I., Robichaud, C., Knopff, K., Nielsen, D., Carveth, C., Melton, D., and R. Novy. 2013. Critical Habitat Assessment using IFC PS6 Criteria. 'IAIA13 Conference Proceedings' Impact Assessment the Next Generation 33rd Annual Meeting of the International Association for Impact Assessment, 13 – 16 May 2013, Calgary, Alberta, Canada.

- Land-use / land cover

In addition, natural features, including topography and hydrology, were reviewed.

To the extent feasible, this analysis was evaluated using maps to visualize the distribution of sensitivities relative to the project area of influence, to determine the overall study area for the Critical Habitat Assessment.

2.2 Initial Literature Review and Stakeholder Consultation

A literature review was conducted to define a list of all candidate biodiversity values that could potentially trigger Critical Habitat criteria.

The literature review included a broad range of secondary sources, including published journal articles, reports from conservation projects in the region, online periodicals, laws, regulations, management plans, and other government publications. Our team included regional experts that had access to unpublished waterbird monitoring reports conducted in the region.

A list of key resources is provided in Appendix B.

This information was supplemented by consulting with relevant stakeholders, including government officials, local administrations, species specialists / recognized external experts, conservation organizations and local communities.

2.3 In-field Data Collection and Verification of Available Information

This Critical Habitat Assessment is based largely on field work conducted in developing the original project EIA, as well as annual monitoring completed by the Bangladesh Spoon-billed Sandpiper Conservation Project (BSCP).

To supplement the above, our team conducted a two-day bird survey and field validation exercise to confirm accuracy of GIS based mapping.

The field survey report is provided in Appendix C.

Based on the data collected in the field and data verification, a final list of biodiversity values that trigger Critical Habitat was defined.

2.4 Discrete Management Unit Description and Mapping

IFC Performance Standard 6 Guidance Note (GN) 65 calls for the project to determine a discrete management unit (DMU), “a sensible boundary (ecological or political) which defines the area of habitat to be considered for the Critical Habitat Assessment.” Further guidance is provided, stating the DMU is “an area with a definable boundary within which the biological communities and/or management issues have more in common with each other than they do with those in adjacent areas.” The DMU was defined as the boundary of the Sonadia Island Ecologically Critical Area, areas observed by BSCP as key habitat for endangered shore birds, the marine component of the Area of Influence (inclusive of areas potentially affected by sedimentation, thermal discharges, safety exclusion zones, and areas of air emissions above WHO ambient air quality guidelines in worst case scenarios, but exclusive of the support vessel

route to Chittagong), plus a 2 km buffer surrounding the marine component of the Area of Influence.

2.5 Critical Habitat Determination

The mapping, literature review, consultation, and field visit provided information on the potential species of flora and fauna present in the region, as well as information on the existing habitat characteristics. The aim of the Critical Habitat Determination was to document where Critical Habitat is present and determine if the project is located in, or will impact, these areas.

The Critical Habitat determination process included:
1) Screening of biodiversity values against IFC's criteria and thresholds for Critical Habitat
2) Evaluating the distribution of Critical Habitat

2.5.1 Screening of Biodiversity Features

Biodiversity features were screened based on the quantitative thresholds required by the Critical Habitat determination criteria described in IFC Performance Standard 6. These criteria include:

Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species
Criterion 2: Endemic and/or restricted-range species
Criterion 3: Migratory and/or congregatory species
Criterion 4: Highly threatened and/or unique ecosystems
Criterion 5: Key evolutionary processes

Criteria 1-3 apply at the species level, Criterion 4 applies at the ecosystem level, and Criterion 5 applies at the landscape and species level. Definitions for each of the criteria are provided in Appendix E.

Noting there are different gradients of Critical Habitat, IFC defines Tier 1 (most critical) and Tier 2 thresholds (sub-criteria) for Criteria 1-3. These definitions are provided in Table 2-1.

Table 2-1: IFC Quantitative Threshold Definitions for Tier 1 and Tier 2 Critical Habitat

Criterion	Tier 1 Threshold	Tier 2 Threshold
1. Critically Endangered (CR)/ Endangered (EN) Species	(a) Habitat required to sustain ≥ 10 percent of the global population of a CR or EN species/subspecies where there are known, regular occurrences of the species and where that habitat could be considered a discrete management unit for that species. (b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.	(c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally- important concentrations of a Red-listed EN species where that habitat could be considered a discrete management unit for that species/ subspecies. (d) Habitat of significant importance to CR or EN species that are wide ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species. (e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.
2. Endemic/ Restricted	(a) Habitat known to sustain ≥ 95 percent of the global	(b) Habitat known to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or

Criterion	Tier 1 Threshold	Tier 2 Threshold
Range Species	population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species (e.g., a single-site endemic).	restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment.
3. Migratory/ Congregatory Species	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management unit for that species.	(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent but < 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where adequate data are available and/or based on expert judgment. (c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance. (d) For species with large but clumped distributions, a provisional threshold is set at ≥5 percent of the global population for both terrestrial and marine species. (e) Source sites that contribute ≥ 1 percent of the global population of recruits.

Source: IFC, 2012[1]

2.5.2 Evaluation of the Distribution of Critical Habitat

As Tier 1 and Tier 2 Critical Habitat thresholds reference population estimates, global populations and the proportion of the global population within the DMU were estimated. Where population estimates were not available, totals were extrapolated from a proportion of the global area of the range map relative to the area of the specific MDU.

Critical Habitat was then delineated based on the combined presence of associated habitat with biodiversity values triggering Critical Habitat. The final product was a map that identifies Critical Habitat.

3 Study Area Description and Mapping

3.1 Study Area

The project area of influence is defined as:

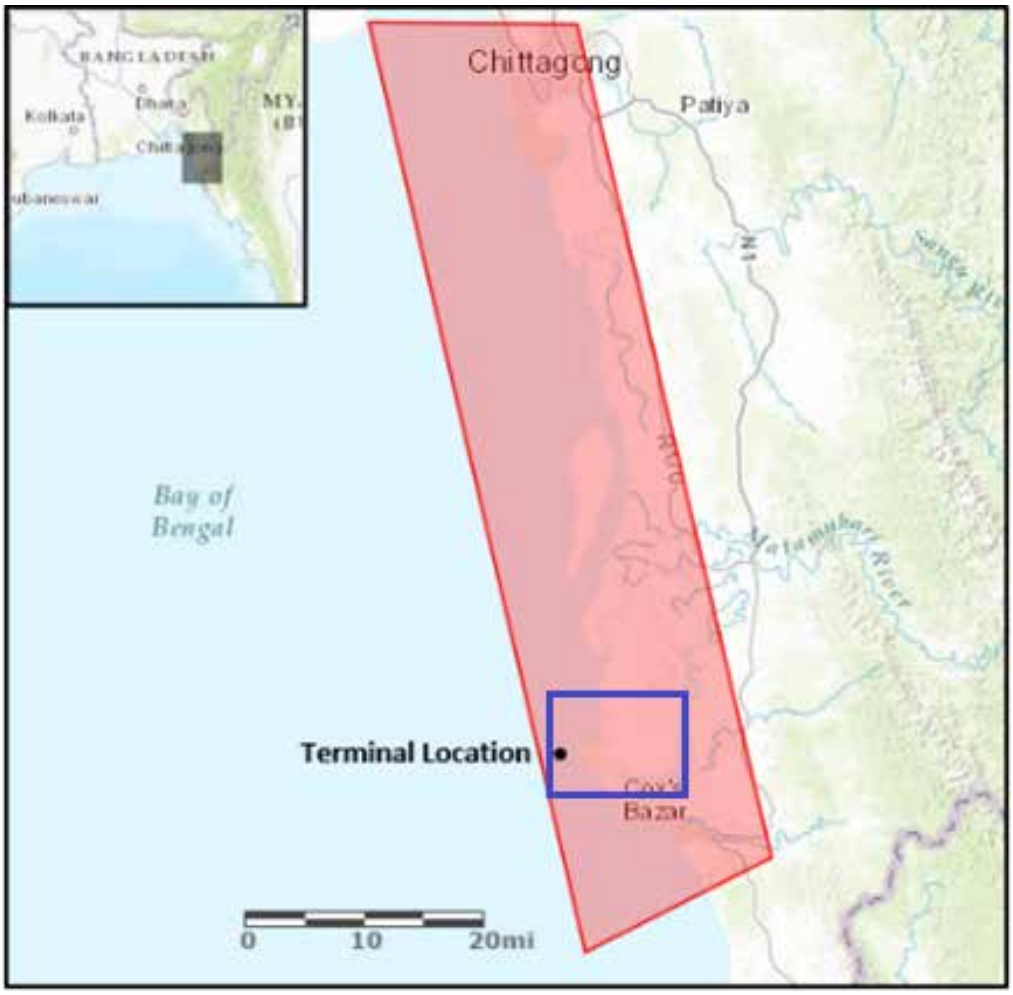
- The physical footprint of the FSRU, including a safety zone, vessel maneuvering zones, and subsea infrastructure
- Physical footprint of permanent and temporary onshore areas needed during construction

- Any required office, port or storage routes (to be identified in early logistics studies) as well as transportation corridor to port
- Areas that may be impacted by project wastes, effluents, emissions, noise and light
- Adjacent onshore areas that are within the viewshed of the FSRU and are home to communities that utilize the area for fishing, salt farming and other economic activities
- Footprint of the 89.4 km pipeline to Chittagong, including a buffer zone on both sides of the route which may be impacted by construction or operations
- Areas that could potentially be impacted by accidental events

The study area for the Critical Habitat Assessment, shown in Figure 3-1, is based not only on areas potentially impacted by the project (Area of Influence), but also on a broad landscape and seascape analysis. The study area is bound by urban areas of Chittagong to the north and Cox's Bazar to the south, and includes coastal marine waters and coastal plains. The study area is bound to the east by the Chittagong Hills, which host markedly different ecosystems, and the west by the Bay of Bengal.

Coincidentally, the study area is essentially the same as the area of influence in this case; however, the study area boundary determination is based on an evaluation of biological functions, as opposed to potential project impacts.

Figure 3-1: Study Area



Notes: Study area shown in red. Focus area outlined in blue.
Source: Acorn International / ESRI

The study area is particularly large as a result of the associated pipeline that travels from the shoreline adjacent to the terminal to Chittagong as well as the potential marine corridor from the terminal location to Chittagong that may be used by support vessels. These areas were included in the screening of Critical Habitat, but none was found so this report focuses on the onshore and coastal areas near the terminal site (outlined in blue above).

3.2 Ecological Characterization

International Union for Conservation of Nature (IUCN) has delineated 25 bio-ecological zones in Bangladesh (Figure 3-2), based on physiographical, hydrological, meteorological, and ecological features.[3] Only five of these are present in the study area, including:

1. Coastal plains
2. Sandy beach / sand dunes
3. Chakaria Sundarbans

[3] Nishat, A., Huq, S.M., Imamul, Barua, Shuvashish, P., Reza, Ali A.H.M., Khan, A.S. Moniruzzaman (eds.). 2002. Bio-ecological Zones of Bangladesh. IUCN Bangladesh Country Office, Dhaka, Bangladesh.

4. Offshore islands
5. Coastal marine waters

A brief description of each is provided below, based on characterizations described by Nishat et al. As described above, the study area is bound to the east by Chittagong Hills, a distinct bio-ecological zone. This region is not considered in the evaluation, given the differences in flora and fauna present compared to the area of influence which is only marine and coastal areas.

3.2.1 The Coastal Plains

The coastal plains encompass most of the coastline in the study area. This region rises slightly above sea level and is dissected by numerous rivers and streams (Figure 3-3). The coastal plains are underlain by heavy marine or tidal clays, with sand or silt deposits near the foot of the hills and along the courses of rivers and streams. The coastline in the plains is comprised primarily of mud flats and submerged sands, and is important for a wide variety of waterfowl.

3.2.2 Sandy Beach/Sand Dunes

Sandy beach and sand dunes in Bangladesh primarily occur from the mouth of the Bakkhali River in Cox's Bazar south to the border of Myanmar. Cox's Bazar is at the southern bound of the study area, so this bio-ecological zone is limited with in the study area. However, approximately 10 km of sandy beach and sand dunes are present on Sonadia Island, adjacent to the terminal location. Sandy beaches on Sonadia are known to support sea turtle nesting for Green Turtle (*Chelonia mydas*) and Olive Ridley Turtle (*Lepidochelys olivacea*), as well as high tide roosts for shorebirds and gulls.

3.2.3 Chakaria Sudarbans

Chakaria Sundarbans are a complex of deltaic mangrove forest of the Mathamuhuri River at Chakaria in Cox's Bazar district. This bio-ecoregion was once a mosaic of newly formed grassy islands, river channels, tidal creeks, aquaculture ponds, mangrove forests and inter tidal mudflats; however, most of this ecosystem has been converted[4]. The initial area of the Chakaria Sundarbans is estimated at 18,200 ha. Encroachment of human settlements prompted the government to set aside 8,510 ha as protected forest in 1906, but the entirety of that set-aside was subsequently leased to farmers between 1926 and 1996. Essentially all of this area has been cleared for salt pans and aquaculture.

3.2.4 Offshore Islands

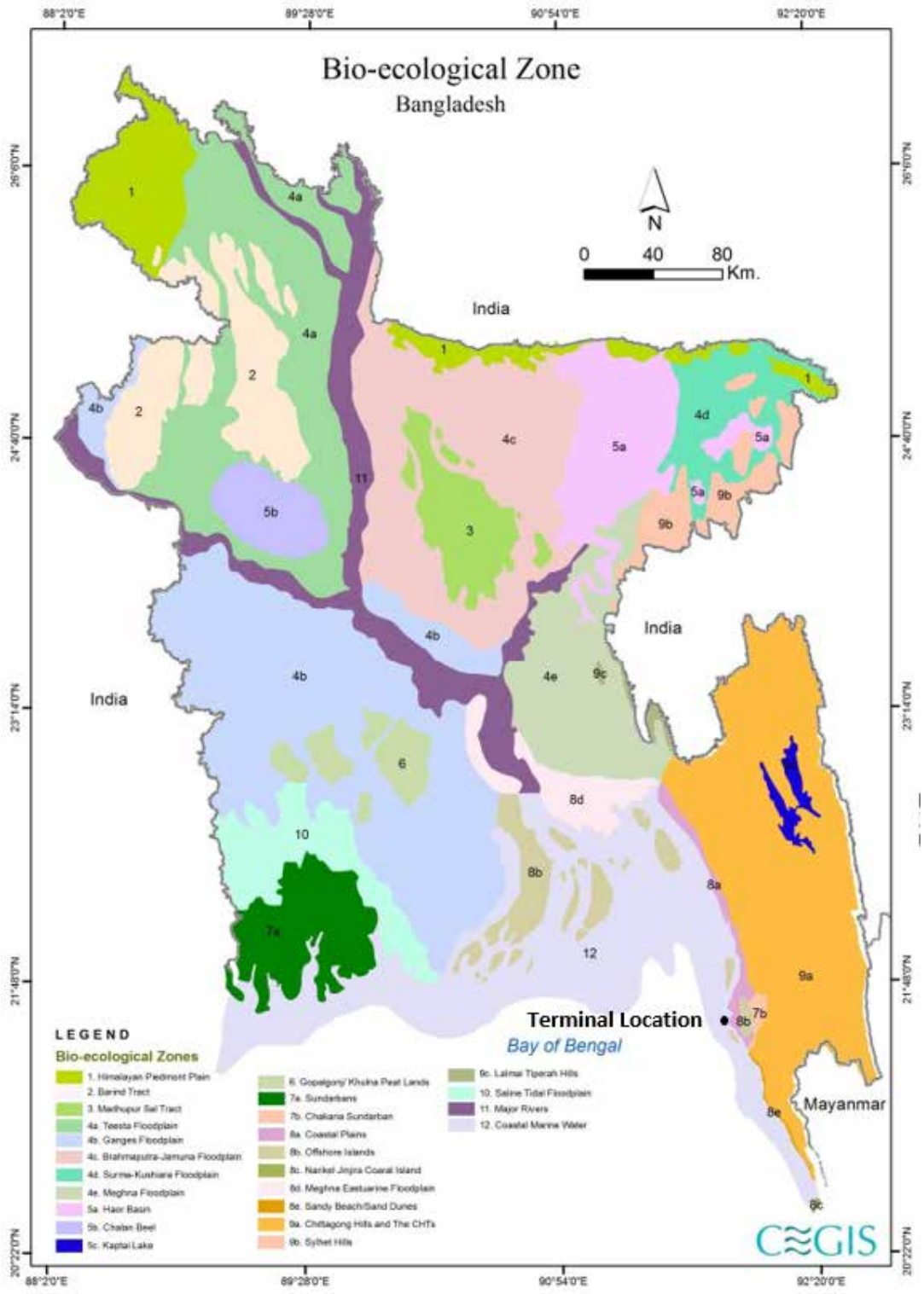
There are many offshore islands in Bangladesh that are continuously changing as a result of erosion and tidal surge. Within the study area, the three main offshore islands include Moheshkhali Island, Sonadia Island and Kutubdia Island. Offshore islands include many features that support biodiversity, including extensive intertidal mudflats, shoals and mangrove forests.

3.2.5 Coastal Marine Water

Costal marine water includes all of Bangladesh's territorial waters and Exclusive Economic Zone, over 100,000 km^2 in total.

[4] Siddique, M. 2012. Destruction of Hundred Years Oldest Mangrove Chakaria-Sunderban Forest: Socio-economic Impact on Coastal Communities. Proceedings of the International Conference: Meeting on Mangrove Ecology, Functioning, and Management. 2-6 July, 2012, Galle, Sri Lanka.

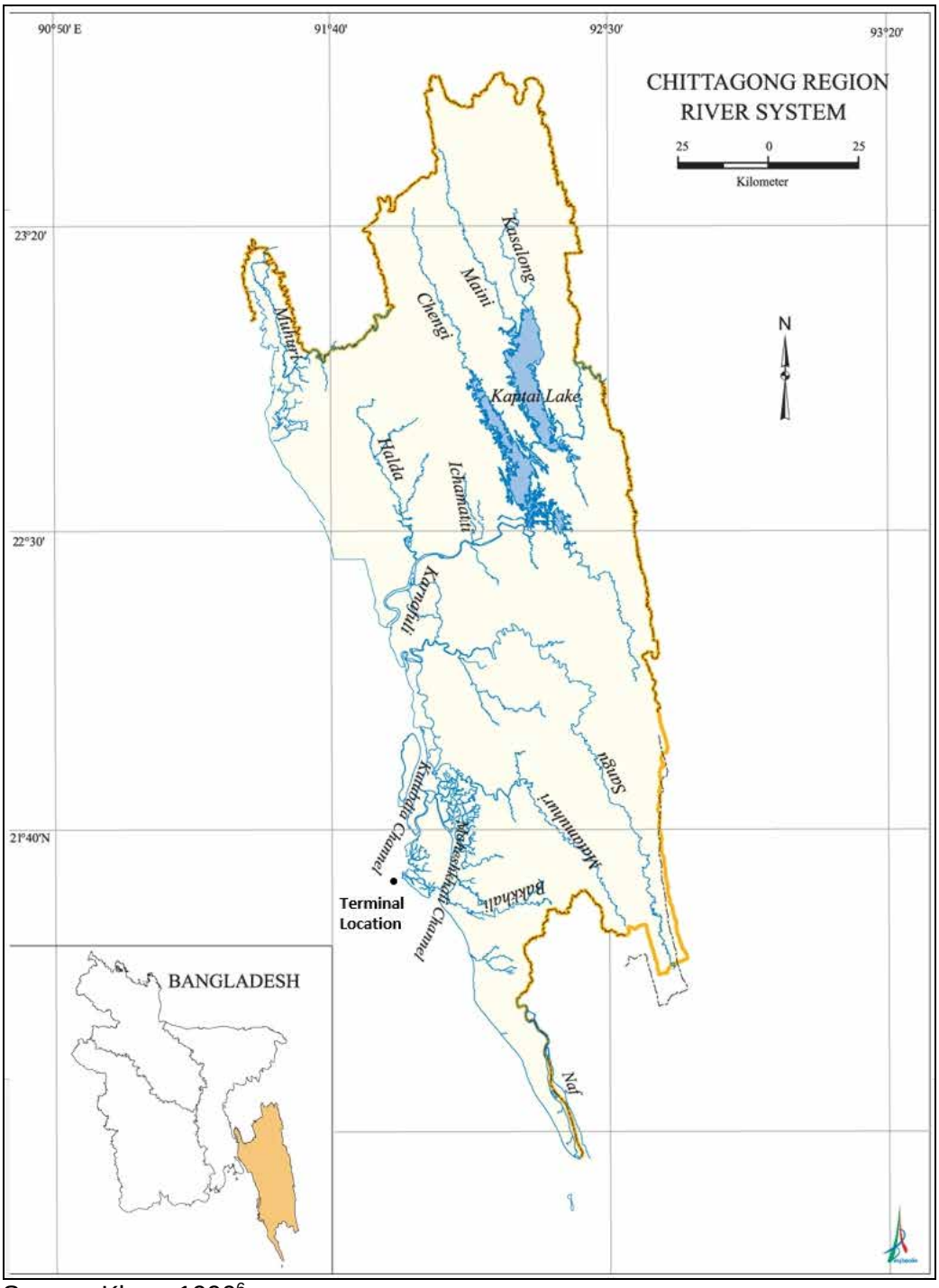
Figure 3-2: Bio-ecological Zones of Bangladesh



Source: Economics Division, Planning Commission, Government of Bangladesh. 2015.[5]

[5] General Economics Division, Planning Commission, Government of Bangladesh. 2015. Bangladesh Delta Plan 2100: Ecological Settings. Accessed from the project website: http://www.bangladeshdeltaplan2100.org/

Figure 3-3: Chittagong Region River System



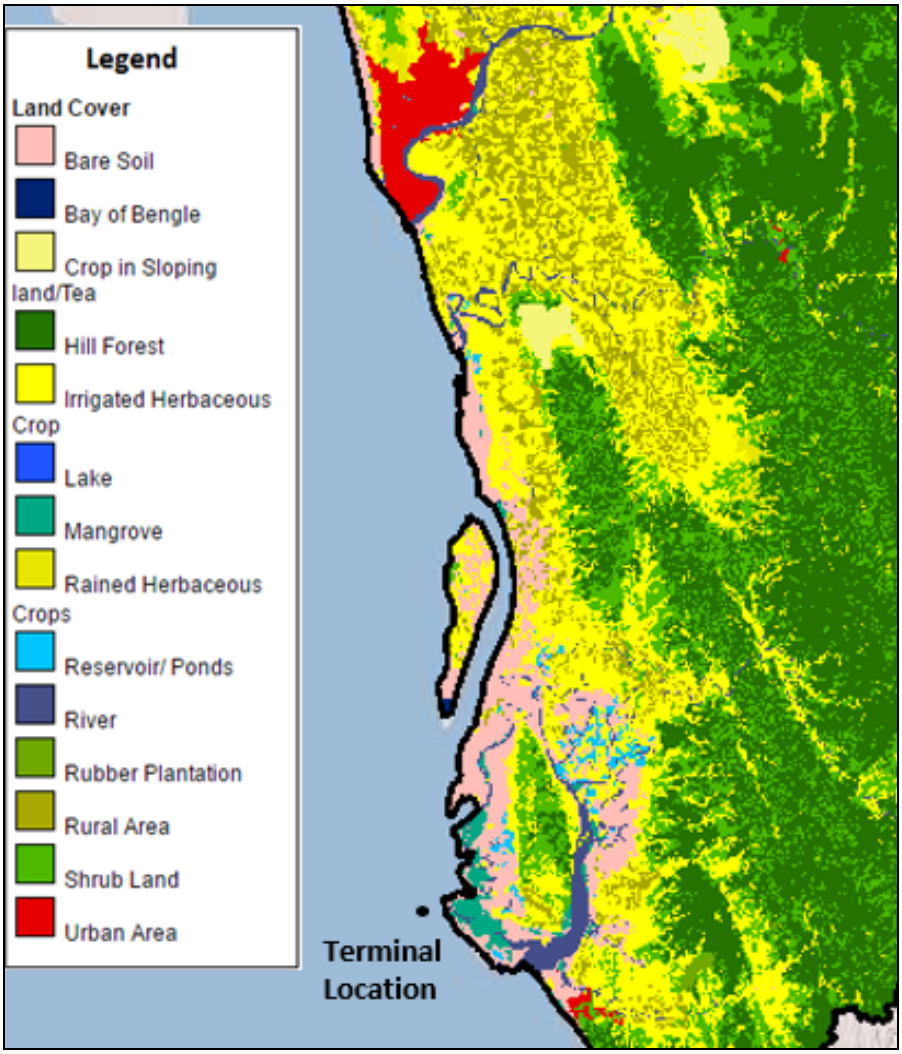
Source: Khan, 1990[6]

[6]Khan, M. 1990. 'Environmental Aspects of Surface Water Development Projects in Bangladesh', in Rahman et al. (ed), Environment and Development in Bangladesh, Vol 2, University Press Ltd, Dhaka, 1990.

3.3 Land Cover

Land cover in the study area is shown in Figure 3-4, and a detailed view of the land cover near the LNG terminal is shown in Figure 3-5.

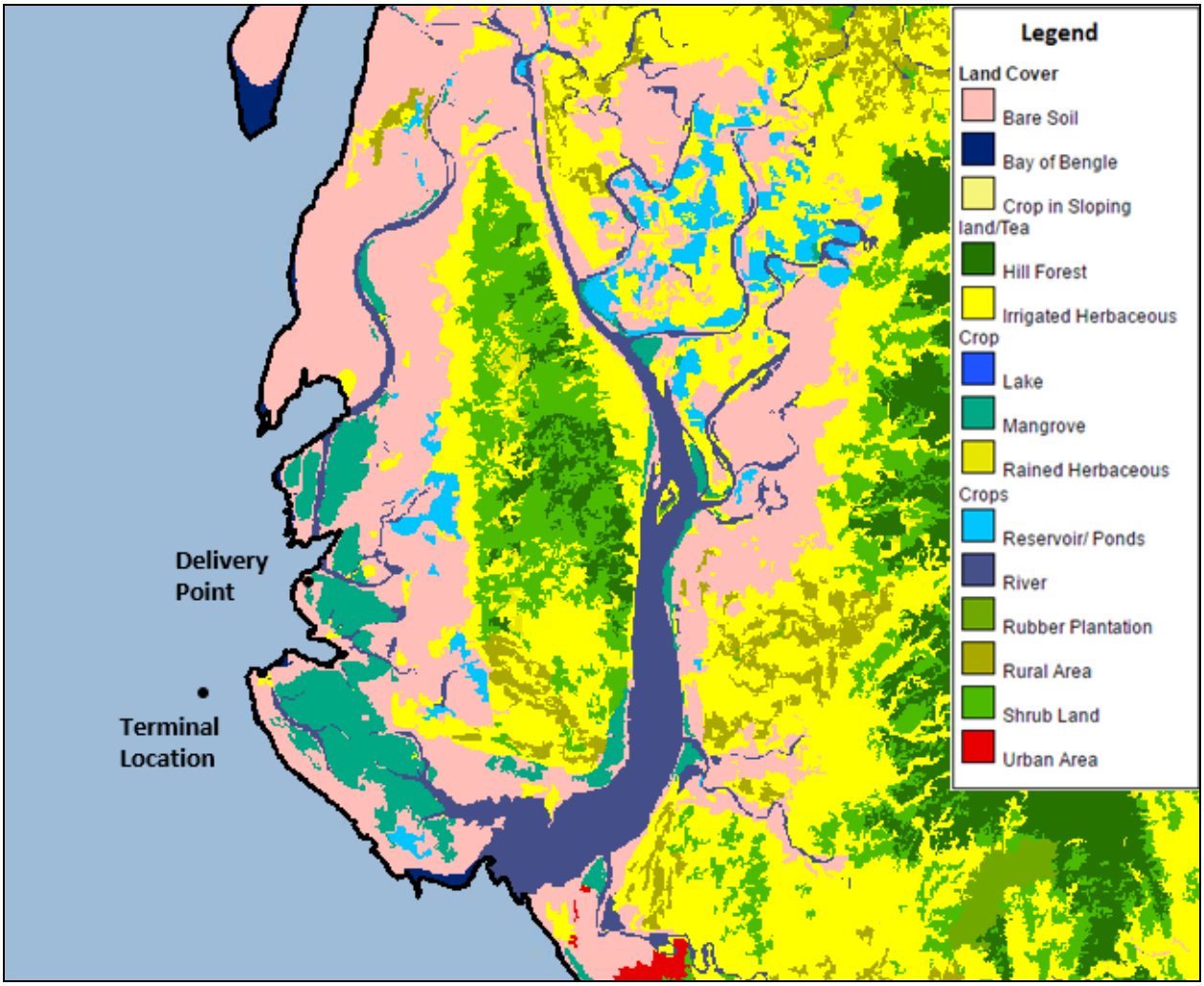
Figure 3-4: Land Cover in Study Area



Source: Acorn International / The International Centre for Integrated Mountain Development (ICIMOD). 2016.[7]
Note: "Bay of Bengle" indicates intertidal substrate area on the southern tip of Kutubdia Island.

[7] The International Centre for Integrated Mountain Development (ICIMOD). 2016. Mountain GeoPortal: Land Cover Dynamics of Greater Chittagong Area. Accessed from the ICIMOD website: http://apps.geoportal.icimod.org/BDLandcover/#

Figure 3-5: Land Cover near Terminal Location



Source: Acorn International / ICIMOD. 2016[7]

The IFC Performance Standard 6 define Natural and Modified habitat as:

> *"Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition."*
>
> *"Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include areas managed for agriculture, forest plantations, reclaimed6 coastal zones, and reclaimed wetlands."*

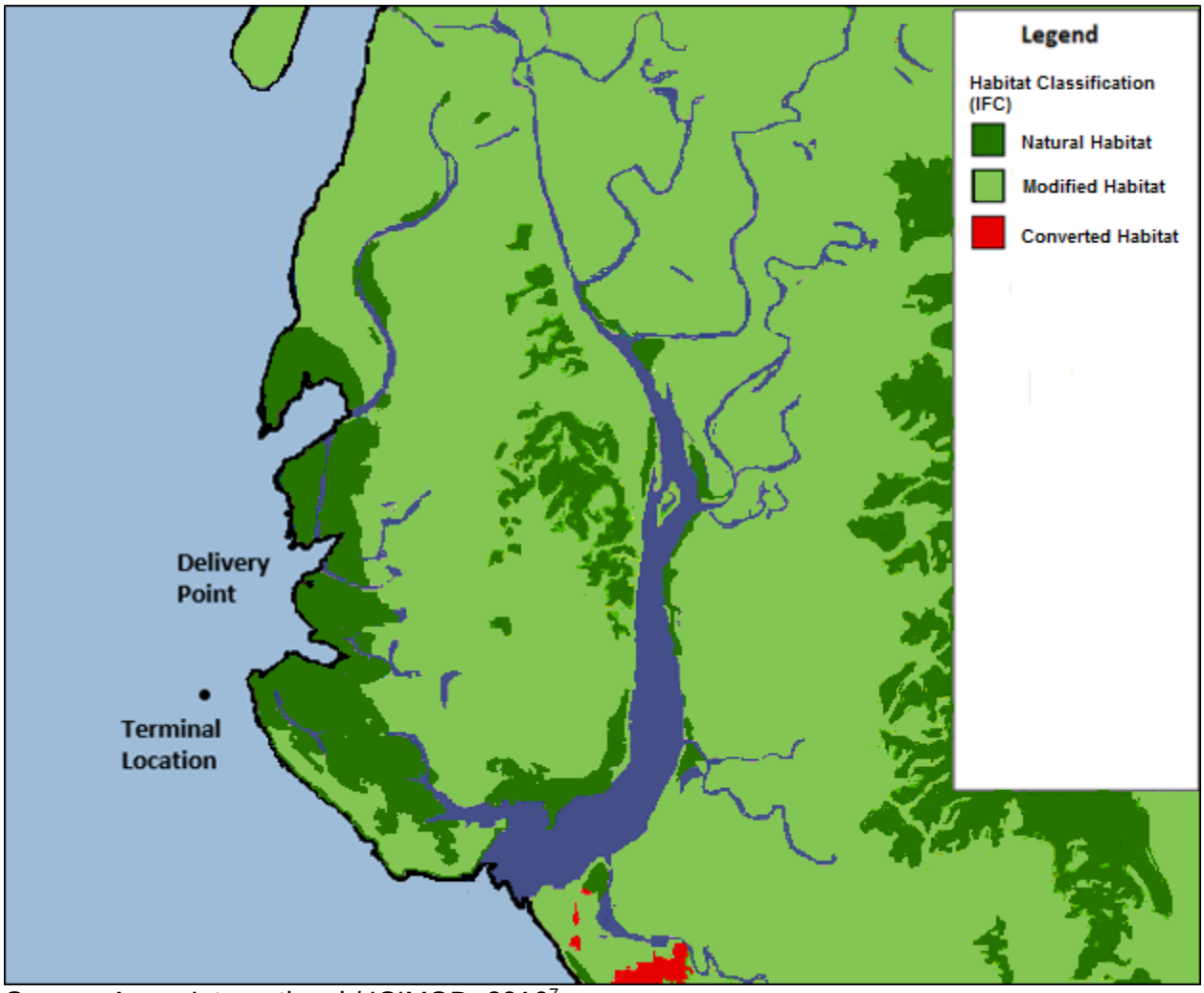
Based on these definitions, the ESIA team characterized each cover type (as defined in the land cover data) as Modified or Natural Habitat to develop a binary map of habitat types. Urban areas were classified as "Converted Habitat". The land cover classifications and rationale are provided in Table 3-1, and a map of Modified and Natural Habitats are provided in Figure 3-6.

Table 3-1: Natural and Modified Habitat Classification by Land Cover Type

Land Cover Type	Natural or Modified Habitat Classification	Rationale
Bare Soil	Mixed	This land cover type is broad, and includes both Natural and Modified Habitats. In order to distinguish the two, the ESIA team evaluated satellite imagery and compared with site visit observations. Beaches, dunes, and intertidal mudflats included in the original land cover mapping were characterized as Natural Habitat. Salt pans, bare soil in agricultural areas, and other cleared lands were characterized as Modified Habitats.
“Bay of Bengle”	N/A	This land cover type was grouped with open ocean, and not categorized.
Crop in Sloping Land / Tea	Modified Habitat	This land cover type includes cleared lands used for crops.
Hill Forest	Natural Habitat	Hill Forests are present in the higher elevations on eastern Moheshkali Island and hills east of Moheshkhali Channel. For the purposes of this mapping the Hill Forests were considered Natural Habitat, although outside of core areas Hill Forests were often part of a mosaic of secondary and/or cleared areas and it is unclear if these fragmented habitats maintain natural species composition and ecological function.
Irrigated Herbaceous Crop	Modified Habitat	This land cover type includes cleared lands used for crops.
Lake	N/A	This land cover type was not present in the study area.
Mangrove	Natural Habitat	Much of Sonadia Island is mangroves that were reclaimed over the past 60 years. While flora species composition is low

Land Cover Type	Natural or Modified Habitat Classification	Rationale
		compared to truly natural mangrove, the ecological function remains. Based on the recommendation of the regional biodiversity experts, we classified these mangroves as Natural Habitat.
Rained Herbaceous	Modified Habitat	This land cover type includes cleared lands used for crops.
Reservoir / Ponds	Modified Habitat	The ESIA team reviewed satellite imagery of areas classified as Reservoirs / Ponds, but could not distinguish these in the landscape from the ponds used for salt pans and aquaculture. Thus, this cover type was classified as Modified Habitat along with those other habitat types.
River	N/A	Surface water bodies were not characterized.
Rubber Plantation	Modified Habitat	This land cover type includes cleared lands used for crops.
Rural Area	Modified Habitat	This land cover type homesteads that have been replanted with fruiting and other food production species, as well as ornamentals.
Shrub Land	Modified Habitat	This land cover type includes secondary growth on areas that were previously cleared.
Urban Area	Converted Habitat	This land cover type includes areas largely covered with buildings and other impermeable surfaces that provide little value.

Figure 3-6: Map of Natural and Modified Habitat



Source: Acorn International / ICIMOD. 2016[7]

3.4 Sonadia Island

The project footprint is located entirely offshore, except for the pipeline tie-in at the Delivery Point. The Delivery Point is on land separated from the main Moheshkhali Island by natural salt water channels, forming a separate feature named Sonadia Island. Sonadia Island comprises a wide variety of wetland habitats including mudflats, sand dunes, mangroves, sand bars, lagoons, man-made saltpans and beaches. The mangrove and shallow shoals surrounding the Island provide an important wintering area for migratory waterfowl and shorebirds, including three globally threatened species. The sandy beaches and sand dunes support one globally threatened marine turtle species. In addition, one globally threatened dolphin species has been recorded in the Moheshkhali Channel.

Mangroves are the dominant vegetation on Sonadia Island. Twenty-seven mangrove species and mangrove-associated vegetation were recorded from Sonadia Island, the common species

include *Avicennia officinalis, Avicennia marina, Avicennia alba, Sonneratia apetala, Aegiceras corniculatum, Ceriops decandra* (Globally Near Threatened) and *Aegialitis rotundifolia*.[8]

The total intertidal mudflat area has been estimated at 1,175 ha in 1999 by the Department of Environment (DoE) and has not changed considerably since. Mangroves within the site are at the sheltered inland part of Sonadia Island and along the edge of the estuary, covering a total mangrove area of around 500 ha.

3.5 Protected Areas

3.5.1 Nationally Protected Areas

Protected areas in Bangladesh were first declared under the Wildlife Preservation Act, 1974 (as amended) and include national parks, wildlife sanctuaries, and game reserves. Areas protected under the Wildlife Preservation Act in and adjacent to the study area are shown in Figure 3-7 and listed in Table 3-2.

The Environmental Conservation Act of 1995 also gives the Department of Environment (DoE) authorization to declare Ecologically Critical Areas (ECAs) by issuing notification in the Official Gazette. On April 19, 1999, a notice declaring ECAs was issued for nine sites in Bangladesh, including Sonadia Island and Cox's Bazar-Teknaf Peninsula (southern extent of the study area). In these ECAs, a ban is imposed on certain activities, including the felling or extracting of trees and forest products; hunting and poaching of wild animals; catching or collection of snails, corals, turtles and other creatures, any activity that may threaten the habitat of flora and fauna; activities likely to destroy or alter the natural characteristics of soil and water; controls over the establishment of industries that may pollute soil, water, air and/or create noise pollution and other activities that may be harmful for the fish and other aquatic life. An Environmental Clearance Certificate, based on Environmental Impacts Assessment (EIA) is required for any development project in the ECA area. The project was granted an Environmental Clearance Certificate in January 2016, allowing the project to proceed as planned.

[8] Rabbi, G. No date. Habitat Management Plan and Conservation of Threaten WaterBirds in Sonadia Island. Accessed from the East Asian-Australasian Flyway Partnership website: http://www.eaaflyway.net/documents/Habitat%20Management%20Plan%20and%20Conservation%20of%20Threaten%20WaterBirds%20in%20Sonadia%20Island.pdf

Figure 3-7: National Parks, Wildlife Sanctuaries and Game Reserves in the Study Area

Source: Adapted from UNEP-WCMC, 2016[9]

[9] UNEP-WCMC. 2016. World Database on Protected Areas. Accessed from the UNEP-WCMC website: www.protectedplanet.net

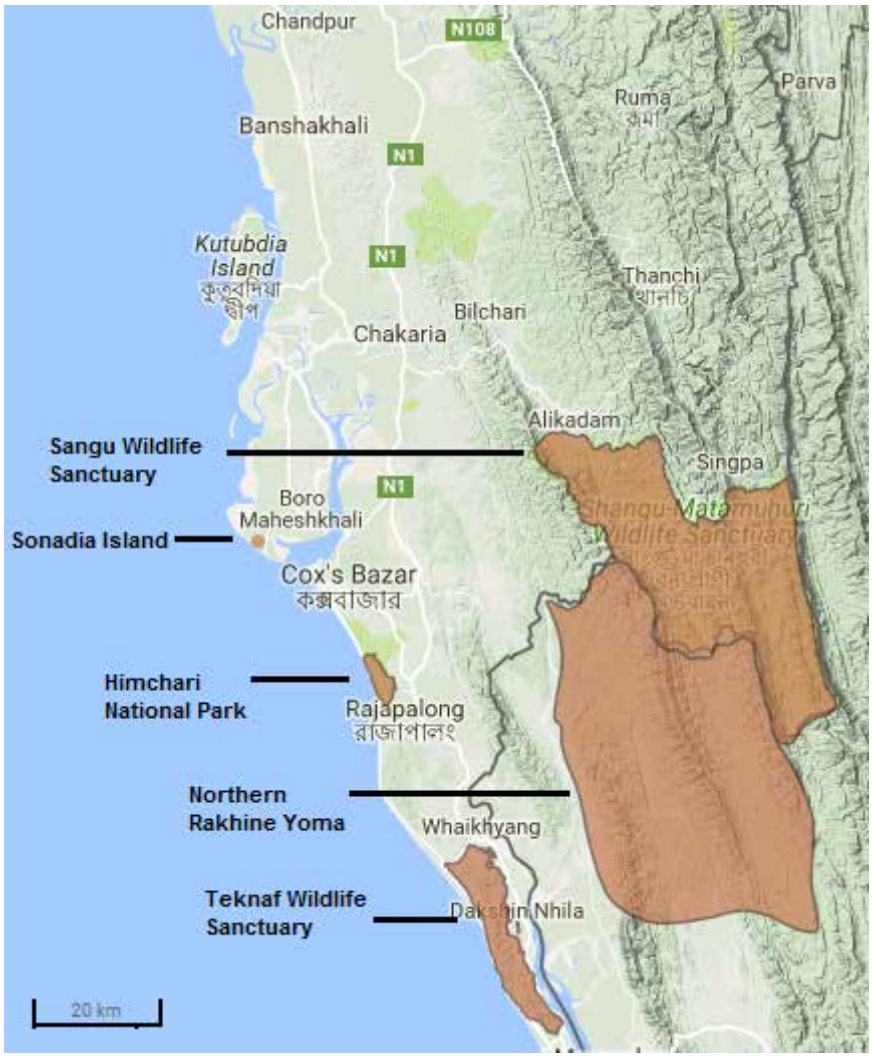
Table 3-2: National Parks, Wildlife Sanctuaries and Game Reserves in the Study Area

Protected Area Name	IUCN Category	Approximate Distance to Project Site
Himchari National Park	V	22 km
Medhakachhapia National Park	IV	27 km
Bangabandhu Safari Park Coxbazar	Not Reported	28 km
Fasiakhali Wildlife Sanctuary	IV	29 km
Sangu Wildlife Sanctuary	II	29 km
Marine Reserve	Not Reported	37 km
Chunati Wildlife Sanctuary	IV	46 km
Inoni National Park	Not Reported	40 km
Teknaf Wildlife Sanctuary	IV	59 km
Dudpukuria-Dhopachari Wildlife Sanctuary	IV	78 km

3.5.2 Internationally Recognized Areas

In 2007, the Bangladesh Ministry of Environment and Forests, Forest Department proposed Sonadia Island as a designated wetland under the Ramsar Convention. The Island was designated an Important Bird Area (IBA) by BirdLife International in 2013. Internationally recognized areas in the study area are shown in Figure 3-8 and listed in Table 3-3. Sonadia Island is also part of the Indo-Burma Biodiversity Hotspot (Figure 3-9).

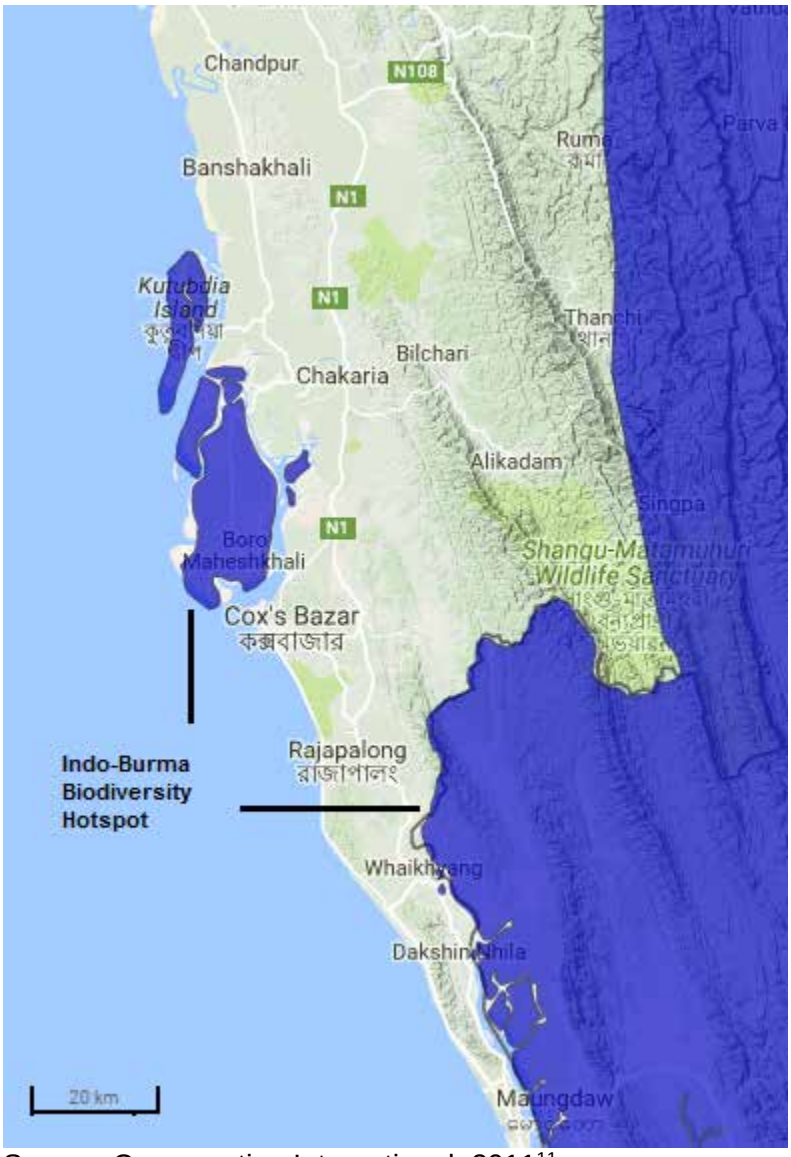
Figure 3-8: Internationally Recognized Areas in the Study Area



Source: Adapted from Birdlife International, 2016[10]

[10] BirdLife International (on behalf of the KBA Partnership), 2016. Key Biodiversity Areas: December 2016 version. Downloaded under licence from the Integrated Biodiversity Assessment Tool. http://www.ibatforbusiness.org

Figure 3-9: Areas of Regional Conservation Importance



Source: Conservation International, 2011[11]

[11] Conservation International, 2011. Biodiversity Hotspots - digital boundaries. Downloaded under licence from the Integrated Biodiversity Assessment Tool. http://www.ibatforbusiness.org

Table 3-3: Internationally Recognized Areas in the Study Area

Protected Area Name	International Recognized Area Type	Approximate Distance to Project Site
Sonadia Island	Important Bird Area and Key Biodiversity Area	0 km
Himchari National Park	Important Bird Area and Key Biodiversity Area	22 km
Sangu Wildlife Sanctuary (also known as Sangu Matamuhari)	Important Bird Area and Key Biodiversity Area	29 km
Northern Rakhine Yoma	Key Biodiversity Area	29 km
Teknaf Wildlife Sanctuary	Important Bird Area and Key Biodiversity Area	59 km

4 Initial Literature Review and Stakeholder Consultation

The literature review identified a number of journal articles and studies of with recent primary data that provide a detailed understanding of the biodiversity values present in the study area, particularly on Sonadia Island. Key references are provided in Appendix B, and a description of primary data is provided in Section 5. In addition to literature review, the Critical Habitat Assessment team integrated specialists with extensive knowledge of Sonadia Island and species of concern. The external specialists were involved with drafting this Critical Habitat Assessment and conducting supplementary field surveys.

Lastly, our team consulted with organizations and individuals with knowledge of biodiversity issues in the study area, including:

- Subject matter experts on biodiversity issues on Sonadia Island - BSCP (part of our team)
- Department of Environment (in Dhaka, Chittagong and Cox's Bazar)
- Department of Forests (in Dhaka, Chittagong and Cox's Bazar)
- Department of Fisheries (in Dhaka, Chittagong and Cox's Bazar)
- Office of Natural Resource Management
- IUCN
- Chittagong University
- Deputy Commissioner of Cox's Bazar
- Upazila Nirbahi Officer
- Union Parishad Chairmen
- Fishing associations and local civil society groups of Moheshkhali
- Local village representatives (limited) closest to the Delivery Point

Details of the stakeholder engagement can be found in Chapter 7 of the EIA Addendum. Based on the literature review and stakeholder consultation a list of potential Critical Habitat triggers was developed.

4.1 Summary of Potential Species Level Critical Habitat Triggers

A list of potential Critical Habitat triggers for Criteria 1-3 is presented in Table 4-1.

Table 4-1: Candidate Critical Habitat Biodiversity Values

Species Information			IFC Species Level Critical Habitat Criteria					Rationale for Inclusion / Exclusion	Key Information Sources
Taxonomic group	Species	Common name	Criterion 1: CR or EN Species	Criterion 2: Endemic / Restricted Range Species	Criterion 3: Migratory / Congregatory Species	Tier 1 Critical Habitat	Tier 2 Critical Habitat		
Birds	*Asarcornis scutulata*	White-winged Duck	EN	N	N	N	N	**Excluded:** Inhabits freshwater wetlands, within or adjacent to evergreen, deciduous or swamp forests, on which it depends for roosting and nesting, usually in tree-holes. While the range map for this species does overlap with the study area north and east of Moheshkali Island, the evaluation is primarily focused on marine and brackish waters of Moheshkhali island, particularly in the south west (Sonadia Island).	IUCN Red List / Birdlife International Factsheet
Birds	*Calidris pygmaea*	Spoon-billed Sandpiper	CR	N	Y	Y	N/A	**Included:** Estimated population in the wintering areas is between 240 and 400 individuals, of which 26 individuals have recently been recorded on Sonadia Island as winter migrants. This represents between 12.5-7.5 percent of the global population. The median estimate meets Tier 1 threshold for habitat required to sustain ≥ 10 percent of the global population of an IUCN Red-listed CR species.	IUCN Red List / Birdlife International Factsheet BSCP Monitoring Bangladesh Forest Department Monitoring Zöckler et al. 2016
Birds	*Calidris tenuirostris*	Great Knot	EN	N	N	N	Y	**Included:** The global population is estimated at 292,000 - 295,000. The estimated population wintering in Sonadia is between 400 and 450 individuals. Sonadia Island does not constitute a DMU for the species, but does represent nationally important concentrations of an EN species.	IUCN Red List / Birdlife International Factsheet BSCP Monitoring Bangladesh Forest Department Monitoring Chowdhury et al. 2011

Species Information			IFC Species Level Critical Habitat Criteria					Rationale for Inclusion / Exclusion	Key Information Sources
Taxonomic group	Species	Common name	Criterion 1: CR or EN Species	Criterion 2: Endemic / Restricted Range Species	Criterion 3: Migratory / Congregatory Species	Tier 1 Critical Habitat	Tier 2 Critical Habitat		
Birds	*Emberiza aureola*	Yellow-breasted Bunting	EN	N	N	N	N	**Excluded**: Inhabits terrestrial and freshwater cultivated areas, rice fields and grasslands, preferring scrubby dry-water rice fields for foraging and reed beds for roosting. While the range map for this species does overlap with the study area, the evaluation is focused on coastal marine and brackish areas.	IUCN Red List
Birds	*Tringa guttifer*	Nordmann's Greenshank	EN	N	Y	N	Y	**Included:** The global population is estimated at 500-1,000 individuals. The estimated wintering population of Sonadia Island is 28 individuals. Sonadia Island does not constitute a DMU for the species, but does represent nationally important concentrations of an EN species.	IUCN Red List Birdlife International Factsheet BSCP Monitoring Bangladesh Forest Department Monitoring
Corals	*Acropora rudis*		EN	N	N	N	N	**Excluded:** The Bangladesh sea floor is largely composed of marine clay. The only known corals in Bangladesh are found on the Narikel Jinjira (St. Martin's Island), outside the study area. Narikel Jinjira is a small island about 9 km south of Cox's Bazar-Teknaf peninsular tip and forms the southernmost tip of Bangladesh.	IUCN Red List Mollah, A.R., 1997
Fishes	*Anoxypristis cuspidata*	Narrow Sawfish	EN	N	N	N	N	**Excluded:** While the exact range is uncertain, the Narrow Sawfish has been recorded in coastal areas from Australia to Yemen. Narrow Sawfish are considered rare in Bangladesh (Roy 2010).	IUCN Red List Roy, B.J. 2010.
Fishes	*Carcharhinus hemiodon*	Pondicherry Shark	CR	N	N	N	N	**Excluded:** This shark was last seen in 1979 and is possibly extinct. Little is known about the species, and it is unlikely to occur in the study area.	IUCN Red List

Species Information			IFC Species Level Critical Habitat Criteria					Rationale for Inclusion / Exclusion	Key Information Sources
Taxonomic group	Species	Common name	Criterion 1: CR or EN Species	Criterion 2: Endemic / Restricted Range Species	Criterion 3: Migratory / Congregatory Species	Tier 1 Critical Habitat	Tier 2 Critical Habitat		
Fishes	*Glyphis gangeticus*	Ganges Shark	CR	N	N	N	N	**Excluded:** Occurrences of this species are extremely rare, and only have been recorded in the Ganges-Hooghly river system in eastern India. It primarily a freshwater riverine species, although it could possibly occur inshore marine and estuarine areas. While the study area is within its potential range, any occurrence would be rare.	IUCN Red List
Fishes	*Lamiopsis temminckii*	Broadfin Shark	EN	N	N	N	N	**Excluded:** This species is primarily found off Pakistan, India, Burma, Indonesia (Makassar Straits), Sarawak, and China. While the study area is in the range map, it is unlikely to occur.	IUCN Red List
Fishes	*Pristis pristis*	Largetooth Sawfish	CR	N	N	N	N	**Excluded:** There are four distinct sub-populations of this CR species: Eastern Atlantic, Western Atlantic, Eastern Pacific, and Indo-West Pacific. In Southeast Asia, localized depletions and extinctions of sawfishes have been reported or inferred from across the region. Northern Australia is thought to be the last viable population in the Indo-West Pacific, thus any occurrence in the study area would be rare.	IUCN Red List
Fishes	*Sphyrna lewini*	Scalloped Hammerhead	EN	N	N	N	N	**Excluded:** This species is wide ranging and can be found nearshore or in waters up to 275 m deep. While it might be a vagrant in Bangladesh, it does not regularly occur in the study area.	IUCN Red List
Fishes	*Sphyrna mokarran*	Squat-headed Hammerhead Shark	EN	N	N	N	N	**Excluded:** This species is wide ranging and highly solitary. It can occur inshore as well as well offshore. While it could occur rarely in the study area, the region is not an important area for the species (as Australia is, for example).	IUCN Red List

Species Information			IFC Species Level Critical Habitat Criteria					Rationale for Inclusion / Exclusion	Key Information Sources
Taxonomic group	Species	Common name	Criterion 1: CR or EN Species	Criterion 2: Endemic / Restricted Range Species	Criterion 3: Migratory / Congregatory Species	Tier 1 Critical Habitat	Tier 2 Critical Habitat		
Mammals	*Balaenoptera musculus*	Blue Whale	EN	N	N	N	N	**Excluded:** Blue Whales are highly migratory, can be found in almost every ocean and have a number of subspecies. Many (but not all) migrate to cold seas in the summer to warmer waters in the winter to breed. No population estimates are available for the northern Indian Ocean, but blue whales are commonly observed in Sri Lanka and Maldives. While they could occur in the study area, this would be rare and the region is not of significant importance.	IUCN Red List
Mammals	*Hoolock hoolock*	Western Hoolock Gibbon	EN	N	N	N	N	**Excluded:** There are estimated to be about 200-280 hoolocks in Bangladesh. However, the species lives in tropical evergreen rainforests, tropical evergreen and semi-evergreen forests, tropical mixed deciduous forests, and subtropical broadleaf hill forests. There is little of such habitats in the study area, thus this species is unlikely to occur.	IUCN Red List Islam et al. 2006 Molur et al. 2005
Mammals	Platanista gangetica ssp. gangetica	Ganges River Dolphins	EN	N	N	N	N	**Excluded:** There are estimated to be about 1,200–1,800 Ganges River Dolphins in the wild. While this species has been recorded in the Moheshkali channel, this species is primarily a freshwater species. Further, Moheshkali Channel and coastal waters in the area of influence are not included in the range map for this species. Thus, the species is likely only a vagrant in the project area.	IUCN Red List Smith, et al. 2012 Hossain et al. 2016

Species Information			IFC Species Level Critical Habitat Criteria					Rationale for Inclusion / Exclusion	Key Information Sources
Taxonomic group	Species	Common name	Criterion 1: CR or EN Species	Criterion 2: Endemic / Restricted Range Species	Criterion 3: Migratory / Congregatory Species	Tier 1 Critical Habitat	Tier 2 Critical Habitat		
Mammals	*Trachypithecus phayrei*	Phayre	EN	N	N	N	N	**Excluded: P**opulations in Bangladesh are small and isolated, though locally common in many places. The species prefers primary and secondary evergreen and semi-evergreen forest and mixed moist deciduous forest. There is little of such habitats in the study area, thus this species is unlikely to occur.	IUCN Red List Choudhury 2001 Molur et al. 2003
Other invertebrates	*Holothuria lessoni*	Golden Sandfish	EN	N	N	N	N	**Excluded:** This species is wide ranging and considered common, however it is a highly valuable commercial species and overfishing has depleted stocks significantly (estimated 50%) over the past 50 years. It may occur in the project area, but given the large extent of suitable habitat the area is not considered significant.	IUCN Red List
Other invertebrates	*Holothuria scabra*	Golden Sandfish	EN	N	N	N	N	**Excluded:** This species is wide ranging and considered common, however it is a highly valuable commercial species and overfishing has depleted stocks significantly (estimated 50%) over the past 50 years. It may occur in the project area, but given the large extent of suitable habitat the area is not considered significant.	IUCN Red List
Other invertebrates	*Thelenota ananas*	Prickly Redfish	EN	N	N	N	N	**Excluded:** This species is wide ranging and considered common, however it is a highly valuable commercial species and overfishing has depleted stocks significantly (estimated 50%) over the past 50 years. It is reef associated, so unlikely to occur in the study area.	IUCN Red List
Plants	*Heritiera fomes*		CR	N	N	N	N	**Excluded:** Globally EN, this mangrove species is considered CR in Bangladesh due to habitat loss, largely from conversion of land to	IUCN Red List Rabbi, n.d.

Species Information			IFC Species Level Critical Habitat Criteria					Rationale for Inclusion / Exclusion	Key Information Sources
Taxonomic group	Species	Common name	Criterion 1: CR or EN Species	Criterion 2: Endemic / Restricted Range Species	Criterion 3: Migratory / Congregatory Species	Tier 1 Critical Habitat	Tier 2 Critical Habitat		
								shrimp farms. While common and abundant in the Sundarbans, it has not been recorded in recent studies conducted on Sonadia. While Sonadia Island is one of the largest mangrove tracts in the region, it was afforested over the last 50 years and is dominated by two species (*Avicennia alba* and *Avicennia marina).*	
Plants	*Sonneratia griffithii*		CR	N	N	N	N	**Excluded:** This mangrove species has a restricted distribution in South Asia, and is considered very rare or is locally extinct in many parts of its range. This species has not been recorded in recent studies conducted on Sonadia. While Sonadia Island is one of the largest mangrove tracts in the region, it was afforested over the last 50 years and is dominated by two species (Avicennia alba and Avicennia marina).	IUCN Red List Giesen 2007
Reptiles	*Chelonia mydas*	Green Turtle	EN	N	N	N	N	**Excluded:** The global population of nesting female green turtles is estimated between 85,000 and 90,000. Green turtles are reported to nest annually on Sonadia Island beaches; however, only 1-4 clutches are recorded annually. The region is outside the range map identified by IUCN, and it is unclear how often other beaches in southeast Bangladesh are used for sea turtle nesting. Thus, it is unlikely the area supports nationally/regionally important concentrations of an EN species.	IUCN Red List Islam et al. 2011
Reptiles	*Gavialis gangeticus*	Gharial	CR	N	N	N	N	**Excluded:** The Gharial (a fish-eating crocodile) is thought to be extinct in Bangladesh.	IUCN Red List

4.2 Summary of Highly Threatened and/or Unique Ecosystem Triggers

No highly threatened and/or unique ecosystem triggers were identified, per IFC Performance Standard 6, Criterion 4.

4.3 Summary of Key Evolutionary Processes Triggers

No landscapes that support key evolutionary processes were identified, per IFC Performance Standard 6, Criterion 5.

5 In-field Data Collection and Verification of Available Information

After initial literature review and stakeholder consultation, a list of biodiversity values that could potentially trigger Critical Habitat was developed. The key concerns in developing this list related to migratory waterfowl and sensitive/protected areas.

The team also leveraged recent primary data from:

- Annual monitoring completed by the Bangladesh Spoon-billed Sandpiper Conservation Project (BSCP)
- Annual monitoring by MarineLife Alliance on sea turtle nesting on Sonadia Island
- Research conducted by Bangladesh Forest Department as part of the 'Habitat Management Plan and Conservation Action for the Critically Endangered Spoon-billed Sandpiper at its Wintering Ground at Sonadia Island, Bangladesh', funded by the World Bank Group
- The original project Environmental Impact Assessment (EIA)

To supplement the above, the team conducted a two-day bird survey and field validation exercise to confirm accuracy of GIS based mapping and define the border of feeding, roosting and staging areas of Kaladia, the closest known area used by wading birds to the Delivery Point based on BSCP long term monitoring data. In-field data collection focused on the primary area of concern, waterfowl habitat. The field survey report is provided in Appendix C.

A summary of the BSCP monitoring, MarieLife Alliance monitoring, and research conducted by the Bangladesh Forest Department are summarized below.

5.1 Bangladesh Spoon-billed Sandpiper Conservation Project

The BSCP project conducts research and promotes conservation of shorebirds of Bangladesh with special focus on the Critically Endangered Spoon-billed Sandpiper. BSCP has been conducting monthly waterbird surveys during the winter (October – March) in Sonadia since 2009, and monthly (all year) in 2012, 2013, 2014, and 2015. This research offers the most up to date data on waterfowl distribution and abundance in the region. The team for this Critical Habitat Assessment includes the BSCP Principal Investigator, and the Coordinator and Assistant Coordinator of Birdlife International's Spoon-billed Sandpiper Task Force.

5.2 MarineLife Alliance Monitoring

MarineLife Alliance has been conducting independent long term monitoring of sea turtle nesting on Sonadia Island since 2005. From October through May, 4-6 observers patrol 12 km of nesting beaches every night. Nightly surveys are also carried out from June through September, although only 3 observers are used and surveys are only conducted every other day. Night

surveys span >6 hours starting 3 hours before and ending 3 hours after high tide. Observers collect information on nesting activity and threats.

5.3 Bangladesh Forest Department Research

Bangladesh Forest Department conducted field surveys on wading birds of Sonadia Island and their habitat as part of the 'Habitat Management Plan and Conservation Action for the Critically Endangered Spoon-billed Sandpiper at its Wintering Ground at Sonadia Island, Bangladesh', funded by the World Bank Group. The study, as described in Rabbi (no date)[8] presents similar findings as the BSCP project with regards to abundance and distribution of sensitive bird species. However, the Forest Department researchers also conducted a habitat survey, as described below.

> *"The vegetation survey was conducted along intertidal mudflats using the quadrate method. All the locations of sampling plots were recorded using a Global Positioning System (GPS). A total of 60 quadrate plots were placed along mudflats for conducting vegetation survey. 10 quadrates (10m x 10m) were randomly placed at each site for the purpose of studying trees (> 2.5 cm in diameter). Trees were counted in each quadrate. The height of stands and diameter at 1.3 m above ground (D130) were measured. Five sub-quadrates (1m x 1m) were also placed inside (10m x 10m) quadrate plot for the purpose of studying herbaceous and grass species. Visual estimation of cover (%) for herbaceous and grass species was recorded from each sub-quadrate. In doing visual estimation, the space inside the sub-quadrate was taken as 100 percent and the cover of each plant of each species within the frame was mentally aggregated into a single percentage value for that species. The total area of all species and bare soil were equated to one hundred percent. Samplings with circumference breast height <10 cm (Pande et al., 1988) were also counted in each sub-quadrate for the purpose of studying the regeneration status.*
>
> *Mangroves on mudflats in the Sonadia Island are not natural rather plantation. During the study six mudflat habitats were investigated and found that all the sites except Tajiakata had tree stands consisting of three mangrove species. However, the sites were mainly dominated by either Avicennia alba or Avicennia marina. Sonadia Purbapara and Kaladia were dominated by A. marina, while A. alba was the dominant species in Mogchar, Sonadia Paschimpara, and Belekardia. Another mangrove species Aegialitis rotundifolia was the least abundant species at all the sites. The dominance pattern of species such as A. alba > A. marina > Aegialitis rotundifolia might be resulted from the selection of one or two species for mangrove plantation in these sites."*

Key learnings from the study include:

1) While one of the largest mangrove tracts in Bangladesh (outside the Sunderbans), the species composition is limited.
2) The area was afforested over the last 50 years and has not regained a natural species density.

6 Discrete Management Unit Description and Mapping

IFC Performance Standard 6 Guidance Note (GN) 65 calls for the project to determine a discrete management unit (DMU), “a sensible boundary (ecological or political) which defines the area of habitat to be considered for the Critical Habitat Assessment.”

The DMU (Figure 6-1) was defined as the boundary of the Sonadia Island Ecologically Critical Area, areas observed by BSCP as key habitat for endangered shore birds, the marine component of the Area of Influence (inclusive of areas potentially affected by sedimentation, thermal discharges, safety exclusion zones, and areas of air emissions above WHO ambient air quality guidelines in worst case scenarios, but exclusive of the support vessel route to Chittagong), plus a 2 km buffer surrounding the marine component of the Area of Influence described.

Figure 6-1: DMU Boundary

Source: Acorn International / ESRI

7 Critical Habitat Determination

Based on the data collected in the field and data verification, and an evaluation of the DMU, a final list of biodiversity values that trigger Critical Habitat was defined. Critical Habitat triggers are described in the following text.

7.1 Critical Habitat Triggers for Criteria 1-3

Table 7-1: Critical Habitat Triggers for Criteria 1-3

Species Information			IFC Species Level Critical Habitat Criteria					Rationale for Critical Habitat	Key Habitat Requirement
Taxonomic group	Species	Common name	Criterion 1: CR or EN Species	Criterion 2: Endemic / Restricted Range Species	Criterion 3: Migratory / Congregatory Species	Tier 1 Critical Habitat	Tier 2 Critical Habitat		
Birds	*Calidris pygmaea*	Spoon-billed Sandpiper	CR	N	Y	Y	N/A	Estimated population in the wintering areas is between 240 and 400 individuals, of which 26 individuals have recently been recorded on Sonadia Island as winter migrants. This represents between 12.5-7.5 percent of the global population. The median estimate meets Tier 1 threshold for habitat required to sustain ≥ 10 percent of the global population of an IUCN Red-listed CR species.	Spoon-billed Sandpipers utilize mudflats for forage and mudflats/beaches for high tide roosts and staging areas.
Birds	*Calidris tenuirostris*	Great Knot	EN	N	N	N	Y	The global population is estimated at 292,000 - 295,000. The estimated population wintering in Sonadia is between 400 and 450 individuals. Sonadia Island does not constitute a DMU for the species, but does represent nationally important concentrations of an EN species.	Great Knots utilize mudflats for forage and mudflats/beaches for high tide roosts and staging areas.
Birds	*Tringa guttifer*	Nordmann's Greenshank	EN	N	Y	N	Y	The global population is estimated at 500-1,000 individuals. The estimated wintering population of Sonadia Island is 28 individuals. Sonadia Island does not constitute a DMU for the species, but does represent nationally important concentrations of an EN species.	Nordmann's Greenshanks utilize mudflats for forage and mudflats/beaches for high tide roosts and staging areas.

7.2 Critical Habitat Triggers for Criteria 4-5

No highly threatened and/or unique ecosystem triggers were identified, per IFC Performance Standard 6, Criterion 4.

No landscapes that support key evolutionary processes were identified, per IFC Performance Standard 6, Criterion 5.

8 Distribution of Critical Habitat

8.1 Critical Habitat Mapping

IFC Performance Standards require project proponents to apply the standard mitigation hierarchy, seeking to first avoid, then minimize, restore and offset impacts to biodiversity. The required conservation outcome under IFC Performance Standard 6 is normally no-net-loss of biodiversity values achieved using the “like-for-like” or better principle of biodiversity offsets. However, when a project occurs in Critical Habitat, a net gain in biodiversity value is required.

In order to define management actions, a robust process was used to map the distribution of Modified, Natural, and Critical habitats. This process included comparing three data sets:

1) Desktop land cover data
2) Areas defined by BSCP as habitat for endangered shorebirds, based on long-term monitoring
3) A satellite color infrared image, acquired from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite

IFC definitions for each habitat type compared with the mapping classification used for each are provided in Table 8-1.

Table 8-1: Habitat Type Definitions

Habitat Type	IFC Definition	Habitat Mapping Classifications[12]
Critical Habitat	Critical habitats are areas with high biodiversity value, including (1) habitat of significant importance to Critically Endangered and/or Endangered species; (2) habitat of significant importance to endemic and/or restricted-range species; (3) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (4) highly threatened and/or unique ecosystems; and/or (5) areas associated with key evolutionary processes.	The presence of Spoon-billed Sandpiper, Great Knot, and Nordmann's Greenshank triggered Critical Habitat under Criteria 1 and 3. Spoon-billed Sandpiper, Great Knot, and Nordmann's Greenshank utilize mudflats for forage and mudflats/beaches for high tide roosts and staging areas. Sonadia Island is a nationally protected area and internationally recognized area. Therefore, the following are considered Critical Habitat: · All mudflats observed by BSCP as habitat for Spoon-billed Sandpiper, Great Knot, and Nordmann's Greenshank · The extent of the Sonadia Island ECA
Natural Habitat	Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.	In discussion with our local subject matter experts, the following are considered Natural Habitat: · All "Mangrove" · All "Hill Forests" · All mudflats · All beaches
Modified Habitat	Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition.	The study area is dominated by heavily modified habitats. The following are considered Modified Habitat: · All "Bare Soil", except mudflats and beaches defined using satellite

[12] Habitat types with quotations are defined categories in the land cover data shown in Section 3.3

Habitat Type	IFC Definition	Habitat Mapping Classifications[12]
		image classification · All “Crop in Sloping Land / Tea” · All “Irrigated Herbaceous Crop” · All “Rained Herbaceous Crops” · All “Reservoir / Ponds” · All “Rubber Plantation” · All “Rural Area” · All “Shrub Land”
Converted Habitat	N/A	The following are considered Converted Habitat: · All “Urban Area”

Source: IFC, 2012

The desktop land cover data largely matched the satellite imagery and field observations, except for mudflats and beaches which were grouped as “Bare Soil”, along with heavily modified areas (e.g. salt pans shrimp ponds). In order to define the extent of mudflats and beaches, as well as to verify the extent of other key habitat types, an image classification process utilizing ESRI’s ArcGIS spatial analyst extensions image classification tool was used. Using BSCP field observations of known mudflats and beaches, as well as known mangrove areas, training samples were assigned to the imagery by the GIS Analyst to establish multiple classes (e.g. mudflats, beaches, and mangroves). Once the different classes had been identified, a maximum likelihood classification was run against the remainder of the unclassified ASTER image. This method produced a categorized raster image in which we were able to discern the approximate extent of the desired classes. Upon review of the output raster image, a few areas were manually reclassified to ensure accuracy in distinguishing between areas of similar wavelengths (i.e. beach areas, salt pans, and urban areas).

This method was successful at defining the key habitat types of interest, although the extent of mudflats was difficult to discern given the quality of the image and because the fringes are submerged in shallow water. To avoid under-classifying Critical Habitat when setting up the GIS image classification the extent of the mudflats is likely larger than the actual extent.

The land cover mapping is shown in Figure 3-4 and Figure 3-5; a natural vs. modified binary map is provided in Figure 3-6; areas defined by BSCP as habitat for endangered shorebirds are defined in Table 8-2 and shown in Figure 8-1; the final output of the GIS mapping is shown in Figure 8-1; and, areas defined as Critical Habitat shown in Figure 8-3.

Table 8-2: Observed Areas of Critical Habitat on Sonadia Island

Site Name	Habitat Function
Tajiakata	Mudflat (waterfowl forage), high tide roost and staging area
Belekardia	Mudflat (waterfowl forage), high tide roost, and staging area
Kaladia	Mudflat, high tide roost, and staging area
Khorir Char	Mudflat, high tide roost, and staging area

Figure 8-1: Observed Areas of Critical Habitat in Sonadia Island

Source: Acorn International / Google Earth

Figure 8-2: GIS Based Sensitivity Map

Source: Acorn International

Figure 8-3: Discrete Management Unit Considered Critical Habitat (Light Orange Shading) and Sensitive Sites for Critical Habitat Values within DMU (Dark Orange Shading)

Source: Acorn International, BSCP, Google Earth

9 Conclusions

This report provides an assessment of potential Critical Habitat distribution relative to Moheshkali Floating LNG project in Moheshkhali, Cox's Bazar, Bangladesh.

Biodiversity features were screened based on the quantitative thresholds required by the Critical Habitat determination criteria described in IFC Performance Standard 6. These criteria include:

Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species
Criterion 2: Endemic and/or restricted-range species
Criterion 3: Migratory and/or congregatory species
Criterion 4: Highly threatened and/or unique ecosystems
Criterion 5: Key evolutionary processes

Based on the evaluation conducted, Critical Habitat is present in the study area based on the biodiversity values described in Table 9-1.

Table 9-1: Critical Habitat Summary

Critical Habitat Trigger	Biodiversity Value	Rationale	Critical Habitat
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species, and Criterion 3: Migratory and/or congregatory species	Spoon-billed Sandpiper *(Calidris pygmaea)*	· Habitat required to sustain ≥ 10 percent of the global population of an IUCN Red-listed CR species. · Meets BirdLife International's Criterion A4i for congregations and Ramsar Criteria 6 for Identifying Wetlands of International Importance	Critical Habitat, Tier 1
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species	Great Knot (*Calidris tenuirostris)*	· Represents nationally important concentrations of an EN species.	Critical Habitat, Tier 2
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species, and Criterion 3: Migratory and/or congregatory species	Nordmann's Greenshank (*Tringa guttifer)*	· Represents nationally important concentrations of an EN species. · Meets BirdLife International's Criterion A4i for congregations and Ramsar Criteria 6 for Identifying Wetlands	Critical Habitat, Tier 2

Critical Habitat Trigger	Biodiversity Value	Rationale	Critical Habitat
		of International Importance	

In addition, Sonadia Island is nationally protected and internationally recognized as a key biodiversity area (Important Bird Area and proposed Ramsar wetland).

The key habitats that support Critical Habitat determination on Sonadia Island are mudflats used by waterfowl for forage, high tide roost and staging. While the Delivery Point is close (700 m) to sensitive mudflats, this ecosystem is resilient and quick to recover from disturbance. However, the area is Tier 1 Critical Habitat and a detailed Biodiversity Action Plan with Biodiversity Monitoring and Evaluation Plan will be required to manage the potential impacts to biodiversity values present. As the Delivery Point is in Critical Habitat, net benefit for Critical Habitat values must be realized.

Appendix A: Critical Habitat Assessment Team *Curricula Vitae* (CV)

CURRICULUM VITAE

Ornithologist, Conservation Biologist and Wetland ecologist

Expertise: Coastal, River and Wetland Management and Restoration, Arctic Waterbird Conservation, Flyway Approach, Protected Area development, Climate Change Impact Assessment, Conservation Policy

Experience: **Over 30 years as Project and expedition leader, consultant and biodiversity and policy adviser in 12 different countries and for intergovernmental agreements (CMS, AEWA, Ramsar) and international organsiations based in UK**

Specific skills: Project management, project coordination, assessment work, data analysis

1.	**NAME**	:	**Christoph Zöckler**
2.	**DATE OF BIRTH**	:	23 Dec 1955
3.	**NATIONALITY**	:	German
4.	**PERSONAL SITUATION**	:	Married
5.	**ADDRESS**	:	30 Eachard Road, Cambridge U.K. CB3 0HY
6.	**EDUCATION**	:	**PhD in Zoology University of Bremen, Germany 2001** **Dipl. Biol. Zoology 1985 University of Kiel, Germany** **Exchange Stipend. at University in Aberdeen, U.K. 1981-82**

8. LANGUAGE & DEGREE OF PROFICIENCY :

Language	Writing	Speaking
German	Mother tongue	Mother tongue
English	Fluent	Fluent
Spanish	Basic	Basic
Russian	Basic	

9. COUNTRIES OF WORK EXPERIENCE : **Germany, U.K., Poland, Russia, Benin, China, India, Bangladesh, Thailand, Myanmar, Peru and Chile and for intergovernmental NGOs based in the UK**

EMPLOYMENT RECORD

1. 1985-1993 (as consultant until 1995) **project leader** of the **WWF**-project "Wümmewiesen" (wet grassland conservation and restoration, river restoration, species conservation, protected area and land use management, land purchase on behalf of WWF, land use policy, hunting regulation, sustainable agriculture, stakeholder consultation, exchange of management experiences with other projects in Germany and adjacent countries, specially Eastern Europe), with a team of up to 5 employees

2. 1993-1995 **Senior Research Officer** at the University of Bremen in the German-wide project: Monitoring, Development and Conservation Strategies for Habitats in Germany (example wet grassland) in a team of 4 biologists and 2 GIS technicians

3. 1996-1998 **Visiting EU Research Fellow** at the World Conservation Monitoring Centre (**WCMC**) in Cambridge, U.K. compiling an Arctic environmental GIS database with emphasis on the Russian Arctic, establishing and maintaining a scientific network throughout the Arctic region

Freelance consultant since 1998, as **Senior Adviser** on Arctic biodiversity, Climate Change and coastal wetlands, freelance for **UNEP-WCMC** in Cambridge, as an advisor for the Manfred Hermsen Stiftung, Bremen since 2007 and for Consulting Firm ArcCona, established in 2003. Main records and achievements:

Arctic

Developing the Arctic project portfolio for UNEP-WCMC and representing WCMC at the CAFF board; contributing to the 2001 Arctic Biodiversity Assessment; Steering Committee member in the 2013 Arctic Biodiversity Assessment. Collecting Arctic breeding bird data and establishing Arctic waterbird database. Combining Arctic biodiversity data with climate change data, which lead to the first circumpolar assessment of the impact of climate change on waterbirds (2000). Co-leading on the Arctic wilderness project in 2001, determining the 25 top wilderness areas in the circumpolar Arctic and describe the biodiversity, level of protection and major threats through fragmentation. Establishing a Circumpolar Biodiversity Monitoring Programme (CBMP) within the CAFF programme of the Arctic Council. Co-organising the CBMP launch with CAFF in September 2005 in Cambridge; follow up activities with CAFF and the CBMP secretariat in 2005/2006 (workshops, indicator development, data management strategy. Contributing author of the Arctic Climate Impact Assessment (ACIA). Report on the impact of 2^{o} C. warming on Arctic biodiversity for WWF International (2004). Report on terrestrial ecosystems and leading and contributing on various CBMP outputs and reports, like the Arctic Species Trend Index (ASTI in 2010 and 2015). Participating in the EU project of the regional integrated risk assessment of climate change impact in the Barents Sea region (BALANCE, 2003-2005). Co-leading author of the regional scenario chapter of the Polar Region for the Forth Global Environmental Outlook (UNEP' s GEO-4, 2007).

Joining 12 summer expeditions to the Russian Arctic to enhance the Arctic breeding bird data base and promote protected area development in the Russian Arctic together with Russian research colleagues and CAFF.

Wetlands and Freshwater

Contracted by the Freshwater Programme of WWF International in Europe in 1999 to evaluate twelve river restoration projects across Europe. In 2000 contracted by WWF Germany to carry out a river restoration project evaluation on the German – Polish border region. Coordinating Chapter 6: 'Water and ecosystems' on behalf of UNEP for the UNESCO Word Water Development Report II (2004, published 2006). Co-leading on the **Water** Chapter within UNEP's GEO-4 production (2004 -2007)

Support for the African Eurasian Waterbird Agreement (AEWA) with focus on data presentation, poster design and the development of the web site and advising the Technical Committee in scientific and technical questions (1999-2004). Co-developing **wetland indicators for biodiversity monitoring** in the Ramsar STRP framework.

Wildlife Tour guiding

Tour leader and wildlife host for the British Tour Company SAGA in Kenya, Namibia, Nepal, India, Iceland and Ecuador (2008-2011) with ArcCona and Bird Holidays in Myanmar (2010, 2013), with Heritage Expeditions to Kamchatka and Chukotka Russia (2011 and 2013) and for a German tour operator to China (2015).

Protected Area Development and Management

Participating in the ArcCona research mission on the biodiversity assessment and protected area management of the Pendjari NP in Benin, West Africa, on behalf of the GTZ in February 2002 and October 2003.

Promoting the development of protected areas in the breeding grounds of the SBS in Chukotka NE Russia and on stop over sites in Bangladesh, namely Sonadia Island.

Initiating the Ramsar site designation of the Gulf of Mottama in Myanmar as the second Ramsar site in Myanmar. Developing an ArcCona strategy paper with Fauna Flora International on the protection of coastal habitats in Myanmar (2013). Enhancing the Meinmahla Kyun Wildlife Reserve and promoting the extension and the establishment of a Man & Biosphere Reserve. Promoting the establishment of further Mangrove Protection sites in the Tanintharyi Region of South Myanmar (2013-2015). Promotion of the Indawgyi Lake, Myanmar as Ramsar site (2013-2014).

Promoting the wetland restoration of the Taldom peatlands and the Vinogradowo floodplain in the Moscow area (2011-2015).

Spoon-billed Sandpiper and coastal conservation
Participating in Russian lead expeditions to the breeding grounds of the Spoon-billed Sandpiper (SBS) in 2000, 2002, 2003 and 2005, 2008, 2009, 2011, 2012 and 2013. Establishing the SBS Recovery Team in Edinburgh in 2004. Leading **Spoon-billed Sandpiper** expeditions to South and South East Asia (2005-2013) and Siberia. Leading a drafting team and organising a species workshop in Thailand and compiling the Species Action Plan of the Spoon-billed Sandpiper (2005-2007). Coordinating the East Asian Australasian Flyway Partnership (EAAFP) Spoon-billed Sandpiper Task Force (2005-2015). Editor of the SBS newsletter (since 2008). Initiating and funding surveys at crucial stop over sites in Jiangsu Province China (2012-2014). Coordinating a team of 12-16 task force members from 10 flyway countries and beyond to implement and promote the conservation of the species.

Mangrove Conservation
Starting in 2005 in India and 2009 in Myanmar through leading surveys for the SBS I became more and more involved in mangrove conservation across the flyway, incl Indian and Bangladeshi Sundarbans (2005, 2013) and Myanmar 2009-2015, including Scoping paper for Myanmar coast (2013) and in depth report for Myeik coastal habitats for bird conservation (2015 and 2016)

Peatland conservation
Established Peatland Conservation Programme of the Manfred Hermsen Foundation in Russia and Eastern Europe (Belarus and Ukraine) and Lower Saxony in 2011-2015.

Field experience and international research expeditions:

1979: fishery research expedition to Greenland and Labrador (10 weeks)
1985- 1993: Field experience as project leader for WWF in wetland protection and restoration in West and East Germany as well as Poland.
1987/88: visit of the research station 'Panguana' in the Peruvian rainforest (3 months)
1995: scientific goose expedition to West Taimyr (Siberia, 6 weeks)
1996: scientific expedition into the Yana Delta (Siberia, 9 weeks)
1997: scientific bird expedition into the Lower Olenyok- and Lena Delta (Siberia, 7 weeks)
1998: scientific expedition into the Orenburg Steppe region in the South Urals and Kazakhstan, 3 weeks
1999: scientific expedition into the Lower Indigirka Basin (Siberia, 7 weeks)
2000: scientific expedition to Chukotka (Siberia, 7 weeks)
2002: scientific expedition to North Benin into the Pendjari NP (4 weeks)
2002: scientific expedition to the Chukchi peninsula, Chukotka, Siberia, 7 weeks)
2003: scientific expedition to South Chukotka (Siberia, 7 weeks)
2003: scientific expedition to North Benin into the Pendjari NP (5 weeks)
2005: leading ornithological expedition to the Sundarbans and Orissa, India (4 weeks)
2005: scientific expedition to South Chukotka (Siberia, 7 weeks)
2006: leading ornithological expedition to Bangladesh (4 weeks)
2006: scientific expedition to Lake Ladoga (3 weeks) and Kolguev, Russia (5 weeks)

2006: scientific survey of the Spoon-billed Sandpiper (SBS) in the Inner Gulf in Thailand (10 days)
2008: leading SBS search expedition to coastal Myanmar (3 weeks)
2008: co-leading SBS search expedition to Kamchatka, Russia (4 weeks)
2009: leading SBS search expedition to coastal Myanmar (3 weeks)
2009: co-leading SBS search expedition to North Kamchatka, Russia (4 weeks)
2010: leading SBS search expedition to coastal Myanmar (4 weeks)
2011: leading expedition to coastal Myanmar (3 weeks)
2011: participating in the SBS search Expedition to the Koryak coast, Russia (2 weeks)
2012: Co-leading search expedition to Coastal Myanmar (4 weeks)
2012: Leading the international Spoon-billed sandpiper Expedition to Chukotka (6 weeks)
2012: Leading SBS autumn surveys at stop over site in Jiangsu, China (10 days)
2013: participating in the SBS search Expedition in Chukchi Peninsula of Heritage Expeditions
2013: Leading SBS autumn surveys at stop over site in Jiangsu, China (10 days)
2013: Expedition to the Ayeyarwaddy Delta and Myeik Archipelago,Tanintharyi, Myanmar
2014: Leading SBS autumn surveys at stop over site in Jiangsu, China (10 days)
2014: Expedition to the Myeik Archipelago, Myanmar and Lake Indawgyi (3 weeks)
2015: Expedition to the Myeik Archipelago and proposed Lenya NP, Taninthary, Myanmar (4 weeks)
2016: Several research and assessment missions along Coastal Myanmar (7 weeks)

PUBLICATIONS

- 64 refereed publications,
- 7 books or Scientific Reports or booklets and 21 book chapters
- Over 20 science articles and policy briefs.

FUND RAISING

Development, with partners, of over 30 successful project proposals worth over 60 million USD. Funding from Asian Waterbird Species Grant, BBC Wildlife Fund, BirdLife International, European Union, Darwin Initiative UK), GEF, German Ministry for Environment, GTZ, Hewlett-Packard Foundation, Ken Dai Ren Fund For Nature, Manfred-Hermsen Stiftung, Lighthouse Foundation, National Geographic, RSPB, Swiss Development Programme, US FWS, WWF.

CAPACITY BUILDING

Contribution to five capacity building projects in Bangladesh and Myanmar
Strong capacity building component in all research and development projects implemented
Supervision of 5 placement students and several field traineeships in Germany, Russia, Bangladesh, Myanmar and China, supervision of two PhD thesis.

PROFESSIONAL NETWORKS

- Organizer of a German wide consortium of campaigning NGOs for wet grassland conservation
- Observer for UNEP-WCMC in the Arctic Council working programme CAFF 1996-2008,
- Co-organising the CBMP launch with CAFF in September 2005 in Cambridge; follow up activities with CAFF and the CBMP secretariat in 2005/2006 (workshops, indicator development, data management strategy.
- Serving as a steering group committee member of the Arctic Biodiversity Assessment 2013
- Member of the AEWA Technical Committee 1999-2004
- Member of the Ramsar STAP from 2000-2004
- Founding member of the Spoon-billed Sandpiper Recovery Team and current coordinator of the EAAFP

SBS Task Force (2004-2016)

- Member of the Advisory Board of the SDC funded project ‘Sustainable Development in the Golf Of Mottama, Myanmar
- Member of several German British and International Nature conservation and scientific organisations

MEDIA COVERAGE AND COMMUNICATION

- Numerous Radio and Television interviews, contributions to national and international magazines and newspapers including SCIENCE (2010), GEO (1987) and BBC (2011 and 2016)

ANNEX

PROJECTS IMPLEMENTED (SELECTION)

Project:	**Identifying Key Coastal Wetlands for Biodiversity and Promoting their Protection in Myanmar**
Location:	Myanmar
Year:	2008 – 2016
Client:	EAAFP Spoon-billed Sandpiper Task Force, BANCA, FFI and ArcCona Consultancy
Position:	**Task Force Coordinator and expedition leader**

Description of the project: Identify and protect the Coastal zone of Myanmar.

Main activities: Conduct and organize coastal habitat surveys and surveys of globally threatened species, such as the Spoon-billed sandpiper and others; liaise closely with national and local NGOs; hold training workshops and high level government meetings to promote coastal protection. Conduct a scoping paper on the status of coastal biodiversity in Myanmar. Promoting the establishment of further Mangrove Protection sites in the Tanintharyi Region of South Myanmar.

Project:	**Establishment of Ramsar Sites in Myanmar**
Location:	Myanmar
Year:	2010 – 2016
Client:	EAAFP Spoon-billed Sandpiper Task Force and BirdLife International
Position:	**Consultant**

Description of the project: Initiating the Ramsar site designation of the Gulf of Mottama in Myanmar as the second Ramsar site in Myanmar. Promotion of the Indawgyi Lake, Myanmar as Ramsar site.

Main activities: Identify key coastal wetland areas; help in identifying key Ramsar criteria; fill-in Ramsar Information Sheet with key national partner BANCA; promote local community support; mitigate hunting and trapping of birds; help delineating site boundaries.

Project:	**Establishment of a Man & Biosphere Reserve**
Location:	Myanmar
Year:	2013-2014
Client:	Fauna and Flora International (FFI-Myanmar)
Position:	**Consultant**

Description of the project: Enhancing the Meinmahla Kyun Wildlife Reserve and promoting the extension and the establishment of a Man & Biosphere Reserve.

Main activities: Surveys and training workshops with field staff and government meeting in Nay Piy Taw (capitol of Myanmar.

Project:	**Spoon-billed sandpiper Conservation project**
Location:	Russia and 12 flyway country in the EAAF, incl. Myanmar, Bangladesh
Year:	2000 – 2016 ongoing
Client:	EAAFP and BirdLife International and ArcCona with multiple donors (e.g. Manfred Hermsen Foundation, US FWS
Position:	**Project Initiator and Leader**

Description of the project: Promoting the species conservation habitat protection and international cooperation on the flyway approach, fund raising and communication

Project:	**Scientific and Technical Review Panel (STRP) of the Ramsar Convention**
Location:	Cambridge, U.K.; Gland, Switzerland
Year:	2007 – Present
Client:	UNEP-WCMC
Position:	**STRP Member representing UNEP-WCMC**

Description of the project: Assisting in the development of wetland indictors for national reporting.

Main activities: Co-developing wetland indicators for biodiversity monitoring in the Ramsar STRP framework.

Project:	**Biodiversity Assessment and Protected Area Management**
Location:	Benin

Year: 2002 – 2003
Client: German Technical Cooperation Agency (GTZ)
Position: **Consultant for ArcCona**
Description of the project: Identify key biodiversity management features.
Main activities: Participating in the ArcCona research mission on the biodiversity assessment and protected area management of the Pendjari NP in Benin. Develop areas and propose specific management measures to promote the characteristic biodiversity for the NP.

Project: **WWF Freshwater Programme**
Location: Europe
Year: 1999
Client: World Wildlife Fund International
Position: **Project Leader**
Description of the project: To evaluate twelve river restoration projects across Europe.
Main activities: Visit, evaluate and analyze the success of river restoration projects.

Project: **River Restoration Project Evaluation**
Location: Germany/Poland
Year: 2000
Client: World Wildlife Fund Germany
Position: **Project Evaluator**
Description of the project: Project evaluation of a trans-boundary river restoration project on the Odra, German/Polish boundary.
Main activities: Field visit and Project evaluation.

Project (4): **Peatland Conservation and Rewetting Programme**
Location: Russia, Belarus and Ukraine
Year: 2011 – 2016
Client: Manfred Hermsen Foundation
Position: **Initiator and Key Advisor**
Description of the project: Initiate and promote the protection of peat land for biodiversity and climate.
Main activities: Initiate a feasibility study for the restoration of peatlands in Belarus, Ukraine and Russia, followed by national implementation phases in all three countries.

Project (4): **WWF Project Wümmewiesen**
Location: Germany
Year: 1985 – 1993
Client: WWF and BUND
Position: **Project leader**
Description of the project: Wet grassland protection and promotion f sustainable agricultural land use and river management
Main activities: wet grassland conservation and restoration, river restoration, species conservation, protected area and land use management, water board meetings, land purchase on behalf of WWF, land use policy, hunting regulation, sustainable agriculture, stakeholder consultation, exchange of management experiences with other projects in Germany and adjacent countries, specially Eastern Europe), with a team of up to 5 employees

Project: **Floodplain Restoration 'Drömling'**
Location: Germany
Year: 1989 – 1992
Client: Regional Conservation and Water Authority and WWF Germany
Position: **Initiator and Key Advisor**
Description of the project: Initiate and support for nation wide funding of 'Drömling' wetland restoration on the East-West German border.
Main activities: Facilitate the project application for a nation wide multi million land purchase and restoration project on the inner German border.

PUBLICATIONS

Selected publications since 2000

GILG, O., R. SANE, D. V. SOLOVIEVA, V. I. POZDNYAKOV, B.SARBARD, D.TSANAOS, C. ZÖCKLER, E. G. LAPPO, E. E. SYROECHKOVSKI JR. AND G.EICHHORN (2000): Birds and Mammals of the Lena Delta Nature Reserve, Siberia. Arctic 53: 118 – 133.

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Baldursson, S. & C. Zöckler (2001): The Circumpolar Protected areas network (CPAN) in CAFF: Arctic Flora and Fauna. Ecology, status and conservation. (eds. Kaankapää, P., Huntingdon, H., Baldursson, S., Sippola, A.L., Kaitala, S. & C. Zöckler) Edita. Helsinki p 78-79.

Zöckler, C (2001): Sandpipers: Birds of the tundra. In CAFF: Arctic Flora and Fauna. Ecology, status and conservation. (eds. Kaankapää, P., Huntingdon, H., Baldursson, S., Sippola, A.L., Kaitala, S. & C. Zöckler) Edita. Helsinki p 146-147.

Lugert, J. & C. Zöckler (2001): Between Taiga and Tundra. The Bird Fauna of the Yakut Horse Pastures in Northeast Siberia. In : Gerken, B & Görner, M.(eds.) Landscape Development with Large Herbivores Natur- und Kulturlandschaft, Höxter/Jena Vol. 4: 458-461

Zöckler , C. & Syroechkovski, Jr. E.E. (2001): Status of the Baikal Teal in the Lower Indigirka Basin, Siberia. TWSG News 13: 21-23.

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EDUCATION

2014 – 2015	**MPhil** (Biodiversity Conservation), Department of Geography, University of Cambridge
2005 – 2010	**BSc Environmental Sciences**. FIRST CLASS (Hons 78.5%). Department of Environmental Science and Management North South University, Dhaka
2010 – 2012	**Home Study Course in Bird Biology**, Cornell Lab of Ornithology, New York

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PROFESSIONAL EXPERIENCE

Oct 2009 – Present *Principal Investigator* : Bangladesh Spoon-billed Sandpiper Conservation Project.

Delivering project proposals, research designs, conducting fieldwork, generating reports and managing a team of five. The project conducts regular monitoring of known sites of the Critically Endangered Spoon-billed Sandpiper along Bangladesh coast, searches for new sites, promotes shorebird conservation through awareness campaign and mitigates of shorebird hunting by providing alternative livelihood support to the hunters. Manage funds, budgets and allocations for all project related expenditures. Lead person for data analysis to achieve the most prolific conclusions for the research and the hunters' livelihood initiative. The project received funds from RSPB, SOS – Save Our Species via Wildfowl and Wetland Trust, U.S. Fish and Wildlife Service, Spoon-billed Sandpiper Task Force, Mohamed bin Zayed Species Conservation Fund, British Ornithologists' Union and The Explorer's Club.

Jun 2011 – Present *Principal Investigator* : Sundarbans Finfoot Research Project.

Delivering project proposals, research designs from the pre-project to the final stage. Supervising and conducting field work and generating reports. This study aims to estimate current population of the Endangered Masked Finfoot, identify the key nesting sites in the Sundarbans, acquire detailed information on breeding biology, identify threats and recommend future conservation measures. The project is funded by The Rufford Small Grants Foundation and Oriental Bird Club.

May 2011 – Present *Coordinator* : Forest Bird Monitoring Programme.

Conducting surveys of selected indicator forest birds at 15 protected areas of Bangladesh under Bangladesh bird club, supported by Integrated Protected Area Co-Management (IPAC) & Climate Resilient Ecosystems and Livelihoods/CREL Projects of USAID/Bangladesh. Tasks involve preparing proposal, conducting field surveys, coordination with Bbc team and producing report.

Dec 2015 – Present *Consultant* : IUCN Bangladesh. Investigation of Wild to Domestic Bird Avian Influenza Transmission

Provide technical support to IUCN Bangladesh on Avian Influenza and its ecology, and assist fieldwork to capture wild birds, collect samples and conduct surveys for monitoring.

Dec 2012 – Apr 2013 *Consultant* : IUCN Bangladesh. Establishment and design of sanctuaries for birds and other wildlife at Tanguar Haor.

Identifying and designing feasible hotspots/sanctuaries for birds and other wildlife in Tangur Haor. Collection of data on habitat preference of selected waterbird families; Identification of bird and other wildlife niches; Identification of suitable sanctuaries for birds and other wildlife in Tanguar Haor; Preparation of detailed GIS based map of the hotspots for birds and other wildlife; Consultation with the local community, Forest Department, Department of Fisheries on the aspects and feasibility of establishing sanctuaries.

Nov 2011 – Apr 2014 *Principal Investigator* : Assessing current status of the Black-bellied Tern in Bangladesh.

Delivering project proposals, research designs from the pre-project to the final stage. Supervising and conducting field work and generating reports. This study aims identify the hotspots of the Black-bellied Tern on Padma-Jamuna river system in Bangladesh, identify threats and recommend future conservation measures. The project is funded by The Oriental Bird Club.

Nov 2010 – Feb 2011 *Principal Investigator* : Understanding Current Status and Ecology of the Endangered Baer's Pochard in Bangladesh.

Delivered project proposals, research designs from the pre-project to the final stage. Supervised and conducted field work and generated reports. The project aimed to determine the current status of the Endangered Baer's Pochard in north-eastern freshwater wetlands of Bangladesh and identify potential threats to the Pochard during its wintering period in Bangladesh. The study is supported by The British Ecological Society.

May – Jul 2010 *Field Researcher* : Dynamics of Cross-species Influenza Transmission.

The study by EcoHealth Alliance (formerly known as Wildlife Trust of New York) aimed to examine spillover of AI between wild and domestic birds in a variety of human contexts by examining their physical proximity to each other in space and time. Conducted a two team field research.

Sep 2009 – Feb 2010 *Research Associate* : Doctoral Research Project Entitled, '"No Park is an Island": Evaluating Management Practices in the Buffer Zones of Selected Protected Areas in Bangladesh.

Conducted line and point transects to determine avian diversity and abundance in agro-forests, secondary and primary forests in north-east Bangladesh - an University of Hawai'i (Department of Botany), USA project.

Oct – Dec 2010 *Field Investigator* : Status and Distribution of Bears in Bangladesh.

Conducted surveys in north and south-eastern hills of Bangladesh on Asiatic Black Bear by tracking bear signs and interviews. Conducted awareness campaigns in local schools and villages engaging youth, local communities on bear conservation. Designed all awareness related materials for field. A project by Wildlife Trust of Bangladesh and funded by International Association for Bear Research and Management (IBA)

NATURAL HISTORY EXPERTISE & RECENT INTENATIONAL FIELD WORK

A month long expedition in Kazakhstan (July 2015) to conduct a study (MPhil, University of Cambridge) on critically endangered Saiga antelope. 1.5 months expedition (2012) in Far East Russia to survey and find nests of the Spoon-billed Sandpiper. Regular winter visits to coastal mudflats of Myanmar and China to conduct shorebird surveys. Avid field ornithologist for over 10 years and extensively travelled across Bangladesh and south-east Asia. Conducting Asian Waterbird census since 2005 and experienced in bird ringing (C ringer) and satellite telemetry activities in Bangladesh thought Bangladesh bird club. In addition, acquired working knowledge on Bangladesh mammals, especially bears and dolphins, etc. Have seen 70% of the birds that occur in Bangladesh.

OTHER WORK AND CURRENT POSITIONS

April 2015 – Present *Assistant Coordinator* : Spoon-billed Sandpiper Task Force

This position is under East-Asian Australasian Flyway Partnership and supported by BirdLife International & RSPB. Tasks involved managing the Spoon-billed Sandpiper database, coordination with SBS wintering country representatives and organizing count data, assisting the coordinator with the SBS TF biannual newsletter, plan SBS TF annual meetings and developing a SBS TF communication strategy with BirdLife International (e.g. Social media).

Jan 2011 – May 2014 *Executive Editor* : The Nature Quest of the Daily Star.

Performing as the executive editor, selecting topics, writer-ups, graphics and nature/wildlife photographs. Thoroughly involved from the selection of pieces to the final make up and printing. The Nature Quest is the very first nature magazine of Bangladesh which aims to spread awareness and knowledge on nature and wildlife conservation amongst all citizens of Bangladesh. The Daily Star is the most read English newspaper in Bangladesh.

Jan 2016 – Present *Vice President:* Bangladesh bird club.

Bangladesh bird club is an organization of people interested in the bird and its conservation in Bangladesh. It promotes the hobby of bird-watching, study of bird and conservation of wildlife and its habitats in Bangladesh. Through publications and promotional activities it seeks to raise public awareness on conservation issues in general, and bird conservation in particular.

Nov 2013 – Present *Member:* IUCN Species Survival Commission [Union Portal username: SayamU.CHOWDHURY]

WORKSHOPS, CONFERENCES ATTENDED AND TRAININGS RECEIVED

21 – 2 Sept 2013 *Brittany, France*: International Wader Study Group Conference.

Presented a paper on the 'Bangladesh Spoon-billed Sandpiper Conservation Project' and participated in shorebird research and conservation discussion.

19 – 22 Mar 2012 *Palembang, South Sumatra*: Sixth Meeting of Partners (MoP6) of the East Asian - Australasian Flyway Partnership.

Attended the meeting as a technical individual expert from Bangladesh. Meetings of existing Working Groups including Anatidae, Crane, Seabird, Shorebird occurred and a new Working Group on Communication, Education, Participation and Public Awareness was established. During the side event sessions.

14 – 16 Sept 2011 *Bangalore, India :* The Student Conference on Conservation Science (SCCS).

Presented a paper on the 'Bangladesh Spoon-billed Sandpiper Conservation Project' at the Student Conference on Conservation Science (SCCS), Bangalore. The conference brought together young researchers in conservation science to facilitate interaction, encourage exchange of research ideas and methods, and help build contacts and capacity.

6 – 8 Dec 2010 *Siem Reap, Cambodia* : Fifth Meeting of Partners (MoP5) of the East Asian - Australasian Flyway Partnership.

Attended the meeting as a technical individual expert from Bangladesh. The meeting also held further discussions of the Spoon-billed Sandpiper, Scaly-sided Merganser and Colour Marking Task Forces. A paper entitled "Spoon-billed Sandpiper Research and Conservation in Bangladesh" was presented.

25 Jul – 5 Sept 2010 *East Java, Indonesia :* Biodiversity, Conservation & Sustainable Development Fieldcourse.

Was selected from Bangladesh in the field course consisting of keen young researchers from south and south-east Asia. During this six-week field course participants studied forest ecology, conservation biology and sustainable development through both resource staff led practical field work and participant-led research projects.

12 – 16 Jul 2010 *Bali, Indonesia* : Experimental Design and Data Analysis.

An Introductory course organized by ATBC Asia-Pacific chapter, targeted participants who have received only very basic training in statistics. It introduced basic concepts in experimental design and sampling and how to analyse data using traditional modeling methods, including ANOVA and regression. Practicals course was conducted in R – a free opensource statistical computing program – and was provided an introduction to its use.

17 Jul 2010 *Bali, Indonesia* : Scientific Paper Writing.

The ATBC Asia-Pacific chapter ran a one day workshop on Scientific Paper Writing in conjunction with the ATBC Bali 2010 meeting. The workshop covered the process of preparing and submitting a scientific paper, how to prepare a good poster, ethical questions surrounding the publication "game", and the review process.

19 – 23 Jul 2010 *Bali, Indonesia* : The 2010 International Meeting of the Association for Tropical Biology and Conservation Tropical Biodiversity: Surviving the Food, Energy and Climate Crisis.

1 – 12 Mar 2010 *Dhaka, Bangladesh* : Workshop and Field Work on Satellite Tracking of Wild Ducks.

Attended a three days workshop and nine days field-work on satellite tagging and tracking of wild migratory ducks.

1 – 10 Feb 2008 *Maharashtra, India* : Capacity Strengthening Programme for Avian Influenza Surveillance in Wild Waterbirds of India.

The training was organized under the Global Avian Influenza Network for Surveillance (GAINS) to improve regional capacity on Avian Influenza Surveillance in Wild Waterbirds.

AWARDS AND GRANTS:

- Received full scholarship from Chevening Scholarship and Cambridge Trust for MPhil in Conservation Leadership, UK.
- Rolex Awards for Enterprise Finalist 2014.
- Received Research Grant from the "Rufford Small Grant Foundation" towards the project entitled "Ecology, Breeding Behaviour and Conservation of the Endangered Masked Finfoot in Bangladesh", 2011.
- Received Conservation Grant from "Oriental Bird Club" to support a survey entitled "Assessing current status of the Black-bellied Tern in Bangladesh", 2011.
- Received Project Grant from the "SBS Recovery Team" to support project entitled "Bangladesh Spoon-billed Sandpiper Conservation Project", 2011.
- Received "Mohamed bin Zayed Species Conservation Fund" for a grant to support the project named "Bangladesh Spoon-billed Sandpiper Conservation & Research Initiative", Abu Dhabi, 2010.
- Received "Small Ornithological Research Grant" from British Ornithologist Union to support the project entitled "Action Research and Conservation of the critically endangered Spoon-billed Sandpiper in Bangladesh", UK 2010.
- Received "Undergraduate Small Ecological Project Support Grant" from British Ecological Society towards the project entitled "Understanding current status and ecology of the endangered Baer's Pochard in Bangladesh", UK, 2010.
- Received Travel Grant to attend and present a paper at the Student Conference on Conservation Science, University of Cambridge, UK in March, 2010.
- Received Scholarship for the Home Study Course in Bird Biology, Cornell Lab of Ornithology, New York, 2009.
- Received publication grant from the "Eric Hosking Trust" for the "a Pictorial Field Gide to the Shorebirds of Bangladesh '', UK, 2009.
- Received the "Youth Activity Award" for "Spoon-billed Sandpiper Conservation Project" from the Explorer's Club, New York, 2009.

WILDLIFE PHOTOGRAPHY AND MEDIA WORK

Wildlife photos published in *BirdingAsia, Nature Quest*, local and international conservation magazines and brochures as well as extensively online. Worked as a paid guide for an international documentary on shorebird hunting in Bangladesh.

PEER-REVIEWED PUBLICATIONS

- **Chowdhury, S. U.,** Chowdhury, A. R. & Ahmed, S. 2015. Human-fishing cat conflicts and conservation needs of fishing cats in Bangladesh. *Cat News* 62: 04-08.
- Zocklet, C., Beresford, A. E., Bunting, G., **Chowdhury, S. U.,** *et al.* The winter distribution of the Spoon-billed Sandpiper Calidris pygmaeus. Accepted. *Bird Conservation International*.
- **Chowdhury, S. U.,** Thompson, P. M. & Lees, A.C. 2011. Status and the distribution of the Endangered Baer's Pochard in Bangladesh. *Forktail* 28: 57-61.
- **Chowdhury, S**. **U.** 2011. Survey and conservation of the critically endangered Spoon-billed Sandpiper in Bangladesh. *IBIS* 154 (1): 210-211.

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Appendix C: Field Survey Report

Field Verification Trip Report

Sayam U. Chowdhury
August 2016
Sonadia Island

Introduction

A field verification trip was conducted between 9 August 2016 and 14 August 2016. The site was visited twice in order to gather basic data on habitat features, GPS coordinates for rough mapping, site boundaries and sensitivity descriptions.

Methods

The field survey was conducted by two researches (Sayam U. Chowdhury and Md Foysal). During the field visit one Garmin *e-trex* GPS unit was used to track survey route and record coordinates of the boundaries. Shorebird surveys were also conducted at Kaladia (Sonadia Island) to determine the boundaries of the foraging and roosting areas. Observations were made using 10x42 binoculars and 25-50x spotting scopes. The field visits and surveys took place during approaching tide on 10 August 2016 and receding tide on 11 August 2016. Maps were generated using Garmin Base Camp software and Google Earth.

Moreover, an informal meeting took place between Sayam U. Chowdhury and Andrew Buchman on 10 August 2016.

Results and discussion

The current construction for the pipeline is taking place 1.70 – 1.20km north of the main shorebird area (Figure 1). The distance between the pipeline and important bird area appears to be safe if no disturbance is caused during the travel to the construction site.

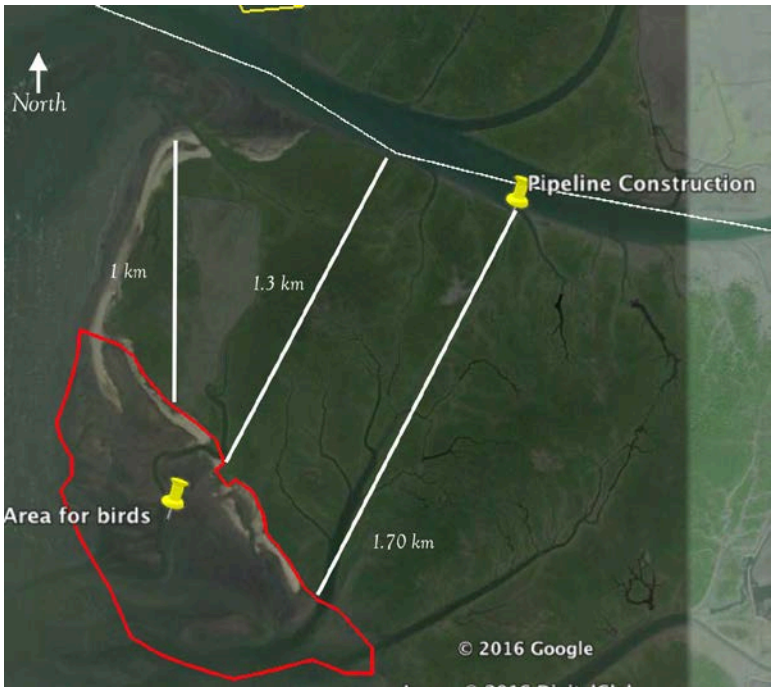

Figure 1: Distance between bird habitat and ongoing pipeline construction

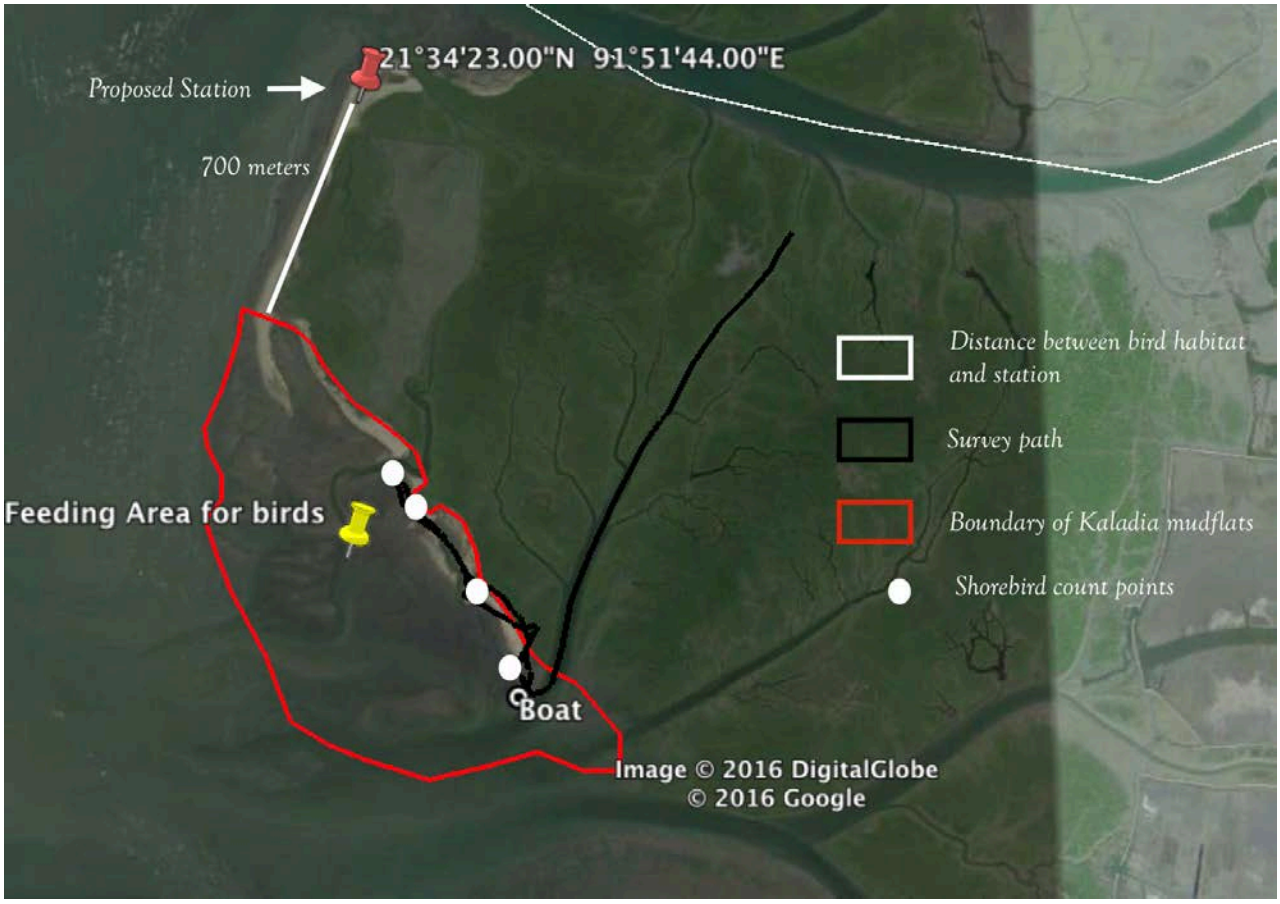

Figure 2: Field survey routes, shorebird count points, and location and distance of the proposed station.

The proposed permanent station is located on a sandy beach (Figure 3), surrounded (200 meters) by hard mud, mangroves, and three channels edging an abandoned saltpan.

Figure 3: Habitat features around 200 meters of the proposed station.

The proposed station is about 700 meters from the boundary (based on shorebird sightings) of Kaladia mudflats. The habitat of Kaladia includes mostly mudflats and mangroves (mostly *Avicennia marina* and *Avicennia alba*), a narrow strip of sandbar and an abandoned saltpan.

A total of 256 shorebirds of 13 species were recorded from Kaladia of Sonadia Island on 10 August 2016. Birds were counted using spotting scopes at four locations (Figure 2). Four globally threatened or near threatened species were recorded, including 80 the endangered Great knot (Table 1). The field visit further confirms that the site is not only important for migratory shorebirds during winter months but also during over-summering period when substantial number of globally threatened species occur.

Table 1: Shorebird species and number counted on 10 August 2016 at Kaladia, Sonadia Island (counting points are indicated in Figure 2).

Species	IUCN Red List Status	Number
Kentish Plover *Charadrius alexandrinus*	Least Concern	15
Lesser Sand Plover *Charadrius mongolus*	Least Concern	60
Greater Sand Plover *Charadrius leschenaultii*	Least Concern	20
Bar-tailed Godwit *Limosa lapponica*	Near Threatened	1
Whimbrel *Numenius phaeopus*	Least Concern	12
Eurasian Curlew *Numenius arquata*	Near Threatened	10
Common Redshank *Tringa tetanus*	Least Concern	8
Terek Sandpiper *Xenus cinereus*	Least Concern	3
Common Sandpiper *Actitis hypoleucos*	Least Concern	1
Great Knot *Calidris tenuirostris*	Endangered	80
Sanderling *Calidris alba*	Least Concern	3
Curlew Sandpiper *Calidris ferruginea*	Near Threatened	13
Little Tern *Sterna albifrons*	Least Concern	30
Total		256

Table 2: GPS coordinates of notable locations.

Description	Coordinates
Proposed Station	21°34'23.00"N; 91°51'44.00"E
Shorebird Count 1	21°33'25.98"N; 91°52'2.53"E
Shorebird Count 2	21°33'33.32"N; 91°51'57.01"E
Shorebird Count 3	21°33'41.25"N; 91°51'51.89"E
Shorebird Count 4	21°33'45.97"N; 91°51'49.36"E

Figure 4: Three different types of habitats of the study area. a) short mangrove – this includes the green areas above the red lines in the map; b) mudflats where shorebirds forage – this includes dark/grey areas within the red lines; c) hard sand dotted with mangroves – the light-white areas in the map.

Appendix D: Threatened and Endangered Species Potentially Present

The table below lists all species contained in the IUCN Red List of Threatened Species whose range maps overlap with the project area of influence.

Taxonomic group	Species	Common name	IUCN Red List Category
Birds	*Anhinga melanogaster*	Oriental Darter	NT
Birds	*Asarcornis scutulata*	White-winged Duck	EN
Birds	*Buceros bicornis*	Great Hornbill	NT
Birds	*Calidris pygmaea*	Spoon-billed Sandpiper	CR
Birds	*Calidris tenuirostris*	Great Knot	VU
Birds	*Ciconia episcopus*	Asian Woollyneck	VU
Birds	*Circus macrourus*	Pallid Harrier	NT
Birds	*Clanga clanga*	Greater Spotted Eagle	VU
Birds	*Emberiza aureola*	Yellow-breasted Bunting	EN
Birds	*Haliaeetus leucoryphus*	Pallas's Fish-eagle	VU
Birds	*Leptoptilos javanicus*	Lesser Adjutant	VU
Birds	*Limosa limosa*	Black-tailed Godwit	NT
Birds	*Limosa lapponica*	Bar-tailed Godwit	NT
Birds	*Calidris ferruginea*	Curlew sandpiper	NT
Birds	*Calidris ruficollis*	Red-necked Stint	NT
Birds	*Limnodromus semipalmatus*	Asian Dowitcher	NT
Birds	*Mareca falcata*	Falcated Duck	NT
Birds	*Mycteria leucocephala*	Painted Stork	NT
Birds	*Numenius arquata*	Eurasian Curlew	NT
Birds	*Pelargopsis amauroptera*	Brown-winged Kingfisher	NT
Birds	*Rynchops albicollis*	Indian Skimmer	VU
Birds	*Threskiornis melanocephalus*	Black-headed Ibis	NT
Birds	*Treron phayrei*	Ashy-headed Green-pigeon	NT
Birds	*Vanellus duvaucelii*	River Lapwing	NT
Corals	*Acropora glauca*		NT
Corals	*Acropora irregularis*		DD
Corals	*Acropora rudis*		EN
Corals	*Heliopora coerulea*	Blue Coral	VU
Corals	*Tubipora musica*	Organ Pipe Coral	NT
Fishes	*Acanthopagrus longispinnis*	Bengal Yellowfin Seabream	DD
Fishes	*Aetobatus narinari*	Spotted Eagle Ray	NT
Fishes	*Aetomylaeus nichofii*	Banded Eagle Ray	VU

Taxonomic group	Species	Common name	IUCN Red List Category
Fishes	*Albula oligolepis*	Smallscale Bonefish	DD
Fishes	*Alopias pelagicus*	Pelagic Thresher	VU
Fishes	*Alopias superciliosus*	Bigeye Thresher Shark	VU
Fishes	*Alopias vulpinus*	Common Thresher Shark	VU
Fishes	*Anguilla bengalensis*	Indian Mottled Eel	NT
Fishes	*Anguilla bicolor*	Shortfin Eel	NT
Fishes	*Anoxypristis cuspidata*	Narrow Sawfish	EN
Fishes	*Atelomycterus marmoratus*	Coral Catshark	NT
Fishes	*Bahaba chaptis*	Chaptis Bahaba	DD
Fishes	*Carcharhinus amblyrhynchoides*	Graceful Shark	NT
Fishes	*Carcharhinus amboinensis*	Pigeye Shark	DD
Fishes	*Carcharhinus brevipinna*	Spinner Shark	NT
Fishes	*Carcharhinus dussumieri*	Widemouth Blackspot Shark	NT
Fishes	*Carcharhinus falciformis*	Silky Shark	NT
Fishes	*Carcharhinus hemiodon*	Pondicherry Shark	CR
Fishes	*Carcharhinus limbatus*	Blacktip Shark	NT
Fishes	*Carcharhinus longimanus*	Oceanic Whitetip Shark	VU
Fishes	*Carcharhinus macloti*	Hardnose Shark	NT
Fishes	*Carcharhinus melanopterus*	Blacktip Reef Shark	NT
Fishes	*Carcharhinus sealei*	Blackspot Shark	NT
Fishes	*Carcharhinus sorrah*	Spottail Shark	NT
Fishes	*Carcharias taurus*	Sand Tiger	VU
Fishes	*Carcharodon carcharias*	Great White Shark	VU
Fishes	*Chaetodon andamanensis*	Yellow Butterflyfish	DD
Fishes	*Chiloscyllium griseum*	Grey Bamboo Shark	NT
Fishes	*Chiloscyllium indicum*	Ridgebacked Bamboo Shark	NT
Fishes	*Chiloscyllium plagiosum*	Whitespotted Bamboo Shark	NT
Fishes	*Dasyatis microps*	Smalleye Stingray	DD
Fishes	*Epinephelus erythrurus*	Cloudy Grouper	DD
Fishes	*Eusphyra blochii*	Slender Hammerhead	NT

Taxonomic group	Species	Common name	IUCN Red List Category
Fishes	*Galeocerdo cuvier*	Tiger Shark	NT
Fishes	*Glaucostegus granulatus*	Sharpnose Guitarfish	VU
Fishes	*Glaucostegus typus*	Common Shovelnose Ray	VU
Fishes	*Glyphis gangeticus*	Ganges Shark	CR
Fishes	*Hemipristis elongata*	Snaggletooth Shark	VU
Fishes	*Himantura gerrardi*	Whitespotted Whipray	VU
Fishes	*Himantura uarnacoides*	Bleeker's Whipray	VU
Fishes	*Himantura uarnak*	Reticulate Whipray	VU
Fishes	*Hippocampus histrix*	Spiny Seahorse	VU
Fishes	*Hippocampus kelloggi*	Great Seahorse	VU
Fishes	*Hippocampus spinosissimus*	Hedgehog Seahorse	VU
Fishes	*Istiompax indica*	Black Marlin	DD
Fishes	*Isurus oxyrinchus*	Shortfin Mako	VU
Fishes	*Isurus paucus*	Longfin Mako	VU
Fishes	*Kajikia audax*	Striped Marlin	NT
Fishes	*Lamiopsis temminckii*	Broadfin Shark	EN
Fishes	*Manta birostris*	Giant Manta Ray	VU
Fishes	*Megachasma pelagios*	Megamouth Shark	DD
Fishes	*Megalops cyprinoides*	Indo-Pacific Tarpon	DD
Fishes	*Mobula eregoodootenkee*	Pygmy Devilray	NT
Fishes	*Mobula japanica*	Spinetail Mobula	NT
Fishes	*Mobula thurstoni*	Smoothtail Devil Ray	NT
Fishes	*Narcine lingula*	Chinese Numbfish	DD
Fishes	*Narcine maculata*	Darkspotted Electric Ray	DD
Fishes	*Negaprion acutidens*	Sharptooth Lemon Shark	VU
Fishes	*Neotrygon kuhlii*	Bluespotted Stingray	DD
Fishes	*Odontaspis noronhai*	Bigeye Sand Tiger	DD
Fishes	*Omobranchus smithi*		VU
Fishes	*Prionace glauca*	Blue Shark	NT
Fishes	*Pristis pristis*	Largetooth Sawfish	CR
Fishes	*Pseudocarcharias kamoharai*	Crocodile Shark	NT
Fishes	*Rastrelliger faughni*	Island Mackerel	DD
Fishes	*Rastrelliger kanagurta*	Indian Mackerel	DD
Fishes	*Rhina ancylostoma*	Bowmouth Guitarfish	VU

Taxonomic group	Species	Common name	IUCN Red List Category
Fishes	*Rhincodon typus*	Whale Shark	VU
Fishes	*Rhinobatos obtusus*	Widenose Guitarfish	VU
Fishes	*Rhynchobatus laevis*	Smoothnose Wedgefish	VU
Fishes	*Scoliodon laticaudus*	Spadenose Shark	NT
Fishes	*Scomberomorus commerson*	Narrow-barred Spanish Mackerel	NT
Fishes	*Scomberomorus guttatus*	Indo-Pacific King Mackerel	DD
Fishes	*Sphyrna lewini*	Scalloped Hammerhead	EN
Fishes	*Sphyrna mokarran*	Squat-headed Hammerhead Shark	EN
Fishes	*Stegostoma fasciatum*	Leopard Shark	VU
Fishes	*Taeniura lymma*	Ribbontailed Stingray	NT
Fishes	*Taeniurops meyeni*	Black-blotched Stingray	VU
Fishes	*Thamnaconus melanoproctes*	Blackvent Filefish	DD
Fishes	*Triaenodon obesus*	Whitetip Reef Shark	NT
Fishes	*Urogymnus asperrimus*	Porcupine Ray	VU
Mammals	*Balaenoptera edeni*	Bryde's Whale	DD
Mammals	*Balaenoptera musculus*	Blue Whale	EN
Mammals	*Capricornis thar*	Himalayan Serow	NT
Mammals	*Feresa attenuata*	Pygmy Killer Whale	DD
Mammals	*Globicephala macrorhynchus*	Short-finned Pilot Whale	DD
Mammals	*Helarctos malayanus*	Sun Bear	VU
Mammals	*Hoolock hoolock*	Western Hoolock Gibbon	EN
Mammals	*Platanista gangetica ssp. gangetica*	Ganges River Dolphin	EN
Mammals	*Indopacetus pacificus*	Indo-pacific Beaked Whale	DD
Mammals	*Kogia breviceps*	Pygmy Sperm Whale	DD
Mammals	*Kogia sima*	Dwarf Sperm Whale	DD
Mammals	*Lutrogale perspicillata*	Smooth-coated Otter	VU
Mammals	*Macaca leonina*	Northern Pig-tailed Macaque	VU
Mammals	*Mesoplodon densirostris*	Blainville's Beaked Whale	DD
Mammals	*Mesoplodon ginkgodens*	Ginkgo-toothed Beaked Whale	DD

Taxonomic group	Species	Common name	IUCN Red List Category
Mammals	*Neophocaena phocaenoides*	Indo-Pacific Finless Porpoise	VU
Mammals	*Nycticebus bengalensis*	Bengal Slow Loris	VU
Mammals	*Orcaella brevirostris*	Irrawaddy Dolphin	VU
Mammals	*Orcinus orca*	Killer Whale	DD
Mammals	*Panthera pardus*	Leopard	NT
Mammals	*Physeter macrocephalus*	Sperm Whale	VU
Mammals	*Pseudorca crassidens*	False Killer Whale	DD
Mammals	*Rusa unicolor*	Sambar	VU
Mammals	*Sousa chinensis*	Indo-Pacific Humpbacked Dolphin	NT
Mammals	*Stenella longirostris*	Spinner Dolphin	DD
Mammals	*Trachypithecus phayrei*	Phayre	EN
Mammals	*Trachypithecus pileatus*	Capped Langur	VU
Mammals	*Tursiops aduncus*	Indo-pacific Bottlenose Dolphin	DD
Mammals	*Ursus thibetanus*	Asiatic Black Bear	VU
Mammals	*Viverra zibetha*	Large Indian Civet	NT
Other invertebrates	*Allopatides dendroeides*		DD
Other invertebrates	*Bohadschia marmorata*	Chalky Cucumber	DD
Other invertebrates	*Bohadschia tenuissima*		DD
Other invertebrates	*Bohadschia vitiensis*	Brown Sandfish	DD
Other invertebrates	*Holothuria arenicola*		DD
Other invertebrates	*Holothuria fuscogilva*		VU
Other invertebrates	*Holothuria impatiens*	Bottleneck Sea Cucumber	DD
Other invertebrates	*Holothuria lessoni*	Golden Sandfish	EN
Other invertebrates	*Holothuria pyxis*		DD
Other invertebrates	*Holothuria scabra*	Golden Sandfish	EN
Other invertebrates	*Holothuria spinifera*		DD
Other invertebrates	*Stichopus herrmanni*	Curryfish	VU
Other invertebrates	*Stichopus horrens*	Selenka's Sea Cucumber	DD
Other invertebrates	*Stichopus monotuberculatus*		DD
Other invertebrates	*Thelenota ananas*	Prickly Redfish	EN
Other invertebrates	*Thelenota anax*	Amberfish	DD
Other invertebrates	*Thenus indicus*	Mud Bug	DD

Taxonomic group	Species	Common name	IUCN Red List Category
Plants	*Aegialitis rotundifolia*		NT
Plants	*Aglaia cucullata*	Pacific Maple	DD
Plants	*Ceriops decandra*		NT
Plants	*Excoecaria indica*		DD
Plants	*Halophila beccarii*	Ocean Turf Grass	VU
Plants	*Heritiera fomes*		EN
Plants	*Phoenix paludosa*	Mangrove Date Palm	NT
Plants	*Sonneratia griffithii*		CR
Reptiles	*Chelonia mydas*	Green Sea Turtle	EN
Reptiles	*Lepidochelys olivacea*	Olive Ridley Turtle	VU
Reptiles	*Crocodylus palustris*	Mugger	VU
Reptiles	*Dermochelys coriacea*	Leatherback	VU
Reptiles	*Gavialis gangeticus*	Gharial	CR
Reptiles	*Hydrophis cantoris*	Gunther's Sea Snake	DD
Reptiles	*Hydrophis stricticollis*	Collared Sea Snake	DD
Reptiles	*Ophiophagus hannah*	King Cobra	VU
Reptiles	*Python bivittatus*	Burmese Python	VU
Snails and Slugs	*Conus capreolus*		DD

Appendix E: IFC Critical Habitat Criteria Definitions

IFC Performance Standard 6 Guidance Notes provide the following Critical Habitat Assessment Criteria:

Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species
Criterion 2: Endemic and/or restricted-range species
Criterion 3: Migratory and/or congregatory species
Criterion 4: Highly threatened and/or unique ecosystems
Criterion 5: Key evolutionary processes

Criteria 1-3 apply at the species level, Criterion 4 applies at the ecosystem level, and Criterion 5 applies at the landscape level. Definitions for each of the criteria are provided below.

Noting there are different gradients of Critical Habitat, IFC defines Tier 1 (most critical) and Tier thresholds (sub-criteria) for Criteria 1-3. These definitions are provided in Table 2-1.

Criterion 1: Critically Endangered and/or Endangered Species

Criterion 1 is triggered by species listed as Critically Endangered and/or Endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (Red List), and nationally/regionally listed species assessed using similar criteria. If discrepancies were identified, a precautionary approach was applied and species were assigned a higher threat level.

In addition, species not listed as CR or EN were included under Criterion 1 evaluation if compelling evidence indicated that the threat level was high enough to warrant a potential Critical Habitat designation based on the intent of PS6.

Criterion 2: Endemic and/or Restricted-range Species

Criterion 2 is triggered if there are endemic or range restricted species (not necessarily threatened or endangered) present.

IFC defines an endemic species as “one that has ≥ 95 percent of its global range inside the country or region of analysis.”

IFC defines a restricted-range species as:

- *“For terrestrial vertebrates, a restricted-range species is defined as those species which have an extent of occurrence of 50,000 km2 or less.*
- *For marine systems, restricted-range species are provisionally being considered those with an extent of occurrence of 100,000 km2 or less.*
- *For freshwater systems, standardized thresholds have not been set at the global level. However an IUCN study of African freshwater biodiversity applied thresholds of 20,000 km2 for crabs, fish, and mollusks and 50,000 km2 for odonates (dragonflies and damselflies). These can be taken as approximate guidance, although the extent to which they are applicable to other taxa and in other regions is not yet known.*
- *For plants, restricted-range species may be listed as part of national legislation. Plants are more commonly referred to as “endemic,” and the definition provided [above] would apply. Particular attention should therefore be paid to endemic plants of smaller countries which are likely, by definition, to be globally rarer and therefore of higher overall priority.”*

Criterion 3: Migratory and/or Congregatory Species

Criterion 3 is triggered if migratory and/or congregatory species of significance are present.

Migratory species are defined as “any species of which a significant proportion of its members cyclically and predictably move from one geographical area to another (including within the same ecosystem).”

Congregatory species are defined as “*species whose individuals gather in large groups on a cyclical or otherwise regular and/or predictable basis; examples include the following:*

- *Species that form colonies*
- *Species that form colonies for breeding purposes and/or where large numbers of individuals of a species gather at the same time for non-breeding purposes (e.g., foraging, roosting).*
- *Species that move through bottleneck sites where significant numbers of individuals of a species pass over a concentrated period of time (e.g., during migration).*
- *Species with large but clumped distributions where a large number of individuals may be concentrated in a single or a few sites while the rest of the species is largely dispersed (e.g., wildebeest distributions).*
- *Source populations where certain sites hold populations of species that make an inordinate contribution to recruitment of the species elsewhere (especially important for marine species).”*

Criterion 4: Highly Threatened and/or Unique Ecosystems

Criterion 4 is triggered if highly threatened and/or unique ecosystems are present.

Highly threatened or unique ecosystems are those:

- *“That are at risk of significantly decreasing in area or quality*
- *With a small spatial extent, and/or*
- *Containing unique assemblages of species including assemblages or concentrations of biome-restricted species.”*

Criterion 5: Key Evolutionary Processes

Criterion 5 is triggered if areas of key evolutionary processes are present.

Areas of key evolutionary processes are defined by:

- *“The physical features of a landscape that might be associated with particular evolutionary processes, and/or*
- *Subpopulations of species that are phylogenetically or morphogenetically distinct and may be of special conservation concern given their distinct evolutionary history. The latter includes evolutionarily significant units (ESUs) and Evolutionarily Distinct and Globally Endangered (EDGE) species.”*

Appendix D: Sediment Dispersion Modeling Report

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Draft Report

Sediment Dispersion Modeling for Pipeline Installation at Moheshkhali, Offshore Bangladesh

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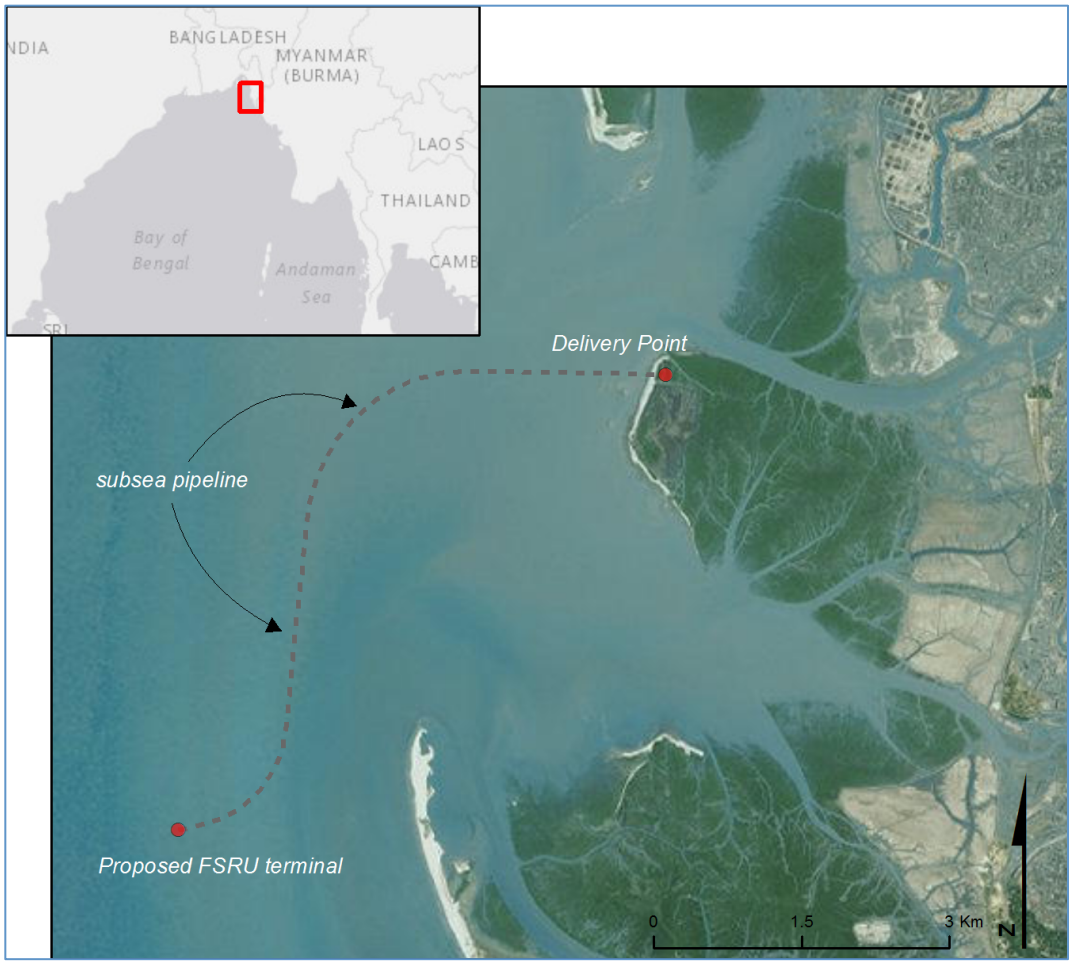

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1. Introduction

Applied Science Associates Inc. (dba RPS ASA) has used numerical models to predict the concentration and subsequent seabed deposition of sediment resuspended into the water column during marine construction activities associated with a proposed liquefied natural gas (LNG) receiving terminal and regasification facility in the Moheshkhali area of Bangladesh (Cox's Bazar district). The project will include the construction of a permanently moored, floating LNG storage and regasification unit (FSRU) terminal offshore of Moheshkhali Island connected to an onshore tie in point at Kalirdiar Char (west of Boro Moheshkhali Union Parishad) via subsea pipeline. This report updates previous modeling of the site in November 2016 with new information about the pipeline route and installation activities. It presents the various analytical and modeling approaches used to predict suspended sediment transport and deposition, describes the environmental inputs and modeling approach, and presents the results of the SSFATE model and its application to the proposed construction activities.

The study area is located in the northeast Bay of Bengal, approximately 5 km offshore of Moheshkhali Island in the South East of Bangladesh, and 90 km south of the port city of Chittagong. An environmental impact assessment (EIA) of the proposed FSRU terminal (BETS, 2015) indicates that area is a relatively undeveloped coastal plain (landforms consisting of beaches and dunes and the Island). Figure 1 shows the proposed location of the LNG facility and highlights the connection to the onshore delivery point. (Table 1 lists coordinates for the proposed delivery point and FSRU.) A thin sandy barrier running parallel to the coastline intersects with the pipeline route near the delivery tie-in.

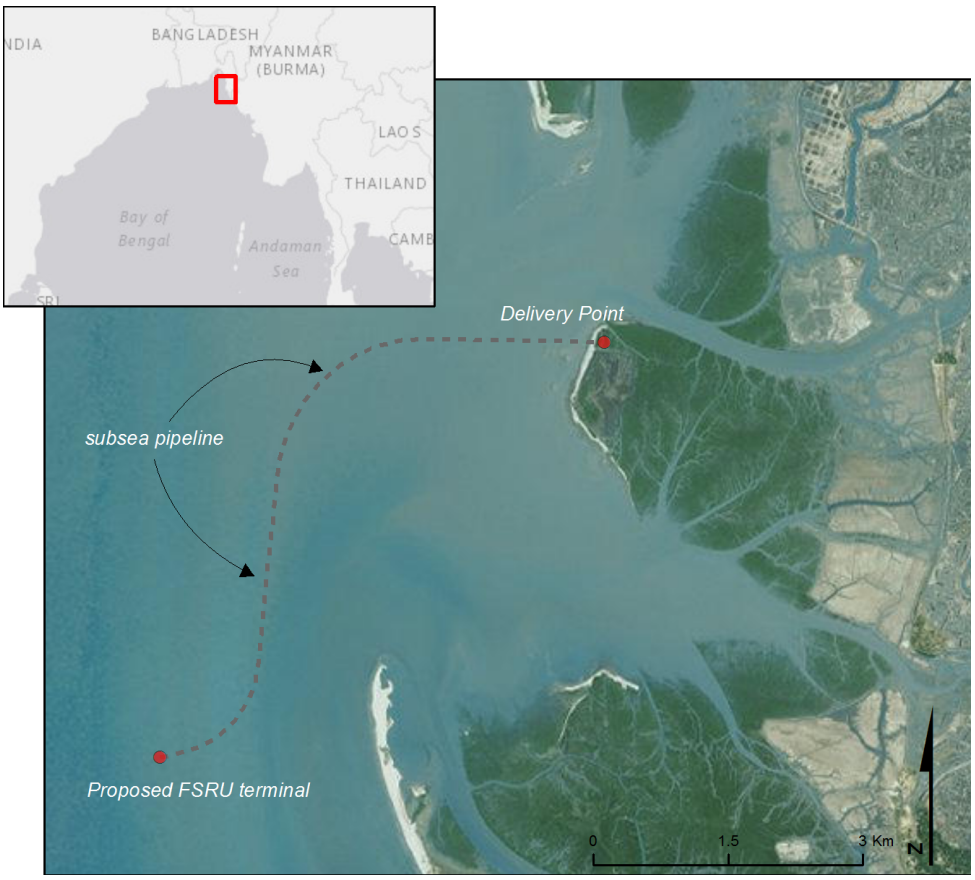


Figure 1. Location of the proposed FSRU terminal and subsea pipeline offshore Moheshkhali Island, Bangladesh.

Table 1. Proposed pipeline start/end points (delivery point and FSRU terminal)

Point Name	Northing	Easting
Delivery Point (Proposed)	21° 34' 22.74" N	91° 51' 46.83" E
Proposed Terminal Location (Subject to Change)	21° 32' 04.00"N	91° 49' 07.00"E

The pipeline will run approximately 7.5 km between the delivery point (KP0) and the FSRU terminal (KP7.548). Pipeline installation will be conducted in four stages:

1. Pre-trenching of the landfall channel by amphibious (land/water) excavators (KP0 – KP0.5)
2. Hydraulic dredging of the main approach area for lay barge access (KP0.5 – KP2.287)
3. Post-lay trenching of the offshore portion of the pipeline via sledge (KP0.5 – KP7.548)
4. Burial of the landfall section following shore pull of the pipeline (KP0 – KP0.5)

Numerical modeling was performed to simulate sediment losses to the water column during the first three construction activities. RPS ASA's SSFATE model was applied to assess the short-term behavior of suspended sediment plumes and sedimentation as a result of each stage of construction. For each activity, two scenarios were modeled using SSFATE to capture potential impacts from trenching/dredging activities originating at different start dates within a monthly ebb/flood tidal cycle.

2. Environmental Conditions

The modeling study required physical characterization of the region, including a description of the shoreline geometry and bathymetry as well as a characterization of the local circulation as it relates to the fate and transport of released sediment in the water column.

2.1. Shoreline and Bathymetry

The shoreline and bathymetry of the study area are complex. Navigation maps and aerial imagery show evidence of migrating sandbars, intricate channels and large intertidal regions along the western side of Moheshkhali Island.

For hydrodynamic modeling, the shoreline was defined based on data obtained from the OpenStreetMap project, though modified based on navigation charts and aerial imagery. The OpenStreetMap project is an open-source mapping effort with most data generated from the U.S. National Geospatial Intelligence Agency (NGA) Prototype Global Shoreline (PGS), which is based on 2000-era LANDSAT satellite imagery. The precision of the PGS is approximately 50 meters.

Bathymetry within the study area was available from electronic navigation charts (C-MAP, Jeppesen Marine) and from client provided survey data (GEOCEAN, 2016a). In areas with limited data some manual editing was required to represent the visible channels (from aerial imagery) correctly.

2.2. Circulation

The circulation in the study area is important relative to the fate and transport of excess sediments in the water column associated with dredging and trenching activities. The project is located in the nearshore environment and the post-trenching activity is anticipated to have duration spanning multiple weeks. In order to incorporate the spatial and temporal patterns of currents in the study area, a hydrodynamic model application of the study area was developed using RPS ASA's hydrodynamic model - HYDROMAP - to capture the range of currents anticipated in the study area. The model application was first validated by comparison of model predicted currents to observational data near the pipeline route and then subsequently used to develop tidal current fields for use in the sediment transport simulations. The model, the model application and the results are presented in the following sections.

2.2.1. HYDROMAP Hydrodynamic Model Application to the Study Site

A hydrodynamic model application of the study area was developed for the purposes of generating spatially and temporally varying current fields for use in modeling of sediment dispersion (documented in another study report) and for developing a characterization of the speed and direction of currents anticipated at FRSU discharge location. The model application was developed using RPS ASA's in house model HYDROMAP. The model application was set up to determine tidal circulation only.

2.2.1.1 HYDROMAP Model Description

HYDROMAP is a globally re-locatable three-dimensional hydrodynamic model (Isaji, et al., 2001) capable of simulating complex circulation patterns due to tidal forcing, wind stress and fresh water flows. HYDROMAP employs a novel stepwise continuous variable rectangular gridding strategy with up to six levels of resolution. The term "step-wise continuous" implies that the boundaries between successively

smaller and larger grids are managed in a consistent integer step. HYDROMAP has been applied in numerous sediment dispersion and transport studies in the U.S. and worldwide. The numerical solution methodology follows that of Owen (1980). Isaji, et al. (2001) provides a detailed description of the model.

2.2.1.2 Model Application Set Up

A model grid of the study area was developed with nested grid resolution increasing along the route of the planned pipeline and at the shoreline in order to better capture complex shoreline and bathymetric features. The grid was developed for the northeast region of the Bay of Bengal, extending from the shoreline approximately 80 km west as measured from Moheshkhali Island. The shoreline was defined based on Open Street Maps delineation, though modified based on aerial imagery. The model grid cells were assigned depth based on soundings from available navigation charts (C-MAP, Jeppesen Marine), survey information provided by the client and edits based on aerial imagery. The model grid resolution is shown in Figure 2 and Figure 3; model bathymetry (zoomed in to the area of interest) is shown in Figure 4.

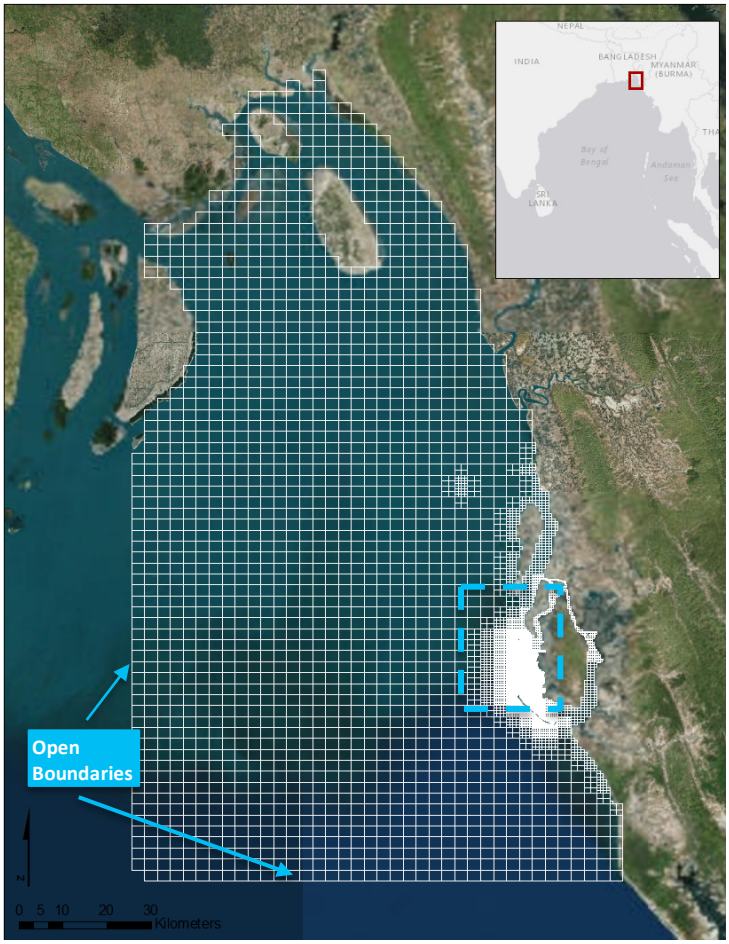


Figure 2. Illustration of entire HYDROMAP model grid, blue dashed outline indicates approximate extent of zoomed in illustration of grid in Figure 3 below.

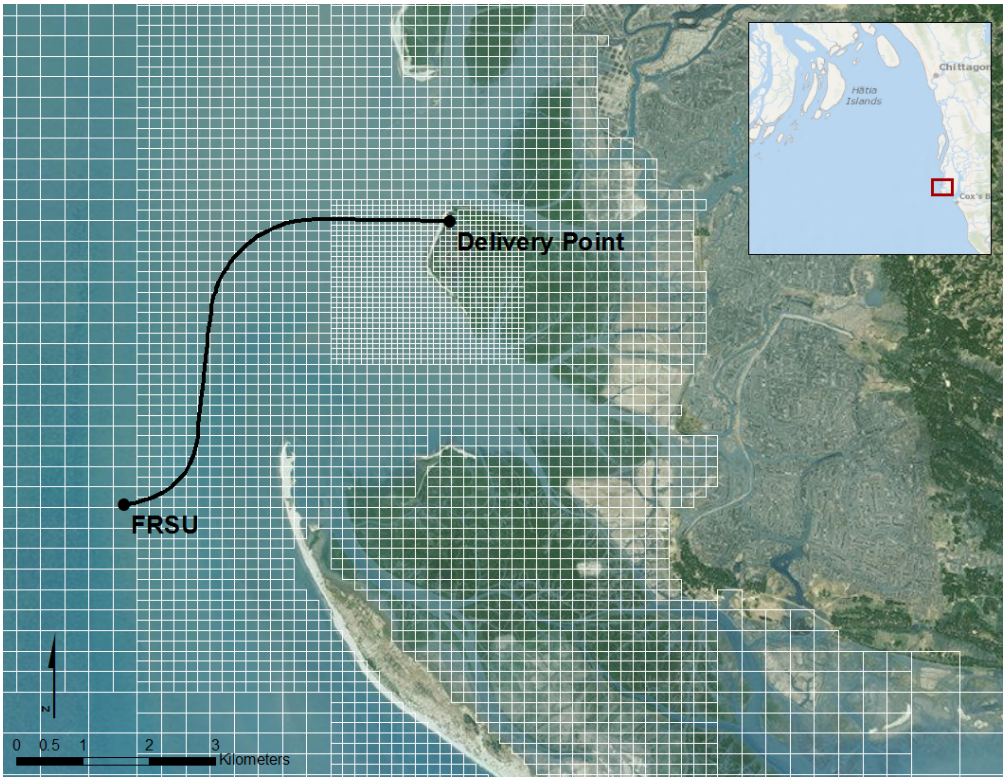


Figure 3. Illustration of HYDROMAP model grid zoomed to the study area near the FRSU and pipeline.

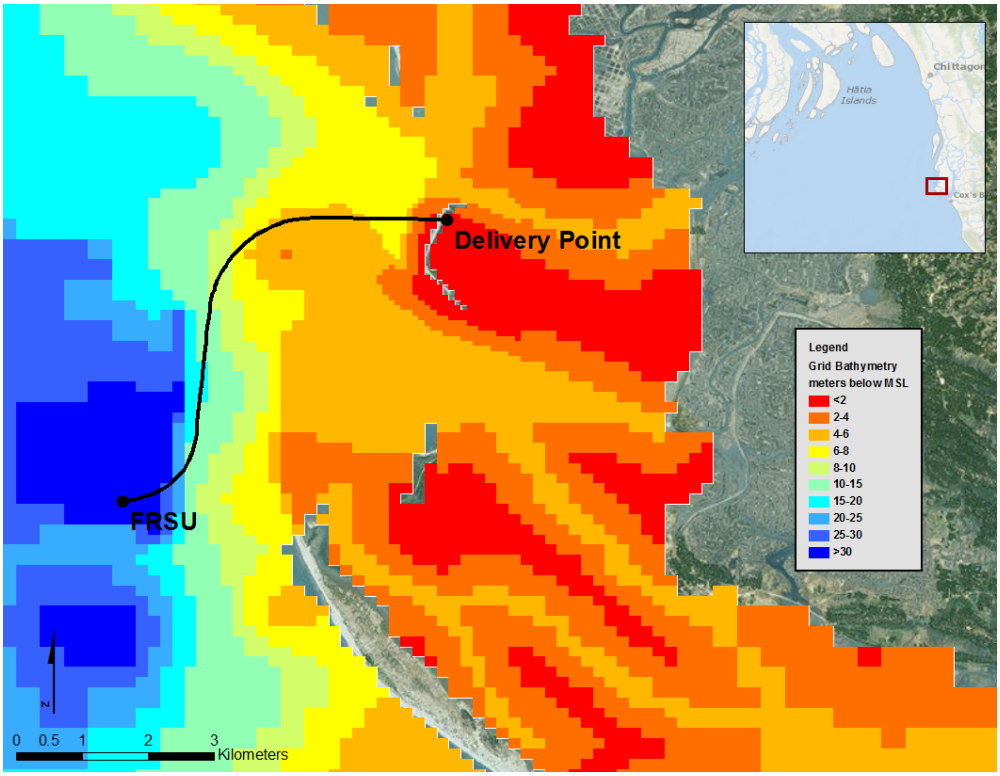


Figure 4. Illustration of HYDROMAP model grid bathymetry zoomed to the study area near the FRSU and pipeline.

The hydrodynamic model simulations were forced with tides based on the harmonic analysis of observed data from the study area presented in client-provided material. The tidal boundary conditions were applied at the open boundary at the southern and western extent of the grid (Figure 2) and were characterized based on the six constituents (M_2, S_2, N_2, K_1, O_1, and Q_1), which comprise the majority of the tidal energy. The constituent phase and amplitude are presented in Table 2. The amplitude refers to the height that the water level may be either above or below mean sea level and the phase is the timing at which the maximum elevation from that constituent occurs relative to a theoretical equilibrium tide. The constituent symbols contain a subscript (e.g. "2") which refers to the approximate number of times a day this tidal cycle repeats. At this site the majority of the tidal energy is characterized by constituents that repeat twice a day (semidiurnal) or once a day (diurnal); the M_2 constituent is dominant, accounting for more than half of the tidal energy.

Table 2. Summary of astronomic tidal constituents used in hydrodynamic model forcing.

Symbol	Name	Amplitude	Phase
		(m)	(Degrees Relative to GMT)
M_2	Principal lunar semidiurnal	1.1347	311.89
S_2	Principal solar semidiurnal	0.4842	325.22
N_2	Larger lunar elliptic semidiurnal	0.3401	305.56
K_1	Lunisolar diurnal	0.1131	319.16
O_1	Lunar diurnal	0.0775	323.56
Q_1	Larger lunar elliptic diurnal	0.0282	332.65

2.2.1.3 Model Verification

In order to verify that the model was able to recreate the general circulation characteristics, comparisons to observations were performed for two different time periods based on data provided by the client (Poten & Partners, 2011). Observation data was available at a single location close to the study area as shown in Figure 5. For the two periods of observations the model predictions were compared to observed data (Figure 6 and Figure 7) for deployment periods of 14 -21 May 2008 and 1-16 February 2009, respectively. Qualitative comparison of the datasets indicates that the model is able to reproduce the magnitude and trend of the currents well. This comparison shows how the tidal strength may vary depending on time, or the phase of the constituents. The peak current speeds during the May 2008 period are relatively constant and reach a maximum at approximately 1.1 m/s whereas during the February 2009 time period the tidal current amplitude nearly doubles between neap and spring tide from 0.6 m/s to 1.20 m/s respectively.

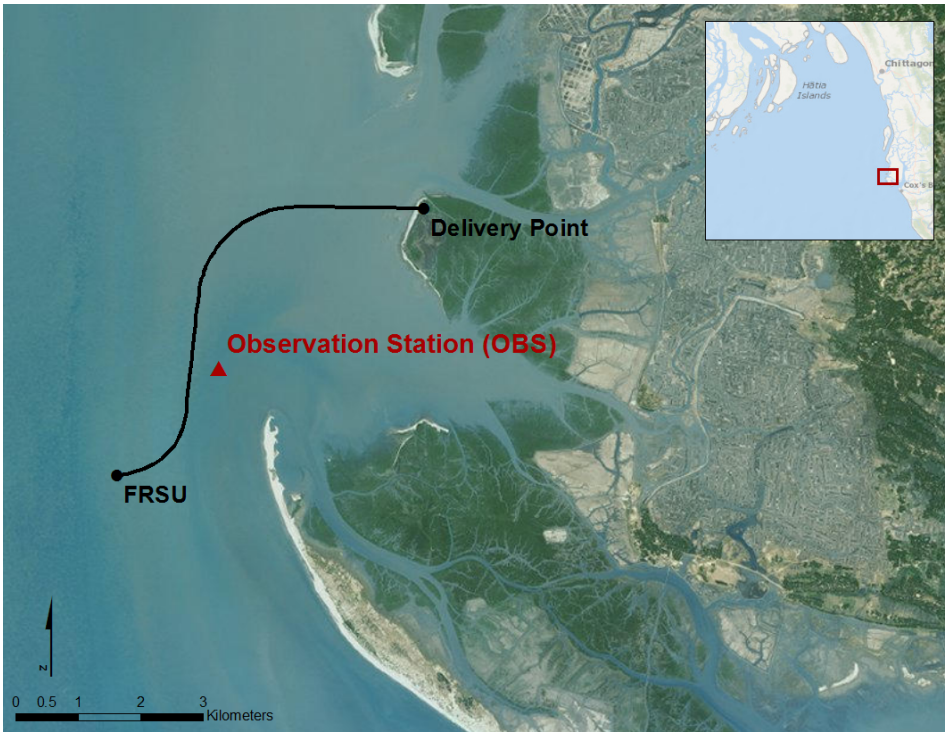
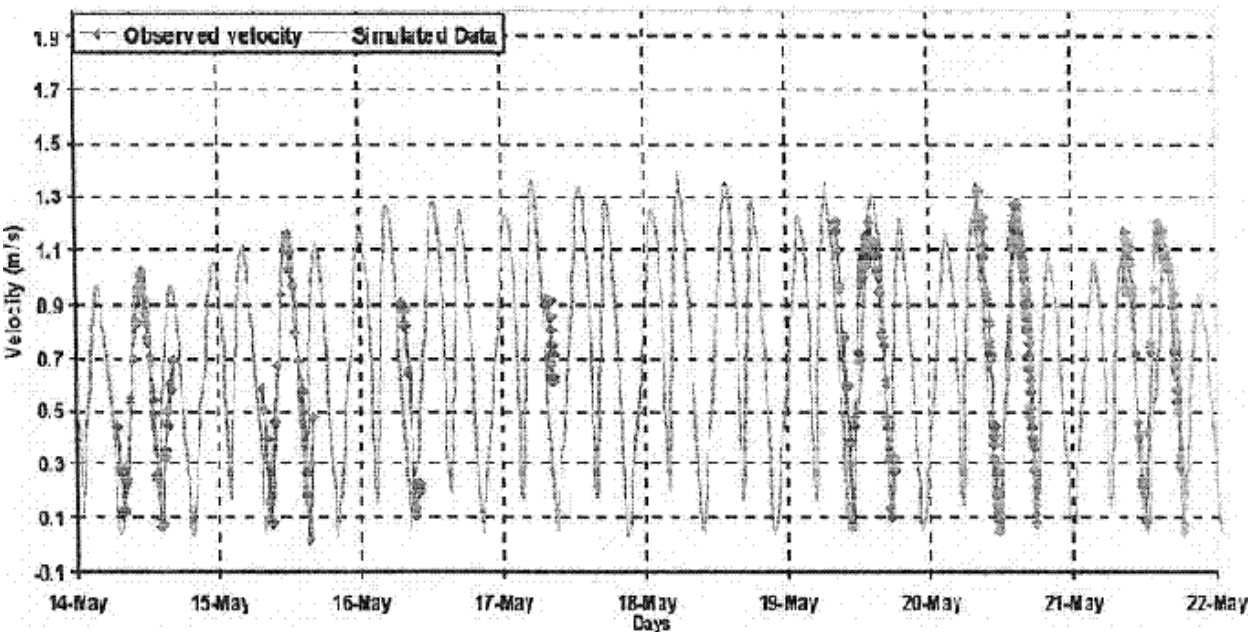


Figure 5. Illustration showing location of available hydrodynamic observations (OBS site).



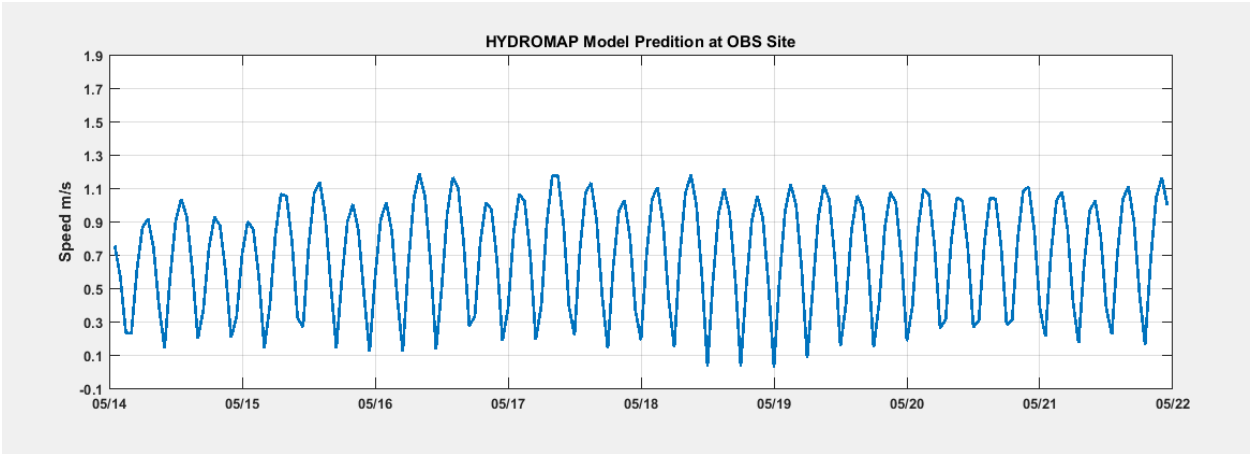
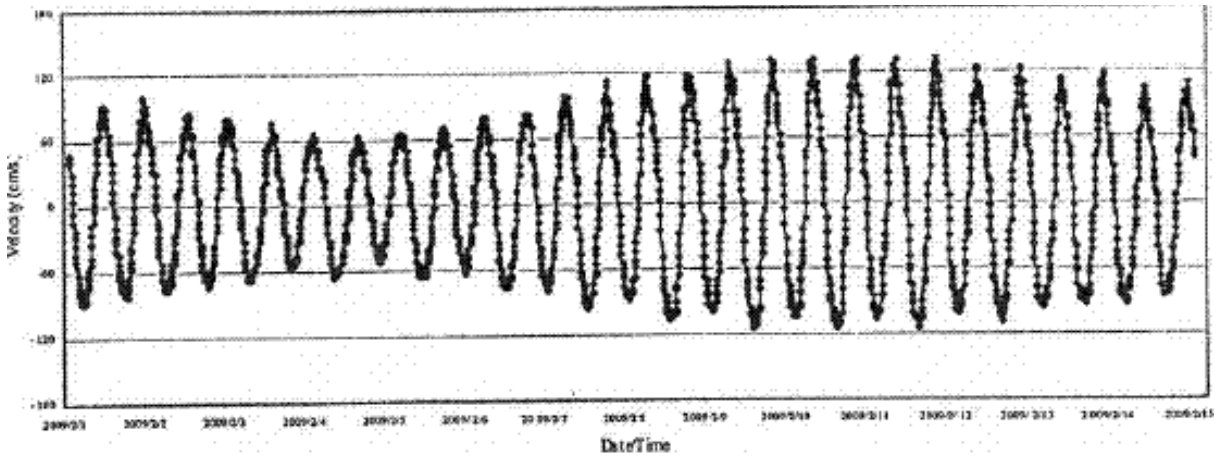


Figure 6. Comparison of time series between client-provided current observations (top) and HYDROMAP predictions (bottom) for May 2008. Note top figure shows both observations (line with markers) and a third party model (lines only) of the currents.



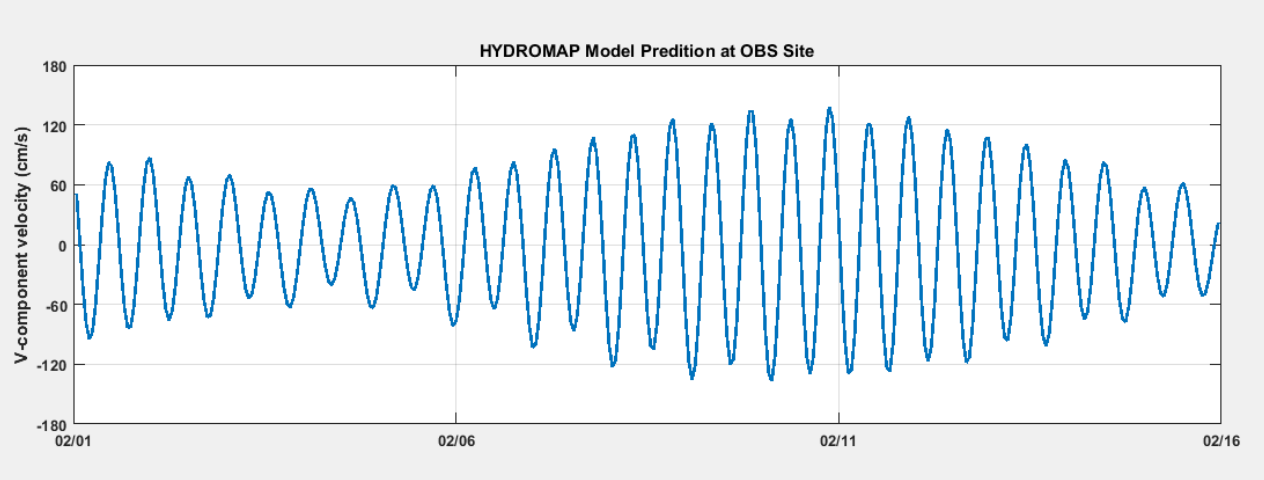


Figure 7. Comparison of time series between client-provided current observations (top) and HYDROMAP predictions (bottom) for February 2009. Note both series present only the north-south (V) component of the currents.

2.2.1.4 Model Scenario Results

The verified model was applied to generate tidal circulation data for use in both the sediment dispersion study and queried at the FRSU site to determine the current characteristics at the FRSU discharge location (see accompanying thermal discharge study).

Tidal currents are relatively strong in this area with magnitude variable depending on time. The tidal constituents result in variable speeds due to the timing of individual constituents. The majority of the variability is captured within a spring/neap cycle of 14 days; however the spring neap cycle can vary throughout time. A nineteen-year record of current speeds was generated at both the FRSU discharge site and the observation site (OBS site) from the model application. The records were analyzed and the statistics are summarized in Table 3. The semidiurnal constituents dominate the tidal regime and as such, the area is subject to two high and two low tides a day, which results in reversing currents twice a day. The direction of the reversing currents is predominately a north-south flow, however in areas

closer to the shoreline the directions vary in response to the effects of bathymetry and shoreline where flow moves in and out of channels and rivers.

Table 3. Summary of current speed statistics at points of interest predicted by HYDROMAP.

Percentile	Terminal	OBS Site
	cm/s	cm/s
5	14.0	10.4
10	20.5	14.7
15	27.0	19.4
20	34.2	24.8
25	41.9	30.7
30	49.7	36.8
35	57.8	43.1
40	66.0	49.5
45	74.3	56.0
50	82.6	62.6
55	91.1	69.3
60	99.8	76.3
65	108.8	83.6
70	118.5	91.4
75	128.8	99.8
80	140.0	109.0
85	153.0	119.8
90	169.6	133.5
95	191.8	151.9
100	252.0	201.6

Snapshots of typical flood and ebb circulation patterns of the M_2 constituent in the study area are shown in Figure 8 and Figure 9 respectively. The model predictions show that the strong tidal influence results in flooding and ebbing approximately twice daily with relatively strong peak current speeds. The illustrations of circulation patterns show how the flow reverses with flow vectors shown in reversing directions (180 degrees phase difference) between flood and ebb. The model predicts current speeds to be greater than ~60-80 cm/s for more than half the time in the general area. Peak speeds reach approximately 1.5 – 2 m/s however for short periods of time. Current roses at the FRSU terminal site and the observation site are presented in Figure 10.

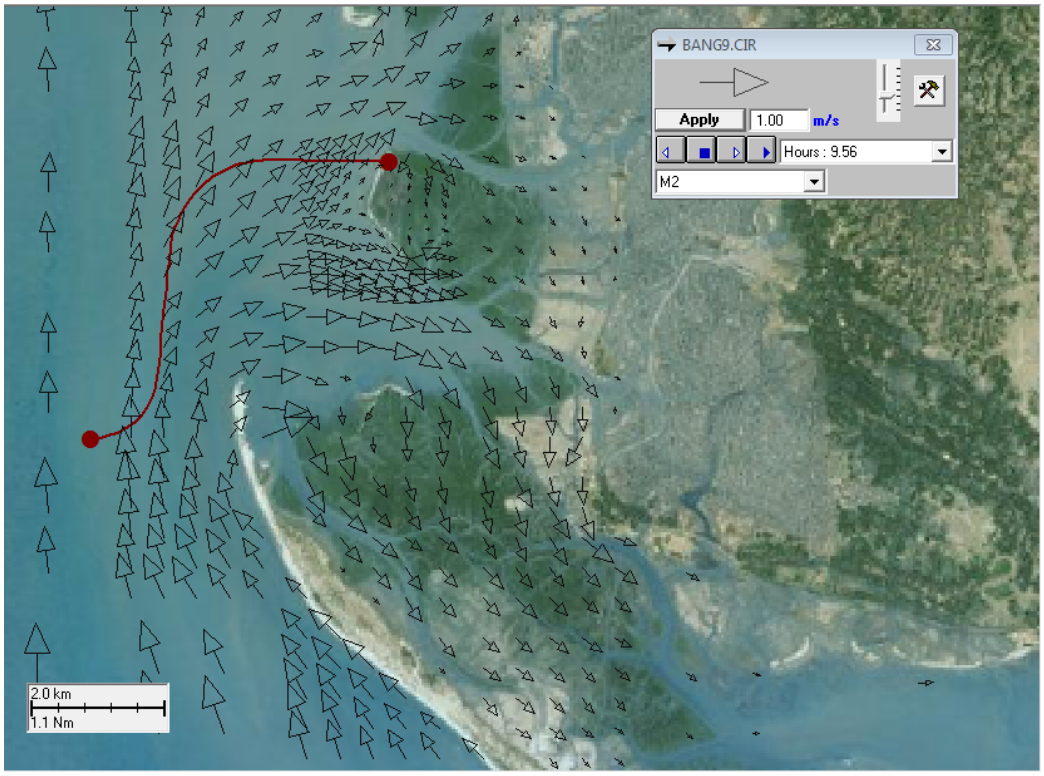


Figure 8. Illustration showing predicted flood current pattern (M2 constituent).

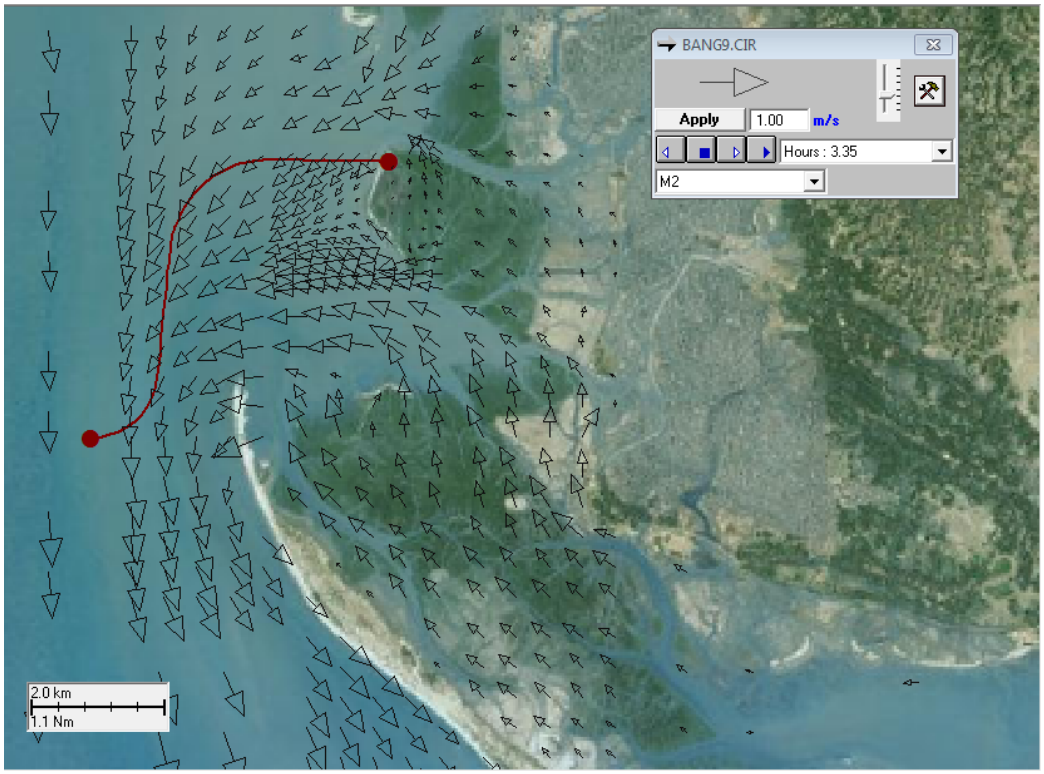


Figure 9. Illustration showing predicted ebb current pattern (M2 constituent).

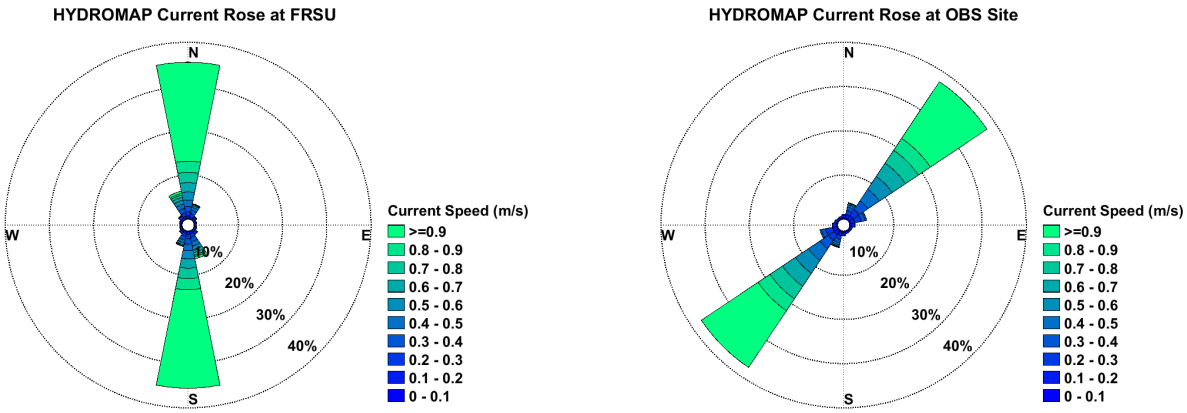


Figure 10. HYDROMAP Current rose at FRSU (left) and Observation Site (right). Oceanographic convention: direction current flowing towards, speeds in m/s.

3. SSFATE Modeling

3.1. SSFATE Model Description

The SSFATE (Suspended Sediment FATE) model was used to predict suspended sediment concentrations and the transport and deposition of suspended sediment resulting from each marine construction activity. SSFATE addresses the short term movement of sediments that are disturbed during mechanical plowing, hydraulic jetting, dredging and other processes where sediment is resuspended into the water column and predicts the path and fate of the sediment particles using three-dimensional currents in estuaries and oceans.

SSFATE was jointly developed by Applied Science Associates (now RPS ASA) and the U.S. Army Corps of Engineers (USACE) Environmental Research and Development Center (ERDC) to simulate the sediment suspension and deposition from dredging operations. It has been documented in a series of USACE Dredging Operations and Environmental Research (DOER) Program technical notes (Johnson et al. 2000 and Swanson et al. 2000); at a previous World Dredging Conference (Anderson et al. 2001) and a series of Western Dredging Association Conferences (Swanson et al., 2006; Swanson and Isaji, 2004). In addition SSFATE has been further developed to include the simulation of cable and pipeline burial operations using water jet trenchers (Swanson et al., 2006), and mechanical plows, and has been used to evaluate natural gas pipeline installations in New York Harbor (ASA, 2011), Massachusetts Bay (ASA, 2005), Tampa Bay (ASA, 2008), and Jobos Bay, Puerto Rico (RPS ASA, 2015).

SSFATE utilizes a Lagrangian (or particle-based) scheme to represents the total mass of sediments suspended over time. The particle-based approach is extremely robust in that it provides a method to track suspended sediment without any loss of mass as compared to Eulerian (continuous) models due to the nature of the numerical approximation used for the conservation equations. Thus, the method is not subject to artificial diffusion near sharp concentration gradients and can easily accept all types of sediment sources. Transport, dispersion and settling of sediment particles released to the water column are predicted using a random-walk procedure. The focus of the model is on the far-field (i.e. immediately beyond the initial release jet) processes affecting the fate of suspended sediment. The model uses specifications for the suspended sediment source strengths (i.e. mass flux), vertical distributions of sediments and sediment grain-size distributions to represent the effect of different types of sediment disturbing activities. Multiple sediment types or fractions can be simulated simultaneously, as can discharges from moving sources. In addition, enhanced settling rates due to flocculation and scavenging have been implemented in SSFATE.

At the end of each model time step the suspended concentration of each sediment class as well as the total concentration is computed on a concentration numerical grid. The size of the grid cells is constant, with the total number of cells increasing as the suspended sediment moves away from the dredging source. The settling velocity of each particle size class is computed along with a deposition probability based on shear stress. Finally the deposition of sediment within each cell of the concentration grid from each size class during the current time step is computed and the calculation cycle begins anew. Deposition is calculated as the mass of sediment particles that accumulates over a unit area. Because the amount of water is not known in the deposit, SSFATE by default converts deposition mass to thickness by assuming no water content.

3.2. SSFATE Model Application

3.2.1.1 Scenario Development

SSFATE was used to simulate the suspended sediment concentration and subsequent deposition resulting from a range of activities that result in seabed disturbance offshore Moheshkhali Island. The pipeline will run approximately 7.5 km between the delivery point (KP0) and the FSRU terminal (KP7.548). Pipeline installation will be conducted in four stages:

1. Pre-trenching of the landfall channel by amphibious (land/water) excavators (KP0 – KP0.5).
2. Hydraulic dredging of the main approach area for lay barge access (KP0.5 – KP2.287).
3. Post-lay trenching of the offshore portion of the pipeline via sledge (KP0.5 – KP7.548).
4. Burial of the landfall section following shore pull of the pipeline (KP0 – KP0.5).

SSFATE was used to simulate sediment losses to the water column during the first three stages of installation. (Sediment dispersion patterns from Stage 4 are generally expected to be similar to Stage 1). The approximate location and dimensions of each construction footprint is based on the General Installation Method Statement prepared by GEOCEAN and MacGregor (GEOCEAN, 2016b) and is shown in Figure 11.

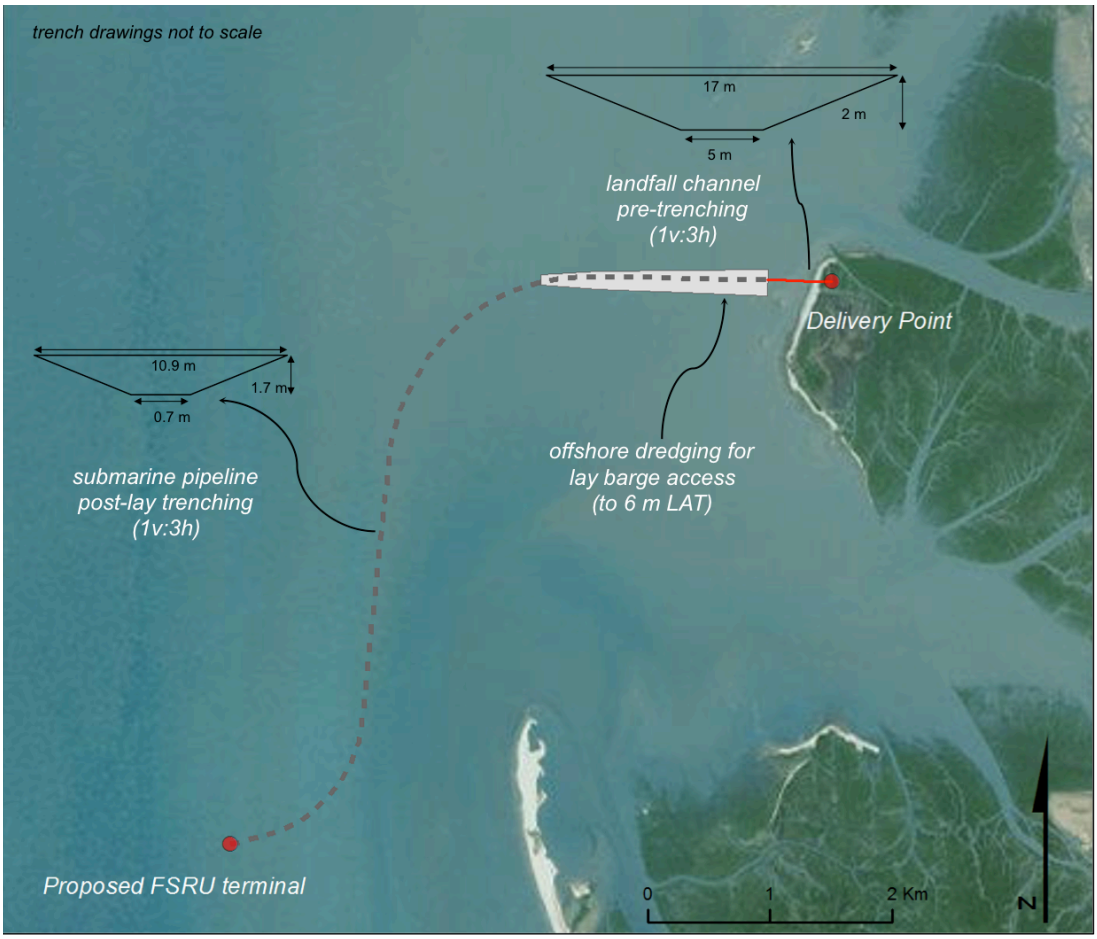


Figure 11. Map of proposed excavation/dredging activities and corresponding trench dimensions. (Trench dimensions estimated using a 1v:3h slope.)

Sediment losses from each excavation/installation activity were represented in the model by characterizing the source strength, vertical distribution, and grain-size distribution for the sediment load. As the final schedule may change because operational constraints or regulatory approvals, the modeling was performed using arbitrary starting dates in December 2016. The duration of each activity was calculated using standard production rates and assuming continuous releases during the period of operation, which ranges from 3.1 to 18.3 days. To ensure that the modeling captured the potential plume and seabed impacts at different stages of the ebb/flood tidal cycle, two scenarios were developed for each construction stage (3) based on a start date of December 1 and December 15 (Figure 12). Further details describing each stage of installation are provided below and summarized in Table 4.

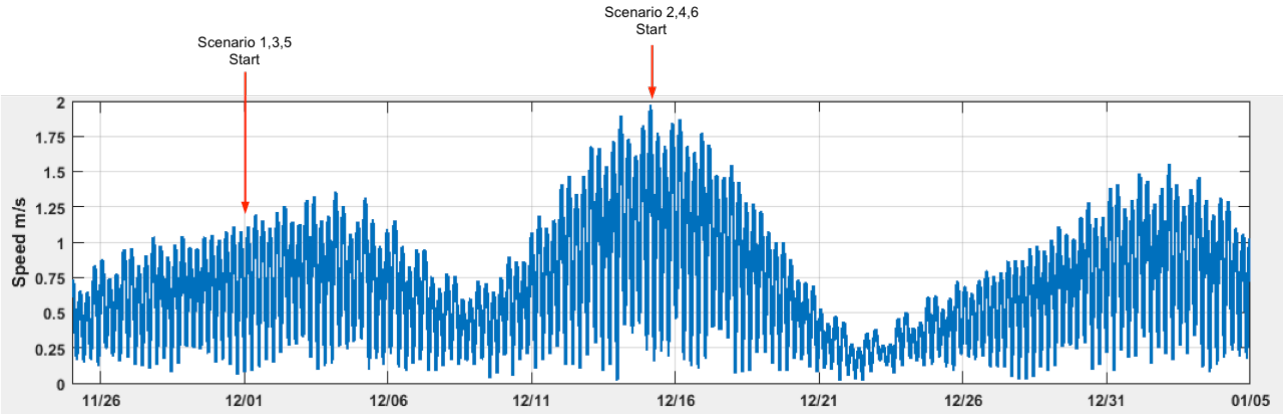


Figure 12. Time series of HYDROMAP predicted current speeds at the observation station (OBS) for periods selected for SSFATE scenarios.

Stage 1 – Landfall channel pre-trenching

Stage 1 will take place prior to pipeline installation and entails excavation of a landfall channel between the onshore delivery point and a location approximately 500 m seaward. Excavation will be achieved using a marine autonomous excavator (e.g. GEOCEAN MAX or SuperMAX). The first portion of this route will extend across the subaerial beach, into the intertidal zone and eventually to water depths of 3-4 meters. The sediment volumes for Stage 1 activities were calculated based on a 500 m long trench approximately 2 m deep and 5 m wide at the base. To account for potential failure of trench sidewalls, the cross-sectional area of the trench was estimated using a 1v:3h slope. Approximately 350 m of the trench route lies seaward of the shoreline where sediment resuspension and transport by waves and currents are active processes. Scenarios 1 and 2 (Table 4) simulate potential losses from the excavator bucket during Stage 1 pre-trenching.

Stage 2 – Hydraulic dredging of approach area

The second stage of construction involves the deepening of an offshore approach area from the landfall channel to a depth of 6 m LAT (KP0.5 - KP2.287) to provide access for the pipeline lay barge. Excavation will take place by hydraulic dredging (cutter suction dredger [CSD] and/or trailing suction hopper dredger [TSHD]) with dredged sediments transported to an offshore discharge location by floating pipeline or hopper. Details provided by GEOCEAN (2016b) indicate that the dredged area will be 60 m in width and extend approximately 1,787 m in the cross-shore direction, roughly parallel to the pipeline route. Excavation volumes were estimated using the above dimensions and client-provided drawings of the nearshore bathymetry. Scenarios 3 and 4 (Table 4) simulate potential losses from the dredge head during Stage 2.

Stage 3 – Post-lay pipeline trenching

During Stage 3, the offshore portions of the pipeline will be buried using a post-trenching sledge (MASURCA), which will make multiple passes over the pipe following its placement on the seabed. During each pass, hydraulic jets will be used to fluidize the underlying sediments and lower the pipeline in stages to a final depth of 1.7 m below the seabed (1 m of sediment cover). The proposed trench length is 7,048 m (Figure 11). To account for the potential failure of trench sidewalls, the cross-sectional area of the trench was estimated using a 1v:3h slope. Scenarios 5 and 6 (Table 4) simulate potential sediment resuspension from jetting during Stage 3 activities.

Table 4. Description of simulated activities for each modeling scenario.

Scenario	Simulation Start Date	Construction Activity	Operating Zone	Feature Length (m)	Total Volume (m^3)	Duration (day)
Scenario 1	1-Dec-16	Landfall channel excavation (pre-trenching) by clamshell excavator	500 m seaward of delivery point (KP0 - KP0.5)	500	11,000	3.1
Scenario 2	15-Dec-16					
Scenario 3	1-Dec-16	Hydraulic dredging of main approach trench for lay barge access	Landfall channel to 6m depth contour (KP0.5 - KP2.287)	1,786	439,602	18.3
Scenario 4	15-Dec-16					
Scenario 5	1-Dec-16	Offshore burial via post-trenching sledge (MASURCA)	Landfall channel to FSRU terminal (KP0.5 - KP7.548)	7,048	69,493	15.0
Scenario 6	15-Dec-16					

3.2.1.2 Sediment Source Strength

Each stage of construction was simulated as a line source (a moving point representing sediment loading to the water column). The advance speed and losses at each time step along the route are model parameters that are based on the excavation method. Further details describing the sediment source strength for each stage of construction are provided below and summarized in Table 5.

Table 5. Parameters used to characterize sediment source strength for each construction activity.

Construction Stage	Activity	Source of Sediment Losses	Production (m^3/hr)	Advance Rate (m/hr)	Loss Rate (%)
Stage 1	Landfall channel excavation (pre-trenching)	SuperMAX excavator bucket	150	6.8	2.10
Stage 2	Hydraulic dredging of main approach area	CSD dredge head	1000	7.9	0.77
Stage 3	Offshore burial via post-trenching sledge	MASURCA jet sledge	194	58.9	25.00

Stage 1 – Landfall channel pre-trenching

Pre-trenching of the landfall channel will be achieved using marine autonomous excavators designed for use in shallow water areas. To parameterize the model line source it was assumed that excavation (and thus losses to the water column) would occur over a single pass along the trench route. A sediment loss rate of 2.1% of the excavated volume was selected for the SSFATE simulations based on average loss rates from a range mechanical dredging programs summarized by Anchor Environmental (2003).

The duration of the trenching segment between KP0 and KP0.5 was calculated using a production rate of 150 m^3/hour (based on the 2.5 m^3 bucket specification for the SuperMAX and a cycle time of 60 seconds [Bergeron, 2000]). The sediment load released to the water column is a fraction of the sediment volume that is lost during (i) the initial impact and closure of the bucket, which produces a pulse of resuspended sediment above the bed, (ii) leakage as the bucket ascends through the water and breaks the water surface, and (ii) spillage and wash-off of residual sediment as the bucket descends and the next cycle begins. Accordingly, the vertical distribution of sediments used to initialize the SSFATE model reflects losses throughout the full water column (Figure 13).

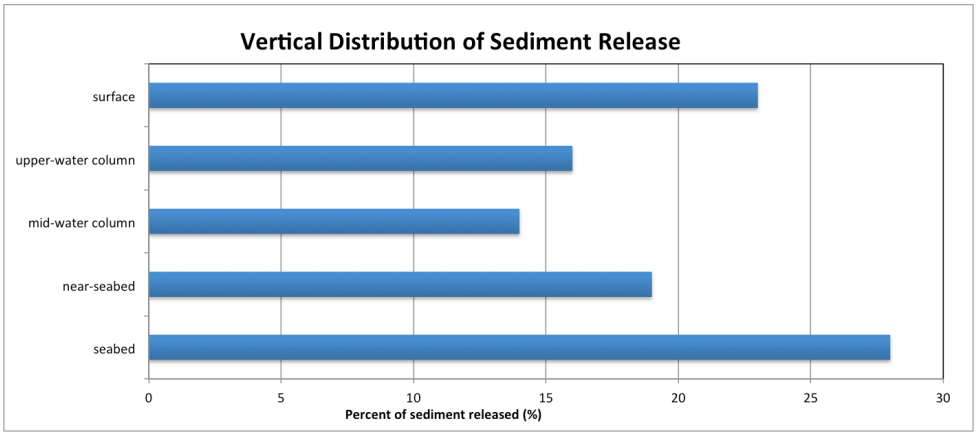


Figure 13. Vertical distribution of sediment released during landfall pre-trenching scenarios in SSFATE (Scenarios 1 and 2).

Stage 2 – Hydraulic dredging of approach area

Excavation of the lay barge approach area will take place by hydraulic dredging methods (CSD or TSHD) with dredged sediments transported to an offshore discharge location by floating pipeline or hopper. In reality, the dredge will advance at a varying rate throughout the route depending upon the volume of sediment required to deepen a given location to 6 m LAT. However, to parameterize the operation within SSFATE, a constant advance rate was used based on average production of 1000 m^3/hour and the total dredge volume. The advance rate also assumes the dredging will require two passes (approximately 20 m apart) within the excavation footprint. The dredging operation was simulated as a loop, starting offshore (KP2.287), advancing to KP0.5, and returning offshore along a parallel dredge path. Sediment losses were set to 0.77% of the dredged volume based on average loss rates from hydraulic dredgers summarized by Anchor Environmental (2003). Resuspension from hydraulic dredging is typically limited to the near-bottom, in the vicinity of the cutter or suction pipe (Bridges et al., 2008) and therefore the vertical distribution used for dredging scenarios confined releases to 2 meters above the seabed (Figure 16).

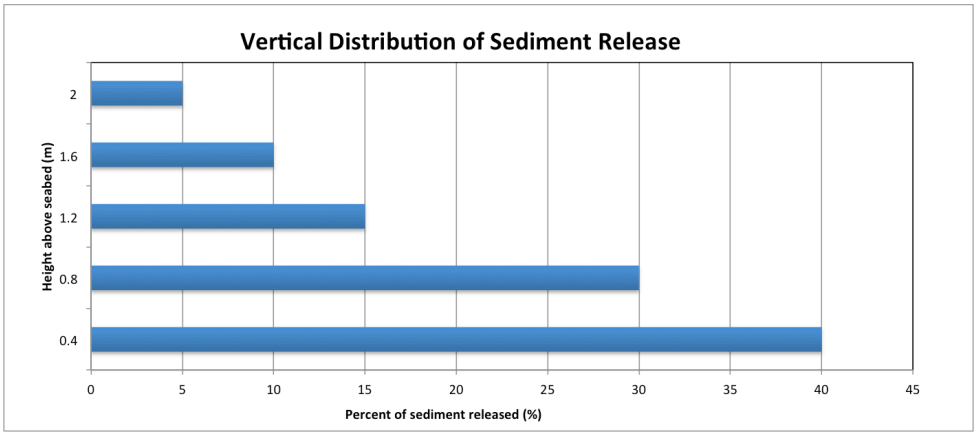


Figure 14. Vertical distribution of sediment released during hydraulic dredging scenarios in SSFATE (Scenarios 3 and 4).

Stage 3 – Post-lay pipeline trenching

Previous information provided by Excelerate indicated that the post-trenching process would require approximately 30 days for the installation of a ~7 km pipeline. A production rate of 193.6 m^3/hour was calculated based on the trench specifications and the assumption that construction would require a daily 12-hour work schedule and that the pipe would be buried in three passes at an advance rate of 58.9 m/hour. The modeling simulated each of the following burial passes in sequence (beginning at the offshore terminal):

- Pass 1 – Sled pass between the FSRU terminal and landfall channel (offshore – onshore)
- Pass 2 – Sled return from landfall channel to FSRU terminal (onshore – offshore)
- Pass 3 – Final pass between the FSRU terminal and landfall channel (offshore – onshore)

Sediment disturbance areas for each pass were set equal to one third of the total trench cross section. During each pass, it was assumed that 25% of the disturbed sediment volume would be resuspended into the water column by the jetting activity. This is a conservative estimate consistent with previous studies that found a range of 10 to 35% (Foreman, 2002). As with previous simulations, releases to the water column were vertically distributed within 5 equal bins of the water column (Figure 15). The majority of sediment resuspended during jetting (90%) is expected to remain within 1 m of the seabed.

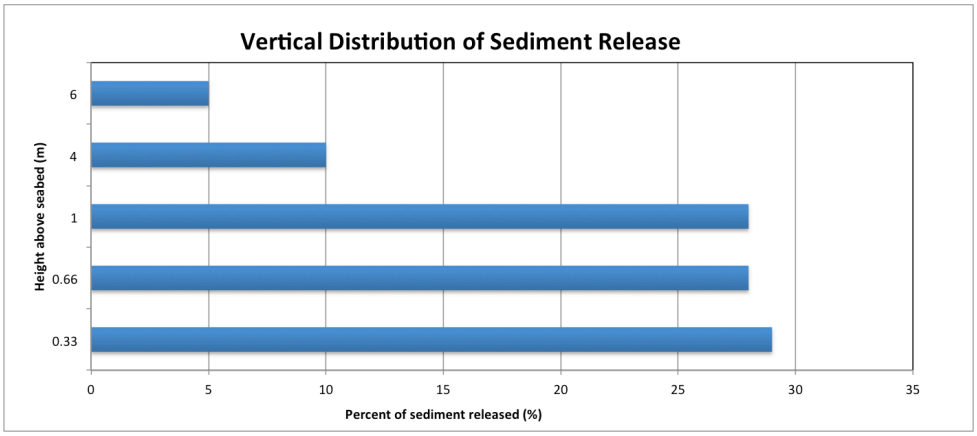


Figure 15. Vertical distribution of sediment released from post-trenching activity used in SSFATE (Scenarios 5 and 6).

3.2.1.3 Sediment Characteristics

Five boreholes and four surface grab samples recovered from the project area as part of a geotechnical site investigation for a proposed deep sea port near Sonadia Island (PCI, 2009) were used to characterize grain size distributions within the model. Figure 16 shows the location and classification of sediment samples with respect to the proposed pipeline route and Figure 17 presents a graph of the relative size distributions for each sample location. This arrangement of the grain size data (west to east, along the pipeline route) indicates a general shift in lithology between offshore locations and the channel and mangrove forests at the eastern end of the study area. Mean grain sizes generally increase closer to the channel mouth while sediments along the pipeline route have higher percentages of silt and clay.

Table 6 lists the sediment grain size distributions used as input to the model at each sample location. For boreholes, the size distribution represents a depth-weighted average using samples collected from the uppermost 2 m of the recovered sediment. The solid fraction listed in Table 6 was calculated from the reported specific gravity and moisture content of each sample.

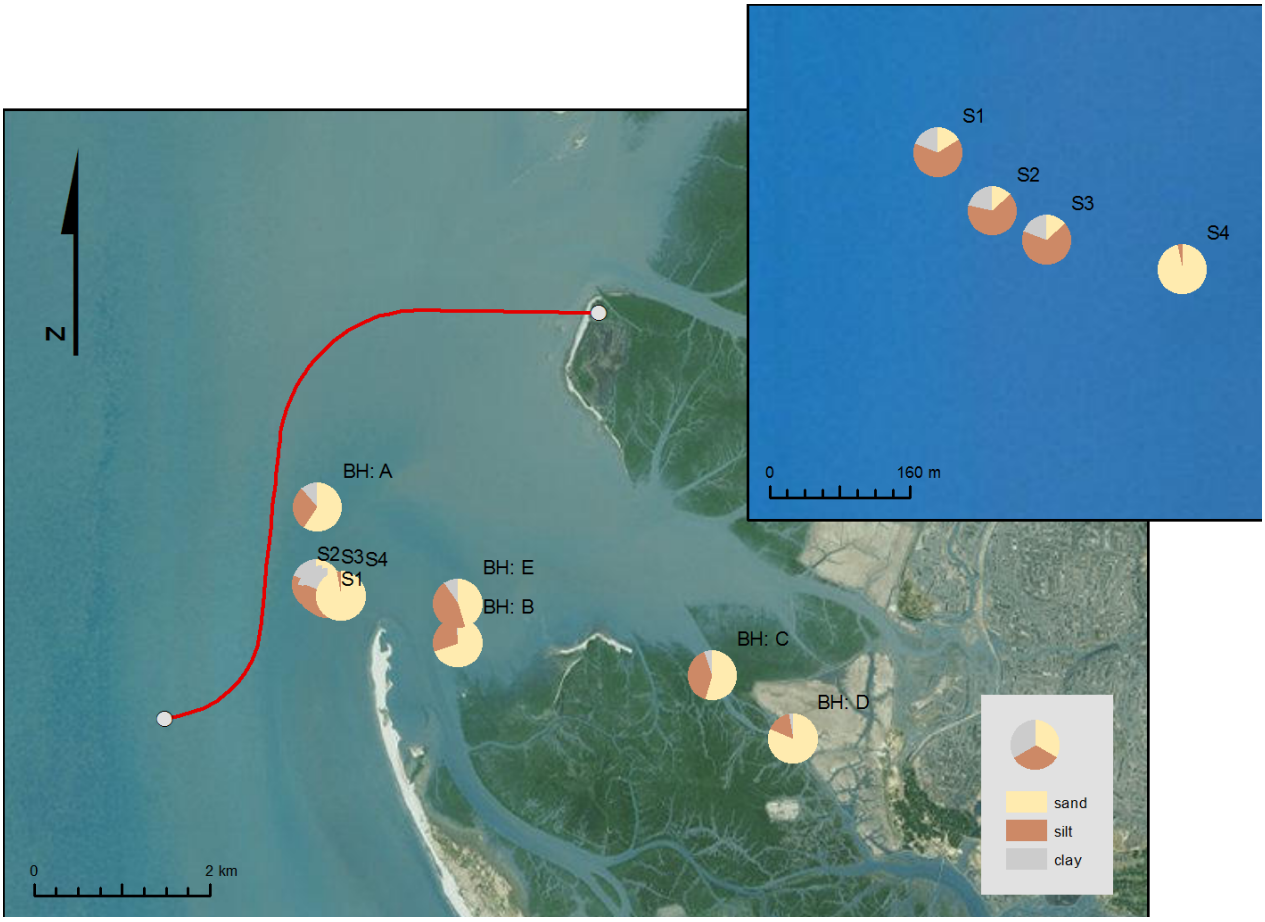


Figure 16. Location and classification of offshore sediment samples. Inset shows cluster of samples east of the pipeline route.

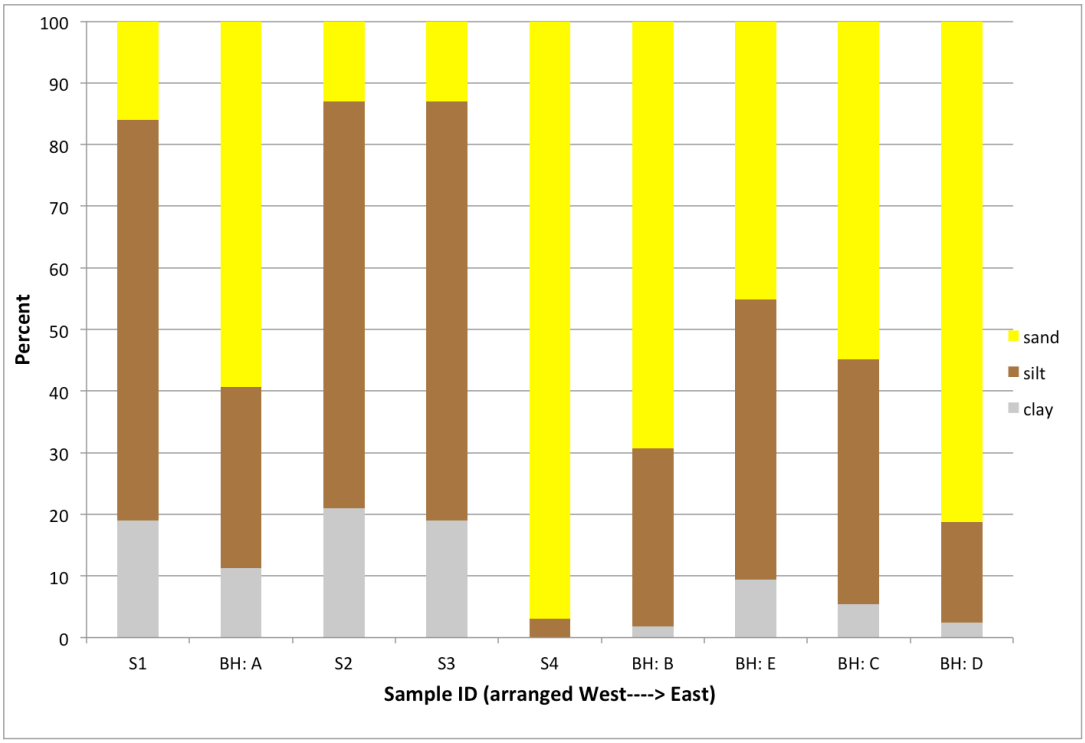


Figure 17. Grain size distribution data for each sediment sample location.

Table 6. Sediment size distribution (class types in percentages) used for modeling based on information provided by client.

Sample ID	% Coarse Sand	% Fine Sand	% Coarse Silt	% Fine Silt	% Clay	%Solid
BH: A	29.68	29.68	14.68	14.68	11.29	57.3
BH: B	34.65	34.65	14.47	14.47	1.76	57.7
BH: C	27.41	27.41	19.88	19.88	5.41	57.9
BH: D	40.65	40.65	8.12	8.12	2.47	57.6
BH: E	22.59	22.59	22.71	22.71	9.41	61.1
S1	8.00	8.00	32.50	32.50	19.00	57.7
S2	6.50	6.50	33.00	33.00	21.00	58.2
S3	6.50	6.50	34.00	34.00	19.00	58.2
S4	48.50	48.50	1.50	1.50	0.00	58.1

3.3. SSFATE Model Results

A total of six deterministic SSFATE simulations were performed, corresponding to pre-trenching, dredging, and post-trenching activities at different tidal stages (Table 4). The results from the model runs are presented below in maps showing the predicted total suspended sediment (TSS) concentration and subsequent deposition along the proposed pipeline route, and in tables listing the area covered by suspended sediment plumes and sediment deposition at selected concentrations and thicknesses. Concentrations reported here are those that are predicted above the background concentration (i.e., a concentration of 0 mg/L equals the background/ambient concentration in the coastal waters surrounding Moheshkhali Island). Owing to the high ambient TSS concentrations observed in the offshore waters near the project area (see for example Table 2.2.1 from PCI, 2009), results are presented to show areas where the sediment plume exceeds the 30 mg/L concentration threshold - representing approximately 20% of the lowest observed natural TSS for the region.

Suspended Sediment Concentrations

Suspended sediment concentrations presented in the figures below show the maximum concentration the model predicts at any time during the post-trenching process and at any depth in the water for each simulation. The maximum concentrations predicted are a composite in both space and time; they do not represent any instantaneous snapshot of water column concentrations, but instead show the maximum, time-integrated suspended sediment within the study domain during each scheduled release. The predictive results presented are therefore inherently conservative.

For each simulation, the shape of the plume generally reflects the local circulation and bathymetric features along the pipeline route. Elevated suspended sediment concentrations are predicted to occur on either side of the pipeline route but are notably elongated near the FSRU terminal and near the proposed dredging area where the pipe runs perpendicular to the orientation of the tidal current. By far, the greatest and most sustained TSS concentrations are predicted from post-trenching burial activities (Scenarios 5 and 6), likely due to the high loss rates expected from the jet sledge compared to other sources. For all scenarios, concentrations at or above 30 mg/L generally remain within 1 km of the pipeline route, although isolated and short-lived plumes of finer suspended material are seen in deeper water, 3 to 5 km from the FSRU terminal point during post-lay trenching. Table 6 summarizes the areal extent of each plume at various concentration thresholds. Results from each activity are briefly summarized below.

Table 7. Areas of total suspended sediment concentration exceeding certain thresholds for each model scenario.

Plume concentration (mg/L)	Cumulative area exceeding (km^2)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
> 30	0.001	0.002	0.266	0.523	8.273	7.130
> 50	-	-	0.102	0.132	4.823	4.270
> 100	-	-	0.002	0.001	1.953	1.607
> 200	-	-	-	-	0.479	0.386
> 500	-	-	-	-	0.002	0.006

Stage 1 – Landfall channel pre-trenching

Suspended sediment concentrations at or above 30 mg/L occur rarely during the pre-trenching activities. The lower production rate and sandy sediments near the channel result in a relatively low sediment load to the water column for this activity. Sediments that do become resuspended during post-trenching either settle or quickly disperse along the coast and as a result, elevated TSS concentrations are only observed in a few model grid cells. The maximum TSS concentrations predicted by the model are 33.3 mg/L for Scenario 1 and 31.6 mg/L for Scenario 2.

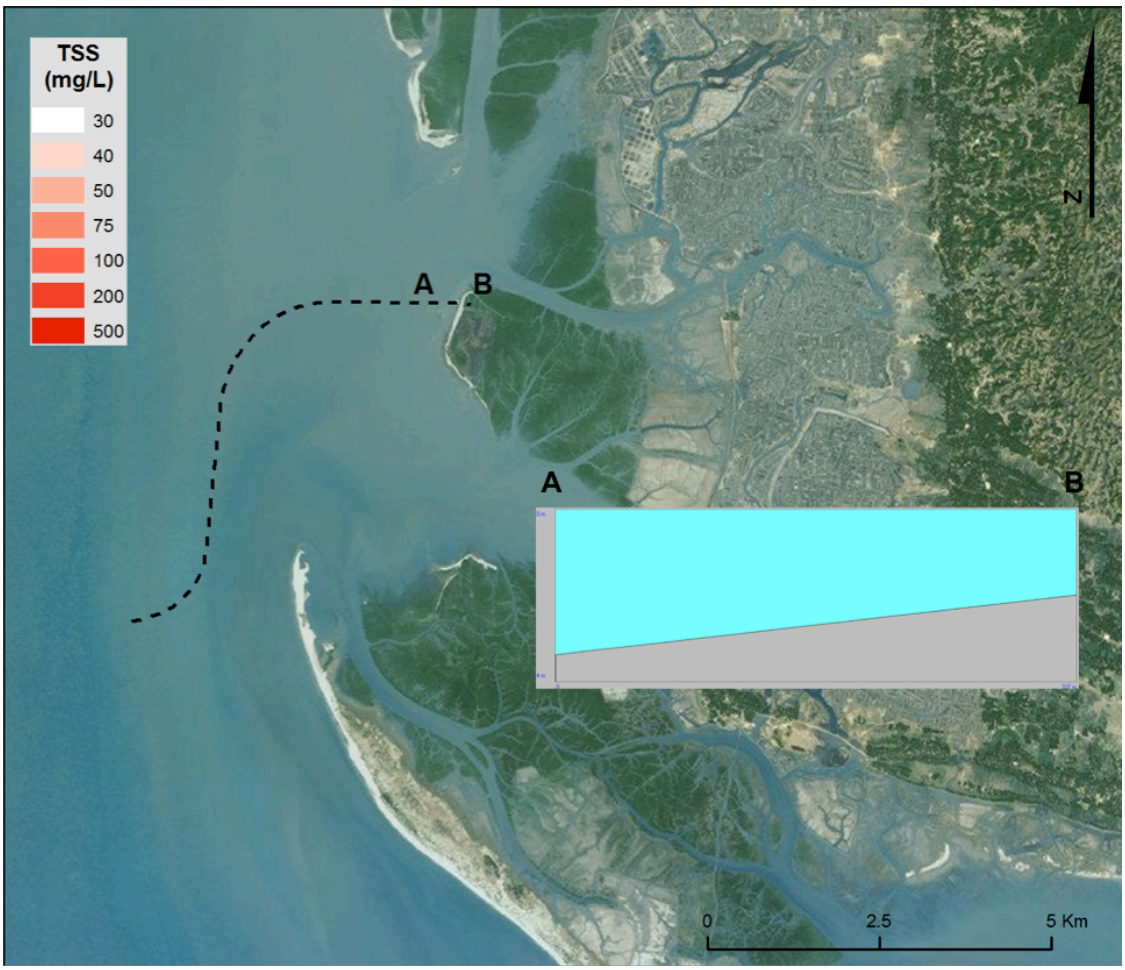


Figure 18. Scenario 1: maximum suspended sediment concentration resulting from pre-trenching excavation of the landfall trench (start date 1 December 2016). Vertical cross-section shows maximum concentrations along the pipeline route (dashed line). Note - model results are presented for concentrations exceeding 30 mg/L

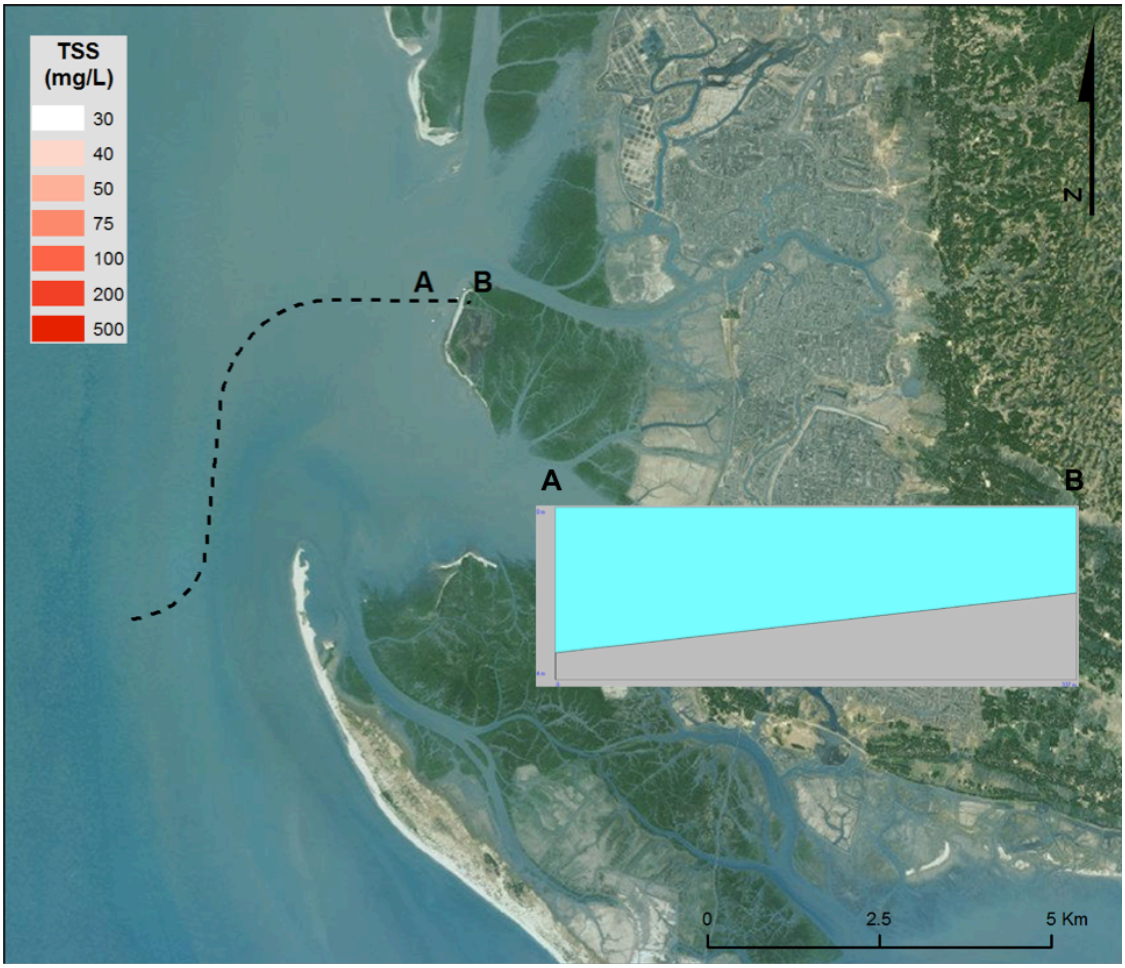


Figure 19. Scenario 2: maximum suspended sediment concentration resulting from pre-trenching excavation of the landfall trench (start date 15 December 2016). Vertical cross-section shows maximum concentrations along the pipeline route (dashed line). Note - model results are presented for concentrations exceeding 30 mg/L

Stage 2 – Hydraulic dredging of approach area

Elevated TSS levels during dredging activities are predicted to remain within the lower 2 meters of the water column and within 1 km of active dredge location. While the production rate of the dredge is comparatively high, losses at the dredge head are low and most resuspended material remains very close to the seabed. Sediment grain sizes become finer toward the seaward end of the approach area and as a result, plume concentrations become higher. The maximum TSS concentrations predicted by the model are 121.3 mg/L for Scenario 3 and 103.5 mg/L for Scenario 4. For both scenarios, concentrations return to levels below 30 mg/L within 6 hours of the conclusion of dredging activities.

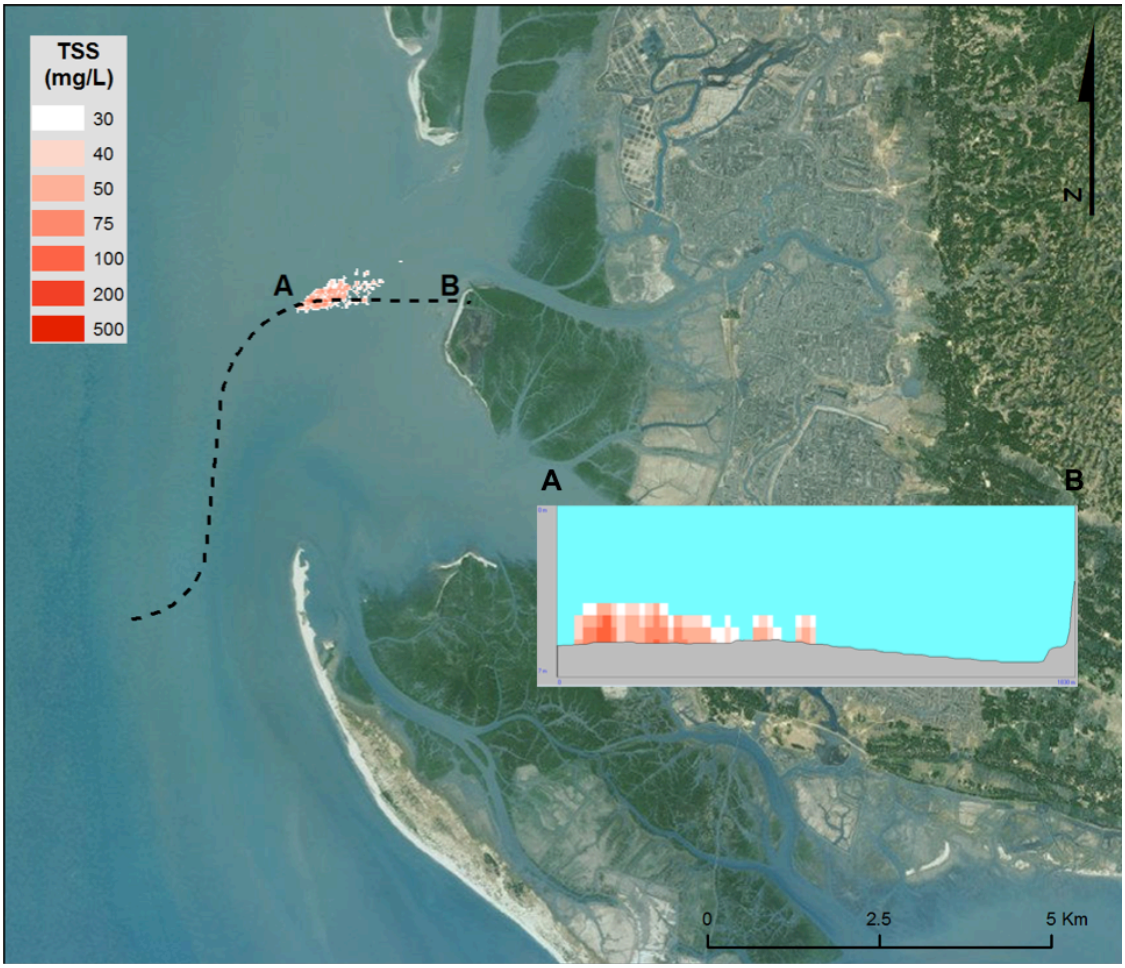


Figure 20. Scenario 3: maximum suspended sediment concentration resulting from hydraulic dredging of the main approach trench (start date 1 December 2016). Vertical cross-section shows maximum concentrations along the pipeline route (dashed line).

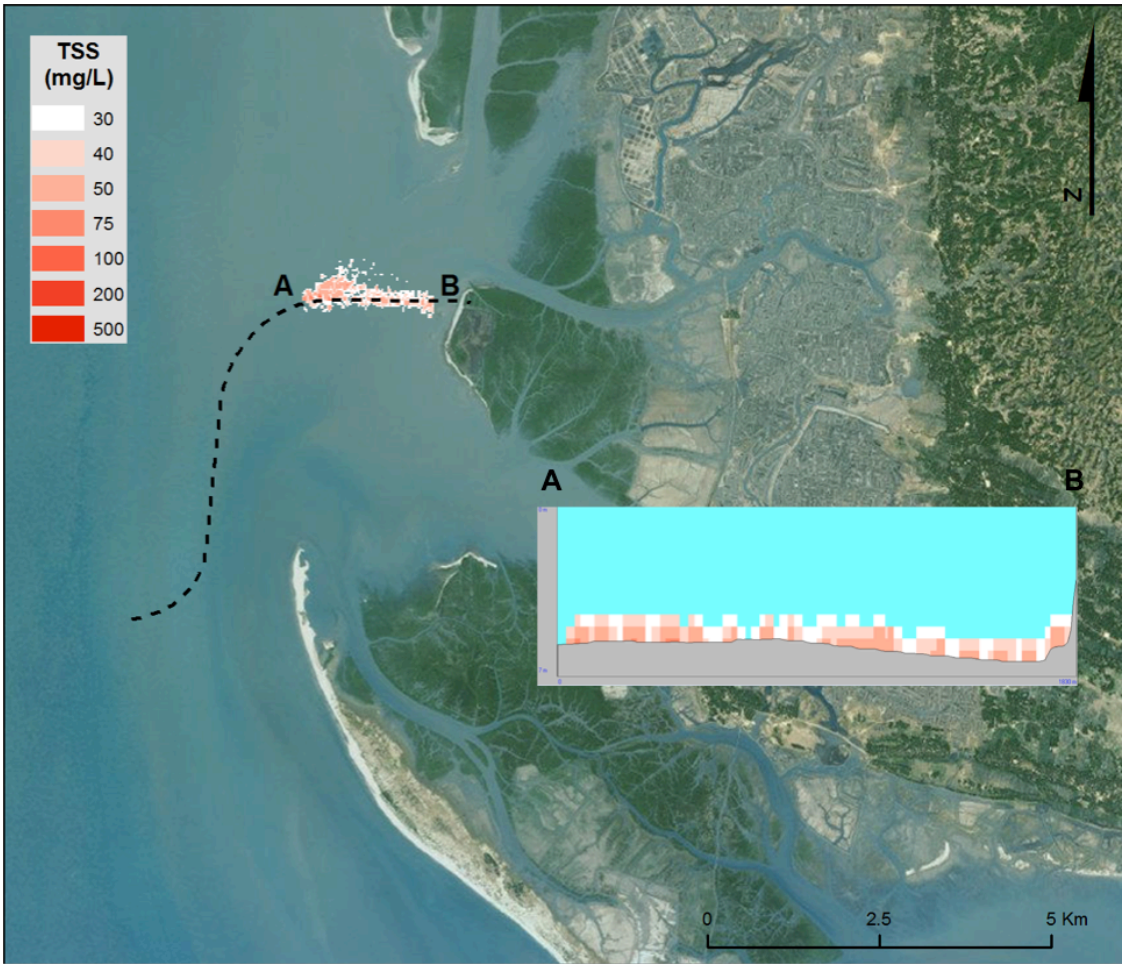


Figure 21. Scenario 4: maximum suspended sediment concentration resulting from hydraulic dredging of the main approach trench (start date 15 December 2016). Vertical cross-section shows maximum concentrations along the pipeline route (dashed line).

Stage 3 – Post-lay pipeline trenching

Plumes generated during post-trenching are more elongated (and occur at lower concentrations) near the southern extent of the route, as sediments are generally finer and flow velocities stronger further from the coast. The seabed sediments that are resuspended during post-trenching are advected along the coast in a pattern that is elongated north and south of the post-trenching site. As shown in the accompanying cross-section for each scenario, the suspended sediments typically remain within ~5 m of the seabed, except near the FSRU terminal where the plumes extend into deeper offshore waters. The maximum TSS concentrations predicted by the model are 618.4 mg/L for Scenario 5 and 644.5 mg/L for Scenario 6. For both scenarios, concentrations return to ambient levels within 12 hours of post-trenching activity.

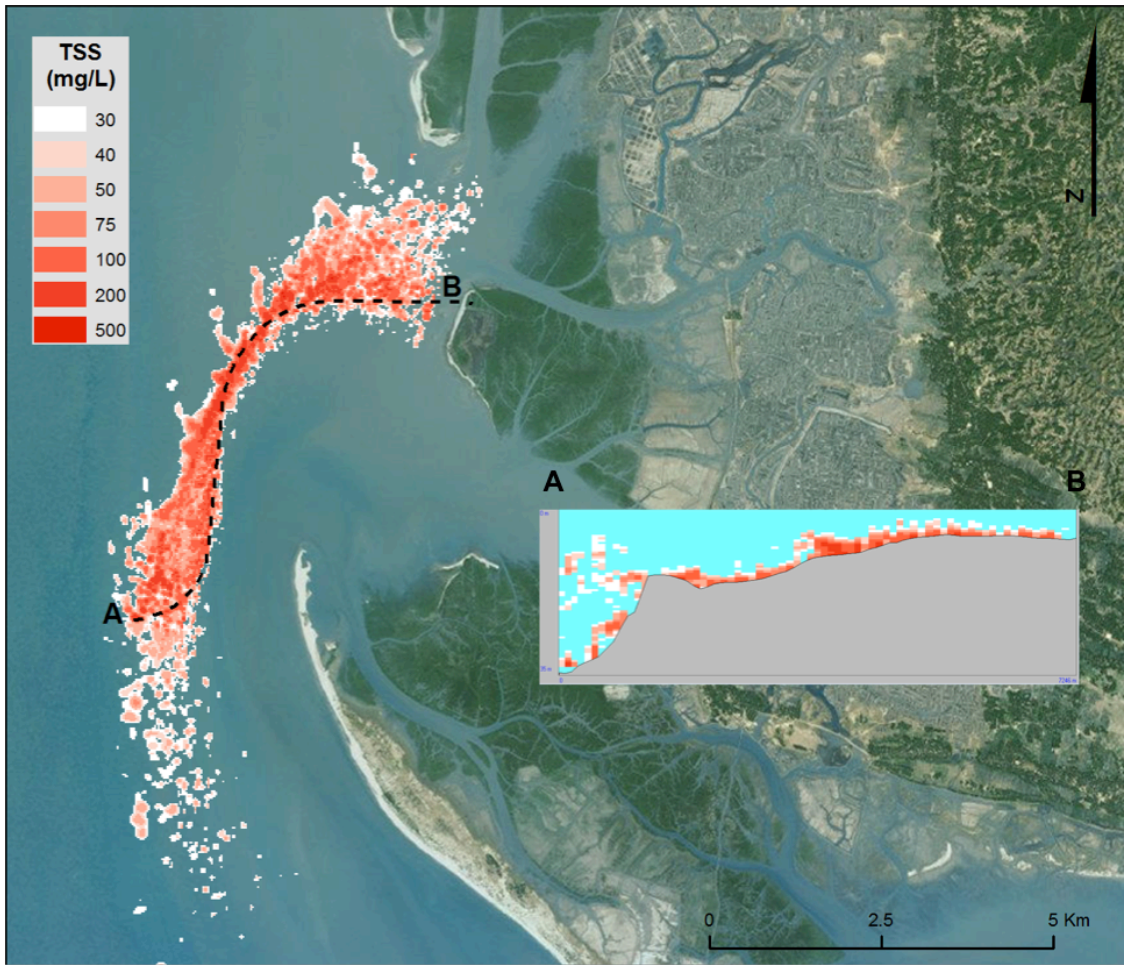


Figure 22. Scenario 5: maximum suspended sediment concentration resulting from post-lay trenching (start date 1 December 2016). Vertical cross-section shows maximum concentrations along the pipeline route (dashed line).

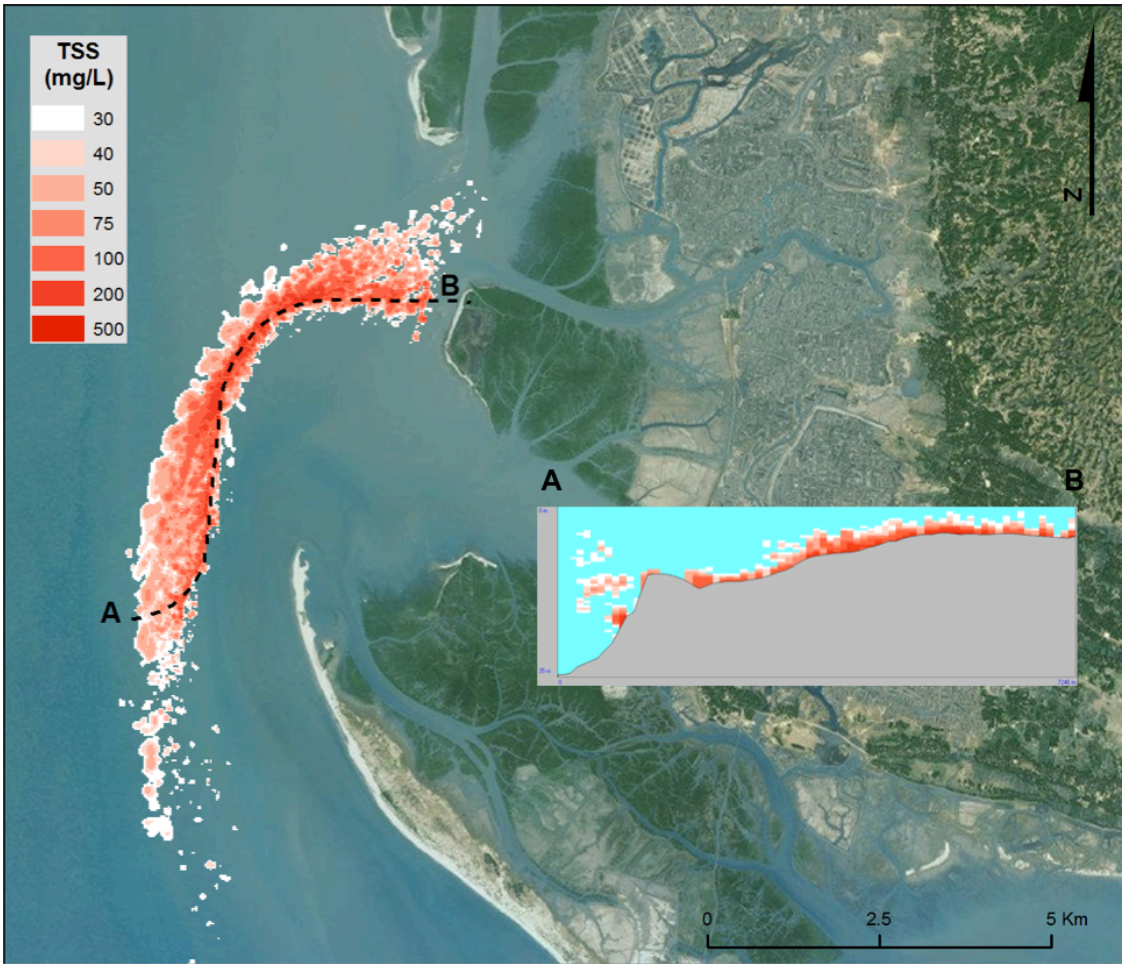


Figure 23. Scenario 6: maximum suspended sediment concentration resulting from post-lay trenching (start date 15 December 2016). Vertical cross-section shows maximum concentrations along the pipeline route (dashed line).

Sediment Deposition

SSFATE was also used to predict deposition on the seabed from resuspended sediment particles during each stage of the dredging and trenching operations. Each simulation was run for additional days following the construction activity to account for any prolonged settling of fine silt and clay particles from the water column. The output of each simulation was a concentration grid describing loading to the seabed from burial activities. Deposit thicknesses were then calculated using the mass loading to the seabed, bulk density of solids, and an assumption of no voids (zero porosity). The figures presented below show the model predicted seabed deposition that results from scenarios defined in Table 4.

For each activity, deposition is primarily confined to a narrow band extending approximately 200 – 300 m along either side of the trench. A few exceptions are noted for very low sediment loads (<1 mm) that extend up to 1 km from the pipeline location. As with TSS concentrations, deposition patterns are elongated near the FSRU terminal and near the proposed dredging area where the pipe runs perpendicular to the orientation of the tidal current and sediments are dispersed further from source. For all activities, deposition at or above 5 mm is limited to areas within 150 m of the pipeline route. As with the TSS results, the relatively fine-grained sediments near the offshore terminal site result in more prolonged settling of particles and greater dispersion around the construction area. Sediments that remain in suspension and are transported greater than 1 km from the construction zones are ultimately deposited at rates that are undetectable by the SSFATE model. Table 8 summarizes the areal impact of deposition for each dredge scenario.

Table 8. Areal extent of seabed accumulation for each dredge scenario at the end of the simulation.

Deposition (mm)	Cumulative area exceeding (km^2)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
> 0.1	0.074	0.072	0.505	0.444	2.151	1.961
> 1	0.008	0.002	0.235	0.219	0.931	0.922
> 5	-	-	-	0.010	0.212	0.237
> 10	-	-	-	-	-	-

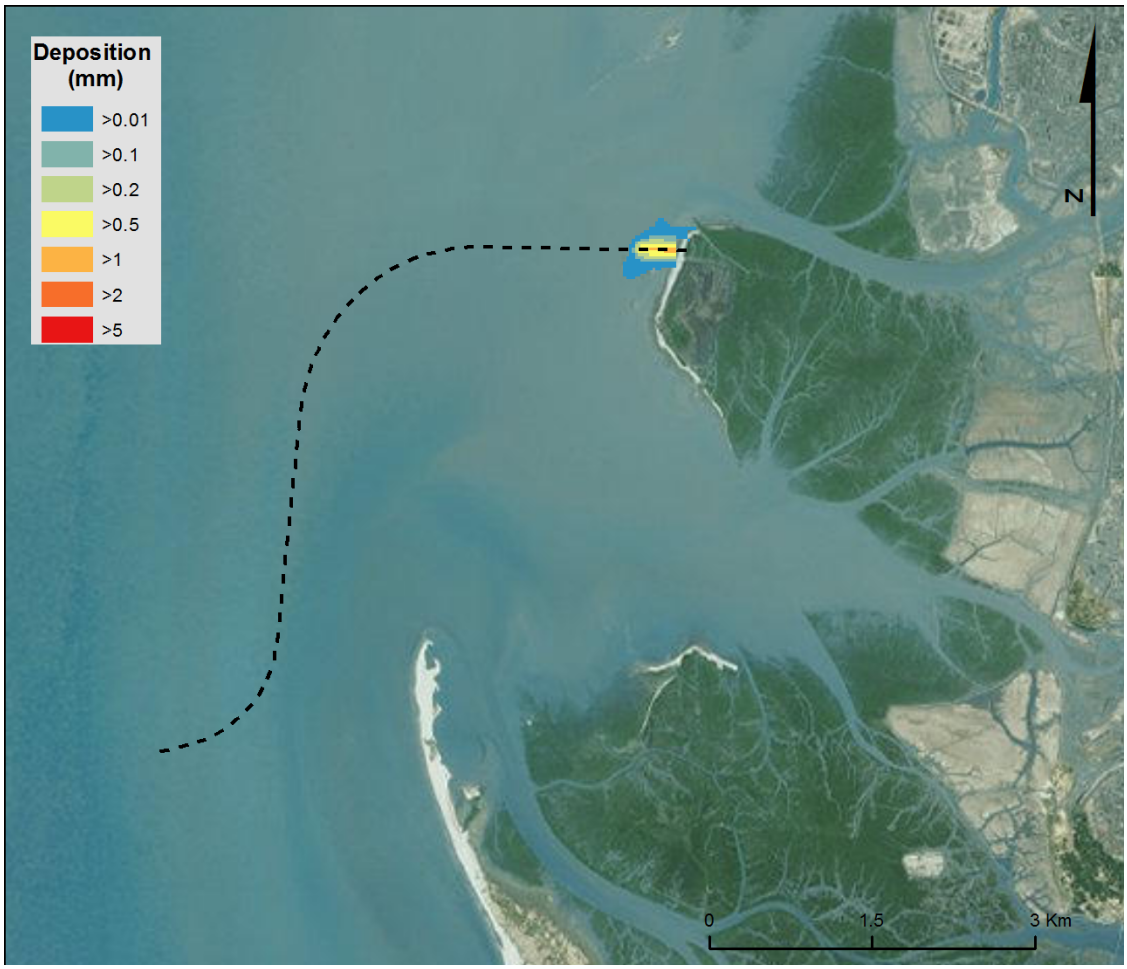


Figure 24. Scenario 1: extent of seabed deposition resulting from pre-trenching excavation of the landfall trench (start date 1 December 2016). Maximum predicted thickness = 1.19 mm.

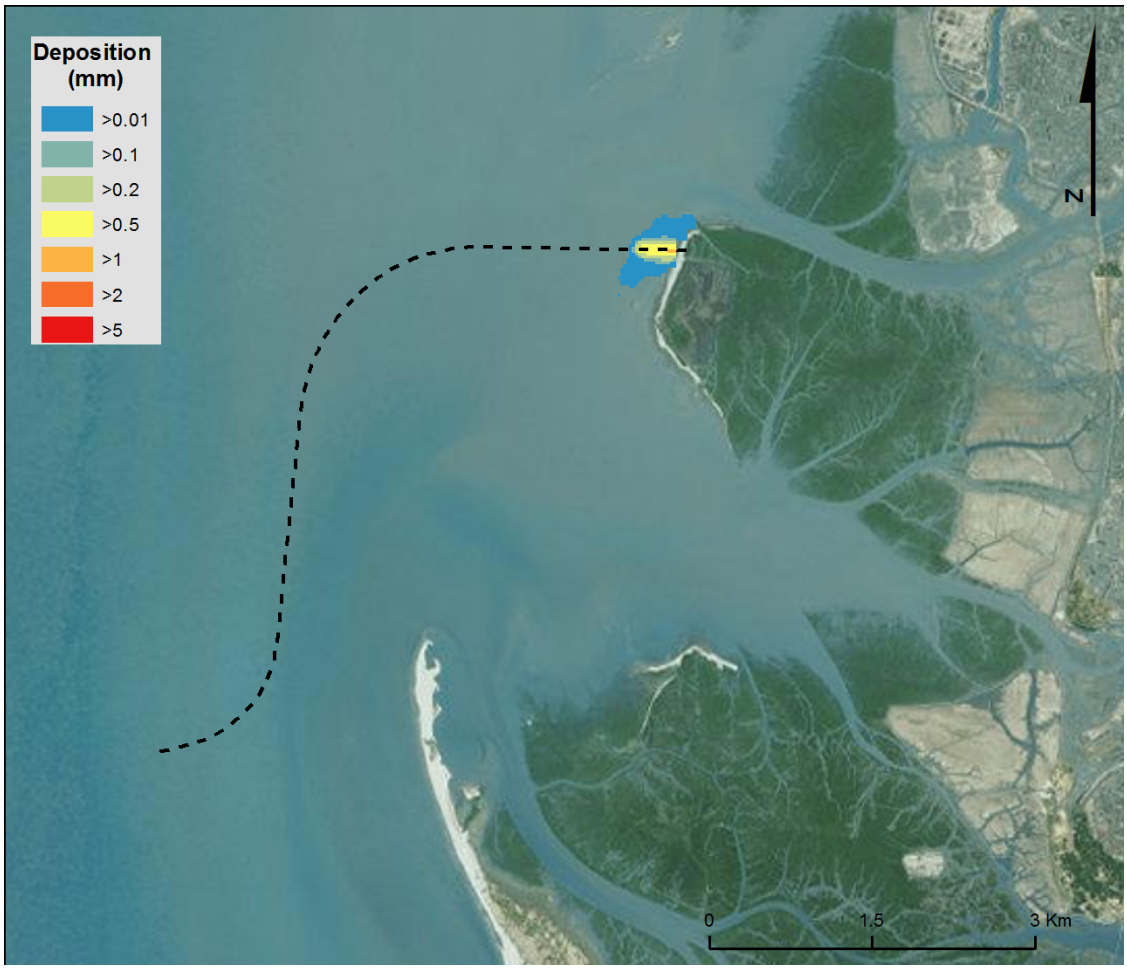


Figure 25. Scenario 2: extent of seabed deposition resulting from pre-trenching excavation of the landfall trench (start date 15 December 2016). Maximum predicted thickness = 1.07 mm.

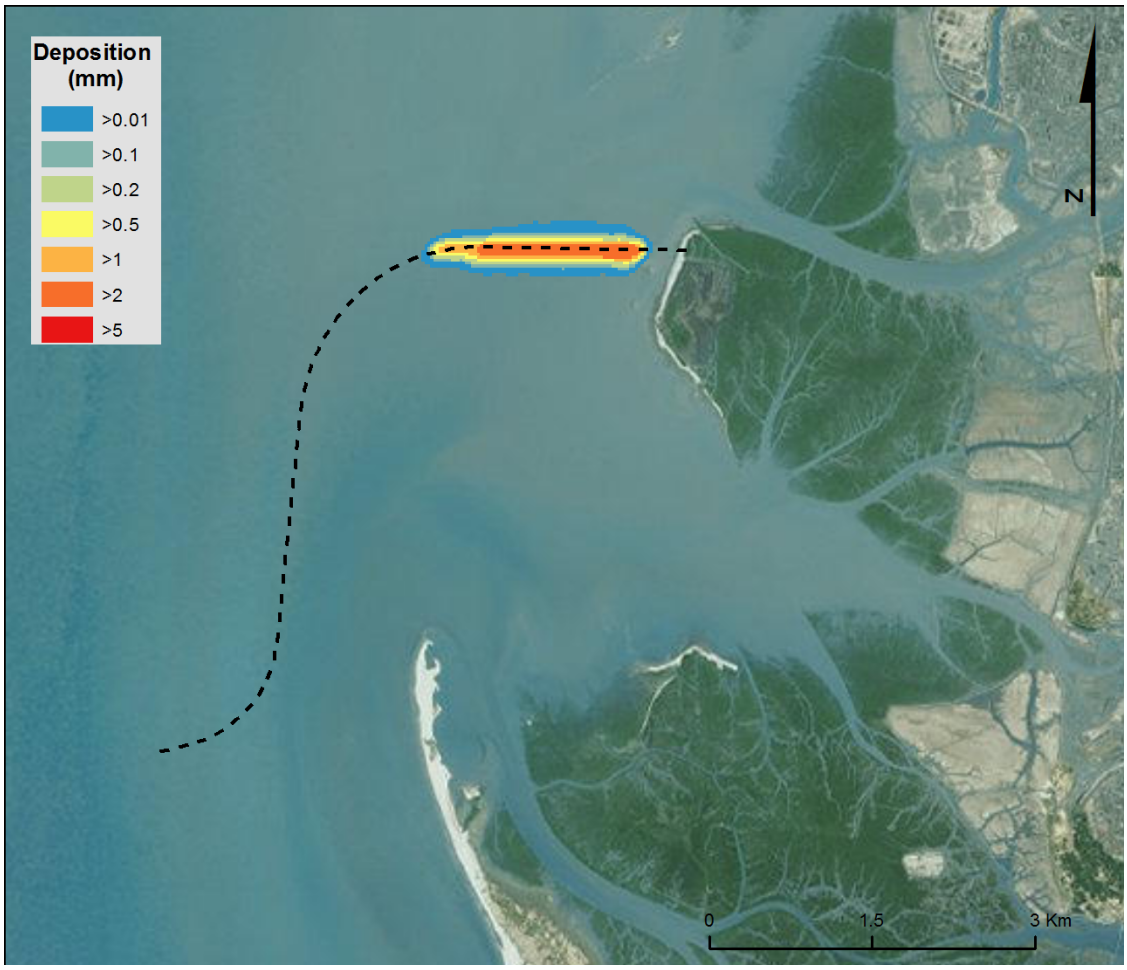


Figure 26. Scenario 3: extent of seabed deposition resulting from hydraulic dredging of the main approach trench (start date 1 December 2016). Maximum predicted thickness = 4.57 mm.

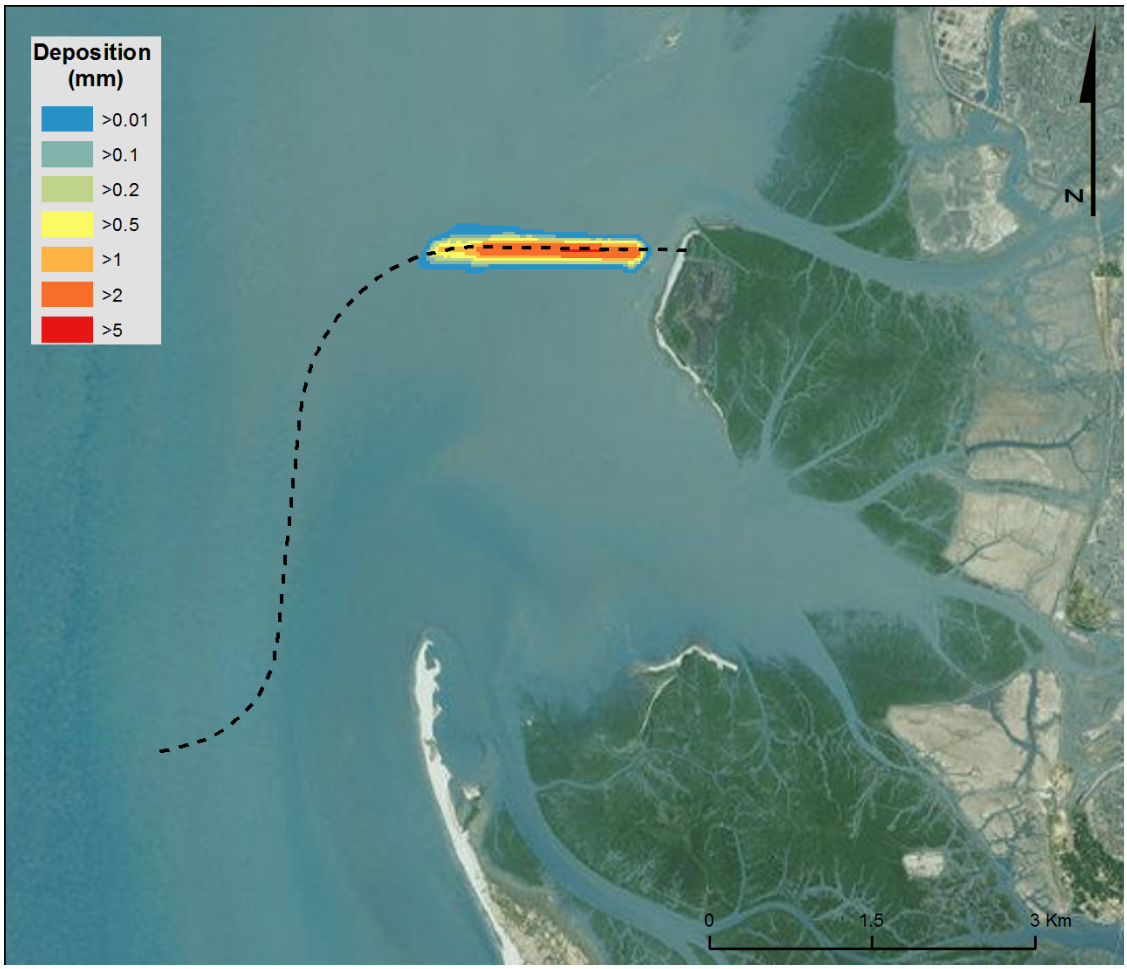


Figure 27. Scenario 4: extent of seabed deposition resulting from hydraulic dredging of the main approach trench (start date 15 December 2016). Maximum predicted thickness = 5.13 mm.

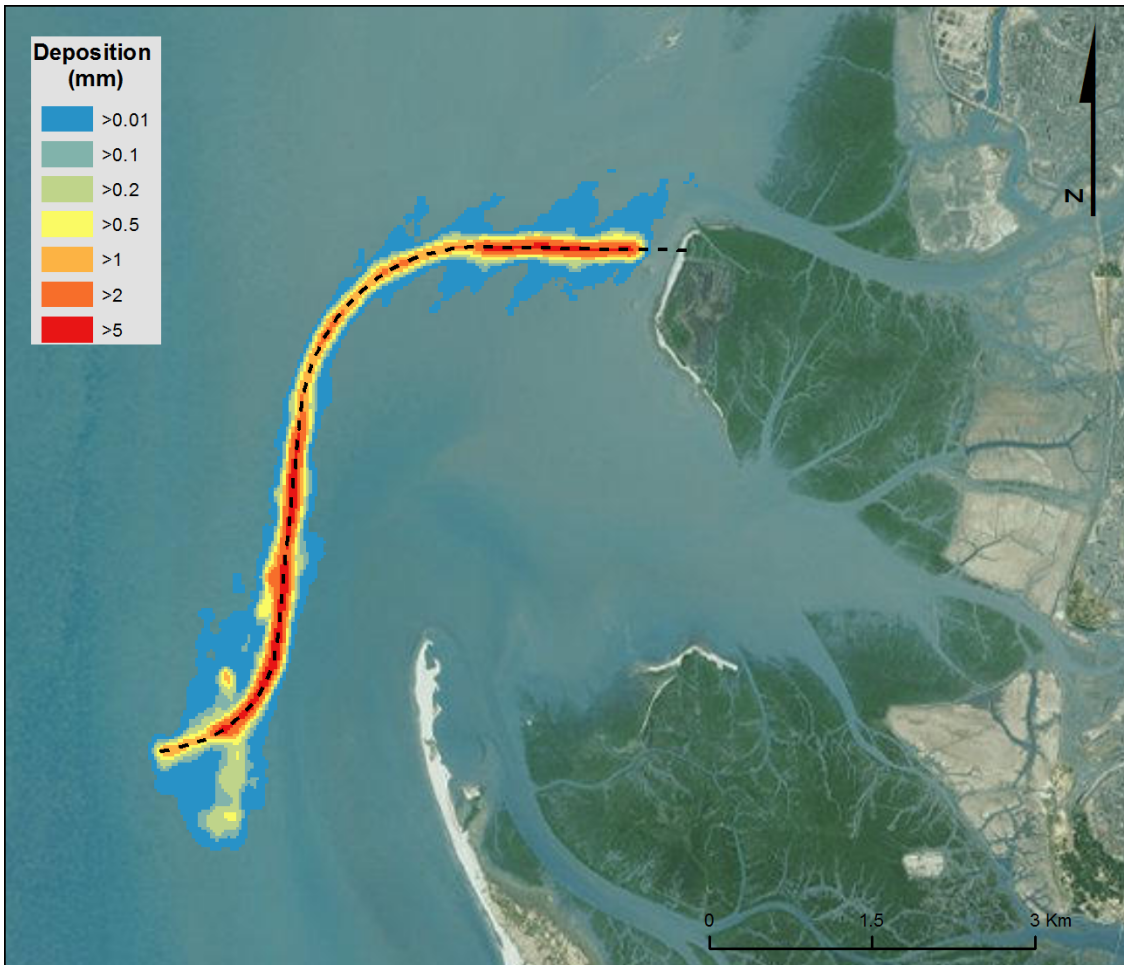


Figure 28. Scenario 5: extent of seabed deposition resulting from post-lay trenching (start date 1 December 2016). Maximum predicted thickness = 9.58 mm.

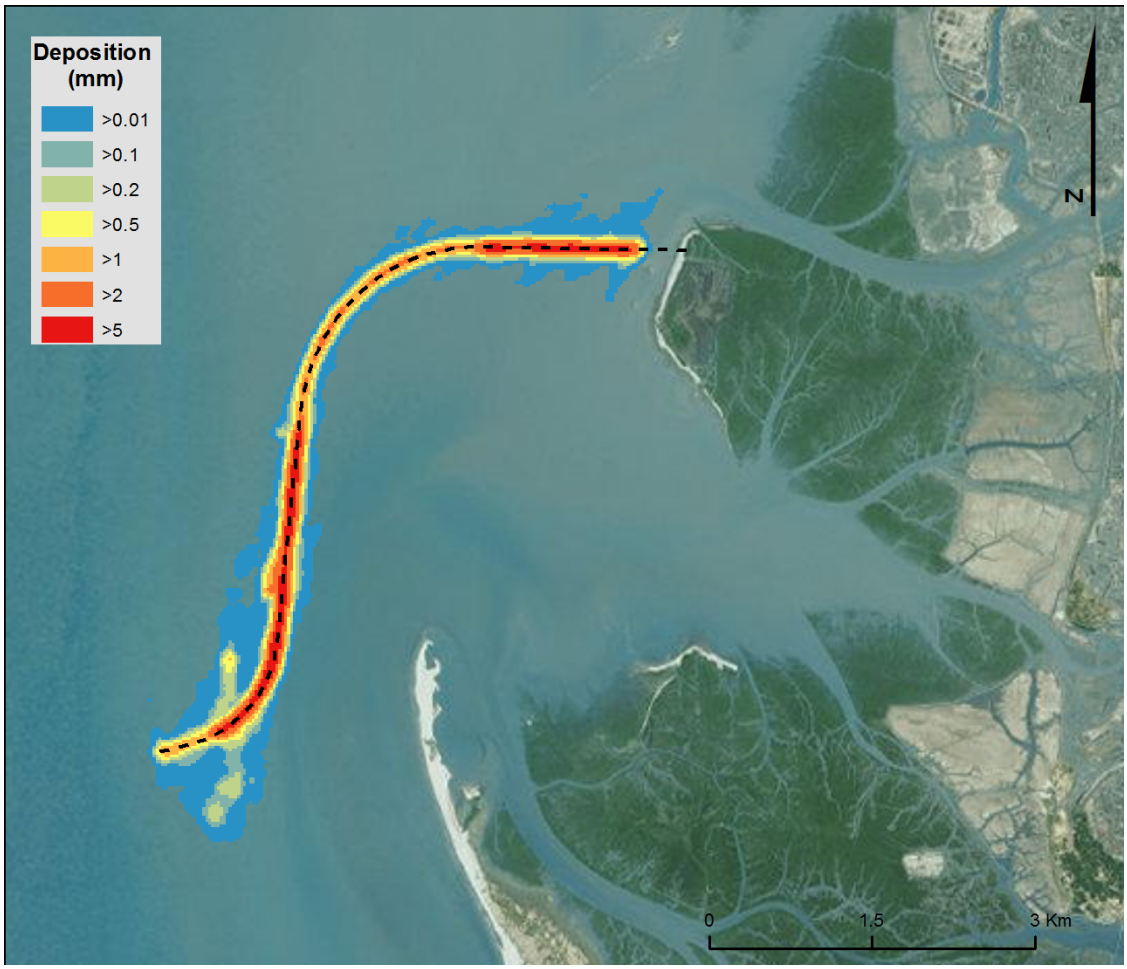


Figure 29. Scenario 6: extent of seabed deposition resulting from post-lay trenching (start date 15 December 2016). Maximum predicted thickness = 9.84 mm.

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Appendix E: Thermal Discharge Modeling Report

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Preliminary Report

LNG Regasification Thermal Discharges Modeling, Bangladesh

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Executive Summary

Acorn International on behalf of *Execrate Energy* contracted *Applied Science Associates, Inc.* (dba RPS ASA) to model the thermal discharge associated with a liquefied natural gas floating storage and regasification unit (FRSU) proposed to be developed offshore Bangladesh in the northeast Bay of Bengal. The project will include the construction of a permanently moored FSRU terminal offshore of Moheshkhali Island connected to an onshore tie in point at Kalirdiar Char (west of Boro Moheshkhali Union Parishad) via subsea pipeline.

The FRSU is located in approximately 36 m water depth and has multiple thermal discharges, both cold and warm, which originate from different process streams and are discharged at different locations within the upper ~ 7-11 m of the water column. The process streams have variable flows and temperature differentials. The largest flow rate is associated with the two separate regasification streams, each with a flow of 4,500 m^3/hr and corresponding temperature differential of 9 °C below ambient. The stream with the largest temperature differential is associated with the F.W generator cooling water which has a flow of 42 m^3/hr and a corresponding temperature differential of 22.5 °C above ambient.

Thermal discharges result in thermal plumes within the receiving waters to which they are discharged. The thermal discharges associated with this project are subject to regulatory oversight and the objective of the modeling study was to evaluate the thermal plume with respect to IFC guidance which states that in lieu of an established mixing zone that the plume must not result in a change in water temperature of more than 3 °C relative to ambient for an extent greater than 100 m from the discharge. Therefore an analysis of environmental and discharge conditions was performed and a plume modeling study was carried out to assess the thermal discharges under the least favorable environmental conditions to determine if the discharges were compliant with the applicable regulations. Least favorable conditions refer to conditions that promote the least amount of dispersion and dilution which occur with small density differential between discharge and receiving water and weak ambient currents.

Environmental data was obtained or developed to characterize the site conditions. A hydrodynamic model application was developed to determine the range of current speeds at the discharge location. A long term history was generated and queried at the FRSU location; analysis of this data was performed and the 5^{th} percentile current speed (a speed that is exceeded 95 % of the time) was calculated for use in the plume modeling as this represents relatively less potential for mixing and is therefore conservative. Water column profiles of temperature and salinity were obtained from the WOA13 global database. These were assessed and used as inputs to calculate the density of both the receiving water and the discharge. The temperature and salinity profiles, and thus density, at this site show relatively little stratification though have variability throughout the year. The average monthly discharge and receiving water densities were calculated and the minimum density differential would occur during the month of January for all discharges. This minimum monthly differential was used in the plume modeling as it represents the minimum buoyancy force available for mixing and dilution.

The USEPA mixing zone model CORMIX was used to determine the plume characteristics associated with each discharge. The modeling showed that all the discharges dilute significantly within close proximity to the discharge and that the regulatory threshold of a temperature differential < 3 °C relative to ambient was met within 10 m from the discharge in all cases and therefore the discharges were deemed compliant with the applicable regulations.

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1. Introduction

Acorn International on behalf of *Execrate Energy* contracted *Applied Science Associates, Inc.* (dba RPS ASA) to model the thermal discharge associated with a liquefied natural gas floating storage and regasification unit (FRSU) proposed to be developed offshore Bangladesh in the northeast Bay of Bengal as shown in Figure 1 with location information provided in Table 1. The project will include the construction of a permanently moored FSRU terminal offshore of Moheshkhali Island connected to an onshore tie in point at Kalirdiar Char (west of Boro Moheshkhali Union Parishad) via subsea pipeline.

Thermal discharges result in thermal plumes within the receiving waters to which they are discharged. Thermal discharge refers to a discharge of water that is similar in composition to the receiving water with the exception of having a modified temperature, in most cases due to the use of the water in an industrial process. The FRSU has multiple thermal discharges, both cold and warm, which originate from different process streams and are discharged at different locations. An overview of the discharges with respect to temperature differential is provided in Table 2. The FRSU takes in seawater and runs it through the regasification system which extracts energy from the seawater in order to raise the temperature of the liquefied natural gas such that it promotes a phase change to gas vapor. This process reduces the water temperature which is then discharged back in to the receiving water, resulting in a cold water thermal plume within the receiving water. Similarly the FRSU takes in water for use in cooling various process streams which result in discharges with elevated temperatures or a warm water thermal plume within the receiving waters. The thermal plume is the resulting plume or region of water within the receiving water that has modified temperature due to the discharge; the size of a thermal plume depends on the temperature differential of interest by which it is defined (e.g. >1 °C above background). This project is subject to regulatory oversight and the objective of the modeling study is to evaluate the thermal plume with respect to IFC guidance which states that in lieu of an established mixing zone that the plume must not result in a change in water temperature of more than 3 °C relative to ambient for an extent greater than 100 m from the discharge.

This document summarizes the modeling inputs including discharge and environmental characteristics as well as the modeling results including a comparison to the applicable regulation.

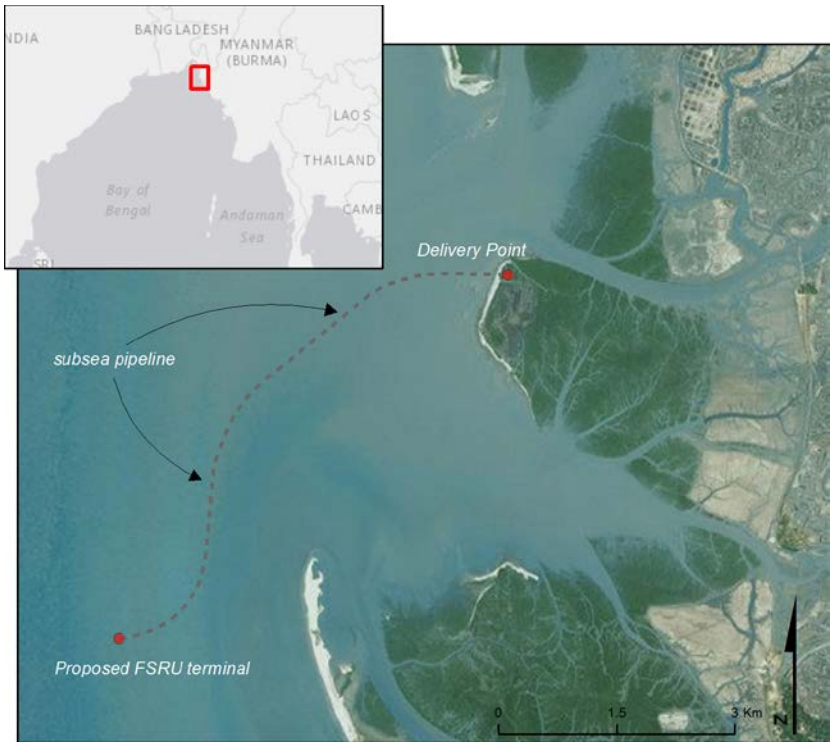


Figure 1. Location of the proposed FSRU terminal and subsea pipeline offshore Moheshkhali Island, Bangladesh.

Table 1. Proposed pipeline start/end points (delivery point and FSRU terminal)

Point Name	Northing	Easting	Depth Relative to MSL
Proposed FRSU Terminal Location	21° 32' 04.00"N	91° 49' 07.00"E	36 m

Table 2. Overview of discharge scenarios.

Parameter	Units	Value			
Scenario ID		S1	S2	S3	S4
Scenario Description		Heating water used in regasification process	Main condenser cooling water	F.W. generator cooling water	Central cooling system
Number of Instances		2	1	1	1
Temperature Differential of Discharge	**°C**	-9	+6.5	+22.5	+6.5

2. Model Inputs: Discharge and Environmental Characteristics

The factors that influence the magnitude and extent of the thermal plume are the discharge flow and initial temperature differential, discharge geometry/configuration and the receiving water characteristics. The environmental aspects of the receiving water that are of importance include the water column depth, distance to shoreline or flow obstruction, receiving water temperature/salinity/density profiles, and the ambient currents. For this study each of these factors was investigated at the site in order to develop appropriate inputs to the near field model. The characterization of these parameters is described below.

2.1. Shoreline and Bathymetry

A characterization of the discharge with respect to the area bathymetry, depth at the discharge and proximity to the shoreline are all required for near field modeling. The shoreline and bathymetry of the study area is complex. Navigation maps and aerial imagery show evidence of migrating sandbars, intricate channels and large intertidal regions along the western side of Moheshkhali Island.

The shoreline was defined based on data obtained from the OpenStreetMap project, though modified based on navigation charts and aerial imagery. The OpenStreetMap project is an open-source mapping effort with most data generated from the U.S. National Geospatial Intelligence Agency (NGA) Prototype Global Shoreline (PGS), which is based on 2000-era LANDSAT satellite imagery. The precision of the PGS is approximately 50 meters.

The distance from the FRSU to the shoreline varies depending on the orientation (direction) at which it is measured. The FRSU is located approximately 2.25 km from shore directly west of the beach shoreline along Sonadia Island. The near field plume is not anticipated to be influenced by the shoreline; however the FRSU discharge originates from the submerged portion of the vessel and may be influenced by the draft of the vessel. In order to account for possible interaction with the vessel draft the simulations were run both unobstructed and assuming a flow obstruction from the vessel.

The bathymetry within the study area was available from electronic navigation charts (C-MAP, Jeppeson Marine) and from client provided survey data (GEOCEAN Entrepose, 2016). In areas with limited data some edits were made manually in order to represent the visible channels (from aerial imagery) as deeper than the surrounding waters.

2.2. Water Column Temperature/Salinity/Density Profile

The water column profile of temperature, salinity and corresponding density is of importance to both the discharge characterization and the initial dilution of the discharge within the receiving water. The discharge is based on the intake (or ambient) seawater properties with a modification to temperature depending on the process stream. This temperature differential results in a change in density from the intake (ambient) seawater. The density differential between the receiving water and the discharge dictates the buoyant force available to drive the plume. The greater the differential, the greater the buoyant force. Therefore the smallest buoyant force, or worst case with respect to buoyancy, would occur when the density differential between the discharge and receiving water is the smallest. A discharge that is less dense than the receiving water will rise and one that is denser than the receiving water will sink. A discharge with the same density as the receiving water will be “neutrally buoyant” and

will not rise or sink. Density is a function of salinity and temperature. Reducing temperature or increasing salinity increase density whereas increasing temperature or reducing salinity decreases density. Relative changes in salinity (psu) have a greater effect on density as compared to changes in temperature (°C), meaning a change of 1 °C results in a smaller change in density than a change of 1 psu.

The ambient (intake) temperature and salinity is the basis for determining the discharge temperature and salinity, though with an incremental temperature change. The density of both receiving water and discharge was calculated based on temperature and salinity using the UNESCO 1980 equations of state (UNESCO 1981) for seawater. In order to determine the temperature and density of the ambient and discharge throughout the year, monthly profiles of temperature and salinity were obtained and analyzed. Profiles of water temperature and salinity values were obtained from the World Ocean Atlas 2013 (WOA13). The WOA13 dataset is compiled and maintained by the United States National Oceanographic Data Center (www.nodc.noaa.com). The WOA originated from the Climatological Atlas of the World Ocean (Levitus, 1982) and has been continuously updated with new records from a variety of oceanographic instruments. Observed data are averaged yearly, seasonally, and monthly and interpolated to fit a grid with ¼ degree horizontal resolution and 35 standard depth levels as applicable to each site depth. For this study monthly averages were obtained for the grid points surrounding the location of the FRSU; the values at these points were then averaged to estimate the water column characteristics at the FRSU.

The estimated average vertical profiles (observations at 0, 5, 10 and 15 m below surface) of temperature, salinity and density for each month within the upper 15 m at the FRSU based on data from available WOA13 grid points are shown in Figure 2; note that there was no data at depths greater than 15 m for any surrounding points. This figure illustrates that there is not a significant difference in values throughout the water column however there is variability depending on time (month). Temperature varies between ~23-30 °C, salinity varies between ~23-33 psu and density varies between ~1,013-1,022 kg/m^3.

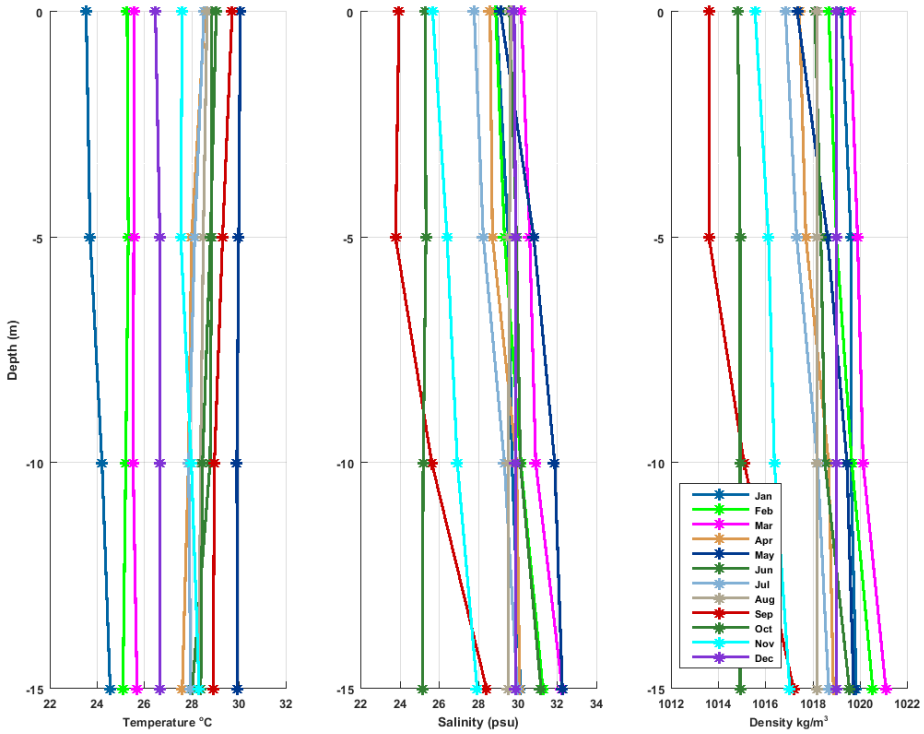


Figure 2. Estimated monthly average profiles of temperature (right), salinity (middle) and density (right) within the upper 15 m at the FRSU.

A proxy for the ambient water temperature, salinity and density was calculated by averaging the values within the available data in the upper 15 m of the water column; this was done since the intake and discharge is located within the submerged part of the vessel which is stated to have a maximum draft of 12.32 m though the client provided guidance that the draft should be assumed to be 11.3 m for this analysis. Based on the ambient specification, the discharge properties were calculated. The monthly averages of ambient and discharge temperature, salinity (same for intake and discharge) and density are shown in Figure 3 - Figure 5 for Scenario 1 (DT=-9C), Scenario 2 & 4 (DT =+6.5C) and Scenario 3 (DT=+22.5C) respectively along with the calculation of density differential between the intake and the discharge. This analysis shows that the month of January has the smallest density differential for all discharge conditions; this relatively small differential represents the worst case for dispersion potential. A summary of the monthly intake/ambient water column characteristics and the varying density differentials for different temperature differentials are provided in Table 3 and Table 4 respectively.

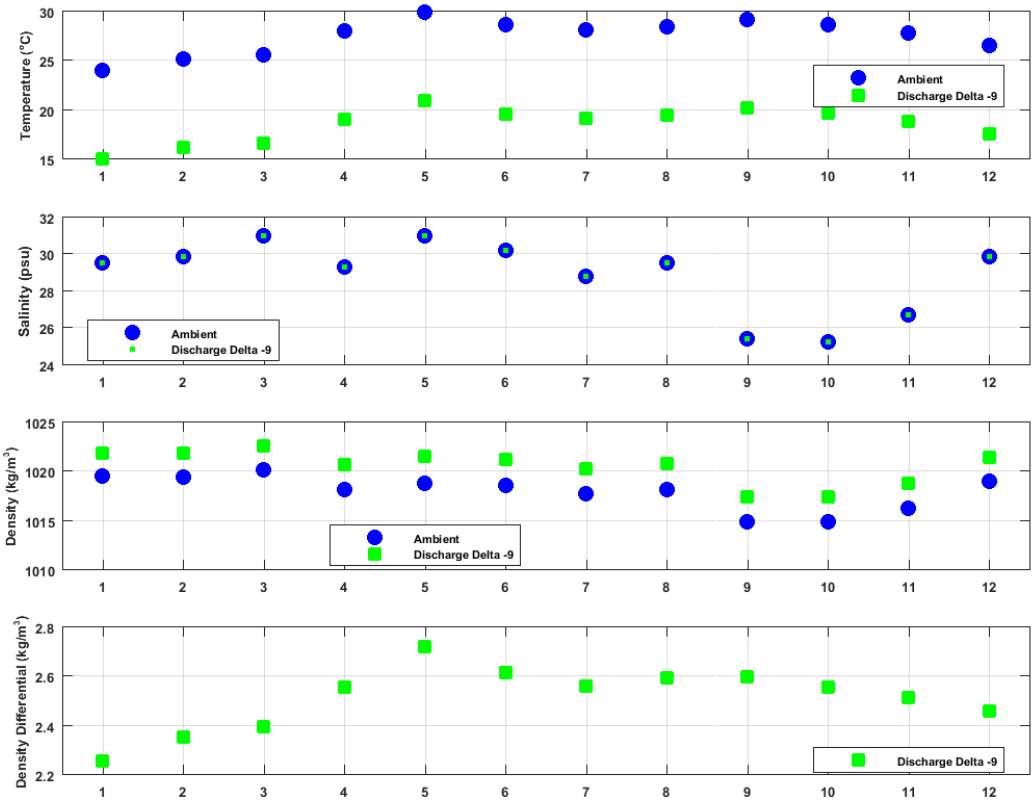


Figure 3. Estimated monthly averages of ambient and discharge temperature (subplot 1), salinity (subplot 2), density (subplot 3) and the density differential between ambient and regasification discharge with a DT=-9 °C (subplot 4).

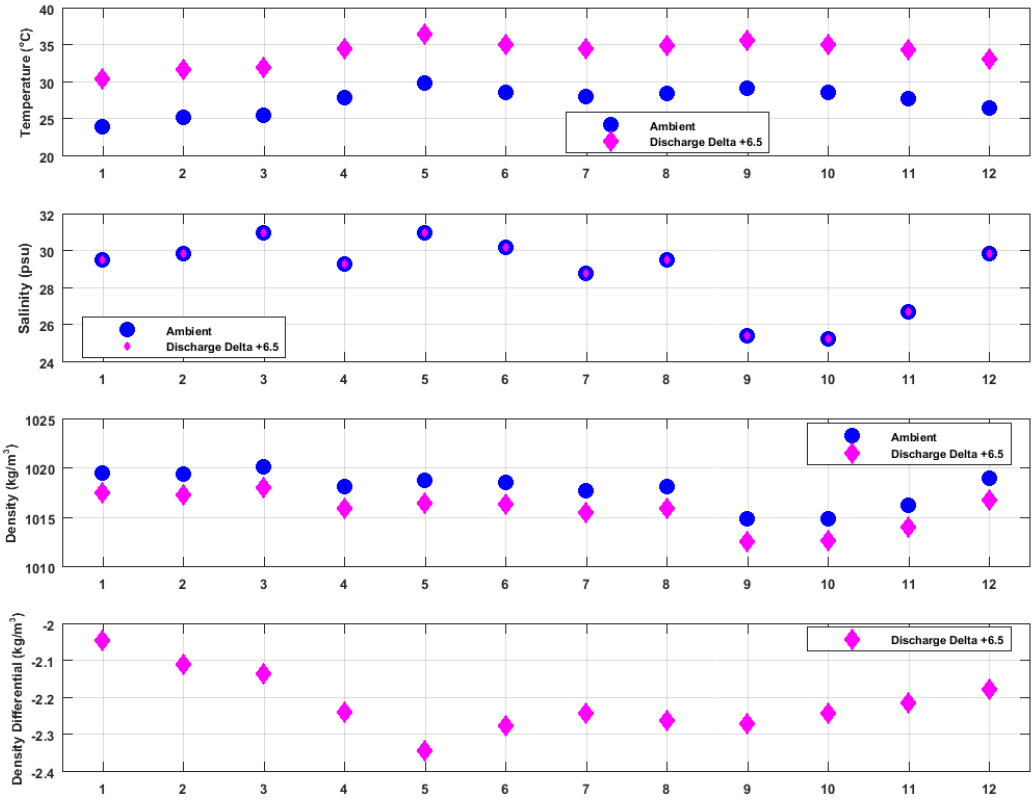


Figure 4. Estimated monthly averages of ambient and discharge temperature (subplot 1), salinity (subplot 2), density (subplot 3) and the density differential between ambient and main condenser discharge & central cooling system discharge both with a DT=+6.5 °C (subplot 4).

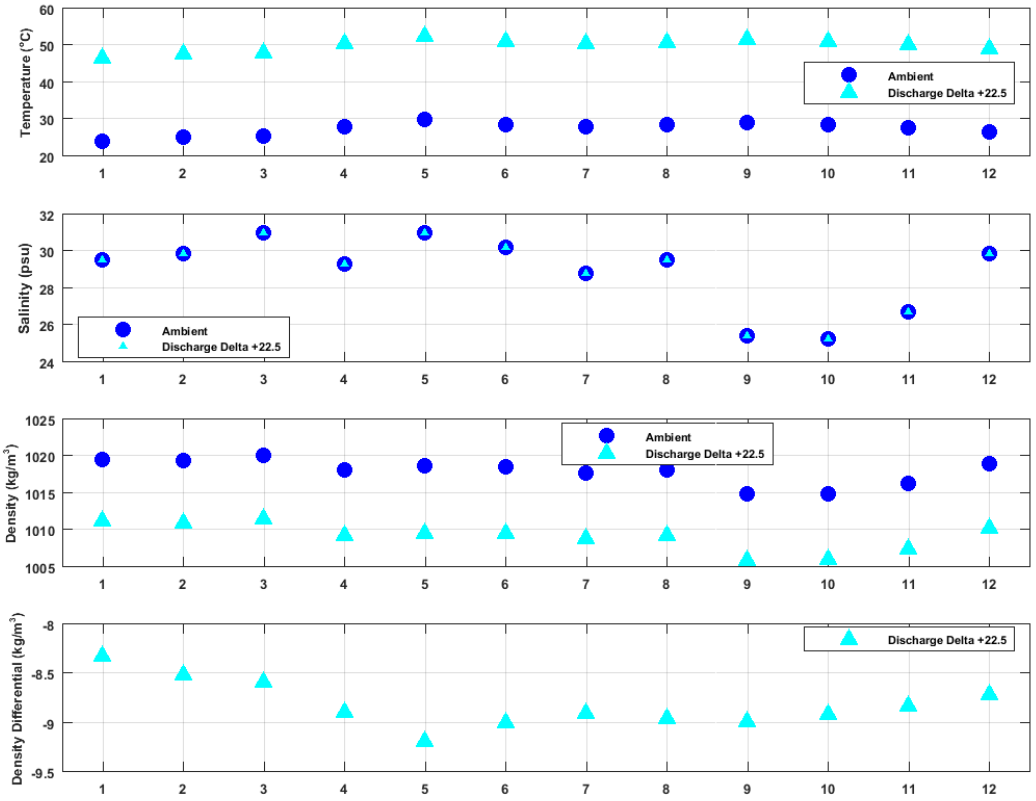


Figure 5. Estimated monthly averages of ambient and discharge temperature (subplot 1), salinity (subplot 2), density (subplot 3) and the density differential between ambient and F.W. generator cooling water discharge with a DT=+22.5 °C (subplot 4).

Table 3. Summary of monthly averaged characterization of ambient/receiving water characteristics.

MONTH	Ambient		
	Surface Water Temperature (°C)	Salinity (psu)	Density (kg/m_3)
January	24.0	29.6	1019.58
February	25.2	29.9	1019.48
March	25.6	31.0	1020.18
April	28.0	29.3	1018.18
May	30.0	31.0	1018.80
June	28.6	30.2	1018.64
July	28.1	28.8	1017.77
August	28.5	29.6	1018.21
September	29.2	25.5	1014.88
October	28.7	25.2	1014.90
November	27.9	26.7	1016.28
December	26.6	29.9	1019.03

Table 4. Summary of the monthly averaged characterization of discharge density differentials for each temperature differential.

MONTH	Differential		Differential		Differential	
	ΔT (°C)	Δdensity (kg/m^3)	ΔT (°C)	Δdensity (kg/m^3)	ΔT (°C)	Δdensity (kg/m^3)
January	-9.0	2.3	+6.5	-2.04	+22.5	-8.32
February	-9.0	2.4	+6.5	-2.11	+22.5	-8.51
March	-9.0	2.4	+6.5	-2.13	+22.5	-8.59
April	-9.0	2.6	+6.5	-2.24	+22.5	-8.89
May	-9.0	2.7	+6.5	-2.34	+22.5	-9.18
June	-9.0	2.6	+6.5	-2.27	+22.5	-8.99
July	-9.0	2.6	+6.5	-2.24	+22.5	-8.90
August	-9.0	2.6	+6.5	-2.26	+22.5	-8.96
September	-9.0	2.6	+6.5	-2.27	+22.5	-8.99
October	-9.0	2.6	+6.5	-2.24	+22.5	-8.91
November	-9.0	2.5	+6.5	-2.21	+22.5	-8.83
December	-9.0	2.5	+6.5	-2.18	+22.5	-8.71

2.3. Circulation

The receiving water circulation plays an important role in the initial dilution of discharges. The ambient current speed and orientation of the discharge relative to the currents contribute to the mixing of the discharge within the waters. Slower ambient currents do not mix as much as stronger currents, however swift currents may also transport the plume further from the discharge prior to significant dispersion. Discharge plume location is first dominated by the discharge (opening orientation and momentum), and subsequently by the magnitude and direction of the receiving water currents; in that sense it is useful to understand the range of range of current speeds, and directions, anticipated at the site in order to evaluate the plume dispersion under the range of potential conditions. For this study a hydrodynamic model application of the study area was developed for use in this study as well as for use in a sediment dispersion study associated with the pipeline burial. The model, the model application and the results are presented in the following sections.

2.3.1. HYDROMAP Hydrodynamic Model Application to the Study Site

A hydrodynamic model application of the study area was developed for the purposes of generating spatially and temporally varying current fields for use in modeling of sediment dispersion (documented in another study report) and for developing a characterization of the speed and direction of currents anticipated at FRSU discharge location. The model application was developed using RPS ASA's in house model HYDROMAP. The model application was set up to determine tidal circulation only.

2.3.1.1 HYDROMAP Model Description

HYDROMAP, a hydrodynamic model developed by RPS ASA, was used to reproduce the local tidal circulation for this study. HYDROMAP is a globally re-locatable three-dimensional hydrodynamic model (Isaji, et al., 2001a, 2001b) capable of simulating complex circulation patterns due to tidal forcing, wind stress and fresh water flows. HYDROMAP employs a novel step wise continuous variable rectangular gridding strategy with up to six levels of resolution. The term "step-wise continuous" implies that the boundaries between successively smaller and larger grids are managed in a consistent integer step. HYDROMAP has been applied in numerous sediment dispersion and transport studies in the U.S. and worldwide. The numerical solution methodology follows that of Owen (1980). Isaji, et al. (2001a, 2001b) provide a detailed description of the model.

2.3.1.2 Model Application Set Up

A model grid of the study area was developed with nested grid resolution increasing along the route of the planned pipeline and at the shoreline in order to better capture shoreline and bathymetric features. The grid was developed for the northeast region of the Bay of Bengal, extending from the shoreline approximately 80 km west as measured from Moheshkhali Island. The shoreline was defined based on Open Street Maps delineation, though modified based on aerial imagery. The model grid cells were assigned depth based on soundings from available navigation charts (C-MAP, Jeppeson Marine), survey information provided by the client and edits based on aerial imagery. An illustration of the model grid is shown in Figure 6 and model grid bathymetry zoomed in to the area of interest is shown in Figure 7.

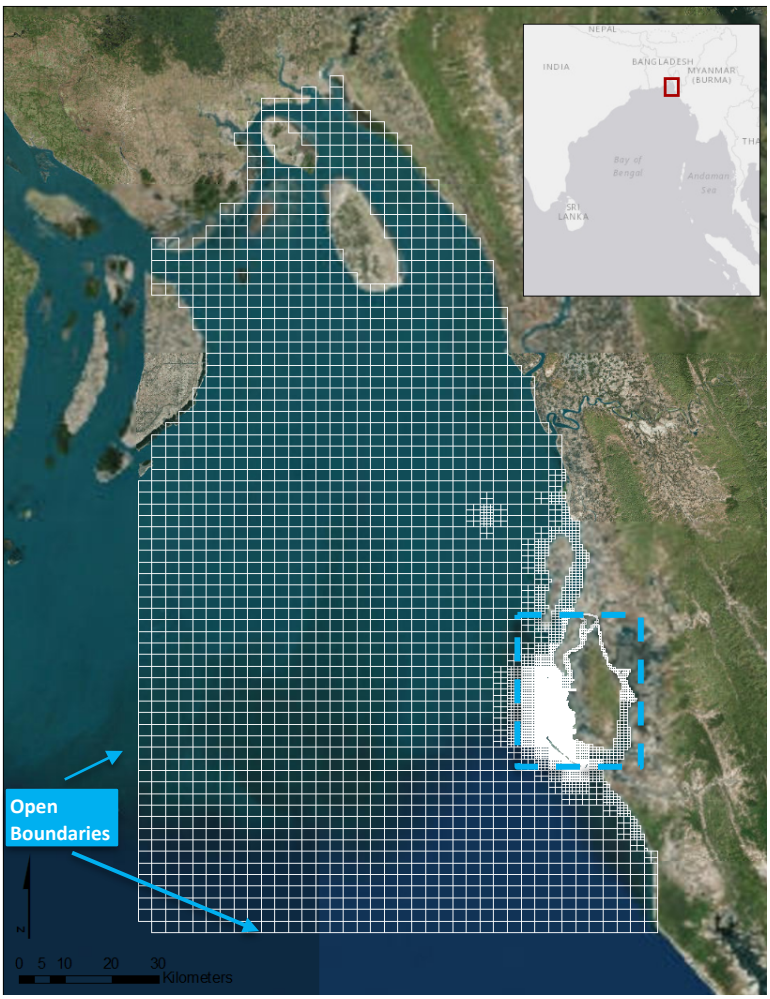


Figure 6. Illustration of entire model grid, blue dashed outline signifies approximate extent of zoomed in illustration of grid in Figure 7 below.

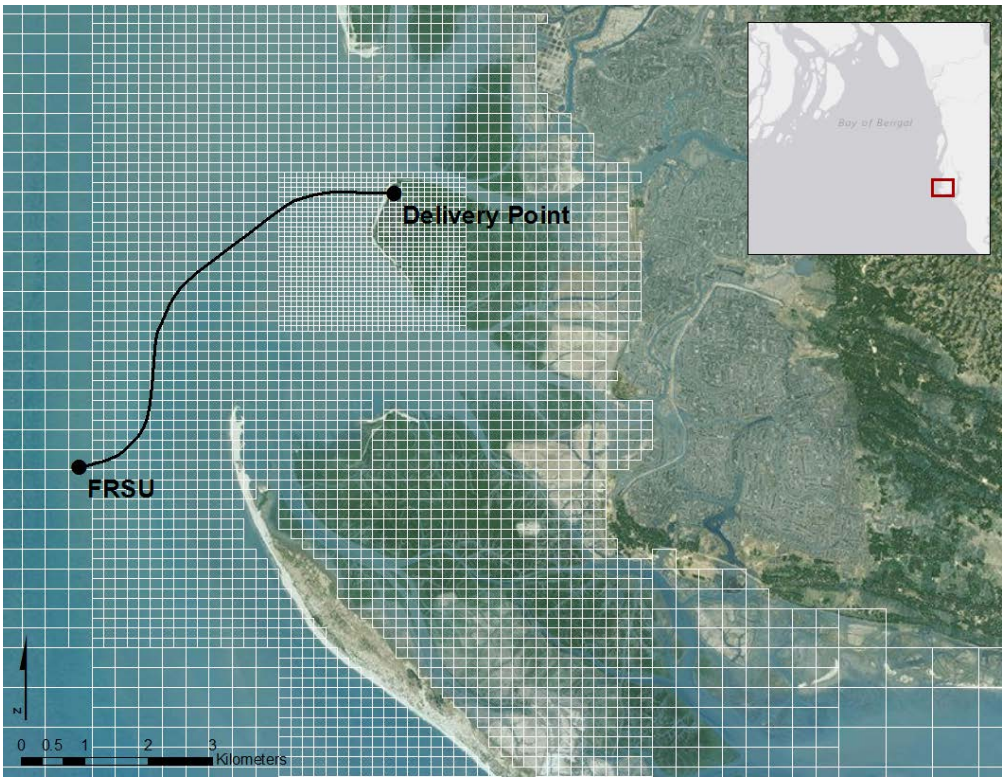


Figure 7. Illustration of model grid zoomed to the study area near the FRSU and pipeline.

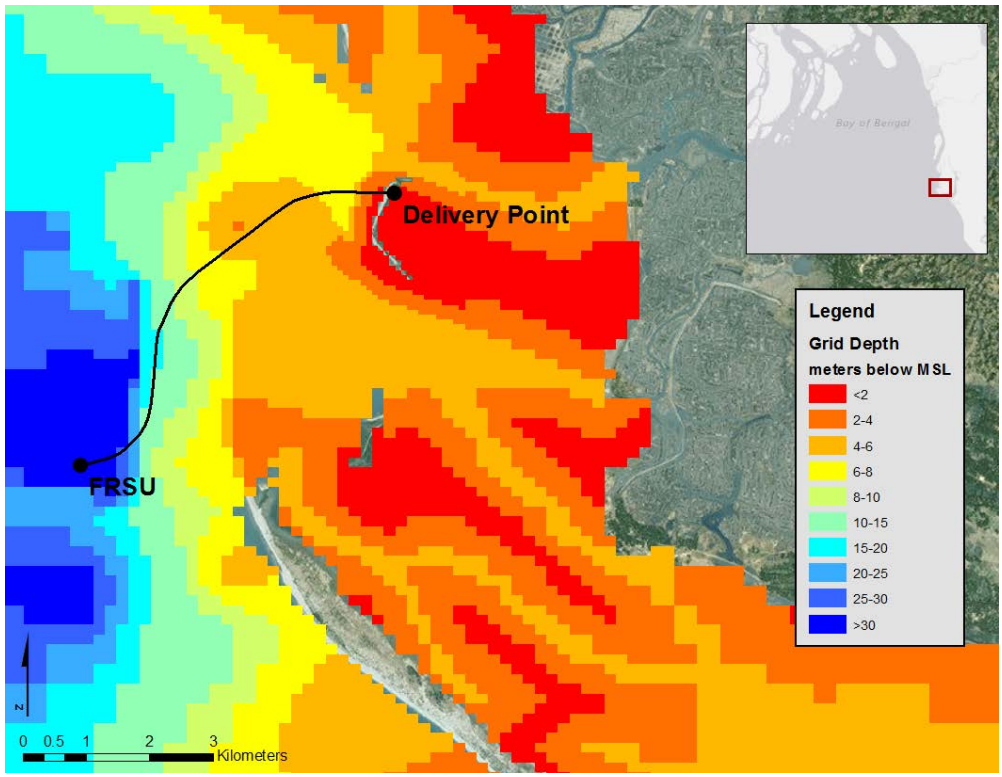


Figure 8. Illustration of model grid bathymetry zoomed to the study area near the FRSU and pipeline.

The hydrodynamic model simulations were forced with tides based on the harmonic analysis of observed data from the study area presented in the client provided material. The tidal boundary conditions were applied at the open boundary at the southern and western extent of the grid (Figure 6) and were characterized based on the six constituents (M_2, S_2, N_2, K_1, O_1, and Q_1) which comprise the majority of the tidal energy. The constituent phase and amplitude are presented in Table 5. The amplitude refers to the height that the water level may be either above or below mean sea level and the phase is the timing at which the maximum elevation from that constituent occurs relative to a theoretical equilibrium tide. The constituent symbols contain a subscript (e.g. "2") which refers to the approximate number of times a day this tidal cycle repeats. At this site the majority of the tidal energy is characterized by constituents that repeat twice a day (semidiurnal) or once a day (diurnal); the M_2 constituent is dominant, accounting for more than half of the tidal energy.

Table 5. Summary of astronomic tidal constituents used in hydrodynamic model forcing.

Symbol	Name	Amplitude	Phase
		(m)	(Degrees Relative to GMT)
M_2	Principal lunar semidiurnal	1.1347	311.89
S_2	Principal solar semidiurnal	0.4842	325.22
N_2	Larger lunar elliptic semidiurnal	0.3401	305.56
K_1	Lunisolar diurnal	0.1131	319.16
O_1	Lunar diurnal	0.0775	323.56
Q_1	Larger lunar elliptic diurnal	0.0282	332.65

2.3.1.3 Model Verification

In order to verify that the model was able to recreate the general circulation characteristics, comparisons to observations were performed for two different time periods based on data provided by the client (Poten & Partners, 2011). Observation data was available at a single location close to the study area as shown in Figure 9. For the two periods of observations the model predictions were compared to the observed data as shown in Figure 10 and Figure 11 for equipment deployment periods of 14 -21 May 2008 and 1-16 February 2009 respectively. Comparing these data sets it can be seen that the model is able to recreate the magnitude and trend of the currents well. This comparison shows how the tidal strength may vary depending on time, or the phase of the constituents. The peak speeds during the May 2008 period are relatively constant and peak at approximately 1.1 m/s whereas during the February 2009 time period the tidal current amplitude nearly doubles between neap and spring tide from 0.6 m/s to 1.20 m/s respectively.

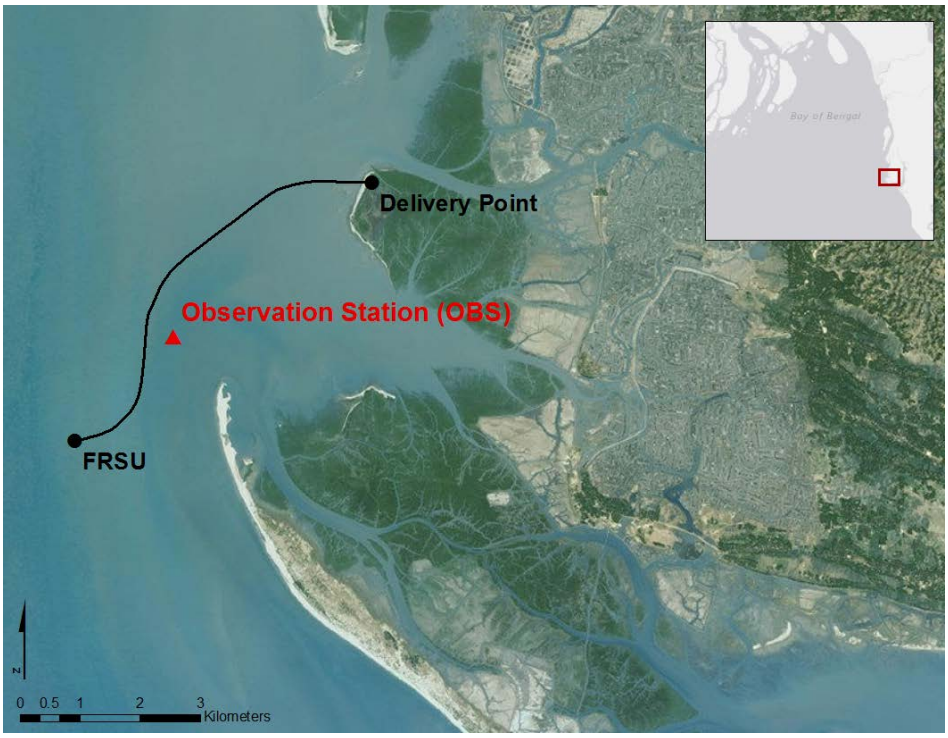
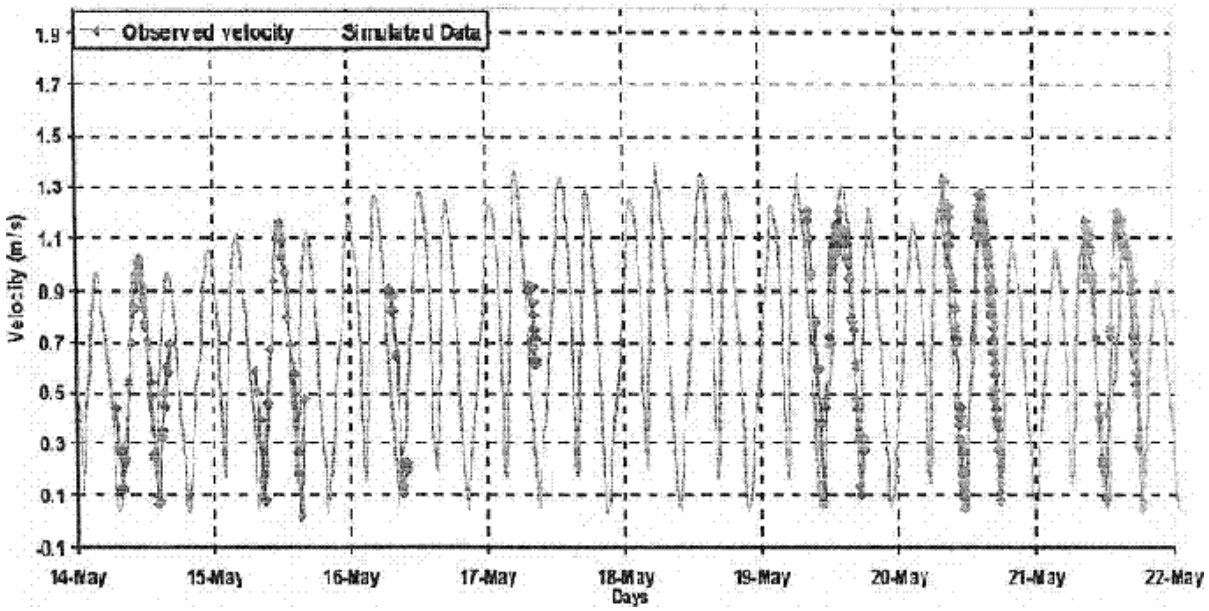


Figure 9. Illustration showing location of available hydrodynamic observations (OBS site).



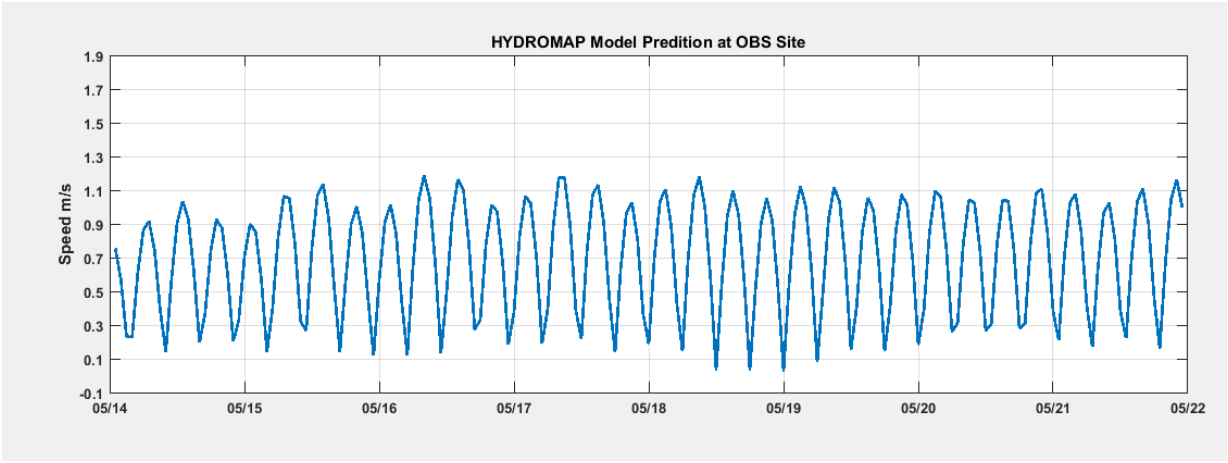
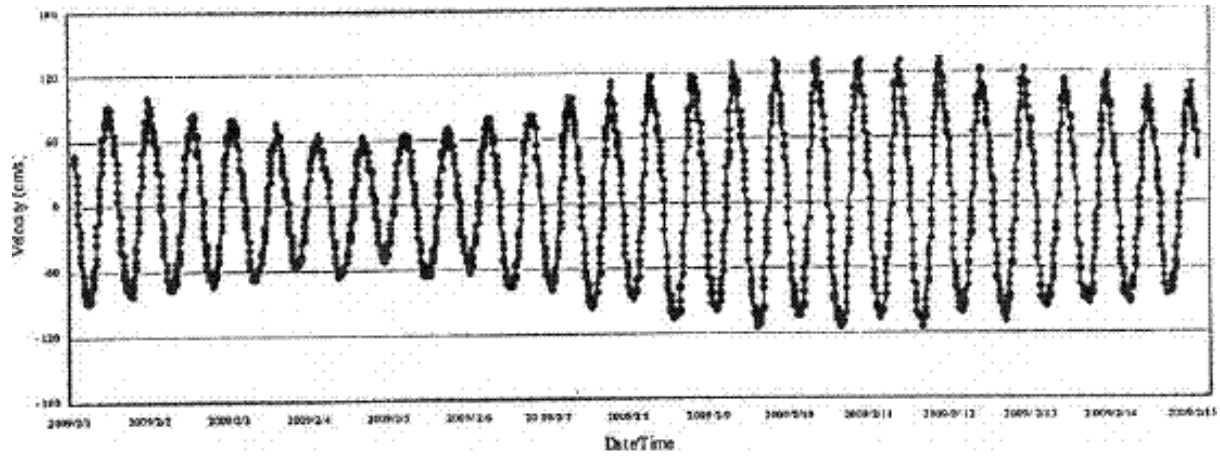


Figure 10. Comparison of client provided observations (Top) to HYDROMAP predictions (Bottom) for May 2008. Note top figure shows both observations (line with markers) and a third party model (lines only) of the currents.



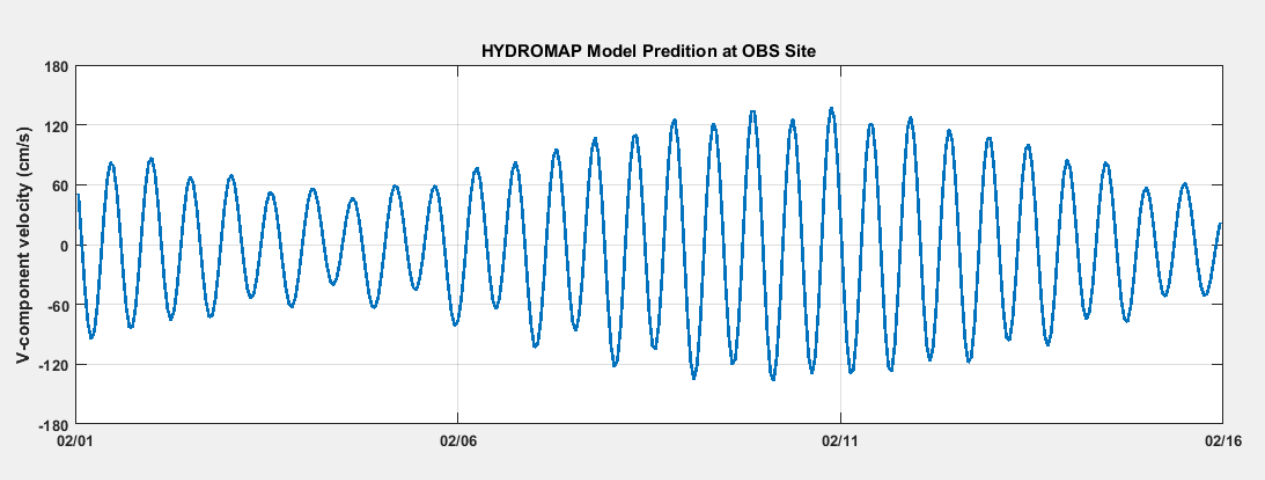


Figure 11. Comparison of client provided observations (Top) to HYDROMAP predictions (Bottom) for February 2009.

2.3.1.4 Model Scenario Results

The verified model application was used to generate tidal circulation data for use in both the sediment dispersion study (documented separately) and queried at the FRSU site to determine the current characteristics at the FRSU discharge location.

The tidal currents are relatively strong in this area with magnitude variable depending on time. The tidal constituents result in variable speeds due to the timing of individual constituents. The majority of the variability is captured within a spring/neap cycle of 14 days; however the spring neap cycle can vary throughout time. A nineteen year record of current speeds was generated at both the FRSU discharge site and the observation site (OBS site) from the model application. The records were analyzed and the statistics are summarized in Table 6. The semidiurnal constituents dominate the tidal regime and as such the area is subject to two high and two low tides a day which results in reversing currents twice a day. The direction of the reversing currents is predominately a north-south flow, however in areas closer to the shoreline the directions vary in response to the effects of bathymetry and shoreline where flow moves in and out of channels and rivers.

Table 6. Summary of current speed statistics at points of interest.

Percentile	Terminal	OBS Site
	cm/s	cm/s
5	14.0	10.4
10	20.5	14.7
15	27.0	19.4
20	34.2	24.8
25	41.9	30.7
30	49.7	36.8
35	57.8	43.1
40	66.0	49.5
45	74.3	56.0
50	82.6	62.6
55	91.1	69.3
60	99.8	76.3
65	108.8	83.6
70	118.5	91.4
75	128.8	99.8
80	140.0	109.0
85	153.0	119.8
90	169.6	133.5
95	191.8	151.9
100	252.0	201.6

A snapshot of typical flood and ebb circulation pattern of the M_2 constituent in the study area are shown in Figure 12 and Figure 13 respectively. The model predictions show that the strong tidal influence results in flooding and ebbing approximately twice daily with relatively strong peak current speeds. The illustrations of circulation patterns show how the flow reverses with flow vectors shown in reversing directions (180 degrees phase difference) between flood and ebb. The model currents predict speeds to be greater than ~60-80 cm/s for more than half the time in the general area. Peak speeds reach approximately 1.5 – 2 m/s however for short periods of time. Current roses at the FRSU terminal site and the observation site were generated and are presented in Figure 14. For the purposes of dispersion modeling a weak ambient current represented by the 5th percentile of 0.14 m/s was used.

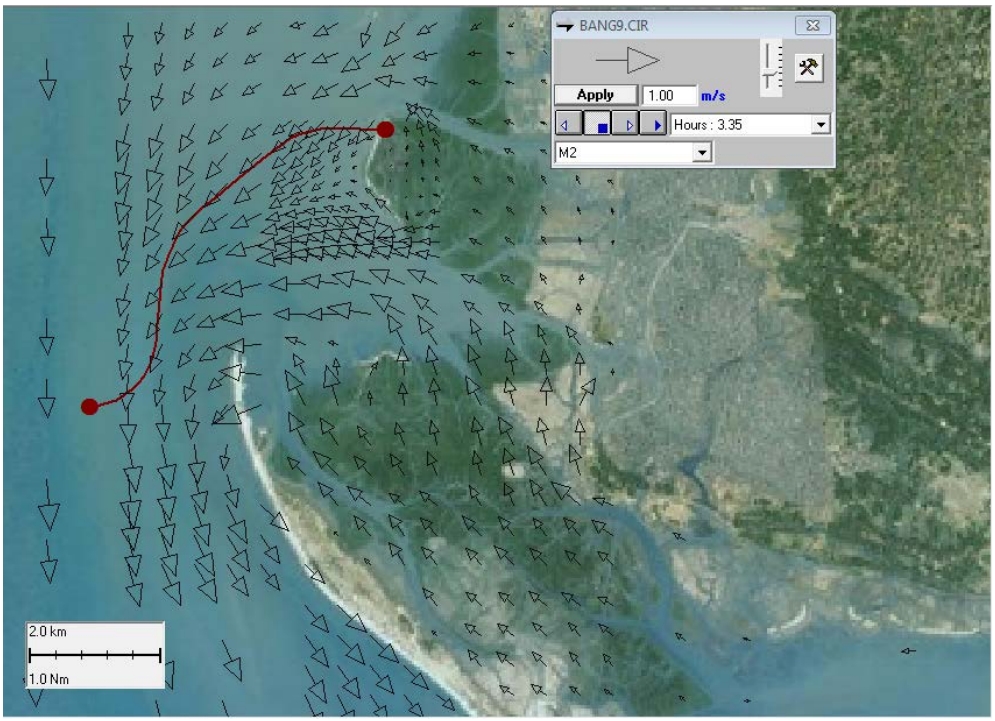


Figure 12. Illustration showing flood current pattern (M2 constituent).

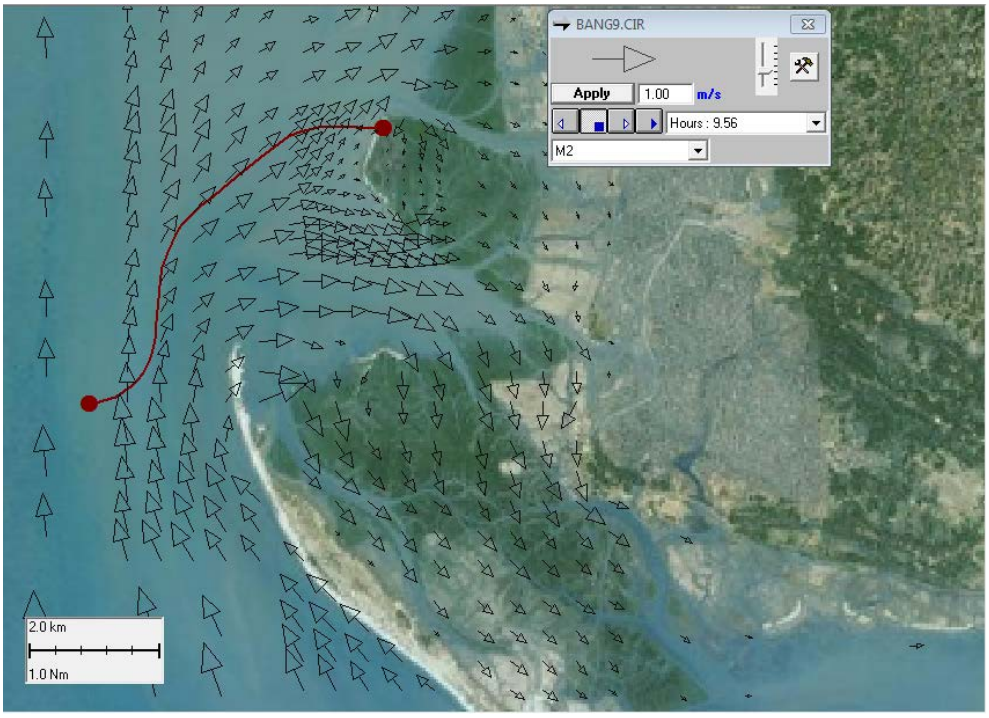


Figure 13. Illustration showing ebb current pattern (M2 constituent).

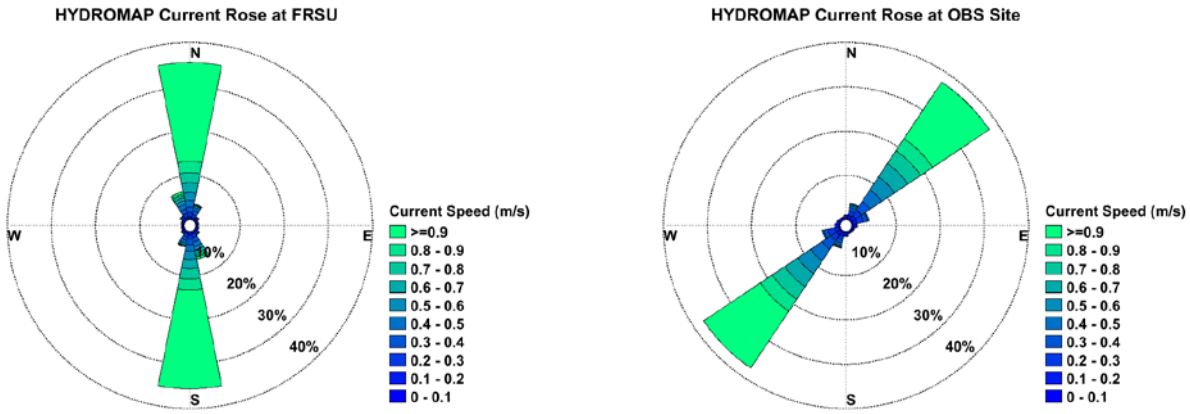


Figure 14. Current rose at FRSU (left) and Observation Site (right). Oceanographic convention: direction current flowing towards.

2.4. Discharge Characteristics

The discharge characteristics that influence the magnitude and extent of the thermal plume are the discharge flow, opening diameter, and initial temperature differential, discharge depth and orientation. A summary of the discharge characteristics for each scenario are shown in Table 7. Note that there are two instances of the regasification process discharge waters, however they are identical.

Table 7. Summary of discharge scenario parameters.

Parameter	Units	Value			
Scenario ID		S1	S2	S3	S4
Scenario Description		Heating water used in regasification process	Main condenser cooling water	F.W. generator cooling water	Central cooling system
# of Instances		2	1	1	1
Location		Port & Starboard	Port	Starboard	Port
Water Depth at Discharge	**m**	36	36	36	36
Discharge Depth	**m**	10.6	7.38	7.99	8.42
Warm/Cold Discharges		Cold	Warm	Warm	Warm
Discharge Pipe Description		600A	1400A	125A	400A
Discharge Pipe Outer Diameter	**in**	24	56	5.53	16
Discharge Inner Diameter	**in**	23.25	55.25	5.014	15.25
Discharge Orientation		90 deg downward	45 deg downward	45 deg downward	90 deg downward
Discharge Flow	**m^3/hr**	4,500	4,000	42	940
Discharge Initial Temperature Differential	**°C**	-9	+6.5	+22.5	+6.5
Required Dilution to Reduce to 3C above Ambient		3	3	8	3

3. Thermal Discharge Modeling

Plume modeling of the thermal discharge within the receiving waters was performed using the CORMIX model. The modeling was performed to determine the location and extent of the thermal plume and to specifically compare the prediction to the applicable regulatory threshold which states the plume must not alter the water temperature more than 3 °C at distances greater than 100 m from the point of discharge.

3.1. CORMIX Model

CORMIX (Doneker and Jirka 1990 & 2007) is a plume model that solves a set of analytical equations to estimate the steady state shape, extent and dilution of an effluent plume from a constant discharge. CORMIX contains a rule based algorithm to implement the appropriate solution based on conditions defined. While it is not a dynamic model, CORMIX can be used to represent snapshots of the worst case conditions or a range of anticipated conditions which can be provided with context representing their statistical significance (e.g. 5th percentile receiving water ambient current speed). This is a standard approach to providing an assessment of the initial dilution. The model contains both near field and far field predictions, near field refers to the region in which the discharge properties dictate the plume characteristics (momentum an buoyancy) and the far field refers to the region in which the fate and transport of the discharge is dominated by the environmental conditions (currents). The near-field results only were queried for this application, as the far field results are not as representative due to spatial and temporal changes in environmental conditions that take place.

The model provides predictions of the “dilution factor” as a function of distance from the release, the dilution factor is the multiple by which the discharge concentration would be attenuated, a useful indicator of the fate of discharged constituents in the near-field. The model also provides excess constituent concentrations of interest based on initial specification, which in this case is temperature. Excess refers to the increment above background/ambient temperatures.

CORMIX simulations require definition of discharge conditions and receiving water characteristics. The modeling inputs required are summarized below:

- Volume flow rate of the discharge and constituent concentration (defines load)
- Discharge pipe diameter used with flow to calculate exit velocity (ability to entrain water promoting dilution)
- Discharge density (effluent sinks or floats)
- Location of the discharge (including vertical position: surface vs. bottom discharge)
- Orientation of the discharge pipe (pointing up or down- can enhance initial mixing)
- Ambient currents at the discharge location (affects entrainment and transport)
- Ambient density of the receiving water
- Surface wind condition (speed)

For this study, it was assumed that no surface wind was present and therefore did not play a role in any temperature exchange with the atmosphere.

3.2. Model Scenarios and Results

A matrix representing the least favorable conditions for plume dispersion was simulated in CORMIX. The least favorable conditions were defined by the minimum density differential between the discharge and ambient and weak ambient currents. The minimum density differential for each scenario was determined based on the monthly analysis of both receiving water and discharge water presented in Section 2.2; for all scenarios January ended up having the smallest density differential. The weak ambient currents were characterized as the 5th percentile current speed that was calculated from output queried from the hydrodynamic model at the FRSU site as presented in Table 6.

Figures illustrating the plume geometry and plume centerline temperature differential relative to ambient are shown in Figure 15 through Figure 18 for the four scenarios. These figures each contain four subplots, the top left show the plume geometry in the plan view, the top right shows the plume cross section, the bottom left shows the plume centerline temperature differential as a function of horizontal distance from the discharge and the bottom right shows the temperature differential as a function of depth and horizontal distance from the discharge. These figures show how Scenario 1: Regasification Waters sinks due to its increased density from its cold temperature while the other scenarios (Scenario 2-4) all have plumes that rise in the water column since they are warmer and less dense than the receiving water. As mentioned CORMIX is a rule based algorithm and the total solution includes multiple modules, each which solve for plume characteristics within a given plume regime; due to this method the solution is somewhat discontinuous and the results reflect that in the sharp changes of geometry. Figure 19 illustrates the plume centerline temperature differential for all four scenarios shown with a two-toned color scale for all four scenarios. The two-toned scale delineates the portion of the plume above the threshold (<3C in green) and below the threshold (<3C in blue).

Table 8 summarizes the scenario inputs including the ambient and discharge density and ambient current as well as the scenario results including distance until the plume temperature differential attenuates to within 3 °C of ambient and the associated plume radius at that location. The plume temperature differential as a function of distance for the four scenarios is shown in Figure 20. As can be seen from these results the plume attenuates quickly and reaches the required attenuation to within 3 °C from ambient within 10 m from the discharge and is therefore compliant with the applicable regulations.

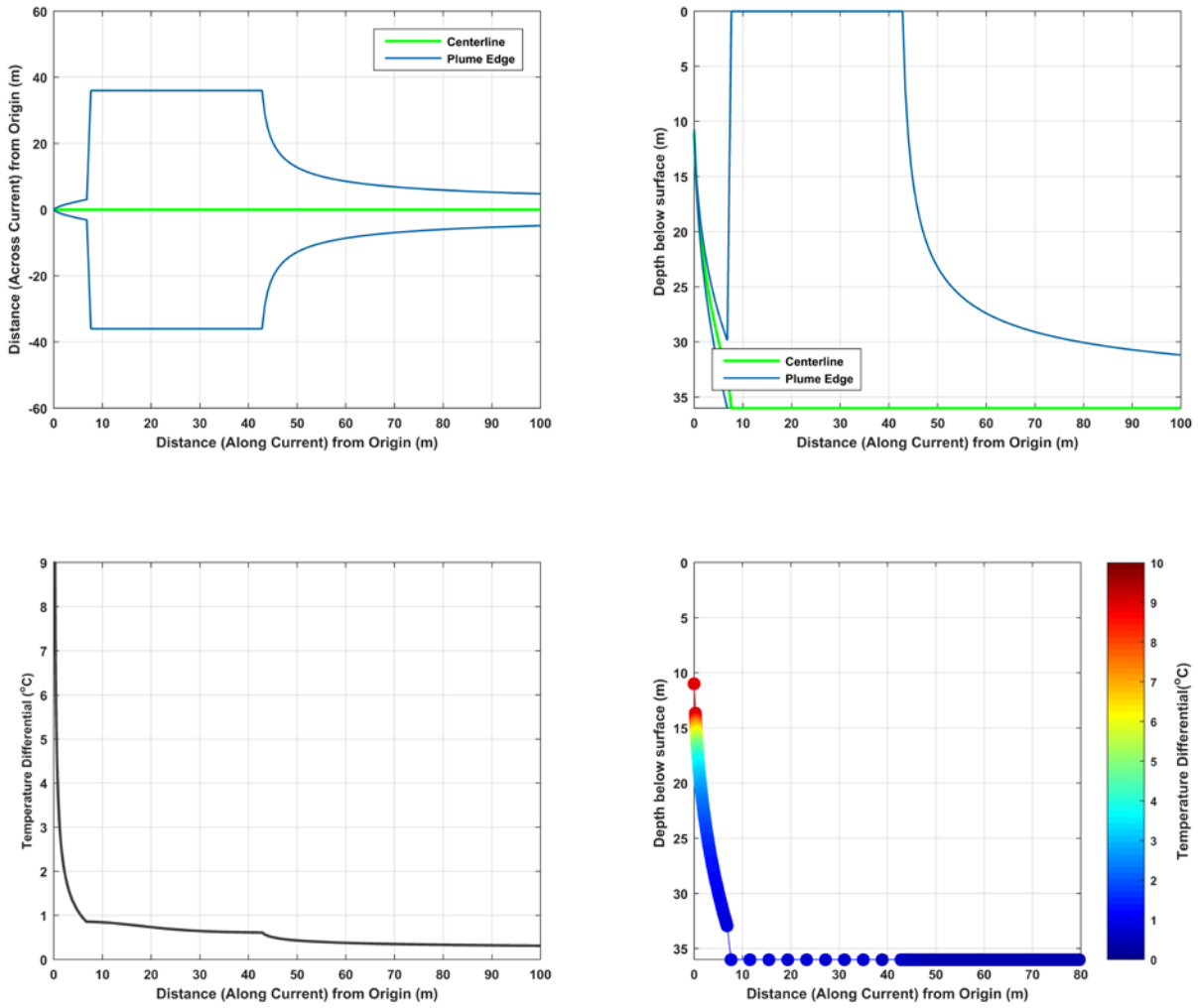


Figure 15. Plume characteristics associated with Scenario 1: Regasification – Flow 4,500 m^3/hr DT = -9C. Upper left shows plan (top) view of plume, upper right shows cross sectional view, lower left shows temperature differential as a function of horizontal distance from the discharge and bottom right shows the temperature differential as a function of both depth and horizontal distance from the discharge.

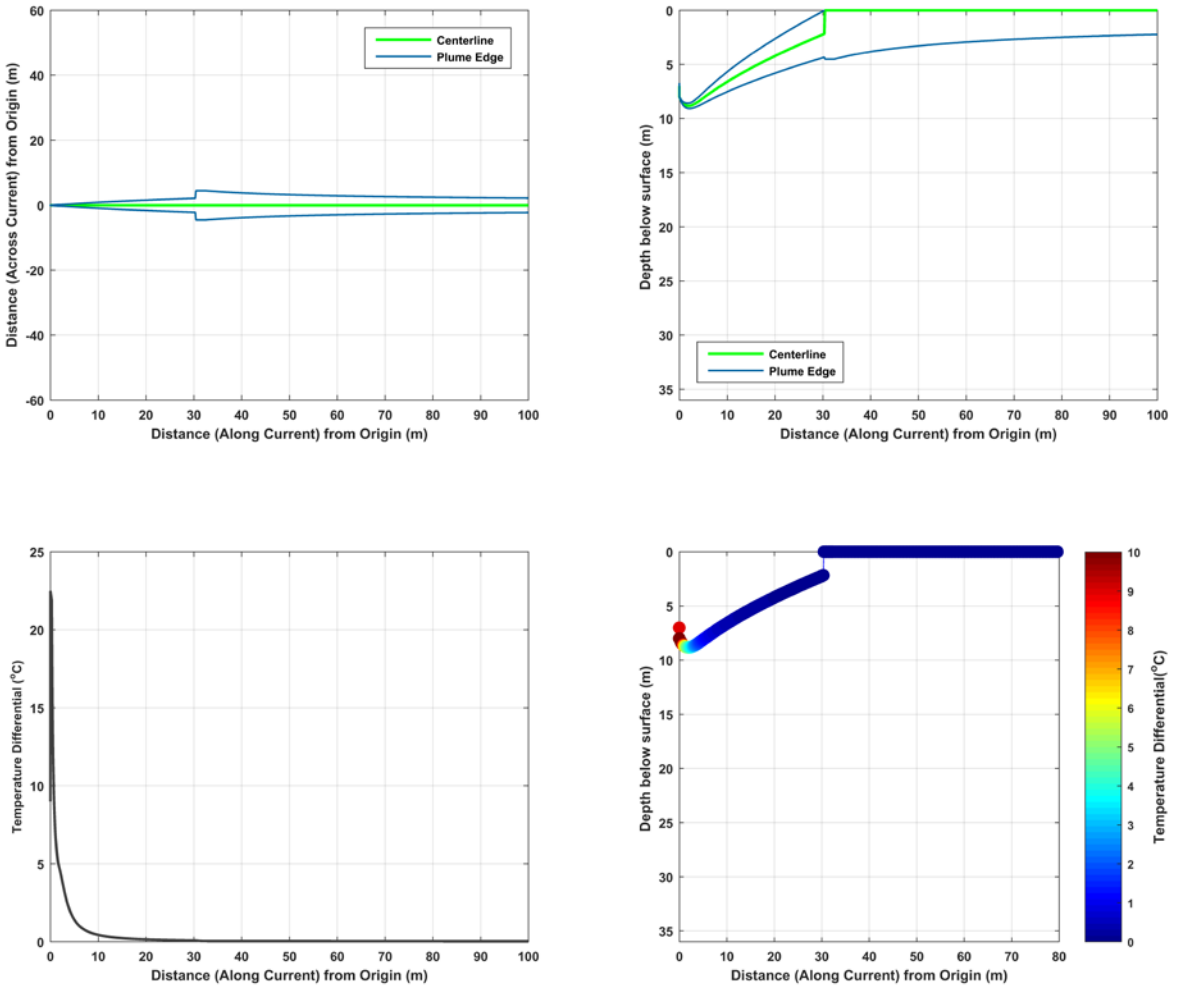


Figure 16. Plume characteristics associated with Scenario 2: Condenser Cooling Water – Flow 4,000 m^3/hr DT =+6.5C. Upper left shows plan (top) view of plume, upper right shows cross sectional view, lower left shows temperature differential as a function of horizontal distance from the discharge and bottom right shows the temperature differential as a function of both depth and horizontal distance from the discharge.

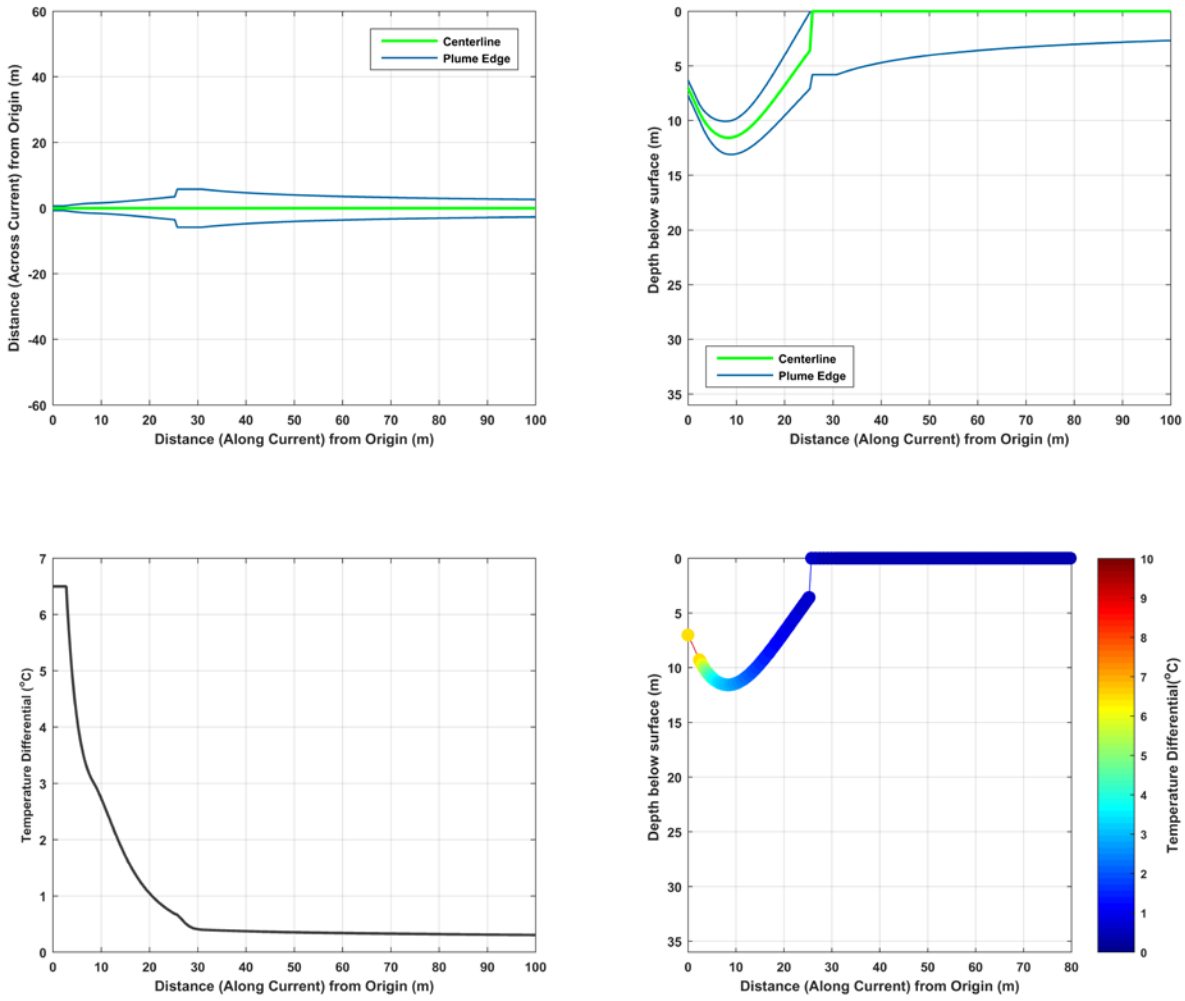


Figure 17. Plume characteristics associated with Scenario 3: F.W. Generator Cooling Water – Flow 42 m^3/hr DT =+22.5C. Upper left shows plan (top) view of plume, upper right shows cross sectional view, lower left shows temperature differential as a function of horizontal distance from the discharge and bottom right shows the temperature differential as a function of both depth and horizontal distance from the discharge.

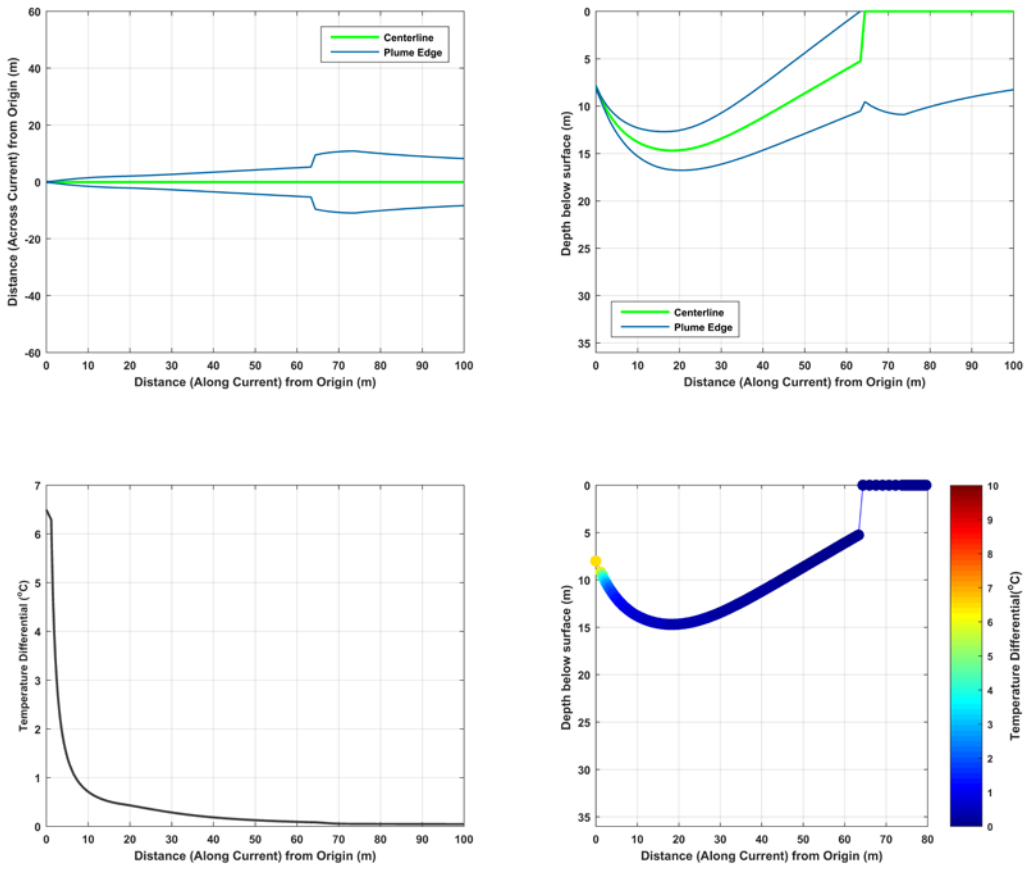


Figure 18. Plume characteristics associated with Scenario 4: Central Cooling Water – Flow 940 m^3/hr DT =+6.5C. Upper left shows plan (top) view of plume, upper right shows cross sectional view, lower left shows temperature differential as a function of horizontal distance from the discharge and bottom right shows the temperature differential as a function of both depth and horizontal distance from the discharge.

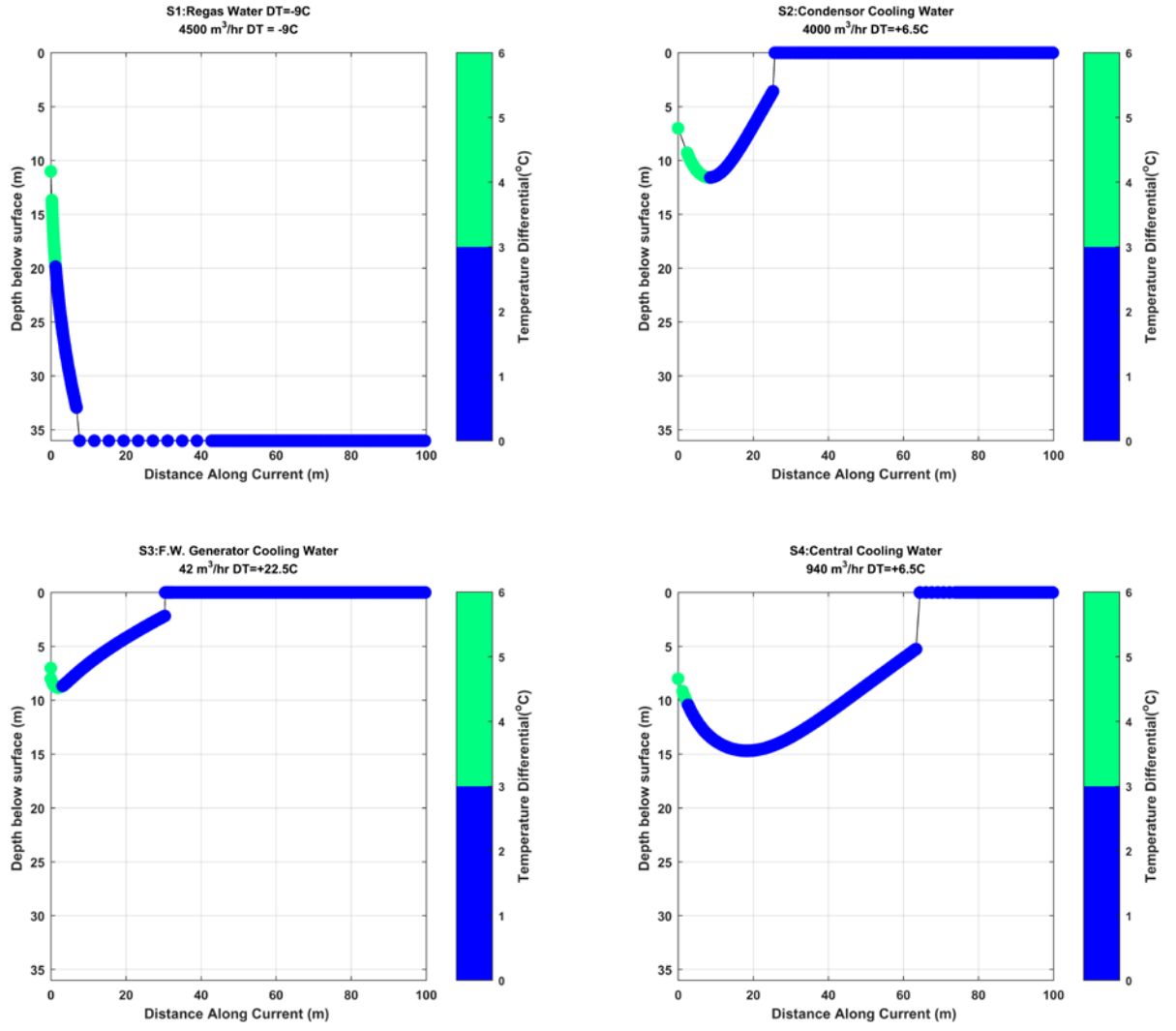


Figure 19. Plume temperature differential for Scenarios 1-4. The temperature scale is shown using two colors for two regimes, blue representing differential <3C and green representing differential >3C since 3C is the regulatory threshold.

Table 8. Summary of discharge scenario parameters.

Parameter	Units	Value			
Scenario ID		S1	S2	S3	S4
Scenario Description		Heating water used in regasification process	Main condenser cooling water	F.W. generator cooling water	Central cooling system
# of Instances		2	1	1	1
Location		Port & Starboard	Port	Starboard	Port
Water Depth at Discharge	**m**	36	36	36	36
Discharge Depth	**m**	10.6	7.38	7.99	8.42
Warm/Cold Discharges		Cold	Warm	Warm	Warm
Discharge Pipe Description		600A	1400A	125A	400A
Discharge Pipe Outer Diameter	**in**	24	56	5.53	16
Discharge Inner Diameter	**in**	23.25	55.25	5.014	15.25
Discharge Orientation		90 deg downward	45 deg downward	45 deg downward	90 deg downward
Discharge Flow	**m^3/hr**	4,500	4,000	42	940
Discharge Initial Temperature Differential	**C**	-9	+6.5	+22.5	+6.5
Required Dilution to Reduce to 3C above Ambient		3	3	8	3
Ambient Density	**kg/m^3**	1019.58	1019.58	1019.58	1019.58
Density Differential	**kg/m^3**	2.26	-2.04	-8.32	-2.04
Discharge Density	**kg/m^3**	1021.84	1017.54	1011.26	1017.54
Ambient Current (5^{th} percentile)	**m/s**	0.14	0.14	0.14	0.14
Distance to 3°C Differential	**m**	1.25	8.59	7.50	2.65
Plume Radius at 3°C Differential	**m**	1.03	1.53	0.33	0.49

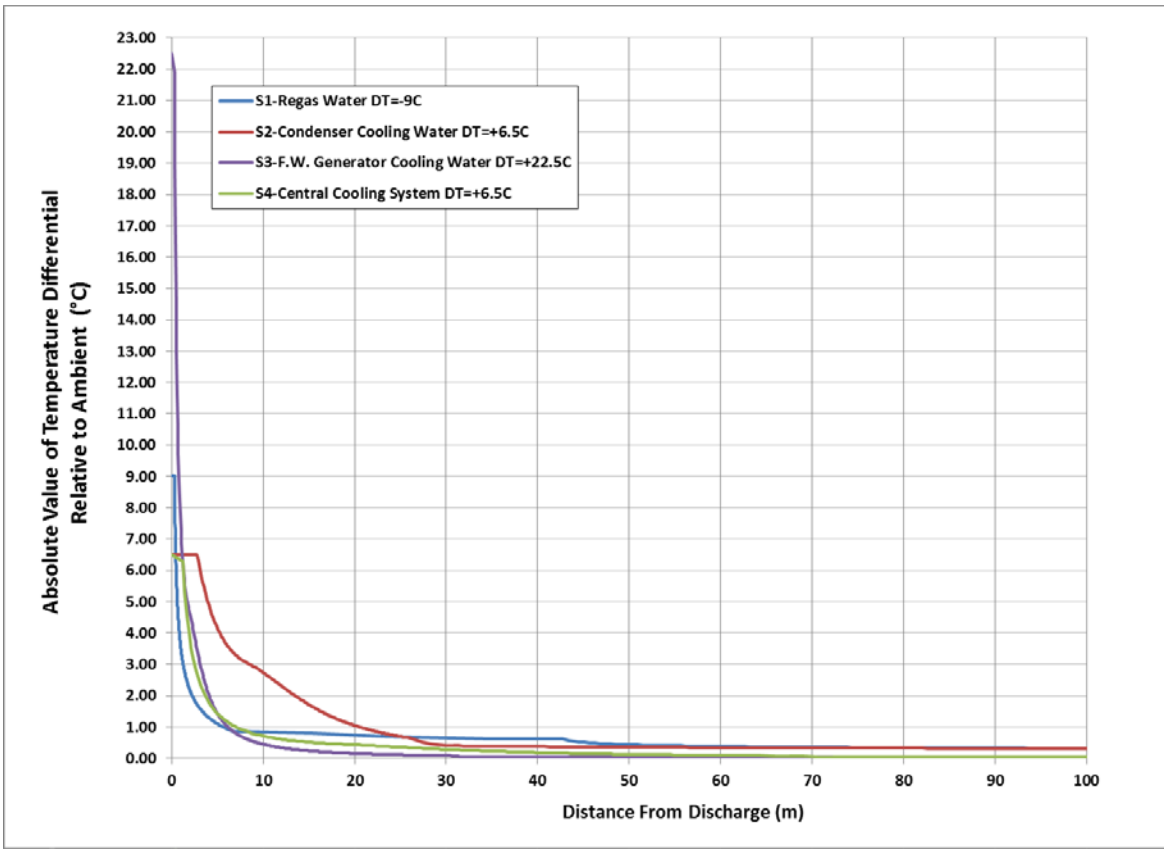


Figure 20. Absolute value of plume temperature differential relative to ambient as a function of distance from discharge.

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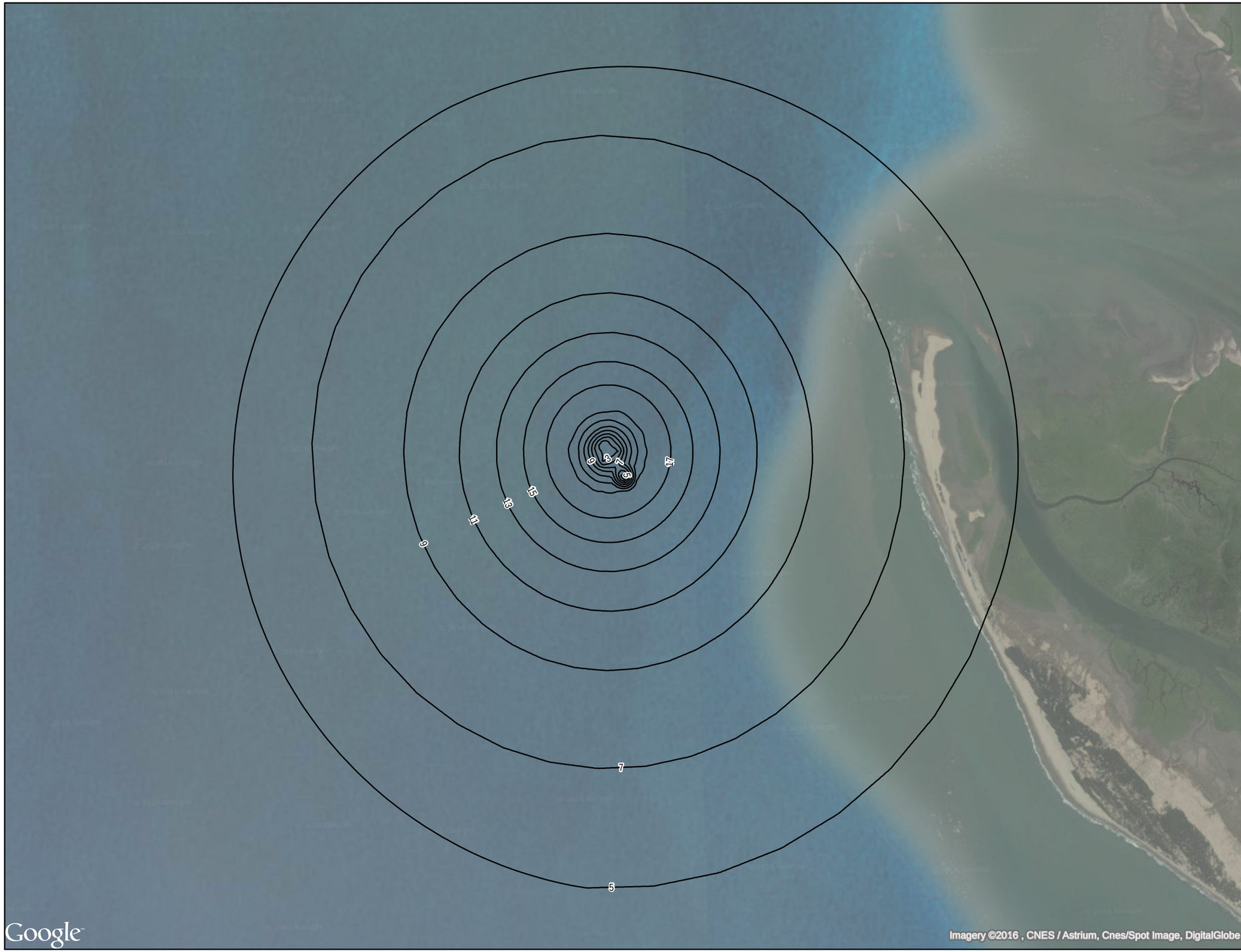
Appendix F: Air Dispersion Modeling Plots



LEGEND

Annual Average NOx Concentrations (ug/m³)

Note:
Bangladesh N0x Annual Average standard: 100 ug/m³

N

0 0.7 1.4

Kilometers

SOURCE: ESRI Imagery Basemap and ASTER Satellite Data

Acorn INTERNATIONAL
LOCAL CONTENT & GLOBAL ASSURANCE

NOx ANNUAL AVERAGE FSRU @ 500 MMScfd Sendout
COX'S BAZAR, BANGLADESH

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LEGEND

Annual Average NOx Concentrations (ug/m³)

Note:
Bangladesh N0x Annual Average standard: 100 ug/m³

N

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Kilometers

SOURCE: ESRI Imagery Basemap and ASTER Satellite Data

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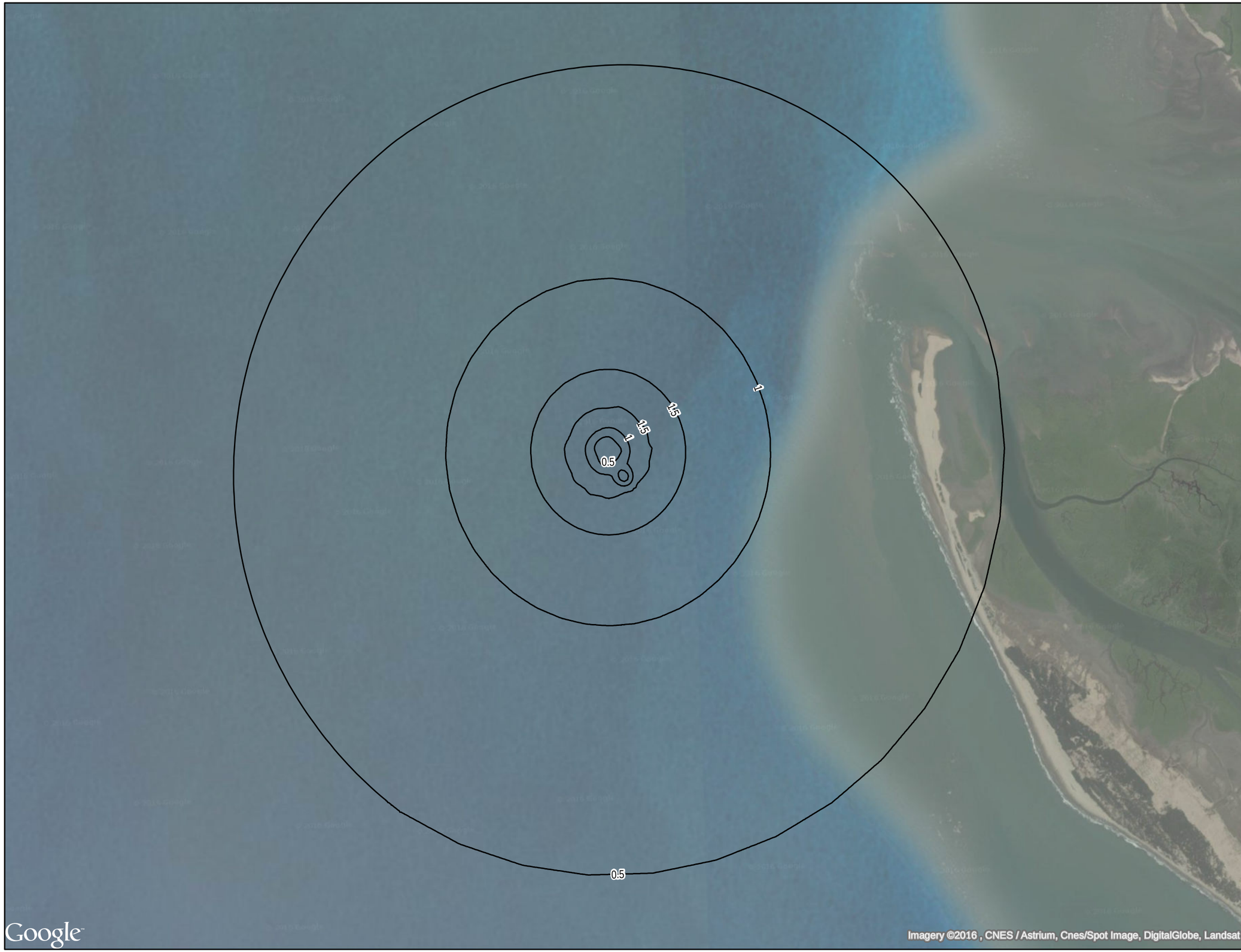

LEGEND

24-Hour Average SO2 Concentrations (ug/m^3)

Note: Bangladesh SO2 24-hour Average standard: 365 ug/m^3

N

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Kilometers

SOURCE: ESRI Imagery Basemap and ASTER Satellite Data

Acorn INTERNATIONAL
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SO2 24-HOUR AVERAGE FSRU @ 500 MMScfd Sendout
COX'S BAZAR, BANGLADESH

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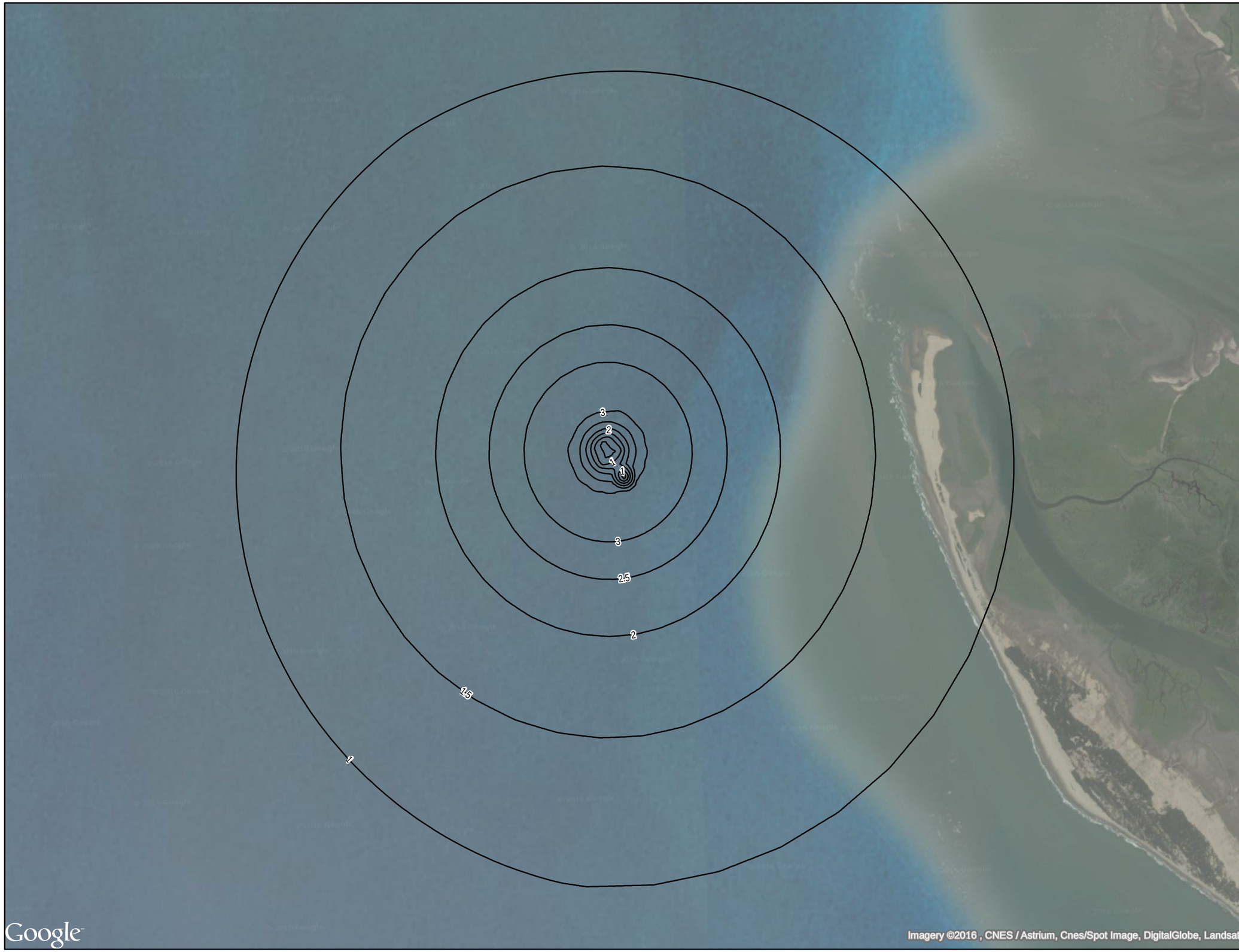

LEGEND

24-Hour Average SO2 Concentrations (ug/m³)

Note: Bangladesh SO2 24-hour Average standard: 365 ug/m3

N

0 0.7 1.4

Kilometers

SOURCE: ESRI Imagery Basemap and ASTER Satellite Data

Acorn INTERNATIONAL
LOCAL CONTENT & GLOBAL ASSURANCE

SO2 24-HOUR AVERAGE FSRU @ 500 MMScfd Sendout with LNGC
COX'S BAZAR, BANGLADESH

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LEGEND

Annual Average NOx Concentrations (ug/m³)

Note: Bangladesh N0x Annual Average standard: 100 ug/m3

N

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Kilometers

SOURCE: ESRI Imagery Basemap and ASTER Satellite Data

Acorn INTERNATIONAL
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NOX ANNUAL AVERAGE FSRU @ 600 MMScfd Sendout
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LEGEND

Annual Average NOx Concentrations (ug/m^3)

Note: Bangladesh N0x Annual Average standard: 100 ug/m3

N

0 0.7 1.4

Kilometers

SOURCE: ESRI Imagery Basemap and ASTER Satellite Data

Acorn INTERNATIONAL
LOCAL CONTENT & GLOBAL ASSURANCE

NO**x** ANNUAL AVERAGE FSRU @ 600 MMScfd Sendout with LNGC
COX'S BAZAR, BANGLADESH

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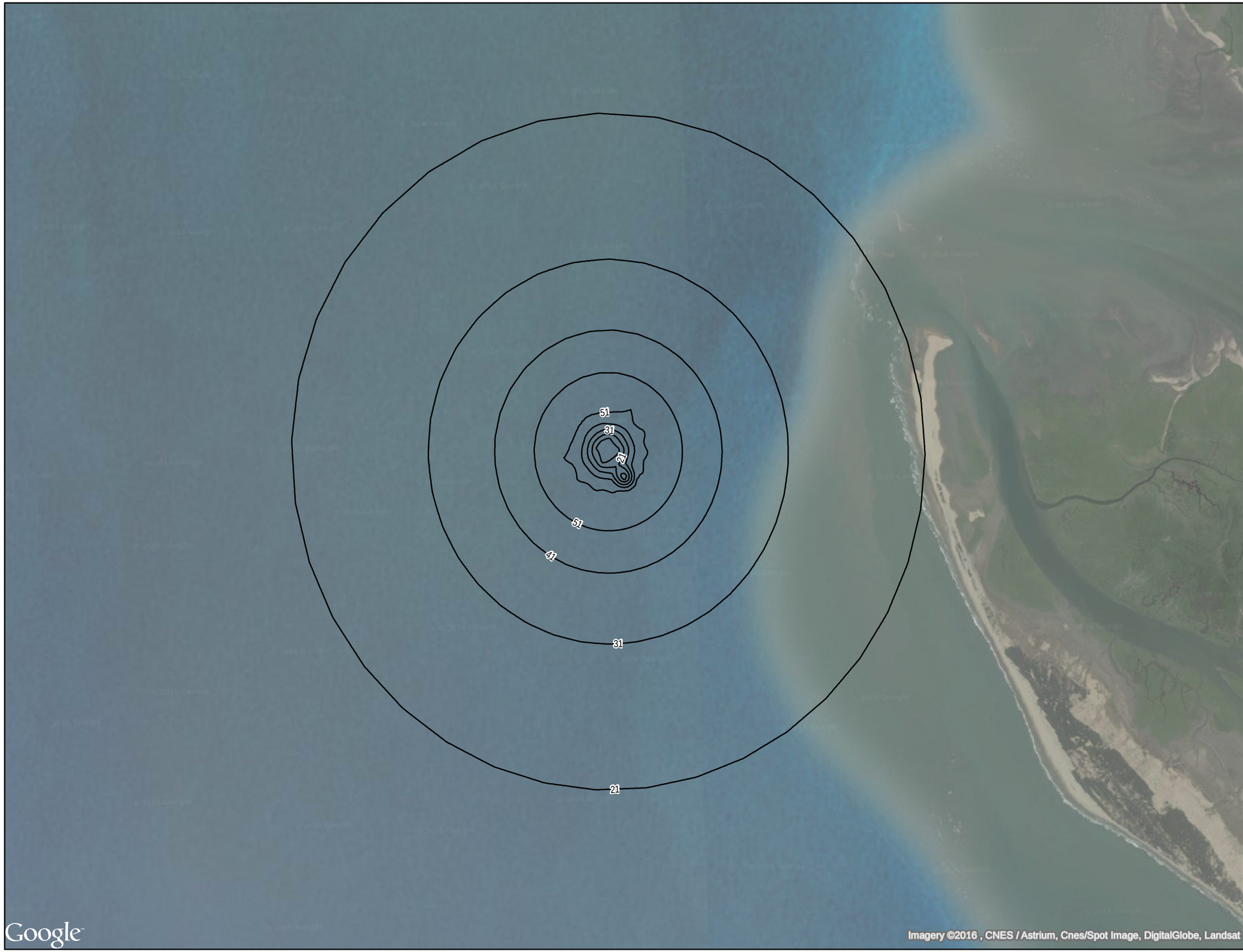

LEGEND

24-Hour Average SO2 Concentrations (ug/m³)

Note: Bangladesh SO2 24-hour Average standard: 365 ug/m3

N

0 0.7 1.4

Kilometers

SOURCE: ESRI Imagery Basemap and ASTER Satellite Data

Acorn INTERNATIONAL
LOCAL CONTENT & GLOBAL ASSURANCE

SO2 24-HOUR AVERAGE FSRU @ 600 MMScfd Sendout
COX'S BAZAR, BANGLADESH

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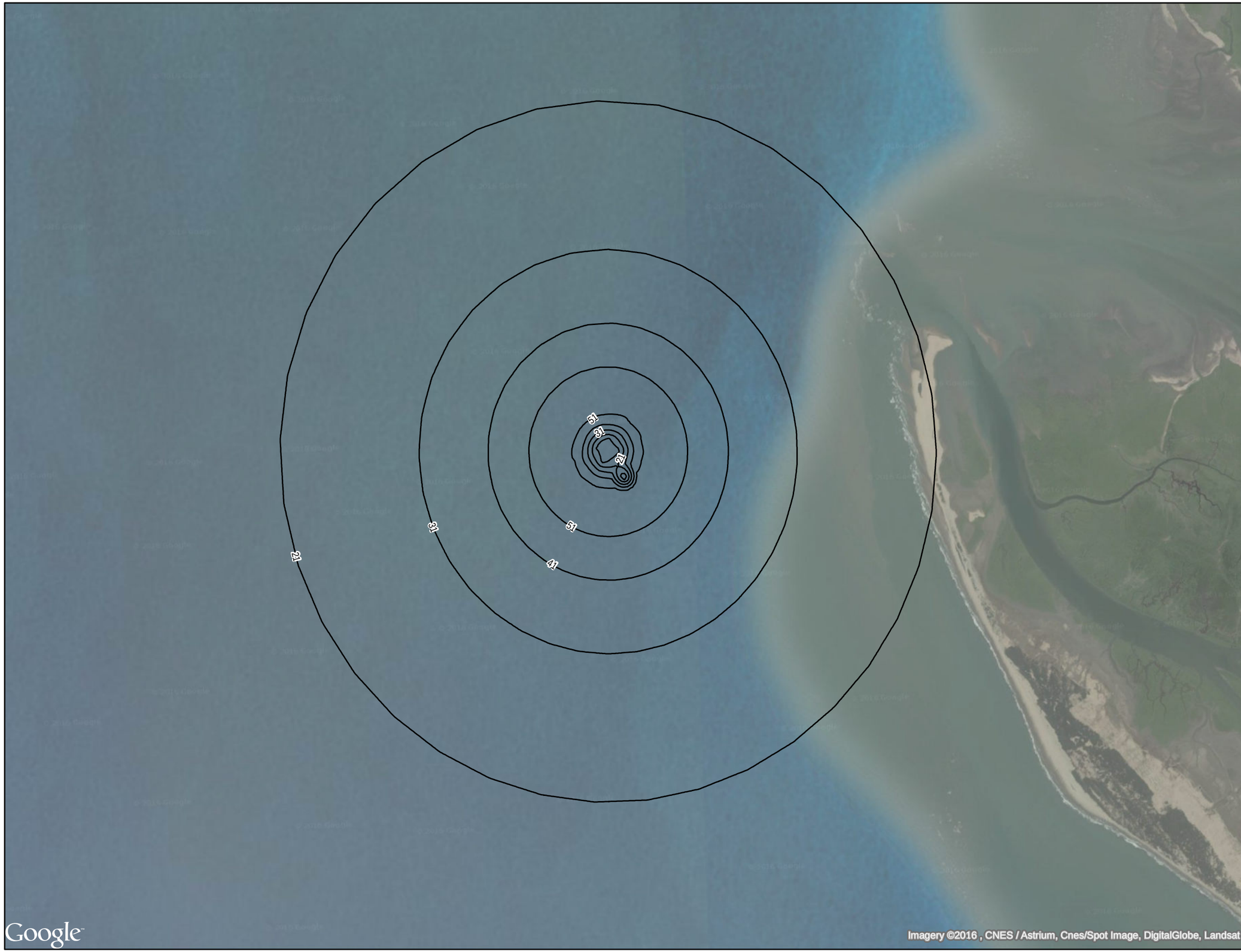

LEGEND

24-Hour Average SO2 Concentrations (ug/m³)

Note: Bangladesh SO2 24-hour Average standard: 365 ug/m3

N

0 0.7 1.4

Kilometers

SOURCE: ESRI Imagery Basemap and ASTER Satellite Data

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Appendix G: LNG Atmospheric Dispersion Modeling

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Draft Report

LNG Atmospheric Dispersion Modeling, Bangladesh

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Project Manager: Eric Comerma

PROJECT NUMBER: RPS ASA 16-230

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1. Introduction: Geographic Location - Area of Interest

Acorn International contracted Applied Science Associates, Inc. (dba RPS ASA) to assess the atmospheric dispersion of Liquefied Natural Gas (LNG) vapor that may be released in the event of a breach of an offshore LNG Floating Storage and Re-gasification Unit (FSRU). The proposed FSRU is to be located near the Cox's Bazar district in Bangladesh (Figure 1). Table 1 and Figure 1 present the locations and types of release scenarios. Releases were simulated assuming 3 different breach hole sizes, and under the range of environmental conditions found at this location. This document summarizes the key findings of the modeling study.

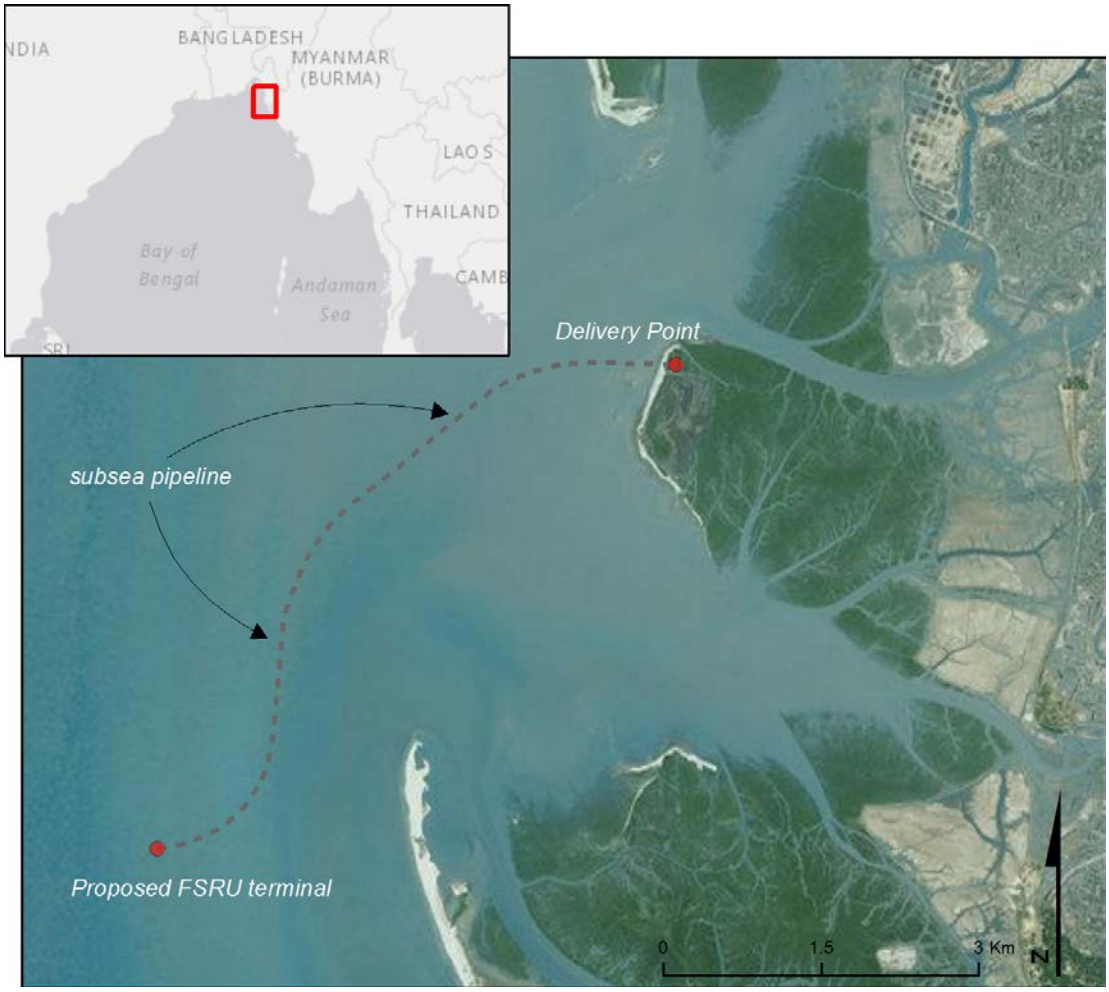

Figure 1. Location of the proposed FSRU, near Cox's Bazar district, Bangladesh.

Table 1. Location and type of potential LNG releases.

Release Site	Description Release Type	Total LNG Volume	Latitude	Longitude
FSRU terminal	Breach of single tank at 50% capacity, with no ignition	17,639 m^3	21.534471 °N	91.818652 °E
	Breach of single tank at 100% capacity, with no ignition	35,277 m^3		

2. Environmental Conditions and Data Analysis

The study area is located in the northeast Bay of Bengal, approximately 5 km offshore of Moheshkhali Island in the South East of Bangladesh, and 90 km south of the port city of Chittagong in Bangladesh.

The following section describes the key environmental conditions that dominate in the region of interest. This analysis will provide an insight of the predominant winds, temperature, and humidity, their temporal variability, and year around and across the area of interest.

The following environmental dataset were gathered:

- Wind speed and direction data was obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis Product for a 10 year period (2005 to 2014). The ECMWF provides the ERA-Interim reanalysis product that includes wind hindcast data on a global scale. The data are generated using an atmospheric model with data assimilation and distributed on a grid with 0.75° horizontal resolution and a three-hour time step interval (ECMWF, 2009). ERA-Interim covers the period of January 1st, 1979 to near-real time. Gridded data products include a large variety of 3-hourly surface parameters, describing weather as well as ocean-wave and land-surface conditions, and 6-hourly upper-air parameters covering the troposphere and stratosphere (Dee et al., 2011). For this region of interest, the spatial east-west horizontal resolution is about 42 km and the temporal resolution is 3h.
- Temperature and humidity data were obtained from the US National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI 2016), for a meteorological station located at Cox's Bazar, Bangladesh. Average monthly values were generated based on observations recorded over the last 10 years (Figure 3).

Based on the review of those datasets, the following conclusions can be highlighted:

- Analysis of the wind data showed 2 general wind regimes. During the winter months (December to February) the wind comes predominantly from the north. During the rest of the months in spring, summer and wet season, the winds are predominantly from the south (Figure 2).
- Peak winter winds occur during the month of January, and peak winds during the wet season occur during July. These two months were selected as the periods to cover with the air dispersion modeling scenarios (Figure 3).
- Temperatures in the region do not vary significantly throughout the year. The monthly average temperatures in the region range from 20.6 to 29.5°C. The monthly average temperature for January is 20.6°C and for July is 27.5°C (Table 2).
- The relative humidity in the region averages 79.5% annually. During the dryer winter season, the average relative humidity in January is 71.0%. During the peak of the wet season, the July average relative humidity is 88.6% (Table 2).

Based on the review of the environmental conditions in the region, a set of 4 conditions (scenarios) were selected for the air dispersion modeling (Table 2). Two seasons were selected, the winter season (January), and the wet season (July). The average temperature and relative humidity for these months were used. Two different wind speeds were selected for each season: the average wind speed and the 95th percentile wind speed of each month. For each wind speed condition an appropriate Pasquill atmospheric stability class was selected (Pasquill 1961).

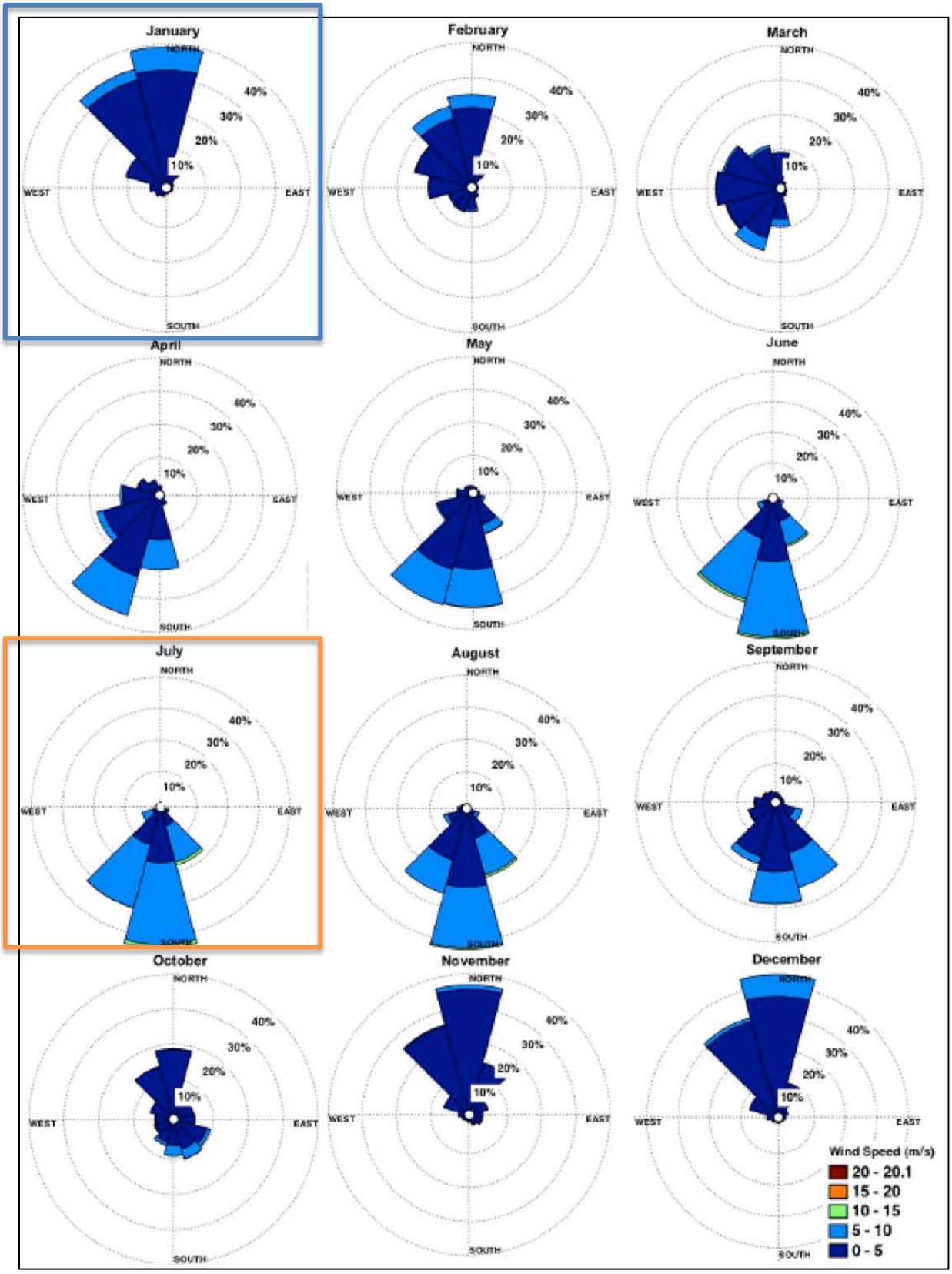

Figure 2. ECMWF Monthly wind roses near the future FSRU location; wind speeds in m/s, using meteorological convention (i.e., direction wind is coming from).

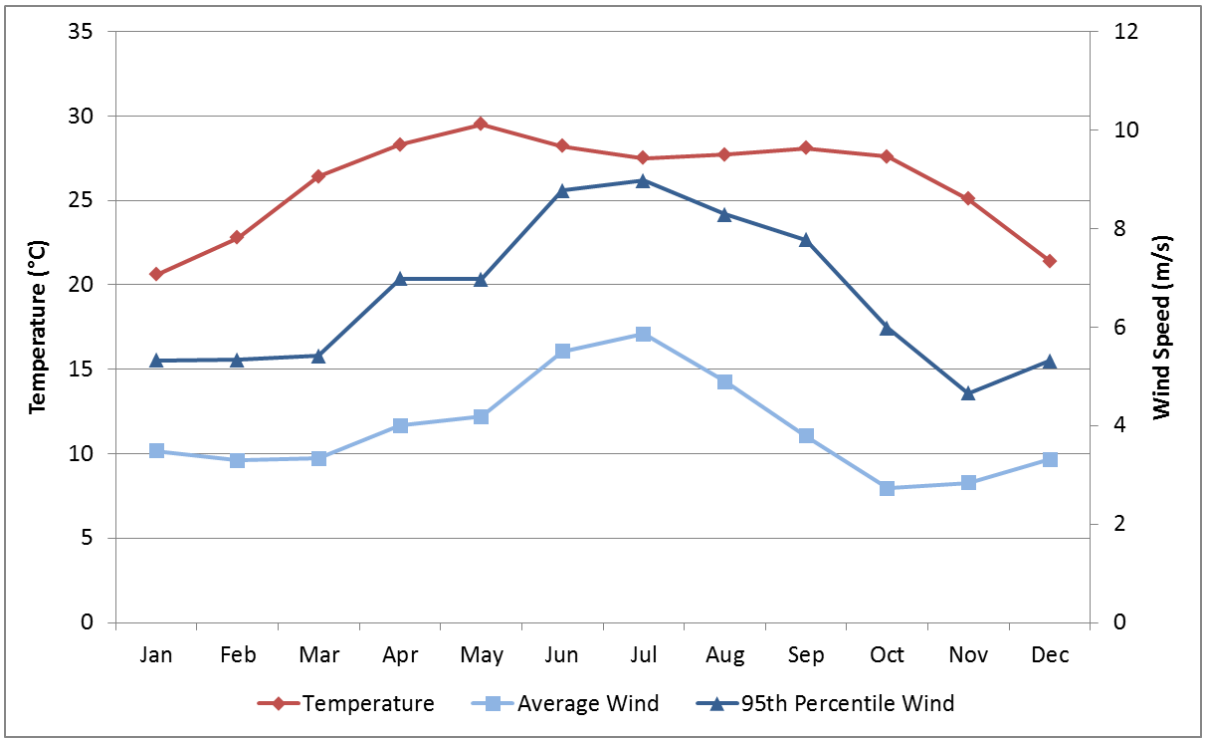

Figure 3. Average temperature, average wind speed, and 95th percentile wind speed by month for the region.

Table 2. Environmental parameters selected for use in the air dispersion modeling.

	January (Winter)		July (Wet Season)	
	Average Wind	95th Percentile Wind	Average Wind	95th Percentile Wind
Wind Speed (m/s)	3.49	5.32	5.87	8.98
Stability Class	B	C	D	D
Temperature (°C)	20.6		27.5	
Relative Humidity (%)	71.0		88.6	

3. Model Setup

This section describes the modeling approach followed in this study and defines the matrix of spill scenarios simulated.

3.1. Release Scenarios

As listed in Table 1 and Table 3, releases were simulated to cover a range of possible scenarios, which include the volume of LNG in the FSRU tank and environmental conditions. An additional variable considered was the size of the hole in the tank that results from a breach. A reasonable range of hole sizes for a near shore FSRU range from 2 - 12 m^2, with a nominal hole size of 5 m^2 (Luketa et al., 2008). For a breach scenarios without an ignition source it is very unlikely that more than one tank could be breached. For these simulations it was assumed that the largest tank (Tank #4) was breached. The breach was simulated both when the tank is at 100% and 50% capacity. It was assumed that the hole type and location would allow the entire contents of the tank to be released.

For each hole size, a maximum liquid pool diameter was defined, based on recommendations from Luketa et al. (2008). This estimated pool diameter is based on when the rate of evaporation rate is in equilibrium with the release rate from the tank.

These release scenarios were simulated for each of the 4 sets of environmental conditions, for a total of 24 model scenarios (Table 3).

Table 3. The 24 LNG release scenarios defined for the air dispersion modeling.

Environmental Conditions	LNG Release Volume	Hole Size (m^2)	Maximum Pool Diameter (m)	Scenario #
January (Winter) Avg Wind	50% 17,638.5 m^3	2	265	1
		5	350	2
		12	550	3
	100% 35,277 m^3	2	265	4
		5	350	5
		12	550	6
January (Winter) 95th % Wind	50% 17,638.5 m^3	2	265	7
		5	350	8
		12	550	9
	100% 35,277 m^3	2	265	10
		5	350	11
		12	550	12
July (Wet Season) Avg Wind	50% 17,638.5 m^3	2	265	13
		5	350	14
		12	550	15
	100% 35,277 m^3	2	265	16
		5	350	17
		12	550	18
July (Wet Season) 95th % Wind	50% 17,638.5 m^3	2	265	19
		5	350	20
		12	550	21
	100% 35,277 m^3	2	265	22
		5	350	23
		12	550	24

3.2. LNG properties

The following Table 4 summarizes the characteristics of the LNG liquid product and storage conditions within the FSRU tank. The LNG product is a mixture comprised of several hydrocarbons, but Methane alone makes up approximately 90% of the LNG volume. The LNG is cooled to keep it stored as a liquid within the FSRU tanks. The typical storage temperature is -159° C. This temperature allows for storage at a relatively low pressure (0.5 bar g), while maintaining the liquid state of the LNG. The nitrogen component of the LNG is very small (less than 1%). Due to the small quantity of nitrogen, and since it is not a flammable gas and is non-toxic, the nitrogen portion of the LNG was not included in the air dispersion modeling analysis.

Table 4. Summary of the oil properties used in the modeling.

Composition		Storage Pressure	Storage Temperature
Chemical	Volume %		
Methane	89.63	0.5 bar (gauge)	-159° C
Ethane	6.32		
Propane	2.16		
Butane	1.2		
Nitrogen*	0.69		

**Nitrogen was not included in the modeling due to small quantity and lack of flammability/toxicity.*

3.3. Modeling Approach and Models Used

The Complex Hazardous Air Release Model (CHARM) was used to determine the release properties for a breach of a FSRU tank. CHARM is useful for preparing for or responding to an accidental release, developing response plans, and supporting response training. CHARM creates a source term for the release based on specifications of the holding container and its operating parameters. Details of the calculations within the CHARM system are described in detail in a technical reference manual (Eltgroth, 2011).

Inputs to the model include the storage conditions of the LNG, the environmental conditions, size of the hole, and the chemical and physical properties of the LNG components. The results of the CHARM model include the properties of the release including the release rate and duration as well as a description of the type of release (i.e. pure liquid, pure vapor, or some combination).

The SLAB model was used to perform the vapor dispersion modeling. The SLAB model is a US EPA approved computer model for simulating the atmospheric dispersion of denser-than-air gas releases and is one of the most widely used dense gas models in the public domain. It was developed at Lawrence Livermore National Laboratory to model releases to the atmosphere from evaporating pools and vertical and horizontal jets released from pressurized containers. It can simulate releases as instantaneous puffs, as a continuous, steady state discharge, or a combination of both. The model predicts downwind centerline concentration and plume width under specified meteorological conditions by solving the conservation equations of mass, momentum, energy and species in the downwind direction. Thermodynamics effects are also calculated, including latent heat exchange due to the condensation or evaporation of the released liquids.

Sub-models within SLAB are used to solve the basic conservation equations. These sub-models describe the dilution of the plume due to turbulent mixing with surrounding air, the formation and evaporation of liquid droplets within the plume and the heat transfer from the ground to a “cold” plume. Turbulent mixing occurs as ambient air is entrained by the plume, causing dilution of the released vapor. Formation and evaporation of liquid droplets is calculated using a local thermodynamic equilibrium approximation where the ratio of liquid to vapor is determined by making the partial pressure of the vapor phase equal to the saturation pressure until all liquid is evaporated. Liquid droplet size is set sufficiently small so that the droplet and vapor mixture can be modeled as a single fluid. In the case where the ground is warmer than the vapor plume, heat is transferred to the plume using a surface heat transfer coefficient.

From the SLAB user manual (Ermak, 1990):

> *The basic conservation laws, along with the various sub-models, form a set of coupled equations that mathematically describe the physics of heavy gas dispersion, including: gravity spread which produces and wider and lower cloud, reduced turbulent mixing due to stable density stratification, the thermodynamic effects due to droplet formulation and evaporation and due to ground heating of the cloud, and the indirect effects of temperature change on density stratification and turbulent mixing with the ambient atmosphere. … The solution of this set of equations yields the instantaneous spatially averaged concentration; density; temperature; downwind velocity; and cloud height, width and length.*

Inputs to the SLAB model include the release rate or evaporation rate of the LNG components, the release duration, the chemical and physical properties of the LNG components, and the environmental conditions at the time of the release. Results of the SLAB model consist of a prediction of the spatial distribution and concentration of vapor in the air. These results can be used to assess the plume dimensions, as well as the extent of concentrations exceeding some concentration threshold of concern. For these simulations, the threshold of concern was the lower explosive limit (LEL) for each component of the LNG.

4. LNG Dispersion Modeling Results

This section describes the results of the air dispersion modeling performed. The results for CHARM release conditions modeling are presented in the vapor release rates section. The results from the SLAB dispersion modeling are presented in the vapor dispersion section.

4.1. Vapor Release Rates – CHARM Results

In the event of a breach of a LNG tank, the release is predicted to be predominantly liquid. Of the total volume of the tank, the release is predicted to between 96.9 and 97.3% liquid across the 24 release scenarios. The liquid released is able to spread over the surface of the water, forming a liquid pool of LNG that then quickly evaporates into the atmosphere. The remaining 2.7 - 3.1% of the LNG volume is released as vapor directly from the tank.

The release rate and duration of the vapor released directly from the tank (Table 5 and Figure 4) is only influenced by the size of the hole in the tank. The volume in the tank or the environmental conditions do not influence this portion of the release. The storage conditions within the tank are constant between scenarios and therefore the release rate and duration are the same. As the size of the hole increases, the release rate also increases, while the duration of the vapor release decreases.

Table 5. Release rate and duration for vapor released directly from the tank.

Hole Size (m^2)	Vapor Release from tank							
	Release Rate (kg/s)				Duration (s)			
	Methane	Ethane	Propane	Butane	Methane	Ethane	Propane	Butane
2	405.7	128.4	79.6	68.9	811.3	20.8	11.5	3.2
5	1,014.2	321.0	199.1	172.3	325.2	8.3	4.6	1.2
12	2,434.0	770.4	477.7	413.6	135.7	3.4	1.9	0.5

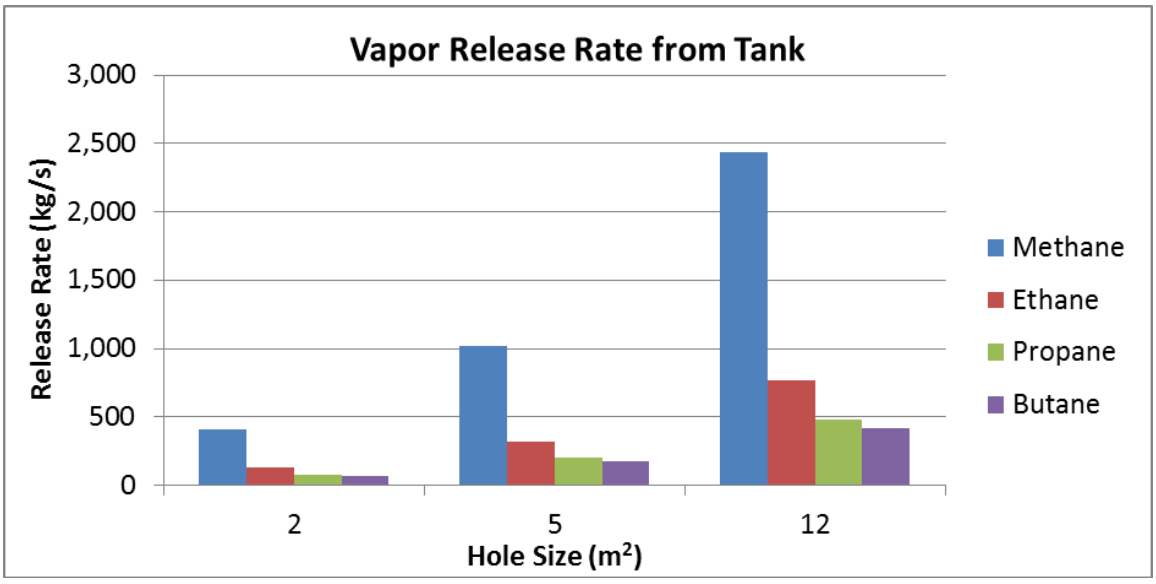

Figure 4. Comparison of release rates for vapor released directly from the tank.

The rate at which the pool of liquid LNG on the water surface evaporates is significantly impacted by the size of the hole in the tank and the environmental conditions at the time of the release (Table 6 and Figure 5). With the larger hole size, and therefore larger maximum pool diameter, the LNG is evaporating more quickly from the water surface. Higher air temperature or higher wind speeds also increase the evaporation rate of the LNG. However, the atmospheric stability also influences the evaporation rate. With more unstable atmospheric conditions (wet season), the LNG is not able to evaporate as quickly, despite the higher air temperature and wind speeds.

Table 6. Release rate and duration for vapor released from the liquid LNG pool.

Scenario	Liquid Evaporation from LNG pool (water surface)							
	Release Rate (kg/s)				Duration (hr)			
	Methane	Ethane	Propane	Butane	Methane	Ethane	Propane	Butane
1	1,705.3	45.8	15.6	8.6	2.10	0.27	0.13	0.12
2	3,060.5	75.6	25.7	14.2	1.23	0.17	0.08	0.07
3	8,424.7	171.2	58.0	31.9	0.52	0.08	0.03	0.02
4	1,953.7	45.8	15.6	8.6	4.20	0.54	0.28	0.32
5	3,704.2	75.6	25.7	14.2	2.51	0.36	0.18	0.18
6	9,960.6	171.2	58.0	31.9	1.06	0.15	0.07	0.06
7	2,924.9	180.8	61.2	33.7	0.55	0.07	0.04	0.06
8	4,833.5	297.8	101.2	55.8	0.33	0.05	0.03	0.03
9	10,897.9	672.9	228.6	125.8	0.16	0.03	0.01	0.01
10	2,924.9	180.8	61.2	33.1	1.08	0.15	0.11	0.17
11	4,833.5	297.8	101.2	55.8	0.66	0.11	0.08	0.09
12	12,196.7	672.9	228.6	125.8	0.30	0.05	0.03	0.03
13	1,773.0	54.1	18.4	10.1	1.78	0.23	0.11	0.10
14	3,771.9	89.2	30.5	16.8	1.02	0.15	0.07	0.06
15	8,808.7	202.3	68.6	37.8	0.44	0.07	0.03	0.02
16	2,032.8	54.1	18.4	10.1	3.56	0.46	0.24	0.27
17	3,851.0	89.2	30.5	16.8	2.12	0.30	0.15	0.15
18	10,434.9	202.3	68.6	37.8	0.89	0.13	0.06	0.05
19	1,840.8	76.2	25.9	14.3	1.27	0.16	0.08	0.08
20	3,930.0	125.8	42.7	23.6	0.74	0.11	0.05	0.05
21	9,124.9	284.3	96.6	53.1	0.33	0.05	0.02	0.02
22	2,111.8	76.2	25.9	14.3	2.53	0.33	0.18	0.23
23	4,020.4	125.8	42.7	23.6	1.52	0.22	0.12	0.13
24	10,807.6	284.3	96.6	53.1	0.65	0.10	0.05	0.04

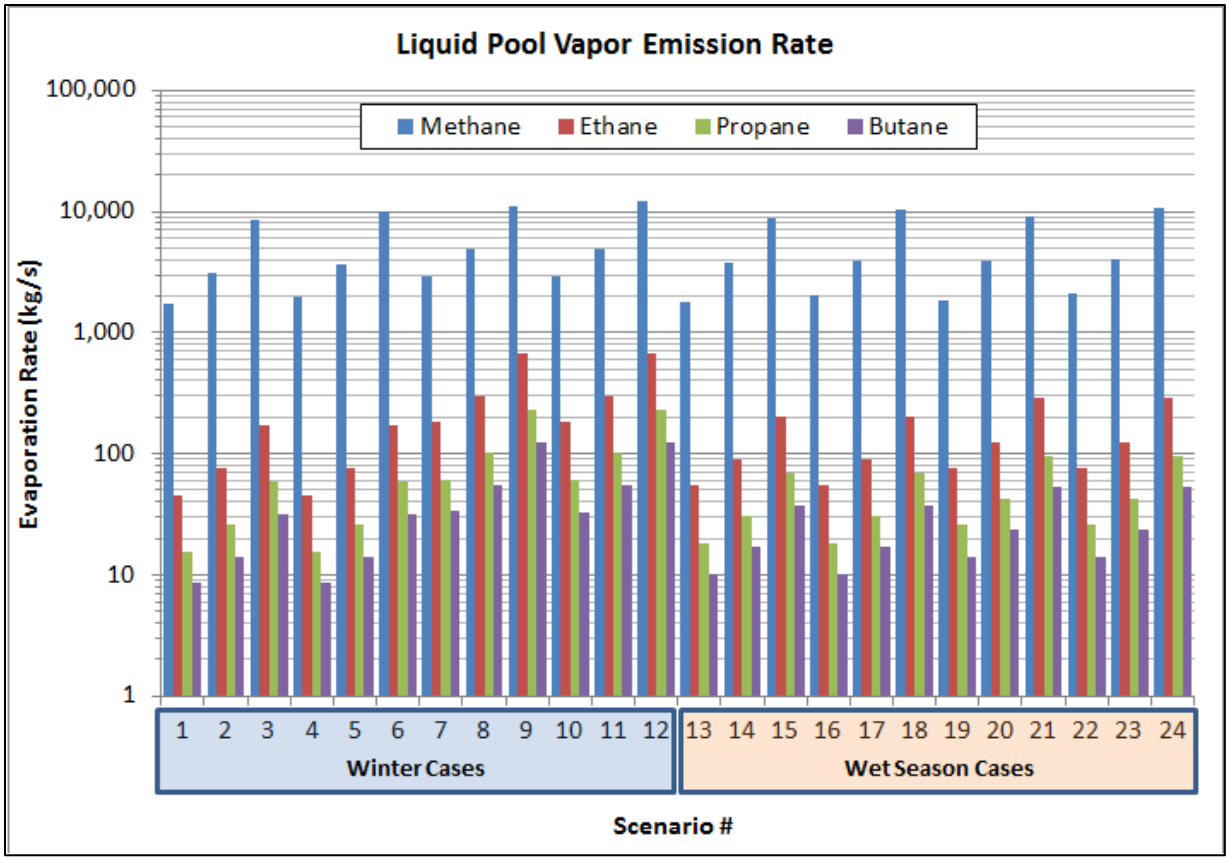

Figure 5. Comparison of evaporation rates from the liquid LNG pool.

4.2. Vapor Dispersion – Results from SLAB

The dispersion of the LNG vapor was simulated in the SLAB model both as a horizontal vapor jet for the vapor released directly from the tank, as well as vapor resulting from evaporation from the liquid pool on the water surface. The extent of the vapor cloud, and the height of the maximum vapor concentrations were assessed. Examples of the resulting vapor cloud a presented for a subset of release simulations. The maximum downwind distance to vapor concentrations near ground level exceeding the lower explosive limit were determined for each scenario.

Of the LNG components, methane makes up the largest portion. Methane is also a very light density gas. When the density of the methane vapor cloud is lower than air, the vapor cloud is able to rise. When that occurs the highest methane vapor concentrations may not be at ground level where they can be harmful. For the winter seasons scenarios, the maximum methane concentrations were found at ground level, both from the evaporating pool releases as well as the vapor releases from the tank. Under the wet season environmental conditions, the methane vapor is able to rise later in the simulation as the vapor cloud disperses and the density drops. For the vapor releases directly form the tank, the maximum vapor concentration is at ground level for the first 150 - 300 meters of the release (Figure 6). After that the methane is able to rise, and the maximum concentrations can reach approximately 50 - 400 meters above the ground.

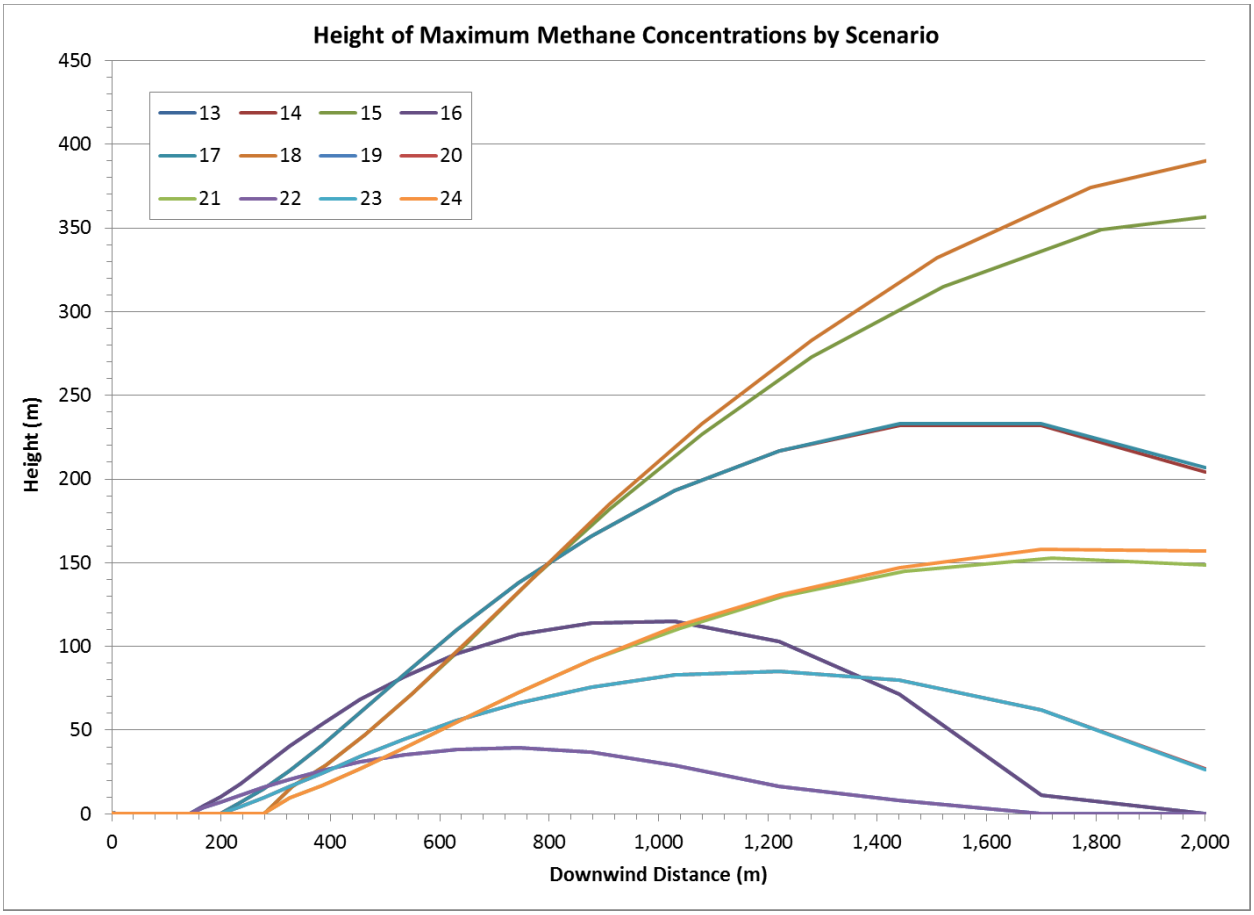

Figure 6. Methane vapor plume centerlines - Height of maximum methane concentrations by scenario during the wet season.

The following sets of figures present the predicted plume extent and concentration of methane, at ground level, scenario 12 (Figure 7 and Figure 8) and scenario24 (Figure 9 and Figure 10). These two scenarios represent the cases with the 12m^2 hole diameter, the full tank volume, and the 95th percentile wind speeds for both the winter and wet seasons. In each figure the black line represents the maximum extent of the vapor concentrations exceeding the lower explosive limit for methane (50,000 ppm). The resulting plume from the vapor release directly from the tank and the pool evaporation are shown for each scenario. These plumes assume the wind direction of the prevailing wind direction for the associated season (from the north for the winter season, and from the south for the wet season).

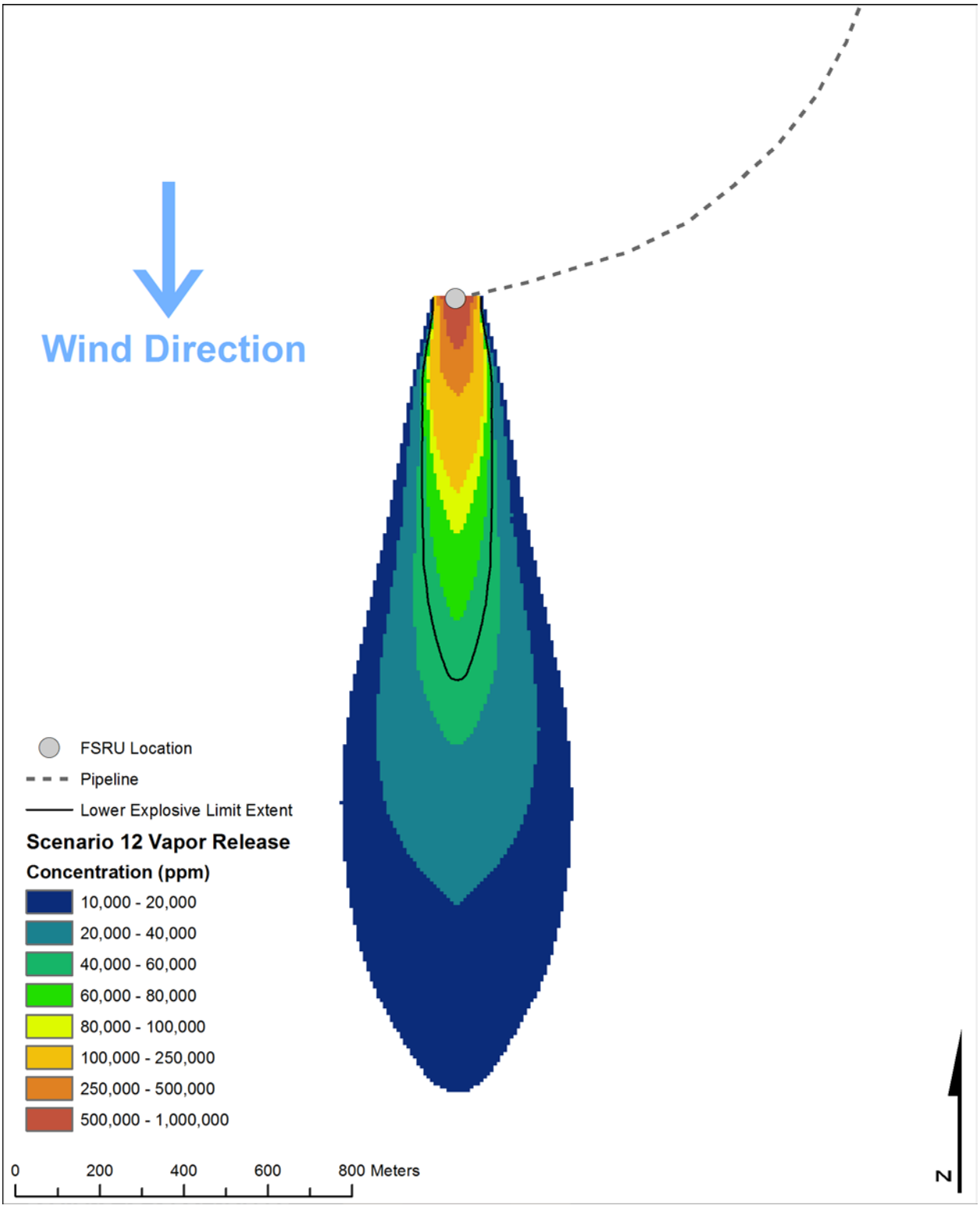

Figure 7. Predicted Methane vapor plume concentrations at ground level from tank vapor release for scenario 12 (Winter 95th wind speed, release 100% tank volume, 12 m^2 hole size).

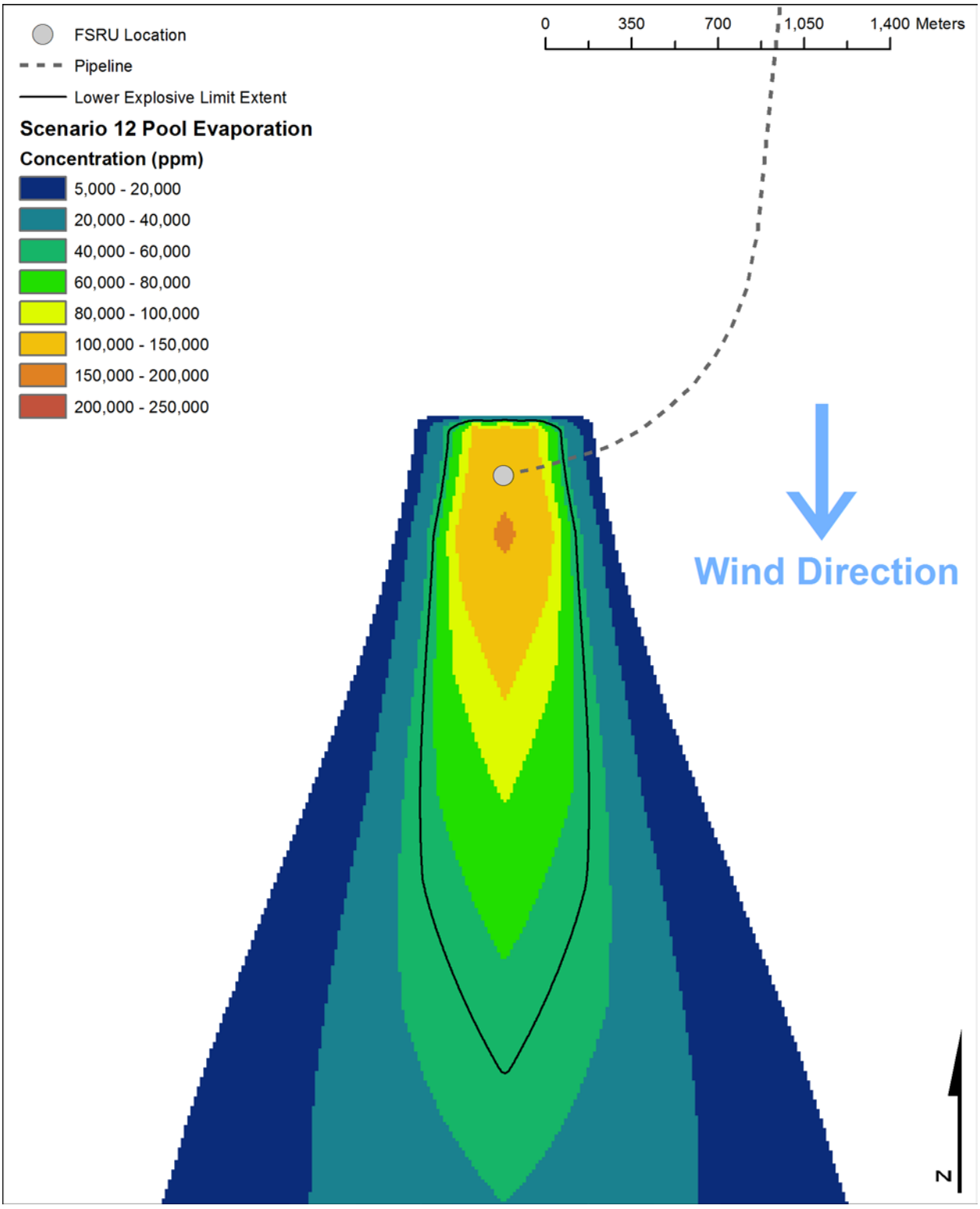

Figure 8. Predicted Methane vapor plume concentrations at ground LNG evaporating pool release for scenario 12 (Winter 95th wind speed, release 100% tank volume, 12 m^2 hole size).

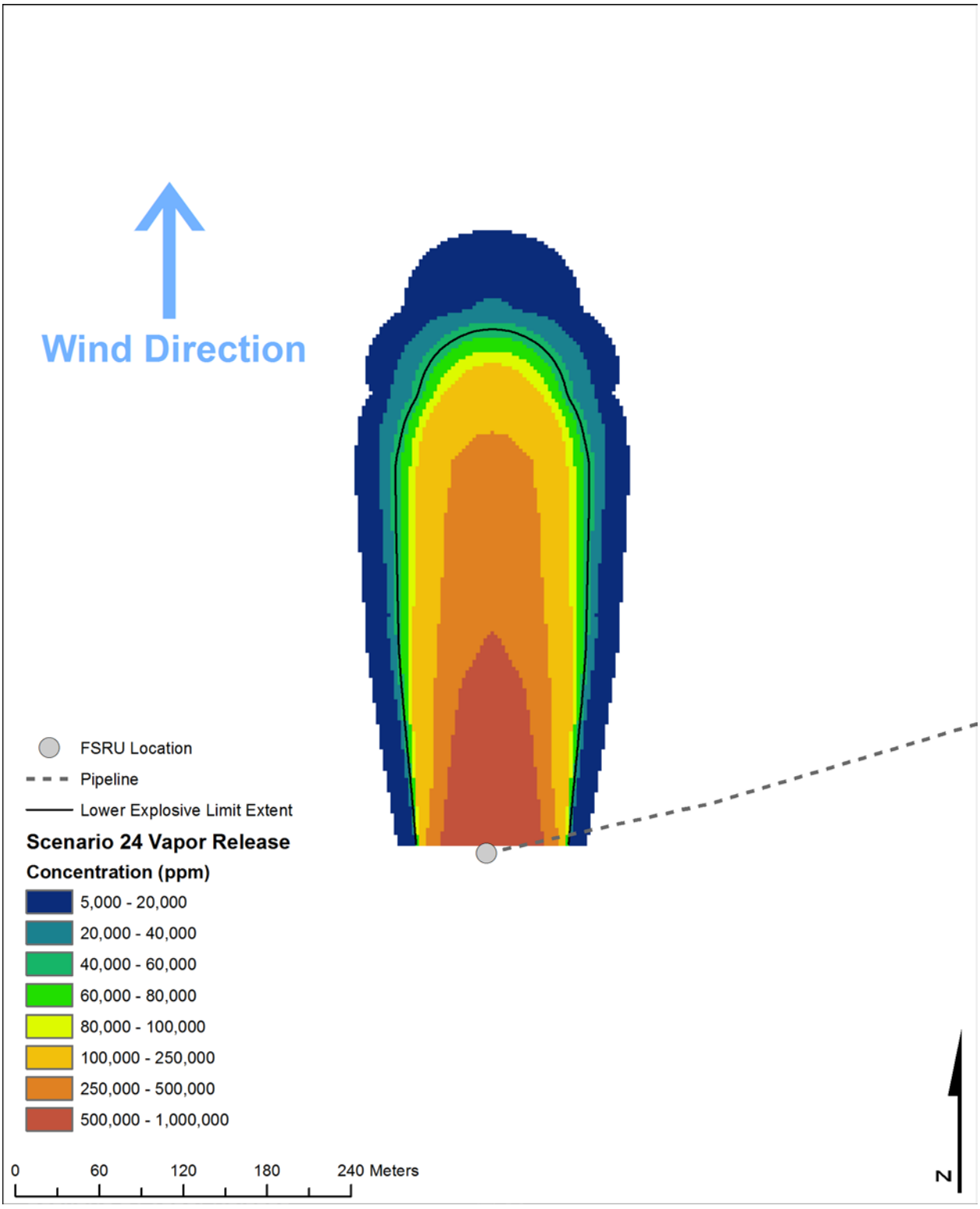

Figure 9. Predicted Methane vapor plume concentrations at ground level from tank vapor release for scenario 24 (Wet season 95th wind speed, release 100% tank volume, 12 m^2 hole size).

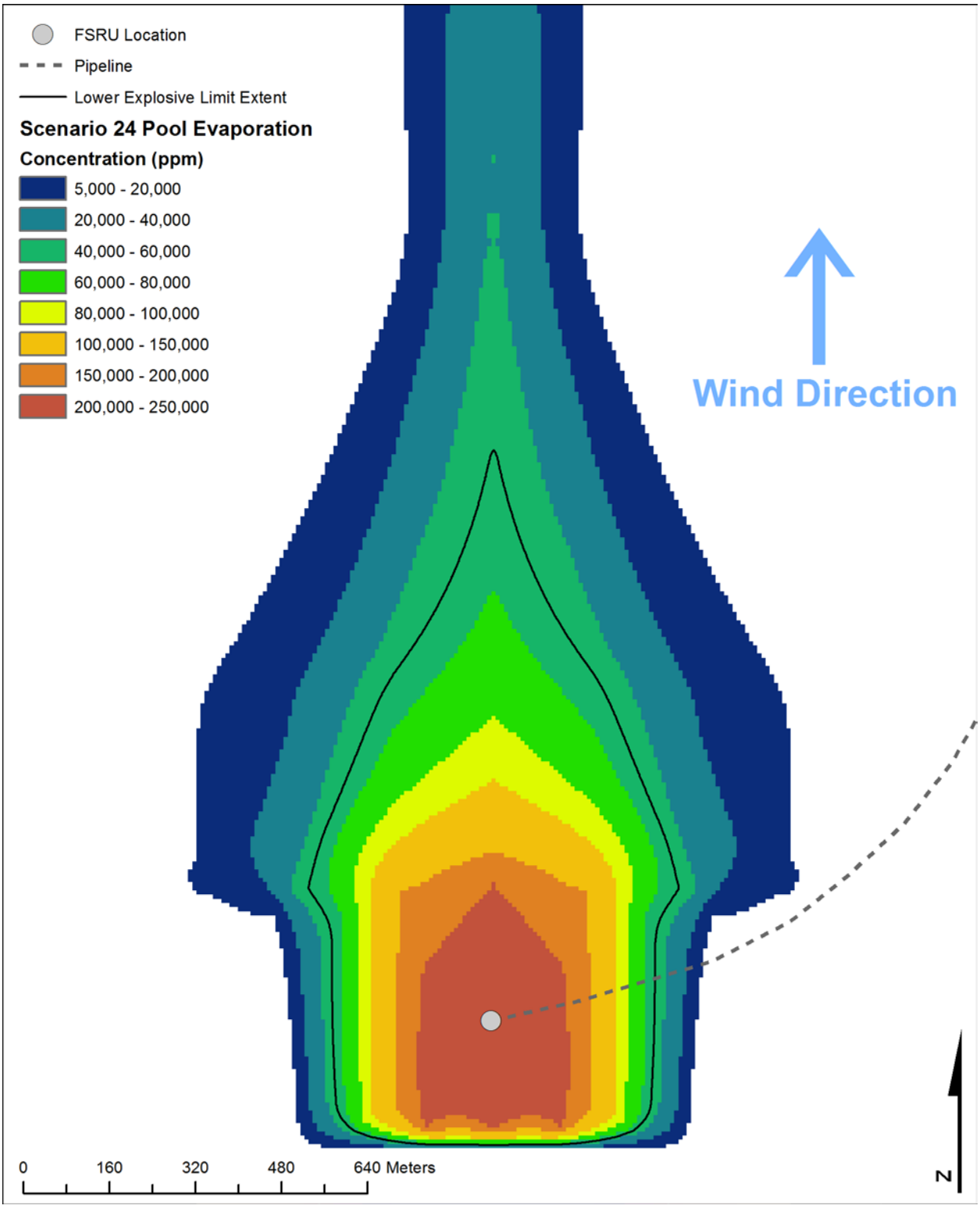

Figure 10. Predicted Methane vapor plume concentrations at ground LNG evaporating pool release for scenario 24 (Wet season 95th wind speed, release 100% tank volume, 12 m^2 hole size).

The overall result of the modeling is the maximum downwind distance that concentrations exceeding the lower explosive limit can reach (Table 7 and Figure 11). For most of the scenarios the maximum distance was the result of the methane released. For the wet season vapor releases from the tank, the maximum distances were the result of the ethane release. This is due to the methane vapor rising from ground level, where the ethane vapors do not. The rising methane vapor is also the reason that the maximum distances in the winter scenarios are significantly larger than the wet season.

Table 7. Maximum distance to lower explosive limit for all 24 model scenarios, for both the evaporating pool and vapor releases.

Scenario	Maximum Distance to LEL	
	From Evaporating Pool	From Vapor Release
1	580	300
2	960	570
3	2,090	910
4	680	300
5	1,150	570
6	2,400	990
7	800	290
8	1,200	520
9	2,200	920
10	800	290
11	1,200	520
12	2,450	940

Scenario	Maximum Distance to LEL	
	From Evaporating Pool	From Vapor Release
13	700	390
14	390	400
15	300	410
16	340	390
17	360	400
18	440	410
19	270	380
20	310	430
21	430	610
22	260	380
23	310	430
24	1,080	610

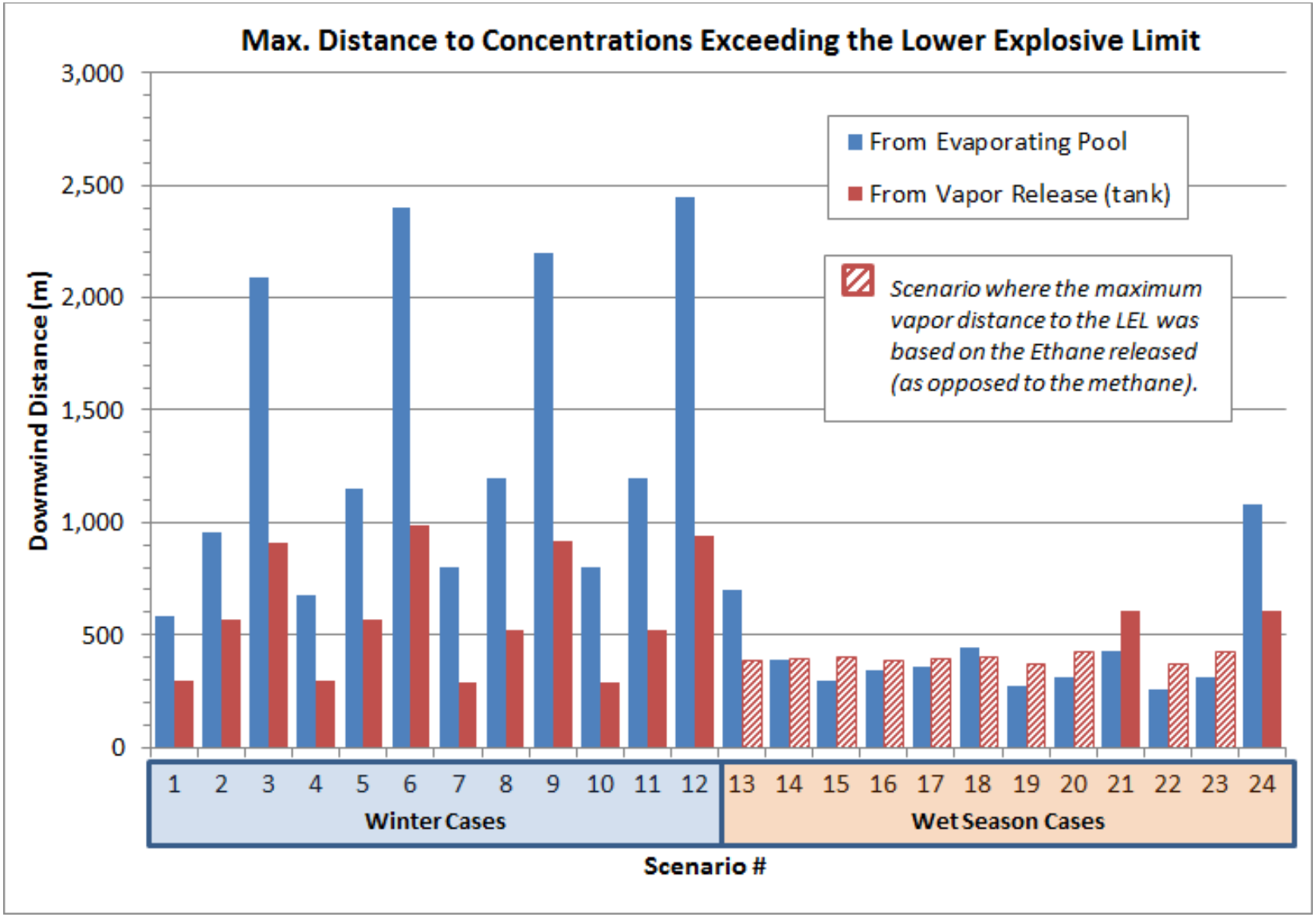

Figure 11. Ground-level maximum distance to Lower Explosive Limit for all 24 model scenarios, from both the evaporating LNG pool and vapor releases (tank).

5. References

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Appendix H: Survey of Environmental and Social Components of the Anowara - Moheshkhali Pipeline

REVIEW OF SOCIAL AND ENVIRONMENTAL IMPACTS OF THE PIPELINE PROJECT OF GTCL

Table of Contents

1. INTRODUCTION 1
2. SCOPE OF WORK 1
3. APPROACH OF THE ASSIGNMNET 1
4. FIELD INVESTIGATION AND SURVEY SCHEDULE 2
5. COLLECTION OF INFORMATION FROM DC OFFICE 2
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7. CONCLUSION 24

1. INTRODUCTION

Excelerate Energy Limited Bangladesh (Excelerate) and Energy Mineral Resources Division and Petrobangla executed a Terminal Use Agreement (TUA), Implementation Agreement (IA) and Side Letter Agreement (SLA) on July 18, 2016, to establish 500 MMSCFD floating Liquefied Natural Gas (LNG) terminal near Moheshkhali Island. Gas Transmission Company Limited (GTCL), a company of Petrobangla, received environmental clearance in January 2016 for the construction and operation of the Floating Storage Regasification Unit (FSRU) and LNG terminal at the proposed site.

Excelerate is continuing the environmental and social review efforts as required by the International Finance Corporation's (IFC) Performance Standards. It is our understanding that GTCL has paid land acquisition and requisition fees to the Office of Deputy Commissioner (DC) in Cox's Bazar to disburse claims for compensation resulting from the construction of the Moheshkhali-Anwara onshore pipeline. To satisfy the IFC Performance Standards, review of Social/human impact of the pipeline project of GTCL has been conducted.

2. SCOPE OF WORK

The Scopes of the assignment are:

- Conduct field visit considering the previously identified potential resettlement areas;
- Conduct field survey;
- Collection of information in photography with detailing the spot information i.e. Photographic 'sample' evidence (samples distributed at various points along pipeline) that show affected households, resettlement results etc.;
- As encountered, summary / anecdotal presentation and analysis of experience of PAPs with some detail about household (size, holdings, etc.);
- Preparation of simple map of community/social impacts with diagram(s) that show where the pipeline impacted people are within the ROW;
- As encountered, summary of anecdotal/interview descriptions of compensation status, property demolition or access loss if any, cultural heritage aspects if any of the project area;
- Overall prepare a report of "Review of Social/human Impacts of the Pipeline Project of GTCL".

3. APPROACH OF THE ASSIGNMENT

At first the survey and investigation team has met with the LNG-Cell to understand the available information of the GTCL regarding the route alignment, list of project affected people (PAP), types of losses, compensation status etc. LNG-Cell introduced the survey investigation team with the Project Director of the Anwara-Moheshkhali project and issued a letter to the DC's (Chittagong and Cox's Bazar) to cooperate in gathering the compensation information collection.

The survey and investigation team initially divided into two teams to carry out the work in parallel. One team visited the DC office and another team conducted the field investigation

simultaneously. GTCL has engaged the field Assistant Manager to guide us to identify the pipeline location as well as to discuss with the PAPs.

4. FIELD INVESTIGATION AND SURVEY SCHEDULE

Keeping in mind the time constraint and field constraints i.e. inaccessible field location, distance from the highway, main road etc., and availability of the PAPs at the time of field visit, the investigation and survey team has conducted the field work from 4th Dec'16 to 7th Dec'16.

5. COLLECTION OF INFORMATION FROM DC OFFICE

A letter was issued from the LNG-Cell to provide information on the followings:

- A report from the DC detailing reimbursements made
- The status of outstanding genuine claims for compensation and
- A list of property loss or demolition

BETS representative contacted with the DC offices to collect the aforesaid information. Details of the collection of the DC office information are stated below:

<table>
<tr><th>Issue</th><th>DC office of Chittagong</th><th>DC office Cox's Bazar</th></tr>
<tr><td>Contacted with DC</td><td>4th December 2016</td><td>8th December 2016</td></tr>
<tr><td rowspan="2">Meeting held with</td><td>
Mr. Mashukur Rahman Shikder, Additional Deputy Commissioner (General)</td><td rowspan="2">
Mr. P.M Emrul Kayes, Nejarat Deputy Collector (NDC) Commissioner, Cox's Bazar.</td></tr>
<tr><td>
Mr. Dipak Kumar Roy (Land Acquisition Officer, LOA-3)</td></tr>
<tr><td>Document Collected</td><td colspan="2">A brief table is shared and translated below.</td></tr>
</table>

A. Status of Compensation in Brief of Anwara, Bashkhali & Patiya Upazila of Chittagong District

Sl. No.	L.A. Case No.	Acquisition / handed over / Requisitioned Land (Acre)	Land Compensation (BDT)	Compensation for infrastructure damage (BDT)	Trees /crop compensation (BDT)	Additional 50% including Compensation (BDT)	No. of People Compensated	Compensated Amount (BDT)	Remarks
1	20/2011-12 (acquisition)	88.9735	264,136,988	21,760,668	4,645,629	435,814,927	737	201,546,536	Compensation process on-going
2	21/2011-12 (requisition)	163.4410							Case work on-going
3	12/2014-15 (acquisition)	2.4130	34,605,828	1,372,764	125,600	54,156,288	30	20,403,739	Compensation process on-going
4	02/2015-16 (Handover)	13.9590	22,164,977	261,445	384,976	34,217,097		27,459,433	Deposition of Khash Land
5	07/2015-2016 (acquisition)	5.1350	80,495,816	889,143		122,077,439			Compensation disbursement not yet started
6	08/2015-16 (requisition)	15.3405							Case work on-going

Table Headings Notes:

i. **L.A. Case No.:** Land Acquisition Case Number. It is a common term of land office. When an acquisition/requisition is required from the DC office, there will be needed to file a document based on the session year i.e. 2011-12 and other no. is serial no. of the project.

ii. Acquisition/handed over/ Requisitioned Land (Acre):

- Acquisition of land is the purchase of land.
- Handed over of land is to exchange of land ownership from one government body to another. Particularly khash (govt. land) land needs to exchange.
- Requisition of land is the temporary acquisition of land.

iii. **Land compensation:** Compensation made for the land acquisition/requisition/handover.

iv. **Compensation for infrastructure damage:** Compensation made for building, roads, power supplies etc.

v. **Trees/crop compensation:** Compensation made for tree cutting, damage of crop etc.

vi. **Additional 50% including Compensation for the Land, infrastructure, trees/crop damages:** 1.5times of the real calculated damage.

vii. **No. of Compensated People:** Total number of peoples who are compensated.

viii. **Compensated Amount:** The amount of money has already been compensated by the DC office.

B. Status of Compensation in Brief of Moheshkhali Upazila of Cox's Bazar District

Sl. No.	L.A. Case No.	Compensation of Land including Additional 50% (BDT)	Compensation of Infrastructure including Additional 50% (BDT)	Compensation of Crop / trees including Additional 50% (BDT)	Total Cost including Administrative Cost (BDT)	Remarks
1	01/2012-13 (acquisition)	147,138,654	10,295,863	1,009,148	170,326,940	Handed over the possession to GTCL on 16/02/2016 after disbursement of compensation
2	01(1)/2012-13 (requisition)	-	54,047,221	39,395,228	100,450,632	Handed over the possession to GTCL on 16/02/2016 after disbursement of compensation

Table Headings Notes:

L.A. Case No.: Land Acquisition Case Number. It is a common term of land office. When an acquisition/requisition is required from the DC office, there will be needed to file a document based on the session year i.e. 2011-12 and other no. is serial no. of the project.

Land compensation: Compensation made for the land acquisition/requisition/handover.

Compensation for infrastructure damage: Compensation made for building, roads, power supplies etc.

Trees/crop compensation: Compensation made for tree cutting, damage of crop etc.

Additional 50% including Compensation for the Land, infrastructure, trees/crop damages: 1.5times of the real calculated damage.

6. FIELD INVESTIGATION AND SURVEY

Interview-1

As per information of the GTCL there was one demolition of structure all along the 91km pipeline route. Present condition of the demolished structure and consultation with the owners has been noted minutely and described in details of the PAP's below with table, photographs and mapping.

Sl. No.	Item	Description	Remarks
1.	Date of Interview	04/12/2016	
2.	**Location**	Village: Purba Goakhali Ward#4, Union: Pekua Upazila: Pekua District: Cox's Bazar GPS Coordinate: 21°48'56.63"N & 91°57'31.10"E	
3.	**Name**	Mohammad Syed Noor	
4.	**Contact No.**	01834501100	
5.	**Profession**	Small Businessman (Hardware business)	
6.	**Structure Type**	(a) Foundation of Four Story (b) Semi Pucka	
7.	**Development Made**	(a) One Story (b) Semi Pucka two rooms house	
8.	**Type of Demolition**	(a) Partial Demolition (two rooms) of the One-Story Building (b) Full demolition (two rooms) of semi Pucka house	
9.	**Loss of Trees**	7 Trees has been cut at the east bank of the Pond	
10.	**Plot Details**	11016, 11015	
11.	**Compensation**	3.6 million BDT (approximately)	
12.	**Impression**	Satisfied with the Compensation made by the Government	

In the Interview: Mr. Mohammad Syed Noor (Right), Mr. Siddique (middle) (BETS) and Mr. Altaf Hossain (Left) (Assistant Manager, GTCL)

Mr. Mohammad Syed Noor standing in front of his House
(Tin fenced is the north boundary of the Demolished Structure)

In addition to the demolition of structure, Mr. Noor lost agricultural land (Plot No.11017) for the pipeline. He was altogether satisfied with the compensation made by the DC office.

Mapping of the demolished structure with photographs

North to South Look

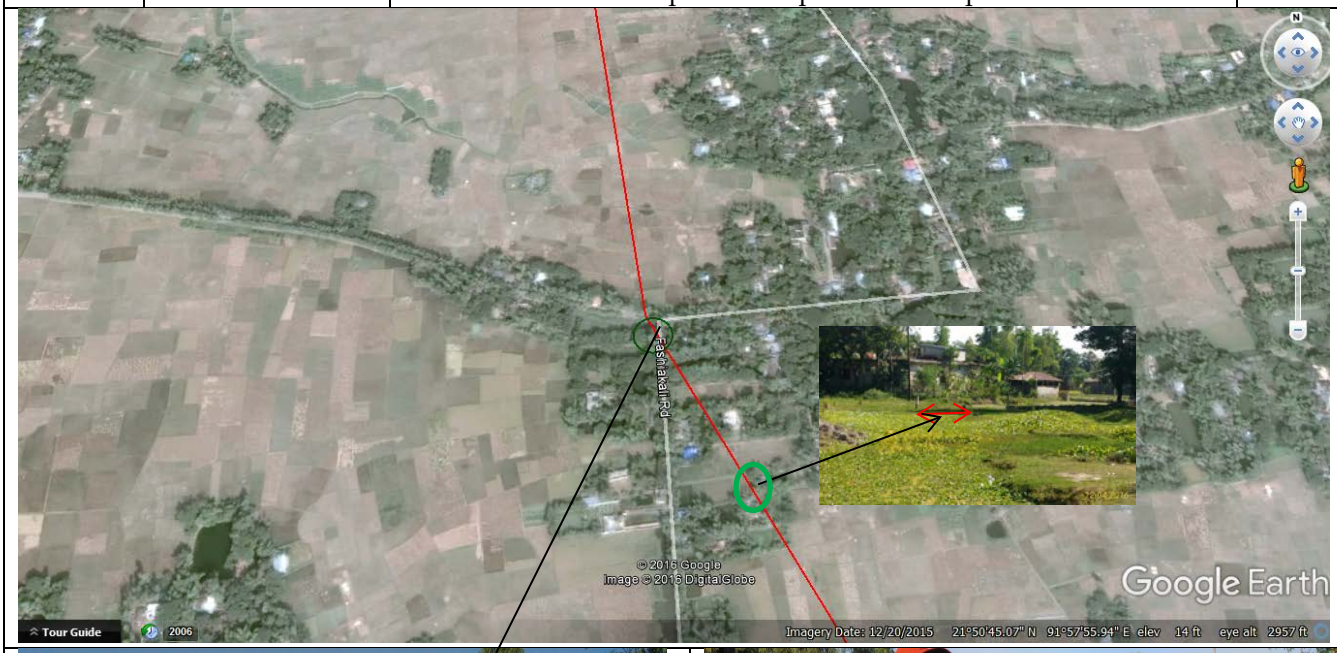
South to North Look

Remaining of the Demolished Structure

Interview-2

Consultation with the land owners of Fashiakhali has been noted minutely and described in details of the PAP's below with table, photographs and mapping.

Sl. No.	Item	Description	Remarks
1.	Date of Interview	04/12/2016	
2.	**Location**	Village: Fashiakhali Ward#7, Union: Barabakia Upazila: Pekua District: Cox's Bazar GPS Coordinate: 21°50'37.22"N, 91°57'32.19"E	
3.	**Name**	Mohammad Idris Badsha	
4.	**Contact No.**	01813367258	
5.	**Profession**	Ex Upazila Vice Chairman, Pekua	
6.	**Type of Loss**	Land, Tree & Fence (140feet)	
7.	**Plot Details**	5423, 4648, 4661, 4672, 4685, 4686, 4694 & 4693	
8.	**Compensation**	1.4 million BDT (approximately)	
9.	**Impression**	Satisfied but it would be excellent if the current land price could be applied for the compensation. In that case the compensation would be 2 to 3 times of the compensation quoted for the period 2011-12.	



Showing the Right of Way

From Left Mr. Altaf (GTCL), Mr. Idris (PAP) and Mr. Siddique (BETS)

Note:

1) Mr. Idris mentioned that during the pipeline laying one of his plot (Plot No. 2683) has been wrongly taken by the contractor for pipeline installation which was later resolved and adjusted the route with the help of GTCL. However, Mr. Idris lost his paddy field for about seven decimals of land. Contractor has compensated only 5000BDT for the paddy but didn't fill the trenched land.
2) During the consultation with Mr. Idris one of the PAP was looking into our discussion. He was Mr. Saber Ahmed son of late Badsha Miah. His plot nos. are 6644 & 6636. He is not interested to go to the DC office to collect the compensation because of so many shareholders (brothers, sisters) of the plots. Comparing to the compensation to get from the DC office to the transport cost and the use of land office broker is really unfeasible.

Observation of Valve Station (VS) -1:

Valve Station Details is tabulated below:

Sl. No.	Item	Description	Remarks
1.	Date of Visit	04/12/2016	
2.	**Name of the VS**	Uttar Nalbila Valve Station	
3.	**Size of the VS**	25mX23m	
4.	**Location**	Village: Uttar Nalbila Upazila: Moheshkhali District: Cox's Bazar GPS Coordinate: 21°43'7.30"N, 91°55'33.90"E	
5.	**Status of the VS**	Almost Completed approach road was under construction	
6.	**Contractor**	PEAL	
7.	**Meet with**	Mr. Masudur Rahman Khan Suvas	
8.	**Designation**	Civil Contractor	
9.	**Environmental Issues**	Workers Occupational Health and Safety Issus were not found in the field.	

Approach road under Construction	Mr. Altaf (GTCL) and Mr. Siddique (BETS) in the VS	Valve Station Under Fisnishing Work

Workers are in Work without PPE	Workers are in Work without PPE and Uncovered Sand

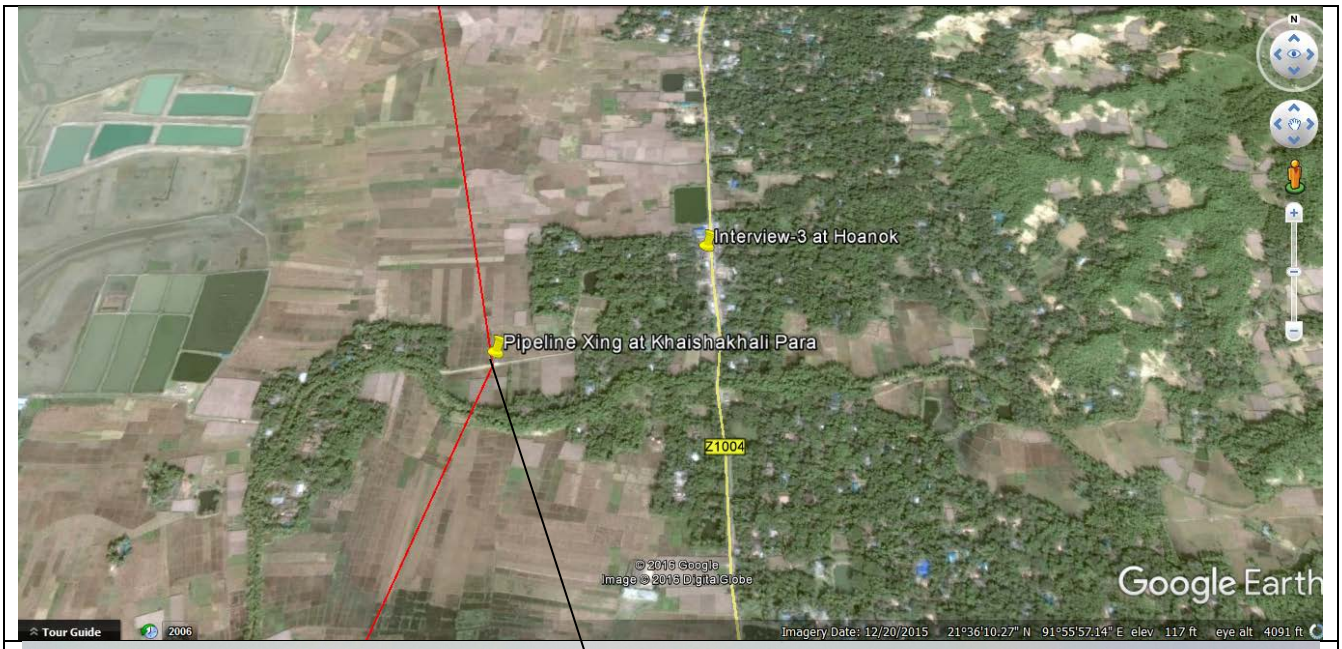
Note:

- It was good to understand that all the workers were from the locality.
- But the project site is out of PPE and first Aid arrangement.
- Uncovered sand and brick chips are haphazardly on the roadside

Interview-3

Consultation with the land owners of Khaishakhali Village of Hoanok Union has been noted minutely and described in details of the PAP's below with table, photographs and mapping.

Sl. No.	Item	Description	Remarks
1.	Date of Interview	04/12/2016	
2.	**Location**	Village: Khaishakhali Union: Hoanok Upazila: Moheshkhali District: Cox's Bazar GPS Coordinate: 21°36'0.14"N, 91°55'24.24"E	
3.	**Name**	Md. Syed Noor	
4.	**Contact No.**	01819821669	
5.	**Profession**	Business	
6.	**Type of Loss**	Bamboo Garden, Land & Paddy field	
7.	**Plot Details**	Khatian BS 850	
8.	**Compensation**	1.5 Lac BDT (approximately) for 14 decimal land value	
9.	**Impression**	Satisfied but the requisition compensation is still pending from the DC office.	



Right feature of the road of the above picture

Left feature of the road of the above picture

From Left Mr. Noor (PAP), Mr. Siddiqque (BETS) and Mr. Altaf (GTCL)

Note:

- Mr. Doyal Kanti Dey (contact no. 01840477813) a tenant has lost his one acre of paddy. He did not get the compensation yet and even though he has not been noticed from the land office. It is a common feature here because the people who are tenant do not have the land document by their name so the land office cannot identify them. But the landowner will get the notice from the land office. During the joint verification of Land office and GTCL this issue should have been cleared in discussion with the land owner and the tenant. As the requisition compensation is not yet provided by the land office so Mr. Dey's issues should be under observation.
- People are using the ROW of the GTCL for cultivation.

RIVER CROSSING AT SANGU RIVER:

Visit the Rig site development on the northwest bank of the Sangu River and Interview the PAPS.

Interview-4

Sl. No.	Item	Description
1.	**Date of Visit**	05/12/2016
2.	**Name of the River**	Sangu
3.	**Size of the Rig Site**	100mX50m
4.	**Location**	Village: Toiler Dip No. 06 Union: Barokain Ward#09 Upazila: Anwara District: Chittagong GPS Coordinate: 22° 9'41.43"N, 91°54'11.77"E
5.	**Status of the River crossing**	Equipment settings were on
6.	**Contractor**	Fuzloyed and Royale JV
7.	**Meet with**	Land Looser of the Rig site and Pipeline ROW
	a. Mawlana Omar Farooq, Teacher of Madrasa Cell No.: 01815612975	Plot No.: 1982 Khatian No.: 523
	b. Mawlana Azizul Haque, Teacher of Madrasa Cell No.: 01812824606	Plot No.: 1972 Khatian No.: 465

Sl. No.	Item	Description
8.	**Designation**	Teacher of Daulatpur Ashraful Ulum Madrasa and Etimkhana
9.	**Loss items**	Land, Trees, Temporary Shifting of Kitchen, Toilet etc. for the Rig Site development.
10.	**Compensation Amount**	Loss of Trees: 114345 BDT, Shifting of Structure: 239473.25BDT, Land Loss: 94295.55 BDT
11.	**Compensation Issue**	Compensation notice issued to the PAP but the shareholders of the plots got some internal dispute of the plots and for this they are not ready to draw the issued compensation amount. This is not the problem of DC but the land owners.
12.	**Impression**	Satisfied on the issued compensation made by the DC office.
13.	**Environmental Issues**	• Safety of the locality seems bad as because there were no temporary fencing/boundary of the rig site area to protect the unwanted entry of the rig site. • Too vulnerable for the children who can curiously get in to the rig site. • There were no sign of safety precautionary slogan in the rig site • Most of the workers were without PPE in the rig site • There were generators open and very close to the nearby residences which will cause huge sound. • Sound level adjustment for the day/night time is not declared in the site area as the rig site is a residential zone. • No alternate system (i.e. a temporary Steel platform for local vehicle movement) has been developed for the use of access road for the locality.

Boom haphazardly arranged at the gate of the Residence

Almost zero PPE use at the Rig Site

Meeting with PAPs

Generator close to the Residences

From the Left Mr. Towfiq (BETS), Mr. Arif (GTCL), Mowlana Omor Farooq (PAP) and Mr. Siddique (BETS)

From the right Mr. Arif (GTCL), Mr. Siddique (BETS), Mr. Yunus (Local), Mowlana Azizul Haque (PAP) and Mr. Towfiq (BETS),

Observation of Valve Station (VS) -2:

Valve Station Details is tabulated below:

Sl. No.	Item	Description	Remarks
1.	Date of Visit	05/12/2016	
2.	**Name of the VS**	Banigram Valve Station	
3.	**Size of the VS**	25mX23m	
4.	**Location**	Village: Banigram; Upazila: Bashkhali; District: Chittagong GPS Coordinate: 22° 7'8.06"N, 91°54'44.97"E	
5.	**Status of the VS**	Almost Completed. Northern pipeline is not yet jointed	
6.	**Contractor**	Gasmin	
7.	**Environmental Issues**	• VS is Well fenced • Unleveled soil heap has been observed • There were no security/safety slogan hanged in the VS area	

Well Fenced VS Site

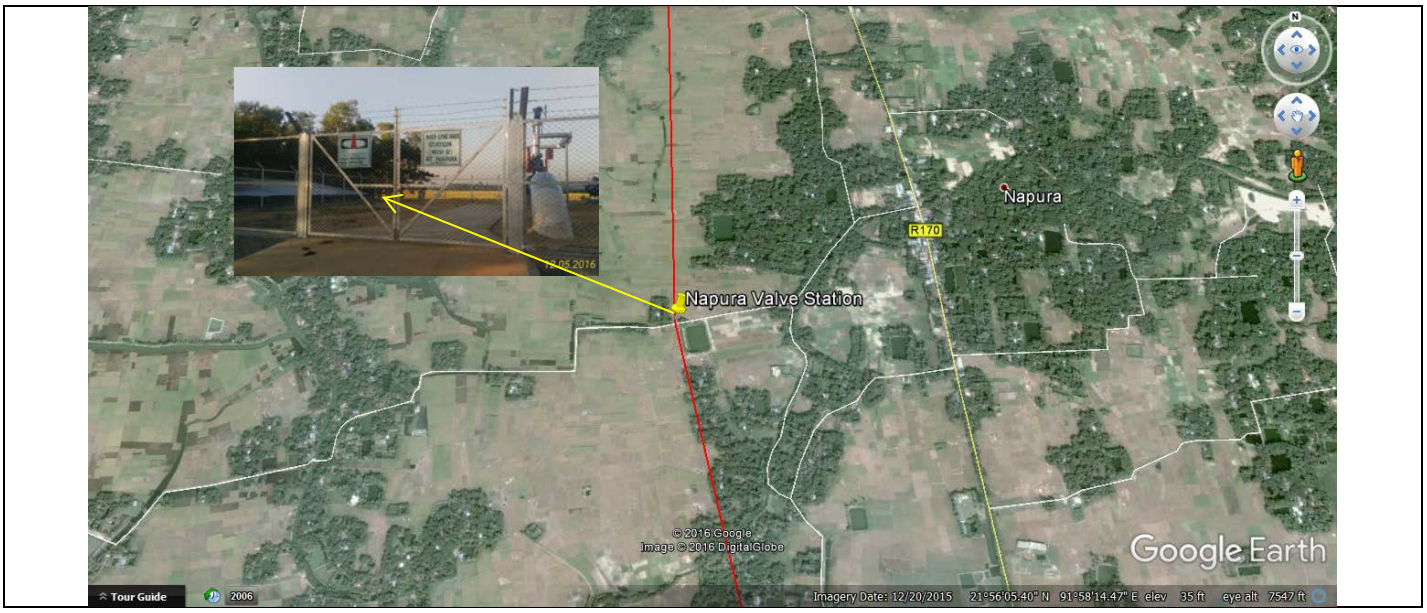
Visit of VS with Mr. Ariful Islam (GTCL) along with Mr. Towfiq and Mr. Siddique

Unleveled Soil Heap Outside the VS

Observation of Valve Station (VS) -3:

Valve Station Details is tabulated below:

Sl. No.	Item	Description	Remarks
1.	Date of Visit	05/12/2016	
2.	**Name of the VS**	Napura Valve Station	
3.	**Size of the VS**	25mX23m	
4.	**Location**	Village: Napura Upazila: Bashkhali District: Chittagong GPS Coordinate: 21°55′49.29″N, 91°57′16.22″E	
5.	**Status of the VS**	Valve Station is Ready	
6.	**Contractor**	PEAL Engineers	
7.	**Land Looser**	Mr. Robi Alam	
8.	**Compensation Status**	Compensation status of this area is not good as because • The land papers are not up to date. This is why PAPs are not submitting documents to the DC office as per the instruction of rule seven. • Illiteracy makes the poor people scared about DC office regulations • Having many shareholders then the PAPs don't felt interest to go to the DC to spend their valuable time.	
9.	**Environmental Issues**	• VS is Well fenced with some Safety/security slogan	

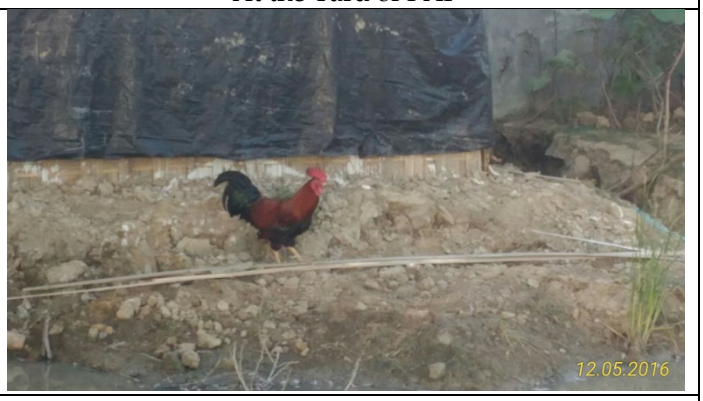


Napura Valve Station

Back view of the Valve Station

At the Yard of PAP

Very Common Domestic Animal in the Rural Area

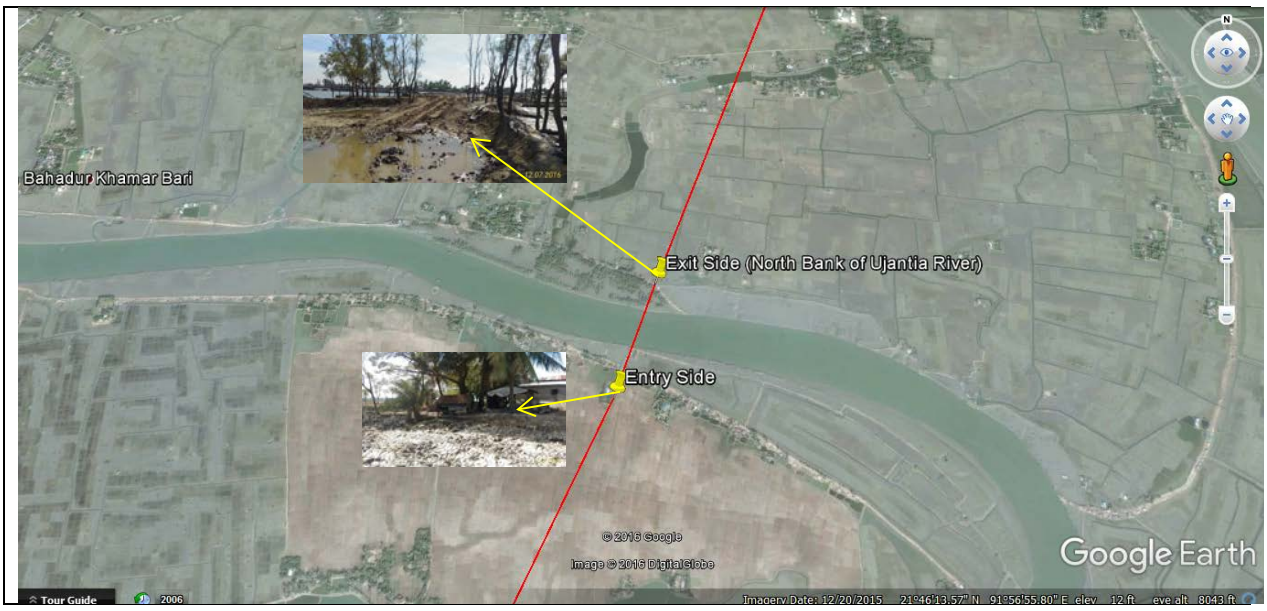


Very Common birds Cock in the Rural Area

RIVER CROSSING AT UJANTIA RIVER:
Visit the Ujantia River Crossed area.

Interview-5

Sl. No.	Item	Description
1.	**Date of Visit**	07/12/2016
2.	**Name of the River**	Ujantia
3.	**Location**	Village: Miajipara, Union: Ujantia, Upazila: Pekua District: Cox's Bazar, GPS Coordinate: 21°45'39.05"N, 91°55'49.13"E
4.	**Status of the River crossing**	Completed
5.	**Contractor**	Fuzloyed and Royale JV
6.	**Meet with**	**Daughter of Mr. Shaha Alam**
7.	**Loss items**	Land, Trees
8.	**Compensation Amount**	Not known and not drawn as well from the DC office because the owner of the land is Mrs. Alam whose land docs are belongs to her Brother.
9.	**Compensation Issue**	Compensation not yet completed.
10.	**Impression**	Satisfied on the issued compensation made by the DC office.
11.	**Environmental Issues**	• Used bentonites were not disposed of by the contractor • Used bentonites were left haphazardly in the HDD sites. • Used lands were not leveled by the contractor • Heap of soil and trenches were observed in the HDD sites



Haphazardly dumped Used Bentonites at the HDD site

Trenched HDD site exposed to the River Bank for Erosion

Left over the HDD site without any leveling of the Land

Consult with Daughter of Mr. Shaha Alam (PAP)

RIVER CROSSING AT KOHELIA RIVER:

Visit the Kuhelia River Crossed area

Sl. No.	Item	Description
1.	**Date of Visit**	07/12/2016
2.	**Name of the River**	Kuhelia
3.	**Location**	Upazila: Pekua District: Cox's Bazar, GPS Coordinate: 21°43'54.30"N, 91°55'19.40"E
4.	**Status of the River crossing**	Completed
5.	**Contractor**	Fuzloyed and Royale JV
6.	**Environmental Issues**	• Used bentonites were not disposed of by the contractor • Used bentonites were left haphazardly in the HDD sites. • Used lands were not leveled by the contractor • Heap of soil and trenches were observed in the HDD sites

Field Information at the South Bank of Kuhelia River Bank
Frpm Left Mr. Imran (Local Boy of Moheshkhali), Mr. Siddique, Mr. Towfiq and Mr Saddam (Boatman)

Haphazardly left over Used Bentonites at the north bank of the Kuhelia River

Unleveled disturbed land in the left and unfilled trenched land in the right, left over by the Contractor

Visit to the Tie-in Point:

Sl. No.	Item	Description
7.	**Date of Visit**	07/12/2016
8.	**Name of Location**	Tie-in Point
9.	**Location**	GPS Coordinate: 21°34'23.10"N, 91°51'46.30"E
10.	**Status Tie-in Work**	Completed
11.	**Contractor**	Dipon Gas Co Ltd.
12.	**Environmental Issues**	• Parabon (Mangroves) were cut during the pipeline laying • Front portion of the Tie in site is getting under sand • Due to siltation and sand deposition in the frontier portions mangroves are dying • This is not because of the pipeline laying but should be the cause of char land development. • Interestingly small mangroves are growing on the buried land on the pipelines. • Unleveled tie in site • Sand bags are all

Dying of Mangroves due to Sand deposition

Sand Bags are haphazardly Placed by the Contractor

Small mangroves are growing on the Soil of the Pipeline

Cleared Mangroves along the Pipeline route

Unleveled Heap of Soil at the Tie-in Site

7. CONCLUSION

The compensation process is still ongoing by the DC office. Compensation for the requisition is under preparation. Most of the PAPs are satisfied with the compensation paid by the DC office. The Tenants are really in problem if they are not properly identified. The environmental health and safety of the contractors are not up to the mark. There are many issues contractors should carefully look into to keep the environment safe.

Appendix I: Phase 1 Consultation, 2011-2012

Strategy, Approach and Findings

The multidisciplinary EIA Team of BETS Consulting along with GTCL engineers visited and examined the site and their surroundings, reviewed social and physical aspects, and obtained information necessary for the purpose of impact study and project consultation.

Consultation with key informants, public and affected groups was carried out under a consultation strategy during the period between February-May, 2012 to ensure that all stakeholders and affected people were fully informed about the project, and the views of these people on the consequences of the project are taken into consideration.

Public Consultation Checklist
For uniformity and clarity in conducting the public consultation meetings, a checklist was devised by the consultants and was used to enable the participants to comprehend the issues easily. This facilitated effective participation in discussions and expression of opinions.

Topics on the Checklist included:

- Name and occupation of the participants
- Awareness of the participants about the Project
- Description of the Project
- Benefits of the Project
- Impacts of the Project on social and environmental components
- Concerns about the Project
- Expectations from the Project
- Suggestions about the Project

During the public consultations, social, environmental as well as cross-cutting issues were discussed in detail. In addition, such discussions also included the potential impacts of the project activities on environmental and social parameters, identification of sensitive issues, risks, potential threats, public concerns and expectations from the project.

Focus Group Discussion Findings
The most common concerns raised were about due compensation and rehabilitation wherever any damage is done and with requests for provision of gas in their localities.

Focus group participants generally noted appreciation for the Project as development progress for the country, as it may help in setting up industries, and generate employment. Though it was understood that impacts are usually temporary, notes of caution were raised regarding how the work should be done carefully to avoid any accident in future.

Since no homestead or trees or structures were in proximity of the project site, the participants in these consultation meetings were the land and house owners and available cross section of the local people around and within 5 km radius of the onshore pipeline and potential Tie-in Point sites.

Participants raised the following as key areas for focus:

- Agricultural products and vegetation may be affected. But more concern was expressed for potential impacts on salt & shrimp cultivation.
- Assembly of people during project activities may damage crops, other trees. and particularly salt & shrimp cultivation at different seasons of the year as long the project activities will continue.
- Noise pollution from vehicles and equipment at the project sites may cause disturbance to people and wildlife.
- Compensation for land as per government rate would not be a fair compensation to the affected person as it is far below prevailing market rate.
- Soil erosion particularly on the shore line / banks, which should be addressed properly.
- Water pollution of the natural water bodies may be aggravated and should be taken care of as this water is used for agriculture and domestic purposes.
- Movement of vehicles may affect movement of people, especially women, children and disabled persons from one place to another.
- Air pollution due to dust and gaseous emission should be controlled.
- Environmental pollution through sanitation and waste materials as well as other social nuisance should be controlled.
- Loss of land fertility should be reduced. Proper compensation should be given to the cultivator of salt production and shrimp cultivation.

Local Expectations

The following expectations were raised by local people during the consultations:

- Local personnel should be employed in different activities of the project on a priority basis.
- Preference should be given to engage local businessmen/ contractors in different phases of the project for construction and development depending in their suitability for such engagements.
- Compensation payment, in whatever form it may be, should be properly and promptly distributed so that the actual affected person gets his full share and in right time.
- Supply of gas would help improving their socio-economic conditions and therefore gas should be made available in the areas through which gas line would be passing through.

Key Informant Interviews (KII), and Consultation Results

One to one consultation was done with individuals at potential project-affected households. A structured questionnaire was devised to collect socio-economic data of people within 5-10 km of the potential Tie-in Point site of the project.

Suggestions regarding impacts and losses, mitigation options and implementation strategies were taken from the people and the information and comments provided by each individual owner or his relative present in the household was duly recorded in the questionnaire, as was attitude towards Project implementation and claims / expectations regarding compensation for potential losses.

Key Informant Interview (KII) were conducted during the visit of the EIA team during 13-16 February, 2012 wherein engineers from GTCL were also present to understand the views and suggestions of the Key Informants on the EIA study in respect of its positive and negative impacts, including market value of their assets being affected, payment of compensation and grievance redress mechanism were discussed in details.

The findings recorded from public consultations are presented in the Table-A.1, indicating issues and concerns. Key Informants and group participants are listed in Table-A.2 and A.3.

Conclusions

2011-2012 Public Consultation results, including Key Informant Interview and Focus Group Discussions, resulted in an elevated level of local understanding and support for the Project. Local consultations emphasized interest in rates of compensation for impacted livelihoods and landowners; local hope that the Project will allow for gas fuel supply made available to local industries and households. Consultant local residents also expressed the expectation that employment priority be given to local labor, while local businessmen should be involved in project activities

Table H-1: Findings of Interviews and Public Consultations, 2011-2012

Project Name	Issues Discussed	Issue Raised	Suggestions
Offshore Floating LNG Storage and Re-gasification Unit (FSRU) Terminal permanently moored at Island/Finger Jetty Activities Project at Moheshkhali area under Cox's Bazar District	Impact of construction of onshore & sub sea Gas Pipeline and operation of the FSRU	- Build up new industries	- New industry will develop upon proper installation of gas pipeline.
		- Reduce Unemployment	- Skilled and unskilled labor should be taken from that locality.
		- Social & Economic development	- Living status will be high.
		- Land & property damage	- Due compensation to be paid according to the latest approval price list.
		- Crop damage	- Due compensation to be paid on the spot.
		- Trees damage	- Due compensation to be paid on the spot.
		- Gas availability	- Discuss with superior person of the locality.
		- Compensation assessment	- Compensation assessment by DC and local leader.
		- Fish breeding	- Must avoid breeding time.
		- Affected Homestead, if any	- Due Compensation to be given.
		- Pollution of air and surface water	- Monitoring shall be adopted.
		- Sanitary problem	- Sanitary system should be developed during gas pipeline installation.
		- Fishing in the Bay	- Due compensation will be paid to the genuine Fishermen affected, if any
		- Salt & Shrimp Cultivation	- Due compensation will be paid to the genuinely affected cultivators and farmers, if any

Table H-2: Findings of KII, 2011-2012

Sl. No.	Date	Time	Place	Name & Designation	Comments
1.	17 Jan'12	12;15 pm	Petrocentre Petrobangla	Mr. Ajoy PB	Opined that it might not be possible to provide necessary detail information and documentation about the project at this stage since these are mostly dependent on the project sponsor which is on the process of selection through Request for proposal. However, he introduced to Dr. Siraj of GSB as a key informant. He also encouraged visiting the selected Tie-in Point at Kalirdia Char while the Team would be going for field survey of Moheshkhali and Offshore Terminal.
2.	17 Jan'12	1 pm	GSB HQ Dhaka	Dr. Shirajul Islam Khan , Division Chief GSB	He opined that it might be difficult, expensive and time consuming to collect samples for geotechnical data from the proposed alternative terminal locations, but there should be similarity of onshore data evaluations to correlate.
3.	18 Jan'12	11:30 am	GTCL HQ Dhaka	Ms. Rukhsana Nazma Ishaque DGM Planning, GTCL	She assured all possible assistance for successful completion of the project.
4.	18 Jan'12	11:30 am	GTCL HQ Dhaka	Mr. Mustafiz GM (P & D) GTCL	He expected that the EIA team will receive support from the public and local administration because of the importance of the project. He also assured that an engineer from GTCL will accompany the EIA Team during field visits.
5.	24 Dec'11	12:30 pm	GTCL HQ Dhaka	Mr. Aminur Rahman MD GTCL	He supported the project for earliest possible implementation since the outcome of which is expected to overcome the current crisis of gas particularly in Chittagong region.
6.	14 Feb'12	12:30 PM	Moheshkhali	Mr. Kawser UNO Moheshkhali	He assured all necessary support for implementing this priority development project of the Government.
7.		12:45 PM	Moheshkhali	Mr. Bishawnath Majumdar, Project Implementation Officer, Moheshkhali	Encouraged the EIA Team and offered any assistance required at any time.
8.		1:00 PM	Moheshkhali	Mr. Shamsul Alam Roni Local Sports & Cultural Organizer	He welcomed the project but requested for retaining provision of supplying gas to Moheshkhali area.
9.		1:15 PM	Moheshkhali	Mr. Jasim Uddin, Ferry Ghat Supervisor	He expressed all his support for the project but requested for due compensation of the project affected persons.
10.		1:30 PM	Moheshkhali	Mr. Badsha Mia Speed Boat Driver	He said any development project of the Government. is good for the nation but he was afraid whether his professional earning would be interrupted. If so, he should be properly compensated
11.			Moheshkhali	Mr. Abul Khair Labor, Salt Culture, Village: Yunus Khali, Matarbari, BadarKhali	Salt Culture season is from Poush to Boishakh every year; It takes 4- 5 days for salt to crystallize following irrigating salty water. on polyethylene bed in the ground.. He earns about Tk. 150/- per day as his wages. He has to be provided with an alternate means of living if he can't work due to disruption of his normal life for execution of the project

Sl. No.	Date	Time	Place	Name & Designation	Comments
12.			Moheshkhali	Mr. Ranjit Kumar Barua Officer–in-Charge Moheshkhali Police Station	
13.	15 Feb'12	09:30	Chittagong	Mr. Md. Sanwar Hossain Chowdhury Managing Director, KGDCL	Gas from LNG import would be a good support in resolving gas shortages in the Chittagong areas
14.		15:45	Cox's Bazar	Mr. Joynal Abedin PS to Deputy Commissioner	It should be an important project and he will provide any assistance as and when asked for.
15.			Cox's Bazar	Mr. Jainul Bari Deputy Commissioner	He welcomed the EIA Team and assured all necessary support for the study.
16.			Cox's Bazar	Commander Coast Guard	Could not be contacted because he was otherwise preoccupied
17.			Cox's Bazar	Naval Contingent Commander	Could not be contacted because he was otherwise preoccupied
18.			Cox's Bazar	Mr. Selim M. Jahangir Superintendent of Police	Could not be contacted because he was otherwise preoccupied
19.			Cox's Bazar	Mr. Mohammed Illias PS to Superintendent of Police	He said it is definitely a good move of the government and requested the EIA team to be in touch with this office for any assistance.
20.				Mr. M Shaiful Islam Director (Planning) Petrobangla	He was optimistic that the project implementation should be an effective option of the gas sector in securing additional gas to complement the local resources.

Table H-3: Details of a FGD Meeting held at Boro Moheshkhali Union Chairman Bari during 11-AM to 12 Noon on May 11, 2012

Sl. No.	Date	Time	Place	Name & Designation	Comments
21.	11May 12	10:00 am to 12 pm	Borodail (Chairman Bari)	Md. Alhaz Sharif Badsha (Chairman) Boro Mohehkhali Moulovi Amzad Ali, Son of Late Hazi Najor Ali (Moulovi) Md. Doulat Mia Son of Late Kalu Mia (Salt Farmer)	- All sorts of cooperation will be given - Proper compensation needed and resettlement - Proper compensation needed during acquisition

Sl. No.	Date	Time	Place	Name & Designation	Comments
				Md. Moson Ali Son of Late Abdur Rahman(Salt Farmer) Md. Zakaria Son of Late Dulu Mia(Salt Farmer) Md. Nasir Uddin Son of Late Mozahar Mia (Business) Md. Chowdhury Mia Son of Late Raza Mia (Salt Farmer) Md. Sahidullah Son of Late Badsha Mia (Salt Farmer) Md. Nuru Ahmed Son of Late Mazzom Mia(Salt Farmer) Md. Nuru Ahmed Son of Late Mazzom Mia (Business) Hazi Kabir Ahmed Son of Late Hazi Najor ali (Business) Dr. Faridul Alam Son of Late Mamun Mia (Salt Farmer & Service) Md. Amin Hosen Halaly Son of Late Fazol Ahmed Md. Ali Ahmed Son of Rowson Ali (Salt Farmer)	
22.	11May 12	2:00 pm to 4.00 pm	Borodail	Md. Zafor Alam Son of Late Kala Mia (Salt Farmer) Abdul Haque Son of Late Chanmon Sikder (Farmer) Vill: Sukuriapara Abdur Rashid Son of Late: Abdur Rahman (Business)	- All sorts of cooperation will be given - Proper compensation needed and resettlement - Proper compensation needed during acquisition - Alternative Employment and resettlement - Skill Training

Sl. No.	Date	Time	Place	Name & Designation	Comments
				Vill: Sukuriapara Md. Anower Son of Md. Badsha Mia Vill: Debangopara (Farmer) Md. Hakim Ali Son of Zinna Ali Vill: Pahartoli (Farmer) Md. Shahjahan Son of Habibullah Borodail (Share cropper) Md. Afser Mia Son of Mamun Mia (Business) Mahmud Hosen Son of Late Hosen Mia (Farmer) Abdus Salam Son of Late Sakender Ali (Farmer) Saied Rahman Son of Affaz uddin (Farmer) Abdul Kuddus Son of Late Mozahar Mia (Farmer) Md. Ali Akber Son of Late Yousuf Ali (Farmer) Md. Radewan Son of Junab Ali (Farmer) Md. Babul Son of Sador Amin (Share cropper) Mawlana Amanul Haq Son of Hafiz Solaiman (Survice) Md. Kasem Son of Hosen Mia	

Sl. No.	Date	Time	Place	Name & Designation	Comments
				(Business) Md. Shah Alam Son of Chandmoon Shikder (Farmer) Md. Abdul Malek Son of Hasem Ali (Share cropper) Md. Abdul Hosen Son of Hasem Ali (Share cropper) Abdul Sukur Son of Dola Mia (Share cropper)	
23.	12May 12	9:50 am to 11.40 am	Fakirakata	Md. Bahadur Late Abdul Gafur (Share cropper) Abu Taher Son of Gura Mia (Farmer) Md. Mokter Mia Son of Golam Kuddus (Share cropper) Md. Siddik Mia Son of Ula Mia (Farmer) Md. Balel Ahmed Son of Hosen Ahmed (Farmer) Md. Mostak Ahmed Son of Golam Kudur (Farmer) Abdul Aziz Son of Kabir Hosen (Farmer) Altas Mia Son of Golam Kuddus (Farmer) Kabir Ahmed Son of Sakender Ali (Farmer)	- All sorts of cooperation will be given - Proper compensation needed - Support of Employment opportunity - Concern of salt cultivation in future - All sorts of cooperation will be given - Proper compensation needed and resettlement - Proper compensation needed during acquisition

Sl. No.	Date	Time	Place	Name & Designation	Comments
				Monu Mia Son of Asir Ahmed (Share cropper)	
24.	12May 12	2:00 pm to 4.00 pm	Panichara Bazar	Md. Faridul Alam Son of Late Osman Goni (Salt Farmer) Md. Samsul Alam Son of Late Abu Saied (Farmer) Md. Rafiqul Alam Son of Late Abu Saied (Farmer) Hazi Gura Mia Son of Late Hazi Kalu Mia (Business) Abdus Salam BA Son of Hazi Ula Mia (Business) Md. Nurul Islam Son of Late Abdur Rashid (Farmer) Hazi Kasem Ali Son of Abdur Rashid (Business) Hazi Ochior Rahman Sof of Nazor Ali (Farmer) Abdul Karim Master Son of Late Anower Ali (Service) Abdus Salam Son of Late Anower Ali (Farmer) Hazi Somser Alam Son of Late : Hazi Tamim Golam (Business) Master Alam Saheb Son of Late: Hazi Tamim Golam (Business)	- All sorts of cooperation will be given - Proper compensation needed and resettlement - Proper compensation needed during acquisition

Sl. No.	Date	Time	Place	Name & Designation	Comments
				Md. Sagir Alam Son of Late Osman (Farmer)	
25.	13May 12	10:00 am to 1.00 pm	Panichara Bazar	Md. Harunur Rashid Son of Late Kala Mia (Farmer) Md. Faridul Alam Son of Late Zafor (Farmer) Abdullah Khan Son of Tamim Dulal (Farmer) Md. Islam Son of Late Tazer Mulluk (Business) Adv. Ansarul Karim Son of Late Hazi Nur Ahmed (Service) Golam Mostafa Son of Hazi Abdul Fazol (Business) Member Mostak Ahmed Son of Late Shafiqur Rahman (Farmer) Md, Abdur Rahim Son of Late Abu Soman (Business) Zafor Alam Son of Late: Abdur Rashid (Farmer) Md.Jalal Son of Hazi Najir Ali (Business) Abul Mostak Son of Late: Asmot Ali (Farmer) Md. Najir Master Son of Md. Sikder Ali (Service /farmer)	- All sorts of cooperation will be given - Proper compensation needed and resettlement - Proper compensation needed during acquisition - Alternative Employment and resettlement - Skill Training

Sl. No.	Date	Time	Place	Name & Designation	Comments
				Md. Mokbul Ahmed Son of Late Abdur Rashid (Farmer)	
26.	13May 12	2:00 pm to 4.30 pm	Vill: Hoyanok	Md. Sultan Sarker Son of Late: Alem Uddin (Business) Md. Chowdhury Mia Son of Late: Puru Mia (Member) Vill: Kalaliya Kata (Business/farmer) Azizul Haque Son of Kulu Mia Vill: Kalalia Kata (Service) Lal Mohammad Son of Kulu Mia (Farmer) Hazi Mohammad Islam Son of Hazi Bacha Mia Vill: Kalaliya kata (Business) Mir Kasem BA Son of Late: Hazi Ali Mia (Vill: Kalaliya kata) Atik Ullah Son of Abul Kalam Badsha, (Business) Md. Chowdhury Son of Bujur Gali (Business / Salt farmer) Master Abdur Rashid Son of Late: Paran Sikder (Business / Salt farmer) Md. Azizul Haq Son of Moulovi Sagir Ahmed (Farmer/ Salt farmer Md. Ekram Son of Late: Kabir Ahmed (Salt Farmer)	- All sorts of cooperation will be given - Proper compensation needed and resettlement - Proper compensation needed during acquisition - Alternative Employment and resettlement - Skill Training

Sl. No.	Date	Time	Place	Name & Designation	Comments
				Md. Akter Hamid Son of Hazi Abdur Maruf (Business/Salt Farmer) Md. Fardous Son of Nur Mohammad Vil: Karontoli (Business/Salt Farmer) Md. Abu Son of Ab Karim dar Sikder (Business / Salt Farmer) Sultan Sardar Son of Late: Alem Uddin (Business)	

Table H-4: Findings of Public Consultations, 2011-2012

Sl No.	Name of the Participants	Designation	Occupation	Age Year	Signature of the Participants	Remarks
1	Hajji Sharif Bhadsha	Chairman	Social Welfare	47	All Participants Signed in the FGD meeting record sheet with the following comments: 1. There will be support for smooth progress of the project activities 2. People of the locality, are ready to help at any time. 3. They hope to get gas line connection in their area and they will be grateful for that.	Field Enumerator Mr.Moazzem Hossain conducted the meeting. and recorded the participant details and their comments & opinions on the impacts of the projects under different phases of implementation as compiled in different subsection of the Chapter on Public Consultation
2	Mohammad Jafor Alam	Chairman, Boro Moheskhali	Social Welfare	40		
3	Mohammad Nurul Islam	Moheskhali Pouroshoba	Business	65		
4	Mohammad Ali Akbar	Secretary, Union Porisod	Service Holder	40		
5	Mohammad BhadurAlam	Fakiragol	Farmer	42		
6	Mohammad Abdul Hoque	Fakiragol	Salt Trader	36		
7	Mohammad Ali Ahammad	Boro Moheskhali	Farmer	64		
8	Mohammad Redhwan	Boro Moheskhali	Farmer	50		
9	Mohammad Nur Ahammad	Fokiragata	Farmer	46		
10	Mohammad Abul Kalam	UP Member Ward No. 1	Social Welfare	55		
11	Mohammad Aklas Mia	Fokiragata	Farmer	36		
12	Mohammad Farid	Bordoil	Doctor	40		

Appendix J: Phase 2 Consultations, August 2016

MINUTES OF MEETING

Date of meet.	07.08.2016
Location	Petrobangla Board Room, 3rd Floor, Petrocenter, 3 Karwan Bazar C/A, Dhaka
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	01
Subject	**Stakeholder Engagement Meeting**
Prepared by	Mohammad Nurul Alam Siddique, BETS
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
A	The Stakeholder Engagement Meeting was led by Mr. Istiaque Ahmad, Chairman, Petrobangla. A summary of the meeting is presented below:	
	1. After participant introductions a power point presentation was made by Mr. McGeachie and Ms. Dondzila.	Sharing of FSRU
	2. GTCL representatives shared the information of almost completed transmission line of Moheshkhali-Anowara 91km Pipeline Project. The construction work started from 21st February 2016.	Info
	3. Ministry of Environment and Forest shared their positive views about this FSRU project.	Info
	4. DOE representative opined that no serious negative environmental impact has been forecasted from the EIA study.	Info
	5. Mr. Rejaul Karim, Joint Secretary, Ministry of Shipping called for another meeting at his office to discuss about the re-fixing of the FSRU project location in consideration of their Deep Sea Port project for the issuance of NOC. Following discussion, it was agreed that the FSRU location was set and cooperation and proactive communication would help both projects succeed.	Request
	6. Petrobangla promised all necessary support for the project. The Chairman concluded the meeting by thanking the participants and wishing best to all in the successful completion of this project.	Info

Enclosure: Photographs and List of attendees.

Annex-I

Snapshot of Meeting

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Stakeholder Engagement Meeting

Moheshkhali Floating LNG Project
Petrobangla Board Room, 3rd Floor, Petrocenter, 3 Karwan Bazar C/A, Dhaka
August 7, 2016 – 9:00 am

Name	Organization	Contact Information
Buck Booth	Excelerate Energy	buck.booth@excelerateenergy.com
Andrew Buchman	Acorn International LLC	ABUCHMAN@ACORNINTL.net
Kenny McGeachie	Excelerate Energy	kenny.mcgeachie@excelerateenergy.com
Emily Dordzila	E.C.	emily.dordzila@excelerateenergy.com
H. N.A. Siddique	BETS	siddique@betsbd.com
Mir Tawfiq Hussain	"	mirtawfiq@betsbd.com
Dr. Mohammad A. Motalib	Department of Environment	motalib.doe@gmail.com
Md. Azmal Hossain	Ministry of Environment and Forests	azmal75020@gmail.com
Monshof Ali	GTCL	monsof_ali@yahoo.com
Fukhsana Nazma Eshaque	GTCL	nazma059@yahoo.com
Kazi Md. Anwarul Azim	Petrobangla	kazpbc yahoo.com
Md. Ghiasuzzaman	Ex. Director, Petrobangla	g29man02@gmail.com
Md. Rejaul Karim	Joint Secretary, MoShiMi	rejaul8253@gmail.com
Zanendra Nath Sarkar	Deputy Secretary	szanendra11@yahoo.com
Kazi Zebunnessa	Joint Secretary EMRD	01753422385 zebuns1@yahoo.com

Excelerate Energy L.P. 1450 Lake Robbins Drive Suite 200 The Woodlands, Texas 77380 TEL 832.813.7100 FAX 832.813.7103

List of Participants:

Sl No.	Name	Organization
1.	Buck Booth	Excelerate Energy
2.	Andrew Buchman	Acorn International
3.	Kenny McGeachie	Excelerate Energy
4.	Emily Dondzila	Excelerate Energy
5.	M. N.A Siddique	BETS
6.	Mir Towfiq Hussain	BETS
7.	Dr. Mohammad A. Motalib	Department of Environment (DOE)
8.	Md. Azmal Hossain	Ministry of Environment and Forests
9.	Monshof Ali	GTCL
10.	Rukhsana Nazma Eshaque	GTCL
11.	Kazi Md. Anwarul Azim	Petrobangla
12.	Md. Quamuzzaman	Ex. Director Petrobangla
13.	Md. Rejaul Karim	Joint Secretary, Ministry of Shipping
14.	Zanendra Nath Sarkar	Deputy Secretary
15.	Kazi Zebunnessa	Joint Secretary, Energy and Mineral Resources Division (EMRD)

MINUTES OF MEETING

Date of meet.	09.08.2016
Location	Deputy Commissioner's Office, Cox's Bazar
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	02
Subject	**Stakeholder Engagement Meeting**
Prepared by	Mohammad Nurul Alam Siddique, BETS
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	Stakeholder Engagement Meeting was led by Mr. Mohammad Ali Hossain, Deputy Commissioner (DC), Cox's Bazar. Mr. Hossain introduced Excelerate Energy (EE) and Petrobangla with his local representatives. The summary of the meeting is provided below:	
	1. Mr. McGeachie and Ms. Dondzila presented the project details in a power point presentation.	Sharing of FSRU
	2. Mr. Kazi of LNG Cell has shared the LNG and the activities of the FSRU in local language as a request of DC.	Info
	3. Mr. Sarder Shariful Islam, Assistant Director, Department of Environment (DOE) expressed his satisfaction on the EIA study.	Info
	4. UNO, Moheshkhali advised to the consultant not to go to the project site without informing the local administration/without local security or alone.	Info
	5. Assistant Conservator of Forests requested a copy of the (completed) EIA report and the specific project location document of the FSRU.	Info
	6. Mr. Rafiq, Manager, LNG Cell shared the information of upcoming Land Based LNG terminal of Moheshkhali.	Info
	7. Union Chairman welcomed this project and assured all kind of local support.	Info
	8. DC concluded the meeting by thanking the participants and wishing success of this project.	Info

Enclosure: Photographs and List of attendees

Snapshot of Meeting

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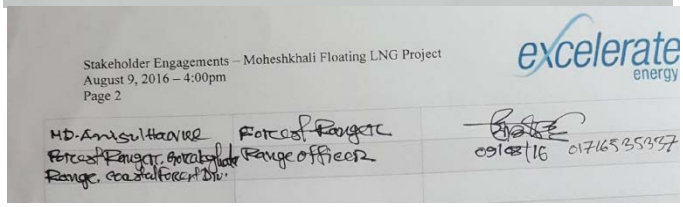
Stakeholder Engagement Meeting

Moheshkhali Floating LNG Project
Cox's Bazar, Bangladesh
August 9, 2016 – 4:00pm

Name	Organization	Contact Information
K.M. Jahirul Islam	RPGCL	01716131900
Md. Babor Ali	RPGCL	01713012093
Engr A.I.M NURULLAH	RPGCL	01713018117
Buck Booth	Excelerate Energy	+1-832-703-9107
Emily Dondzila	Excelerate Energy	+1 281.908.7697
Kerry McGeachie	E.E.	+1 713 315 7593
MD RAFIQUL ISLAM	PETROBANGLA	01711495481
Kazi Md Anwarul Azim	PETROBANGLA	01911420046
Mohammed Abul Kalam	Upazila Administration, Moheshkhali	01733-373209
Mojamel Haque Kanel	Assistant Commissioner	01722-329295
MD. SARIF	U.P	0732-662523
M.D MOSTAFA Kamal	U.P	01814111327
Sanders Khanjibul Bhuiyan (Also: Director)	DoE	01556340776 sandersdoe@gmail.com
Azam Buchmann	Excelerate/Acorn Intl.	+1-281-841-5927
Md. N. A. Siddique	BETS	01819463345 siddique@bets-bd.com
G.M. Mohammed Kabir	ACF, F.D cfg. Coastal Forest Div	01824-973771
Md. Abul Hashem Bhuiyan	Forest Ranger, Moheshkhali Rng. cfg. Coastal Forest Divn.	01727-072211

Excelerate Energy L.P. 1450 Lake Robbins Drive Suite 200 The Woodlands, Texas 77380 TEL 832.813.7100 FAX 832.813.7103



Stakeholder Engagements – Moheshkhali Floating LNG Project
August 9, 2016 – 4:00pm
Page 2

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MD. Amirul Haque	Forest Ranger		01716535357
Forest Ranger, Moheshkhali Range, Coastal Forest Div.	Range Officer	09/08/16	

List of Participants:

Sl No.	Name	Organization
1.	K.M Jahirul Islam	Rupantarita Prakritik Gas Company Limited (RPGCL)
2.	Md. Babor Ali	RPGCL
3.	Engr. A.I.M Nurullah	RPGCL
4.	Buck Booth	Excelerate Energy
5.	Emily Dondzila	Excelerate Energy
6.	Kenny McGeachie	Excelerate Energy
7.	Md. Rafiqul Islam	Petrobangla
8.	Kazi Md. Anwarul Azim	Petrobangla
9.	Mohammed Abul Kalam	Upazila Administration, Moheshkhali
10.	Mojammel Hoque Rasel	Assistant Commissioner
11.	Md. Sarif	Union Parishad Chairman
12.	Md. Mostafa Kamal	Union Parishad Chairman
13.	Sarder Shariful Islam	Assistant Director, DOE, Cox's Bazar
14.	Andrew Buchman	Excelerate/Acorn International
15.	M. N.A. Siddique	BETS
16.	G.M. Mohammad Kabir	ACE, F.D Ctg. Coastal Forest Division
17.	Md. Abul Hashem Bhuyan	Forest Ranger, Moheshkhali Range, Ctg. Coastal Forest Division
18.	Md. Anisul Haque	Forest Ranger, Gorakghata Range, Ctg. Coastal Forest Division

Appendix K: Phase 3 Consultations, October 2016

MINUTES OF MEETING

Meeting Date	19th October 2016 at 10.10am
Location	IUCN Conference Room
	House 16, Road 2/3, Banani, Dhaka 1213, Bangladesh
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	01
Subject	**Stakeholder Engagement Meeting**
Met With	Mr. Ishtiaq Uddin Ahmad, Country Representative (CR), IUCN Bangladesh
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting, CR welcomed all. Mr. M.N.A. Siddique, BETS introduced the team members. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- CR asked about the criteria for selection of FSRU location i.e. choice of location.	Asking
	- Mr. Booth answered the question of CR.	Replied
	- CR wanted to know about the GTCL pipeline status.	Asking
	- Mr. Booth answered the question of CR.	Replied
	- CR asked about any sort of air modeling is undertaken or not?	Asking
	- Mr. Khalsa answered the question of CR.	Replied
	- CR opined that in general perspective the project area is sensitive as because of presence of endangered species.	Info
	- Cautioned about the water pollution, chemical pollution, fuel/oil spillage etc. in construction and operation phases of the project.	Info
	- IUCN is working on the Sandpiper, manmade coastal forest, changes of coastal environment etc.	Info
	- Talked about the aquatic animals i.e. crabs, shrimp species, molluscs, shellfish, turtles of Sonadia etc. for especial precautionary measures in construction and operation phases of the project.	Info
	- NACOM as a local eNGO was advised by CR to visit to gather natural conservation information	Info

- Local environmental NGOs who worked on specific interest of the local areas i.e. birds, turtles etc. of the Cox's Bazar should be visited.	Suggestions
- Mentioned about the Bird Club, Turtles Alliance activities in the project areas	Info
- Informed about the presence of Dolphin close to the project area and also mentioned about the Wildlife Conservation Society where Mr. Jahangir involved to deals with the Dolphins related environmental issues.	Info
- Mr. Buchman inquired about details regarding the man-made forest of the project area.	Asking
- CR shared the Mangroves Restoration, its history in Bangladesh starting from 1960, Cox's Bazar lately started in 1980, covering at present 200,000hectres man made forest involving the Department of Forest. Due to high salinity of the Cox's Bazar regions the worst species are under plantation. Mangroves plantation are on in a newly accreted land.	Info
- Finally CR assured us his support and requested us to be in touch in future for any information.	

Enclosure: Photographs and List of Attendees

Snapshot of Meeting

Snapshot at the IUCN Office Gate

List of Participant:

Sl. No.	Name	Organization
1.	Ishtiaq Uddin Ahmad	IUCN
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	19th October 2016 at 11.30am
Location	Chamber of Chief Conservator of Forest (CCF) Ban Bhaban, Plot No- E-8, B-2; Agargaon, Sher-e-Bangla Nagar; Dhaka-1207
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	02
Subject	**Stakeholder Engagement Meeting**
Met With	Md. Yunus Ali, Chief Conservator of Forest (CCF) Md. Mozaharul Islam, Deputy Chief Conservator of Forest (DCCF)
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting, CCF welcomed all. Mr. M.N.A. Siddique, BETS introduced the team members. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- CCF asked about the FSRU location i.e. in the land or in the sea.	Asking
	- Mr. Booth answered the question of CCF.	Replied
	- CCF wanted to know about the GTCL pipeline status.	Asking
	- Mr. Booth answered the question of CCF.	Replied
	- CCF shared the formation of Delta	Info
	- Informed that 15% wind velocity of the coastal areas can be reduced by Mangrove forest.	Info
	- Mangrove forest is shield against cyclone and surges.	Info
	- Cox's Bazar Mangrove forestry is a learning outcome of the south-west mangrove forestry.	Info
	- DCCF suggested for formulation of Environmental Management Framework (EMF) for this FSRU project.	Suggested
	- CCF asked if any Strategic Environmental Assessment (ESA) is conducted for this project before the EIA study or not.	Asking
	- Mr. Khalsa answered the query of CCF	Replied
	- CCF opined that the EIA is a simplified form of impact assessment.	Info
	- CCF shared his concern of Tectonic plate movement of the project areas.	Info
	- Changes of soil formation due to development interventions in the mangrove forest areas will cause no afforestation of mangrove species	Info

but afforestation of other local plant species.

- CCF suggested us to meet the local forest officer to understand the forest information in and around the project area.
- Finally CCF assured us his support and requested us to be in touch in future for any information.

Suggestion

Enclosure: Photographs and List of Attendees

Snapshot of Meeting

List of Participant:

Sl. No.	Name	Organization
1.	Md. Yunus Ali	Department of Forest
2.	Md. Mozaharul Islam	Department of Forest
3.	K.M Jahirul Islam	RPGCL
4.	Buck Booth	Excelerate Energy
5.	Atma Khalsa	Acorn International
6.	Andrew Buchman	Acorn International
7.	M. N.A. Siddique	BETS
8.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	19th October 2016 at 01.15pm
Location	Chamber of Director (Environmental Clearance Certificate (ECC))
	Paribesh Bhaban, E/16, Agargaon, Sher-e-Bangla Nagar, Dhaka-1207
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	03
Subject	**Stakeholder Engagement Meeting**
Met With	Syed Nazmul Ahsan; Director (ECC) (D,ECC)
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting, D, ECC welcomed all. Mr. M.N.A. Siddique introduced the team members. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- D,ECC talked about every year renewal of the EIA report considering the conditions applied in the issued ECC of this project.	Suggestion
	- A copy of EIA report for IFC should be submitted to the DOE Local office and the Head office as well.	Info
	- Suggested to make sure the sedimentation modeling, Air Modeling, thermal flume modeling etc.	Suggests
	- Identify fish sanctuary if any in and around the project area.	Suggestion
	- For the mangrove forest cutting and laying of gas pipeline, GTCL will be responsible in consideration of creation of environmental impact.	Info
	- To identify the exact demarcation of the Ecologically Critical Area (ECA), EE should meet the Natural Resource Management (NRM) wing of DOE.	Info
	- For the issue of Emergency Plan the D,ECC shared that DOE has prepared a draft “National Oil Spillage Contingency Management Plan” which will be implemented by the Coast Guard.	Info
	- Suggest about the public consultation of the project area.	Suggestion
	- Finally D,ECC assured us his support and requested us to be in touch in future for any information.	

Enclosure: List of Attendees

List of Participant:

Sl. No.	Name	Organization
1.	Syed Nazmul Ahsan	Department of Environment
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	20th October 2016 at 10.30am
Location	Chamber of Chief Inspector of Explosives (CIE) Shed No. 2, 12 std. Commissioner Building Campus, Segunbagicha, Dhaka-1000
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	04
Subject	**Stakeholder Engagement Meeting**
Met With	Md. Shamsul Alam, Chief Inspector of Explosives (CIE)
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting, CIE welcomed all. Mr. M.N.A. Siddique introduced the team members. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- CIE asked about any storage facilities of Re-gasification unit on land or on sea.	Asking
	- Mr. Booth Answered about the asking of the CIE.	Replied
	- CIE shared that the DOE is the administrative authority for questions relating to the Rules of commercial explosives, flammables and unfired pressure vessels.	Info
	- CIE informed that the Gas Safety Rules 1991 conform the CFRs.	Info
	- Also shared the Pressure Vessel Rules of 1995 and its latest amendment 4th October 2016.	Info
	- Showing the Exclusive safety zones, i.e., 500 meters buffer zone centering the FSRU unit, four copies of drawings of the FSRU, necessary treasury chalan fee of Explosives the LNG-Cell/PB will apply to DOE for their Clearance.	Info
	- Every year renewal of DOE will be required and for this the DOE will inspect the FSRU site after getting written request from PetroBangla.	Info
	- CIE suggested us to meet the Chittagong Port Authority (CPA) to understand the navigability condition of the project area. And also shared the CPA exclusive zone of 1km radius centering the FSRU.	Suggestion
	- CIE also suggested us to look into the Safety Standards Volume-49 Part-93 and for vessel standards Volume-93 CFR Part 1-7.	Suggestion
	- Finally CIE assured us his support and requested us to be in touch in future for any information.	Info

Enclosure: Photographs and List of Attendees

Meeting with CIE

List of Participant:

Sl. No.	Name	Organization
1.	Md. Shamsul Alam	Department of Explosive
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	20th October 2016 at 03.30pm
Location	Paribesh Bhaban, E/16, Agargaon, Sher-e-Bangla Nagar, Dhaka-1207
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	05
Subject	**Stakeholder Engagement Meeting**
Met With	Mr. A. K. Rafiqul Islam, Deputy Director (DD), Natural Resource Management (NRM) Mr. Mahbubur Rahman, Project Manager (PM), Strengthening and Consolidation of CBA-ECA Project.
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting, DD welcomed all. Mr. M.N.A. Siddique introduced the team members. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is presented below:	
	- PM asked about any storage facilities of Re-gasification unit on land or on sea.	Asking
	- Mr. Booth answered about the asking of the PM.	Replied
	- Shared a soft copy of the ECA boundary.	Info
	- In 2003 the Coastal and Wetland Biodiversity Project (CWBP) was been developed involving the local community (firewood collector, shrimp collector etc.), stakeholders, village conservation groups etc.	Info
	- Upazila level coordination community group has been formed for the CWBP.	Info
	- Due to soil reclamation of the Sonadia Island more than 600 Acres of land is now under Mangrove forestry.	Info
	- The FSRU project should consider the Sand dunes protection of the Sonadia Island.	Suggestion
	- NRM informed that they have taken 18 Months Project to develop solar based desalination plant, solar based agriculture etc. in the Sonadia Island.	Info
	- NRM is always in favor of the FSRU project but it should have the permission of Department of Forest, a well-organized Biodiversity Management Plan.	Info
	- Advised to share the project information with the district Department of Environment, village communities and if possible an academician who got enough knowledge of the project site.	Suggestion
	- Finally they assured us their support and requested us to be in touch in future for any information.	Info

Enclosure: Photographs and List of Attendees

Meeting at NRM

List of Participant:

Sl. No.	Name	Organization
1.	Mr. A. K. Rafiqul Islam	Department of Environment
2.	Mr. Mahbubur Rahman	Strengthening and Consolidation of CBA-ECA Project
3.	K.M Jahirul Islam	RPGCL
4.	Buck Booth	Excelerate Energy
5.	Atma Khalsa	Acorn International
6.	Andrew Buchman	Acorn International
7.	M. N.A. Siddique	BETS
8.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	22nd October 2016 at 12.10pm
Location	Chittagong University Club, Chittagong
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	06
Subject	**Stakeholder Engagement Meeting**
Met With	Dr. Md. M. Maruf Hossain, Professor (former Director); Institute of Marine Sciences & Fisheries (IMSF); University of Chittagong
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting, Prof. Hossain welcomed all. Mr. M.N.A. Siddique introduced the team members. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- Prof shared a hard copy of Pollution Monitoring in Rivers, Estuaries and Coastal Areas of Bangladesh with Artificial Mussels (AM) Technology: Findings Ecological significance Recommendations.	Info
	- Prof talked about some modeling i.e. Sediment Transport Modeling, Air Emission Modeling, thermal modeling etc. which are important for the project to conduct.	Info
	- Professor addressed the concern of sedimentation during construction of the FSRU.	Suggestion
	- Prof requested us to provide him the EIA report and expressed his desire of involvement in the project study.	Request
	- Finally Prof assured us his support and requested us to be in touch in future for any information.	Info

Enclosure: Photographs and List of Attendees

Meeting at Professor at Chittagong Club

List of Participant:

Sl. No.	Name	Organization
1.	Dr. Md. M. Maruf Hossain	Chittagong University
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	23rd October 2016 at 10.30am
Location	CGO Building-2, 5th floor, Agrabad, Chittagong-4100
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	07
Subject	**Stakeholder Engagement Meeting**
Met With	Md. Tofazzal Hossain, Assistant Inspector of Explosives (AIE)
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting, AIE welcomed all. Mr. M.N.A. Siddique introduced the team members. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- AIE opined that the big projects like FSRU are dealt with the Head office.	Info
	- AIE only inspect the project site after getting order of Head office in commissioning stage of any project and in renewal of the project licenses.	Info
	- Finally AIE assured us his support and requested us to be in touch in future for any information.	Info

Enclosure: Photographs and List of Attendees

Meeting with AIE

List of Participant:

Sl. No.	Name	Organization
1.	Md. Tofazzal Hossain	Department of Explosives (DOE), Chittagong
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	23rd October 2016 at 12.30pm
Location	Bandar Bhaban, Chittagong-4100 Chittagong Port Authority
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	08
Subject	**Stakeholder Engagement Meeting**
Met With	Rear Admiral M Khaled Iqbal BSP,ndc,psc, Chairman
	Commodore Zulfiqur Aziz, (E), PSC, BN (Member Engineer)
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	There were two meetings held in the CPA. One meeting was at the Chairman's room at the onset. At the beginning of the meeting, Chairman welcomed all. Mr. Chairman introduced his member engineer Commodore Zulfiqur Aziz. And then Member Engineer guided us to sit his chamber to discuss the project issue in detail. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- Mr. Chairman shared about the importance of one kilometer exclusive safety zone for large vessel.	Info
	- Mr. Chairman asked about the Tug Boat location, accommodation of FSRU workforce.	Asking
	- Mr. Booth replied the question of Mr. Chairman.	Replied
	- Mr. Chairman also asked about the Techno-feasibility Study of the FSRU project.	Asking
	- Mr. Jahirul replied the question of Mr. Chairman.	Replied
	- Member Engineer talked about the Administrative permissions and tariff issues of LNG importing.	Info
	- Member Engineer advised us to prepare a draft primary report incorporating the detail of FSRU and its technical drawing and then submit it to the CPA and present a power point presentation. Finally submitting the final report incorporating suggestions of CPA will approve the Clearance.	Suggestion
	- Member Engineer shared that the Tug boats, berthing facilities and other logistic support of CPA could be provided to PetroBangla following the CPA administrative policy.	Info
	- Member Engineer requested us to keep communication with the CPA for any issue to share by addressing the Chairman, CPA and CC to Commodore Zulfiqur Aziz, (E), psc, BN (Member Engineer).	Info

Enclosure: Photographs and List of Attendees

Meeting with Member Engineer

List of Participant:

Sl. No.	Name	Organization
1.	Rear Admiral M Khaled Iqbal	Chittagong Port Authority
2.	Commodore Zulfiqur Aziz, (E)	Chittagong Port Authority
3.	K.M Jahirul Islam	RPGCL
4.	Buck Booth	Excelerate Energy
5.	Atma Khalsa	Acorn International
6.	Andrew Buchman	Acorn International
7.	M. N.A. Siddique	BETS
8.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	23rd October 2016 at 2.30pm
Location	CGO Building-1, Agrabad, Chittagong-4100
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	09
Subject	**Stakeholder Engagement Meeting**
Met With	Mr. Adhir Chandra Das, Assistant Director (AD), Department of Fisheries
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting, AD welcomed all. Mr. M.N.A. Siddique introduced the team members. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- AD defined the Artisanal Fishing (<40m WD fishing) and Industrial Fishing (40-100m WD)	Info
	- For the industrial fishing the type of gears (passive) are Behendi Jal, (Local), ESBN net, Marine Sellback Net, Vasan Jal, Tana Jal etc.	Info
	- The marine fishermen do fishing all over the year but government prohibit for fishing from 12th Oct to 2nd Nov to protect the Hilsha fish breeding in their special monitoring program.	Info
	- For the Mechanized fishing the restriction for fishing started from 10th May to 65 days onward.	Info
	- There are many Artisanal fishing activities in the Project area.	Info
	- The fish landing Ghat (jetty) is at the Cox's Bazar which is known as Bangladesh Fisheries Development Corporation (BFDC) ghat.	Info
	- The survey of the Bangladesh Marine Fisheries Capacity Building Project -2015 found that 222 engine boat/Mechanized Boat owned by 168 Fishermen in the Moheshkhali Upazila of Cox's Bazar district. Boat size varies in width 1.83m to 24m, length 9.15m to 45m and Engine Horsepower 12 to 75 HP.	Info
	- AD asked about the compensation of the fishing community of the project area due to intervention of fishing activities by the Project work.	Asking
	- Mr. Khalsa replied on the query of AD's asking.	Replied
	- AD recommended for keeping provision in the project for managing alternate income generation for the Artisanal Fishing community during the project construction phase.	Recommendation
	- For grievance issues bottom up approach is the best approach as suggested by the AD.	Suggestion
	- Upazila Fisheries officer should be involved in the project study stage to understand the fishing community, fisherman and environment related	Suggestion

to fisheries.

- AD expressed concern about the loss of biodiversity and breeding & nursing ground due to the construction activities of the FSRU. — Concern
- Finally expressed positive attitude about the project. — Attitude

Enclosure: Photographs and List of Attendees

Meeting with AD

List of Participant:

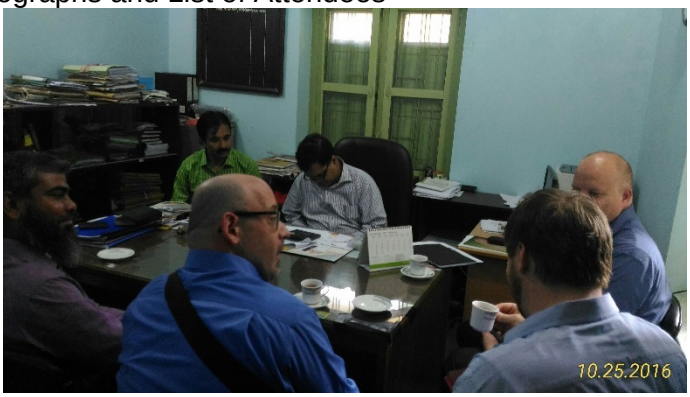
Sl. No.	Name	Organization
1.	Adhir Chandra Das	Department of Fisheries
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	25th October 2016 at 8.30am
Location	DOE Cox Bazar District Office, Sayman Road, Jhawtala, Coxsbazar
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	10
Subject	**Stakeholder Engagement Meeting**
Met With	Mr. Md. Masud Karim, Director, Chittagong Division Mr. Sordar Shariful Islam, Assistant Director (AD), Department of Environment, Cox's Bazar
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting, AD welcomed all. And then Director joined in the meeting room and chaired the meeting. Mr. Booth of EE gave a brief description of the project and Mr. Khalsa of Acorn International described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- Director asked about the project details.	Asking
	- Mr. Booth briefly described the project.	Replied
	- Director talked about the temperature change of the sea due to discharge of hot water.	Info
	- Director asked about any mangrove forest cutting due to the project activities or not.	Asking
	- Mr. Booth replied on the query of the Director.	Replied
	- Director wanted to know about the FSRU construction and operation experience of EE.	Asking
	- Mr. Booth shared the EE experience.	Replied
	- AD requested us to discuss with the local forest officer.	Request
	- AD consented to share the available baseline information with BETS through email.	Sharing
	- Finally expressed positive attitude about the project.	Attitude

Enclosure: Photographs and List of Attendees



Meeting with Director at AD Chamber

List of Participant:

Sl. No.	Name	Organization
1.	Md. Masud Karim	Department of Environment
2.	Sordar Shariful Islam	Ditto
3.	K.M Jahirul Islam	RPGCL
4.	Buck Booth	Excelerate Energy
5.	Atma Khalsa	Acorn International
6.	Andrew Buchman	Acorn International
7.	M. N.A. Siddique	BETS
8.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	25th October 2016 at 9.45am
Location	Deputy Commissioner's Office of Cox's Bazar
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	11
Subject	**Stakeholder Engagement Meeting**
Met With	Md. Ali Hossain, Deputy Commissioner & District Magistrate
	Mohammed Anwarul Naser, Assistant Deputy Commissioner (ADC Revenue)
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	ADC started the meeting at the DC chamber because of the engagement of the DC in another program. DC joined the meeting and chaired as well after 20 minutes of the start of the meeting. At the beginning of the meeting, ADC welcomed all. Mr. Siddique introduced the team members. And then Mr. Booth of EE shared the update of the project and the planned program of the project. The summary of the meeting is discussed below: - Mr. Booth shared about the project progress and the program of the stakeholder engagement - DC and ADC talked about the security of the team. - DC advised us to keep police protocol for the visit of Maheshkhali unions - At the end of the meeting DC pronounced that the FSRU is a dream project of the country and the administration is ready to provide all-out support and cooperation to the EE.	Sharing Advising Info

Enclosure: Photographs and List of Attendees

Meeting with DC

List of Participant:

Sl. No.	Name	Organization
1.	Md. Ali Hossain	Deputy Commissioner's Office of Cox's Bazar
2.	Mohammed Anwarul Naser	Deputy Commissioner's Office of Cox's Bazar
3.	K.M Jahirul Islam	RPGCL
4.	Buck Booth	Excelerate Energy
5.	Atma Khalsa	Acorn International
6.	Andrew Buchman	Acorn International
7.	M. N.A. Siddique	BETS
8.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	25th October 2016 at 2.50pm
Location	Department of Fisheries, Cox's Bazar
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	12
Subject	**Stakeholder Engagement Meeting**
Met With	Amitos Sen, District Fisheries Officer (DFO), Cox's Bazar
	Dr. Moinuddin, Upazila Fisheries Officer, Cox's Bazar Sadar, Cox's Bazar
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting DFO welcomed all. Mr. Siddique introduced the team members. And then Mr. Booth gave a brief description of the project and Mr. Khalsa described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- DFO shared that the Hilsha fish spawning ground is up to the Kutubdia and its migration path is close to the FSRU project.	Info
	- Migration path linked to the estuary of the Shankha river at the Gondamara Point	Info
	- There are four spawning ground of Hilsha Fish and the Gondamara point is one of them	Info
	- Talked about the sensitivity of the coastal area especially the Para forest	Concern
	- The artisanal fisheries are all along the coastal areas	Info
	- Shared the gears of artisanal fisheries i.e. setback net (marine), MSBS etc.	Info
	- 10000 registered fishermen and there are many unregistered fishermen in Moheshkhali	Info
	- Total catch of Cox's Bazar district: 250 millions tons/year (BFDC: Bangladesh Fisheries Development Corporation)	Info
	- Fishing community is guided by the boat owner	Info
	- Main fish landing point is in Cox's Bazar	Info
	- Brood Hilsha Conservation Program is now ongoing	Info
	- Advised to meet Mr. Sabedul Haque, Upazila fisheries officer, Moheshkhali	Advising
	- Suggested EE to interview the local fishermen	Suggestion
	- Expressed his worries about the fate of the fishing community due to the industrial and commercial engagement of the Moheshkhali Upazila	Concern

- DFO shared his email contact to share any information about the Cox's Bazar fisheries. Sharing

Enclosure: Photographs and List of Attendees

Meeting with DFO

List of Participant:

Sl. No.	Name	Organization
1.	Amitos Sen	Department of Fisheries
2.	Dr. Moinuddin	Ditto
3.	K.M Jahirul Islam	RPGCL
4.	Buck Booth	Excelerate Energy
5.	Atma Khalsa	Acorn International
6.	Andrew Buchman	Acorn International
7.	M. N.A. Siddique	BETS
8.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	26th October 2016 at 10.00am
Location	UNO Office, Moheshkhali
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	13
Subject	**Stakeholder Engagement Meeting**
Met With	Mohammad Abul Kalam, Upazila Nirbahi Officer (UNO) Moheshkhali
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting UNO welcomed all. Mr. Siddique introduced the team members. And then Mr. Booth gave a brief description of the project and Mr. Khalsa described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below:	
	- Asked about the establishment of project office in Moheshkhali	Asking
	- Mr. Booth replied on the query of the UNO.	Replied
	- Asked about the survey activities and related accommodation facilities	Asking
	- Mr. Booth replied on the query of the UNO.	Replied
	- UNO shared the registered and unregistered fishermen information i.e. 10000 registered and 25000 unregistered fishermen	Info
	- During the registration period the maximum fishermen worked in the sea and that's why the registered number are too less than of unregistered	Info
	- Suggested to meet the union parishad chairman and upazila fisheries officer to understand the fisheries information correctly.	Suggesting
	- UNO guided us to travel to the Upazila fisheries office.	Assisting

Enclosure: Photographs and List of Attendees

Meeting with UNO

List of Participant:

Sl. No.	Name	Organization
1.	Mohammad Abul Kalam	Local Administration
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	26th October 2016 at 10.45am
Location	Upazila Fisheries Office, Moheshkhali
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	14
Subject	**Stakeholder Engagement Meeting**
Met With	Mr. Sabedul Hoque, Upazila Fisheries Officer (UFO) Moheshkhali
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting UNO welcomed all and introduced UFO. Mr. Siddique introduced the team members. And then Mr. Booth gave a brief description of the project and Mr. Khalsa described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. The summary of the meeting is discussed below: - Shared the registered and unregistered fishermen information, i.e. 10000 registered and 25000 unregistered fishermen. - UFO shared again about the reason of too many unregistered fishermen. - UFO assured that he will share the fish production information with calculation later on.	Info Info Assuring

Enclosure: Photographs and List of Attendees

Project Briefing of Mr. Booth

Snapshot at the Entrance of UFO Office

List of Participant:

Sl. No.	Name	Organization
1.	Sabedul Hoque	Department of Fisheries
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	26th October 2016 at 11.15am
Location	Union Chairman Office, Boro Moheshkhali
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	15
Subject	**Stakeholder Engagement Meeting**
Met With	Mr. Jafor Alam, Panel Chairman, Boro Moheshkhali
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting Panel Chairman welcomed all. Mr. Siddique introduced the team members. And then Mr. Booth described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. Mr. Siddique translated the discussion of Mr. Booth. The summary of the meeting is presented below: - Initial presentation to make project activities more clear - There was a confusion, including the mistaken notion that there had been discovery of a subsea gas field, was cleared up during the briefing - Talked about the engagement of the local people. - Assure all-out support.	Info Request Assurance

Enclosure: Photographs and List of Attendees

Meeting with Panel Chairman

List of Participant:

Sl. No.	Name	Organization
1.	Jafor Alam	Union Parishad
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	26th October 2016 at 12.15pm
Location	Union Chairman Office, Kutubjom
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	16
Subject	**Stakeholder Engagement Meeting**
Met With	Mr. Mosharrof Hossain Khokon, Chairman, Kutubjom
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting Mr. Chairman welcomed all. Mr. Siddique introduced the team members. And then Mr. Booth described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. Mr. Siddique translated the discussion of Mr. Booth. The summary of the meeting is discussed below: - Initial presentation made to go over scope of project activities. - Address confusion, misinformation, including idea of gas field discovery - Talked about the engagement of the local people if possible. - Chairman assured the local support as and when required.	Info Request Assurance

Enclosure: List of Attendees

List of Participant:

Sl. No.	Name	Organization
1.	Mosharrof Hossain Khokon	Union Parishad
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

MINUTES OF MEETING

Meeting Date	26th October 2016 at 1.30pm
Location	Gotibanga
Client	LNG Cell, Petrobangla
Project	Moheshkhali Floating LNG Terminal
Doc. No.	16
Subject	**Stakeholder Engagement Meeting**
Met With	Dr. Amiruzzaman Anju, Chairman of FA
Prepared By	Mohammad Nurul Alam Siddique
Participant(s)	As per attendee list enclosed

Item	Topics	Findings
1	At the beginning of the meeting Mr. Chairman welcomed all. Mr. Siddique introduced the team members. And then Mr. Booth described the project location, operation of the LNG terminal station and its linked project the gas transmission system etc. Mr. Siddique translated the discussion of Mr. Booth. The summary of the meeting is discussed below:	
	- Make clear about the project activities.	Info sharing
	- Talked about two special fishes i.e. Lakkha and Kalapoa (Black Zopia) which are big in size and found in and around the FSRU project area.	Info
	- In the Chairman's association there are 88 fishermen (listed) and 150 unlisted fishermen.	Info
	- In his fishing association the monthly sale is 3-4 million BDT.	Info
	- Address confusion, misinformation, including idea of gas field discovery	
	- Talked about the engagement of the local people if possible.	Info
	- Chairman assured all kind of local support needed to the project.	Assurance

Enclosure: Photographs and List of Attendees

Project Briefing in Bengali of Mr. Siddique

List of Participant:

Sl. No.	Name	Organization
1.	Dr. Amiruzzaman Anju	Fishing Association
2.	K.M Jahirul Islam	RPGCL
3.	Buck Booth	Excelerate Energy
4.	Atma Khalsa	Acorn International
5.	Andrew Buchman	Acorn International
6.	M. N.A. Siddique	BETS
7.	Mir Towfiq Hossain	BETS

Appendix L: Geotechnical and Environmental Baseline Survey Services Environmental Baseline Survey Report Coast of Moheshkhali Island, Offshore Bangladesh

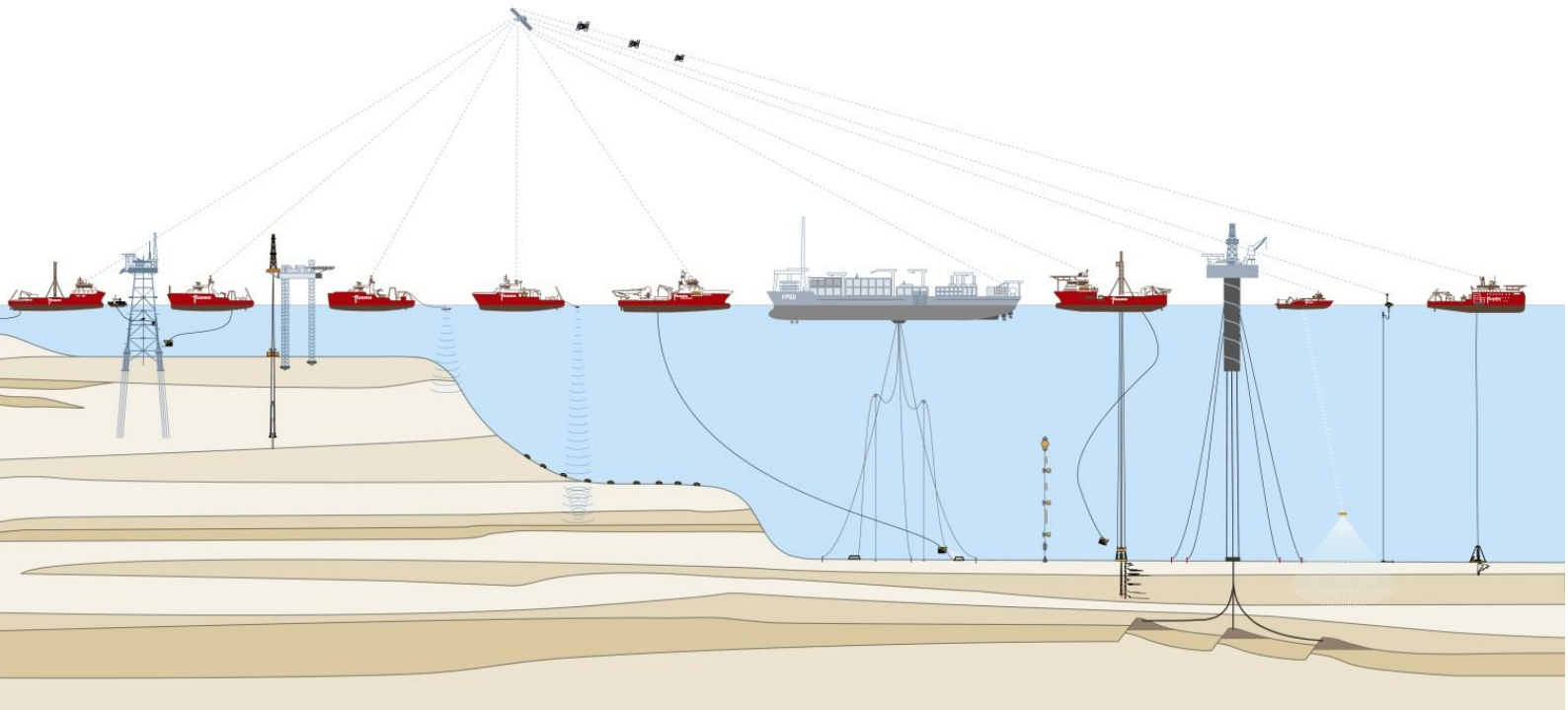
FUGRO

Geotechnical and Environmental Baseline Survey Services
Environmental Baseline Survey Report
Coast of Moheshkhali Island, Offshore Bangladesh

Fugro Document No.: 160924_1Rev1

Excelerate Energy Bangladesh Ltd

Draft



Geotechnical and Environmental Baseline Survey Services
Environmental Baseline Survey Report
Coast of Moheshkhali Island, Bangladesh

23 November to 7 December 2016
Fugro Project No.: 160924

Prepared for:

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Premier FM Heights, 1st Floor House No. 88
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EXECUTIVE SUMMARY

Introduction

Fugro undertook a survey comprising geotechnical and environmental data acquisition off the coast of Moheshkhali Island in the Bay of Bengal, Bangladesh. Operations were undertaken onboard the vessel MV Mariner between 23 November and 7 December 2016. This report details the results of the environmental baseline survey.

Survey Strategy

Nine environmental sampling stations were originally proposed for water column and seabed sampling, but only eight of these were sampled, due to shallow water preventing access to one of the stations. Water profiles (measuring conductivity (salinity), temperature, depth, dissolved oxygen, pH and turbidity) were acquired using Hydrolab DS5X CTDs and water samples were acquired at two depths per station using 5 litre Niskin bottles; these water samples were subsampled for nutrient, hydrocarbon and heavy/trace metal analyses. Benthic samples were acquired using a dual 0.1m^2 van Veen grab, with the resultant samples processed for particle size, organic carbon, hydrocarbon, heavy/trace metal and macrofaunal analyses.

Sediment Characterisation

The sediment was variable across the survey area, with three stations being dominated by sand sediments, two stations dominated by mud sediments and three containing almost equal proportions of sand and mud sediment. All of the samples contained little (<1%) or no gravel. Total organic carbon (TOC) was consistently low across the site (mean of 0.48%) and total organic matter (TOM) was also present at low levels (mean 0.86%)

Sediment Hydrocarbons

All but one of the USA Environmental Protection Agency (EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) concentrations were below detectable limits from all stations. The single detectable PAH was benzo(a)pyrene, which was present at very low levels and would not be expected to have a major detrimental effect on sediment dwelling biotic communities.

Sediment Heavy/trace Metals

The majority of the metals results displayed low to moderate inter-station variability. Comparison of the sediment metals concentrations against indicative ecological effect thresholds (Effects Range Low - ERLs) showed the majority of metal concentrations were below the values where they would be likely to cause any adverse effects on sediment biota. The only exception was nickel, which was present at concentrations that slightly exceeded the ERL value. Most metals were shown to strongly trend with particle size data, with most being shown to increase, but some decrease, in response to variation in fines (silt and clay) content.

Macrofauna

The community across the survey area was observed to be highly variable between samples and overall faunal richness and diversity was low. Several of the species recorded were relatively large bodied and robust organisms, typically associated with mobile sediment habitats. Data interpretation suggested that a single community occurred throughout the survey area and that this is probably typical of similarly dynamic, physically disturbed environments in the region.

Water Profiles

Water profiles for temperature, salinity, pH and dissolved oxygen showed a well-mixed water column at all stations with no thermocline or halocline. A subsurface increase in dissolved oxygen was observed at one station and was attributed to wave and tidal action in shallower water causing oxygen over-saturation. Turbidity values were more variable and increases in turbidity with depth were observed at all stations. Variation in pH, temperature and salinity were recorded between stations but this was attributed to temporal changes from changes in environmental conditions during the survey period, rather than inter-station spatial variation.

Water Quality

Total Petroleum Hydrocarbons (TPH) concentrations were consistently low throughout the survey area, with all values below detectable limits. Metals concentrations in the water column samples were generally low with all metals measured at concentrations less than the US EPA saltwater quality standards, with the exception of copper which exceeded the Criterion Continuous Concentration (CCC) at four stations. The proportion of total suspended solids and depth had a positive correlation with many heavy and trace metals. Nutrient levels were generally low, with some below levels of detection.

Incidental Observations

During the survey a lot of fishing activity was observed and several times it affected survey operations. All of the fishing vessels observed utilised gill nets. The geophysical survey identified potential fishing gear on the seabed, with 57 sonar contacts and 26 magnetic anomalies attributed to fishing activity.

The amount of marine life observed during the survey (e.g. seabirds and pelagic fish) was minimal; no marine mammals or reptiles were observed. Overfishing, and the consequently limited food supply for larger marine fauna, may explain this.

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ABBREVIATIONS

As	Arsenic
Ba	Barium
CCC	Criterion continuous concentration
Cd	Cadmium
CEMP	Coordinated Environmental Monitoring Programme
CMC	Criteria maximum concentration
CM	Central meridian
CTD	Conductivity/Temperature/Depth
Cr	Chromium
Cu	Copper
DO	Dissolved oxygen
EPA	Environment Protection Agency
ERL	Effects range low
ERM	Effects range medium
FA/FB/FC	Fauna replicate A, B or C
FSGU	Floating Storage Regasification Unit
FID	Flame Ionisation Detection
GC	Gas chromatography
GC-FID	Gas chromatography –flame ionisation detection
GC-MS	Gas chromatography with mass spectrometry
HC	Hydrocarbon (sample)
Hg	Mercury
HM	Heavy metal
ICP-MS	Inductively coupled plasma-mass spectrometry
ICP-OES	Inductively coupled plasma optical emission spectroscopy
LOI	Loss on ignition
MDS	Multi-dimensional scaling
MV	Motor vessel
Ni	Nickel
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Units
PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
PC	Physico-chemical (sample)
PLEM	Pipeline End Manifold
PRIMER	Plymouth Routines in Multivariate Ecological Research
PSA	Particle size analysis
PSD	Particle size distribution
PSU	Practical salinity unit
RSD	Relative standard deviation
SD	Standard deviation

SIMPROF	Similarity profiling
Sr	Strontium
TOC	Total organic carbon
TOM	Total organic matter
TPH	Total Petroleum Hydrocarbons
TSS	Total suspended solids
USBL	Ultra-short baseline
US EPA	United States Environmental Protection Agency
UTM	Universal transverse mercator
V	Vanadium
WGS84	World Geodetic System 1984
Zn	Zinc

1. INTRODUCTION

1.1 Background

Excelerate Energy Bangladesh Ltd (Excelerate) has contracted Fugro to perform an offshore geotechnical and environmental baseline survey to facilitate the design and installation of the Floating Storage Regasification Unit (FSGU) anchor foundations and its gas delivery lines near the coast of Moheshkhali Island, offshore Bangladesh. The environmental fieldwork was performed to characterise the seabed sediment and its associated biological communities and determine the physico-chemistry of the water column. The Pipeline End Manifold (PLEM) and pipeline land fall location are provided in Table 1.1

Operations were undertaken onboard the vessel MV Mariner between 23 November and 7 December 2016.

This environmental baseline survey (EBS) report presents the results of *in situ* testing, physico-chemical laboratory analyses and the macrofaunal sample analysis. This report revision (160924_1Rev1) follows on from the interim characterisation report (160924_1Rev0), which reported *in situ* testing and physico-chemical laboratory analyses only.

Table 1.1: Survey Area Boundary Coordinates (Client Supplied)

Geodetic Datum: WGS84, UTM Zone 46 N, CM 93° E				
Location	**Easting [m]**	**Northing [m]**	**Longitude**	**Latitude**
Pipeline Land Fall	382 315.00	2 386 028.00	91° 51' 48"	21° 34' 24"
PLEM	377 800.00	2 381 669.00	91° 49' 12"	21° 32' 01"

1.2 Scope of Work

The purpose of the geotechnical site survey was to carry out a soil investigation below the mudline down to sufficient depth in order to obtain pertinent data to define soil stratification and mechanical properties, as well as fulfilling the specifications laid down in the contract.

The objective of the environmental survey was to collect environmental data relating to the physico-chemical and biological composition of seabed sediment and water at the proposed site of the FSGU and its gas delivery line. Environmental survey operations comprised a combination of seabed sediment sampling and water sampling and profiling. Seabed sampling was undertaken using a dual van Veen grab; the samples acquired were subsampled for macrofaunal (biological) and physico-chemical analysis. Water profiling was undertaken to determine water column characteristics (temperature, salinity, turbidity, pH and dissolved oxygen) in relation to depth and water samples were acquired to determine other water quality parameters.

1.3 Comparative Environmental Data

Where possible, the physico-chemical data acquired in the current study have been compared with summarised data collected during a recent seabed survey conducted in another part of the Bay of Bengal, located approximately 300 km from the survey area (Fugro, 2016). Sampling and some analytical methodologies utilised during the previous survey were comparable to those used during the

current survey, allowing direct comparison of data results. Data from this previous survey have been collated and minimum, mean, maximum, standard deviation (SD) and relative standard deviation (RSD) values displayed for comparison.

An environmental impact assessment was completed for the construction of a coal fired power plant and associated facilities that took water samples 14 km north of the survey area (TEPSCO, 2013). Relevant physico-chemical data from this survey has been collated and presented for comparison, however some of the analytical methodologies are different between the surveys and direct comparison is not possible for all analytes of interest.

No macrofaunal data from the local area were available for comparative purposes and an initial review of the data obtained during the current survey, alongside those of the previous Bay of Bengal survey, suggested that meaningful comparison between the two biological communities identified was not possible.

1.4 Regional Standards

In the absence of any regional standards specific to the waters of Bangladesh or the wider Bay of Bengal, internationally recognised environmental standards have been adopted. These include the OSPAR (2014) Coordinated Environmental Monitoring Programme (CEMP), which provides assessment criteria for contaminants in sediments in the form of effects range low (ERL) values. Sediment heavy and trace metals have also been compared to National Oceanographic and Atmospheric Administration (NOAA) ERL and effects range medium (ERM) values (Buchman, 2008). Nutrient and heavy metal concentrations analysed from water samples have been compared with environmental quality standard (EQS) criteria maximum concentrations (CMC) and criterion continuous concentrations (CCC) developed by the United States Environmental Protection Agency (EPA, 2015).

1.5 Geodetic Parameters

All coordinates detailed in this report are referenced to the World Geodetic System 1984 (WGS84) and Universal Transverse Mercator (UTM) Projection Zone 46 N and Central Meridian (CM) 93° E. Detailed geodetic and projection parameters are provided in Table 1.2.

Table 1.2: Projection Geodetic Parameters

Global Positioning System Geodetic Parameters [1]							
Datum:	World Geodetic System 1984 (WGS84)						
Spheroid:	World Geodetic System 1984						
Semi major axis:	a = 6 378 137.000 m						
Reciprocal flattening:	1/f = 298.257 223 563						
Local Geodetic Datum Parameters							
Datum:	World Geodetic System 1984 (WGS84)						
Spheroid:	World Geodetic System 1984						
Semi major axis:	a = 6 378 137.000 m						
Reciprocal flattening:	1/f = 298.257 223 563						
Datum Transformation Parameters from WGS84 to Local Coordinate Frame Rotation Convention [2]							
Shift dX:	0.0	m	Rotation rX:	0.0	arc sec	Scale Factor:	0.0 ppm
Shift dY:	0.0	m	Rotation rY:	0.0	arc sec		
Shift dZ:	0.0	m	Rotation rZ:	0.0	arc sec		
Project Projection Parameters							
Map Projection:	Transverse Mercator						
Grid System:	UTM Zone 46 N						
Longitude of Origin:	93° 00′ 00″ East						
Latitude of Origin:	000° 00′ 00″ North						
False Easting:	500 000 m						
False Northing:	0 m						
Scale factor on Central Meridian:	0.9996						
Units:	metre						

Notes:
1. Fugro Starfix navigation software always uses WGS84 geodetic parameters as a primary datum for any geodetic calculations
2. This is the right-hand coordinate frame rotation used by the Fugro Starfix navigation software

2. ENVIRONMENTAL SURVEY METHODS

2.1 Survey Strategy

An environmental survey strategy was prepared prior to project mobilisation. Nine stations were proposed for sampling from the MV Mariner. Two additional stations S06 and S11, located in the very shallow water closer to the pipeline land fall, were to be completed by a team onshore and will be reported separately.

At each station sediment and water samples, as well as water profiles were to be acquired.

The survey strategy was revised during the survey operations. The location of station S02 was moved to the PLEM borehole location. Station S10 was moved from shallow water borehole location (B18) to a deeper borehole location (B30) and station S08 was moved 50 m west.

The final proposed coordinates at which all seabed sampling was undertaken are provided in Table 2.1 and are spatially displayed in Figure 2.1.

Table 2.1: Environmental Sampling Stations

Station	Borehole location	Position		Water Depth [m]
		Easting [m]	Northing [m]	
S01	B01	377 274.19	2 381 640.70	37
S02	PLEM	377 800.00	2 381 669.00	38
S03	B04	377 603.48	2 382 157.55	37
S04 (reference)	B07	377 775.97	2 381 379.51	37
S05	B09	377 921.99	2 382 340.11	35
S07	B13	378 581.63	2 382 990.50	24
S08	B14	378 704.52	2 383 459.66	21
S09	B16	379 147.46	2 384 382.35	15
S10	B30	379 484.89	2 385 125.29	10

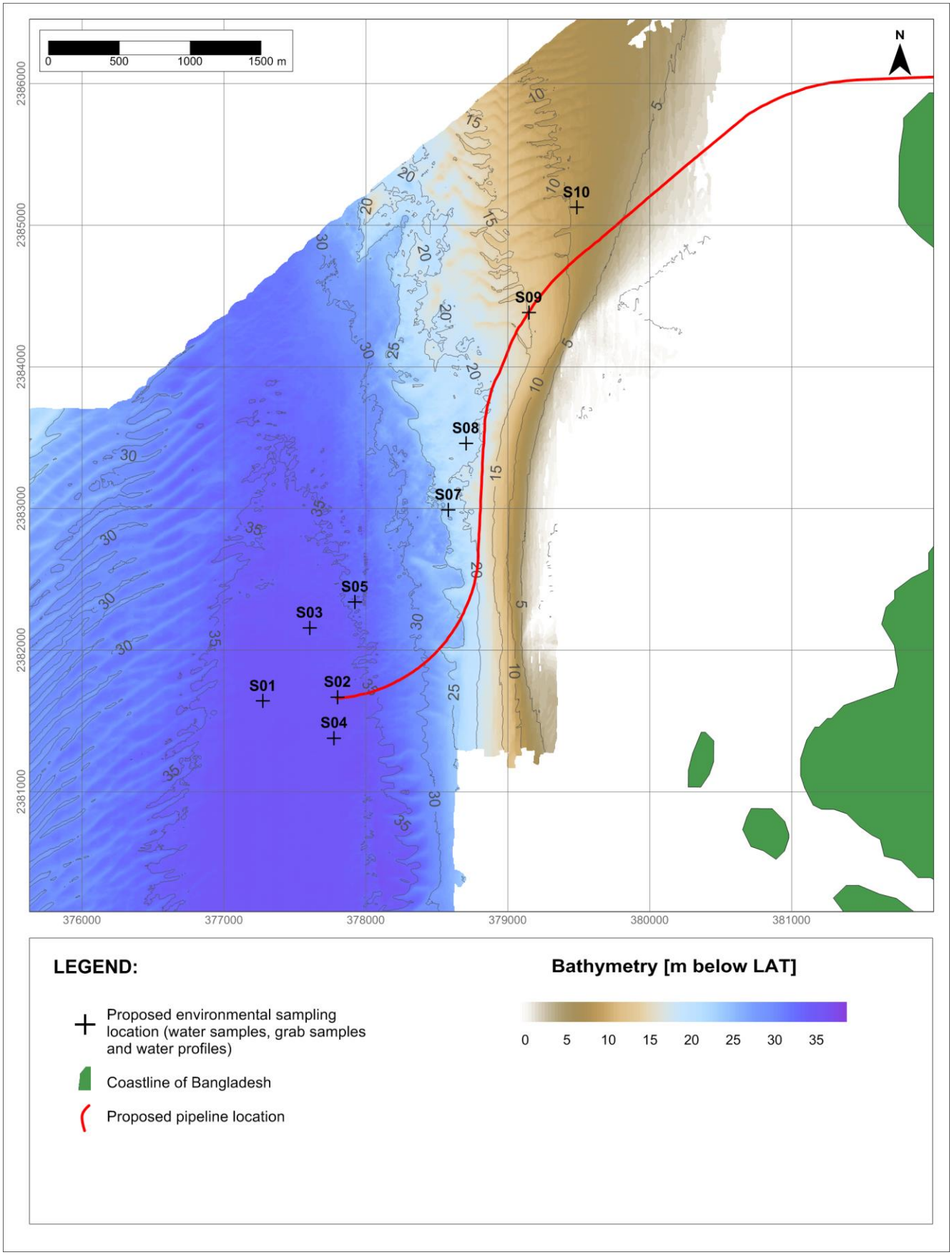


Figure 2.1: Environmental survey strategy

2.2 Survey Methods

2.2.1 Sampling Operations

Seabed samples were collected using a dual 0.1 m^2 van Veen grab with manual fixes taken for each sample. A 0.1 m^2 Day grab was available as a backup, but was not used during the survey. Four samples were acquired at each station (requiring a minimum of two deployments of the dual Van Veen grab) Three samples were processed for faunal analysis (fauna replicates FA, FB and FC) and a single sample for physico-chemical analysis (PC sample). The PC samples were subsampled for laboratory analysis, including heavy and trace metal (HM) duplicates A and B, hydrocarbons (HC) duplicates A and B, and particle size distribution (PSD) duplicates A and B. Deck logs were kept of all the sample details including sample number, sediment type, colouration (Munsell chart), layering and depth, volume of samples and any notable features such as smell, bioturbation or fauna.

Water profiles were collected using a Hydrolab Series 5 multi-parameter probe, fitted with an array of sensors to record pressure (to derive depth), temperature, conductivity (to derive salinity), turbidity, pH and dissolved oxygen (DO).

Water samples were collected using 5 litre Niskin water samplers. Samples were taken from the water surface and near the seabed from all stations with a water depth of less than 30 m (stations S01 to S05). At stations where water depth was greater than 30 m (stations S07 to S9) samples were also collected at mid-depth. Water samples from each depth were subsampled for heavy and trace metals, total suspended solids (TSS), chlorophyll total aromatic hydrocarbons, nutrients and chlorophyll.

2.2.2 Analytical Strategy

The following list briefly describes the suites of analyses carried out. Further description of the methods used during the analyses are detailed in Appendix A.

- Sediment particle size analysis (PSA) and characterisation including organic matter content (Section 5)
- Total hydrocarbon content by gas chromatography-flame ionisation detection (GC-FID) and polycyclic aromatic hydrocarbons (PAH) by gas chromatography-mass spectrometry (GC-MS) (Section 6);
- Metals by microwave assisted acid digest and inductively coupled plasma – optical emission spectrometry (ICP-OES) (Section 7);
- Macrofaunal analysis by microscopy, including statistical analyses of phyletic composition, diversity and multivariate community structure (Section 8);
- In-situ water profiles including temperature, salinity, turbidity, pH and dissolved oxygen content (Section 9);
- Water quality including nutrients by colorimetry, chlorophyll by spectrophotometry hydrocarbons by GC-FID and GC-MS and metals by ICP-OES (Section 10).

3. FIELD OPERATIONS

A full suite of seabed samples (PC/FA/FB/FC) were taken from five of the nine proposed locations. Partial sampling success at S05 allowed PC, FA and FB samples to be taken but no FC sample and partial sampling success at S07 and S08 allowed the PC sample to be taken from each, but no fauna samples. Grab sampling was not attempted at S10 as the shallow water depth limited safe working for the vessel. All samples were acquired using a 0.1 m^2 dual van Veen grab. The samples acquired are detailed in Table 3.1 and full positional and sample logs are provided in Appendices C.1 and C.2, respectively.

Water samples and profiles were acquired successfully at eight of the nine proposed locations with a summary provided in Table 3.2. No samples were acquired at S10 as the station was too shallow for the vessel to safely perform sampling operations.

Table 3.1: Completed Grab Sampling

Station	Easting [m]	Northing [m]	Depth [m]	Samples
S01	377 264.58	2 381 627.52	37	PC, FA, FB, FC
S02	377 808.65	2 381 683.52	38	PC, FA, FB, FC
S03	377 609.13	2 382 172.07	37	PC, FA, FB, FC
S04	377 784.76	2 381 393.29	37	PC, FA, FB, FC
S05	377 913.33	2 382 326.48	35	PC, FA, FB
S07	378 572.26	2 382 976.17	24	PC
S08	378 713.41	2 383 473.49	21	PC
S09	379 132.62	2 384 391.77	15	PC, FA, FB, FC

Notes:
PC = Physico-chemical
FA/FB = Faunal replicate A or B

Table 3.2: Completed Water Quality Sampling

Station	Easting [m]	Northing [m]	Sample Depth [m]			Samples Acquired
			Top	Middle	Bottom	
S01	377 264.58	2 381 627.52	2	18	35	Profile/water samples
S02	377 808.65	2 381 683.52	2	19	36	Profile/water samples
S03	377 609.13	2 382 172.07	2	18	35	Profile/water samples
S04	377 784.76	2 381 393.29	2	18	35	Profile/water samples
S05	377 913.33	2 382 326.48	2	17	33	Profile/water samples
S07	378 572.26	2 382 976.17	2	-	22	Profile/water samples
S08	378 713.41	2 383 473.49	2	-	19	Profile/water samples
S09	379 132.62	2 384 391.77	2	-	13	Profile/water samples

4. SEABED FEATURES

A geophysical survey was conducted to identify any potential seafloor and subsurface hazards. The proposed site is in open water approximately 3 km west of Moheshkhali Island. Water depths range from -0.6m (i.e. drying heights above chart datum) and 38.2 m.

In general, the seafloor morphology shows a topography steadily sloping down from the east reaching maximum depth in the central part and gently sloping up towards west, thus representing a channel like feature in the centre of the survey corridor trending in the North-South direction.

Based on the acoustic reflectivity of the side scan sonar data and multibeam echosounder backscatter data, seabed sediments within the survey area were classified into two sediment types Low to medium reflectivity sediments as ‘Silty CLAY with Sand’ and high reflectivity sediments interpreted as ‘Silty SAND with coarser sediments’.

Grab sampling allowed groundtruthing of the acoustic facies identified and showed that sediments in the area interpreted as ‘Silty CLAY with Sand’ comprised fine silt, coarse silt, fine sand and very fine sand. The stations in the area interpreted as ‘Silty SAND with coarser sediments’ were shown to comprise coarse silt and very fine silt, but this overlay a consolidated clay, which appeared to have been the cause of the high acoustic reflectivity evident from the side scan sonar data.

Sand ripples dominate the south-western and south eastern part of the survey area. A few small sediment undulations, seabed depressions, scattered irregular sediment lumps and disturbed seabed (attributed to fishing activity) were observed in the surveyed corridor.

The seabed features are mapped in Figure 4.1.

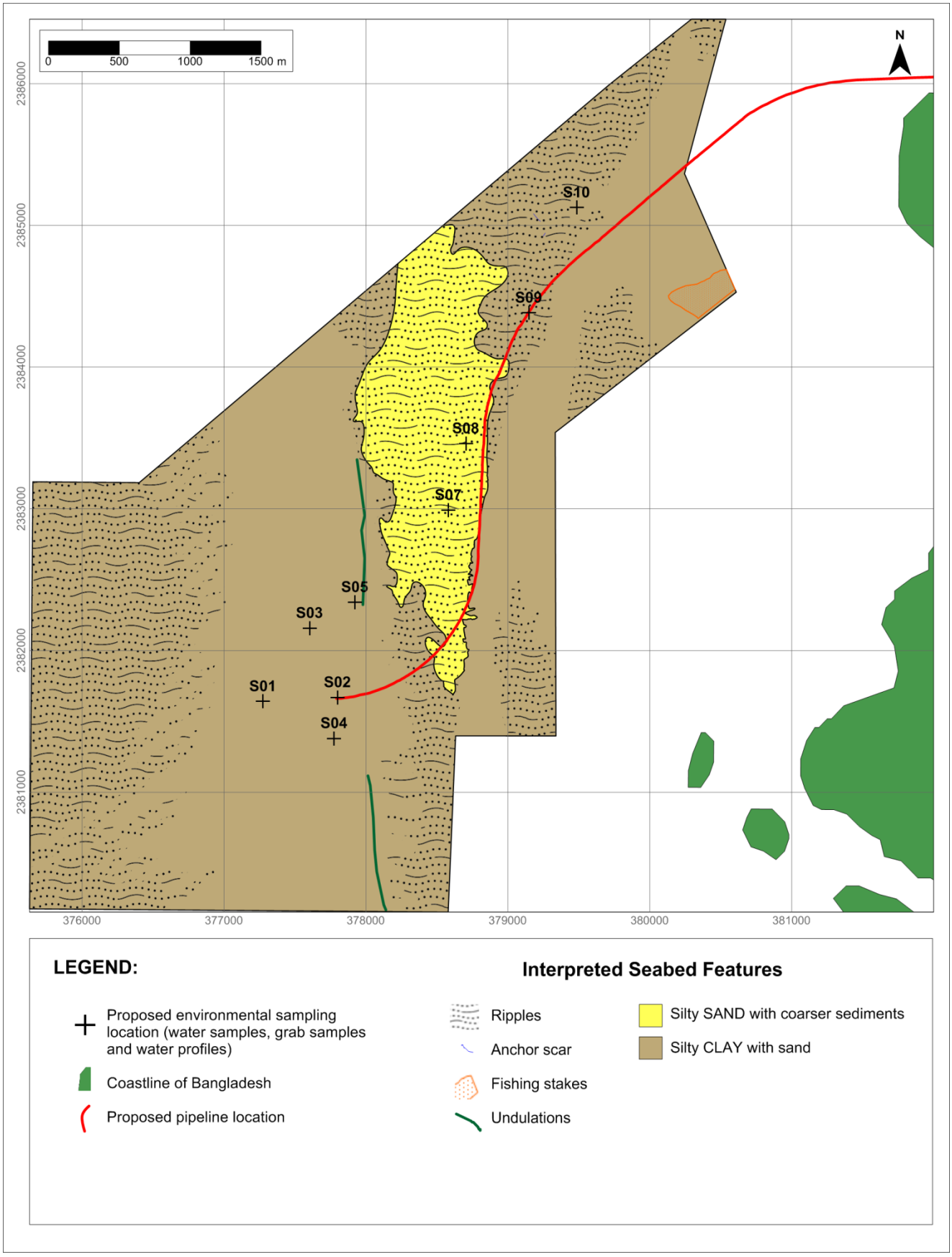


Figure 4.1: Seabed features in relation to environmental sampling locations

5. SEDIMENT CHARACTERISATION

5.1 Introduction and Methods

Sediment samples were analysed for their particle size distribution using a combination of two techniques; sieve analysis for all material retained by a 63 µm sieve followed by hydrometer analysis of the finer material. The results of the particle size analysis (PSA) were treated statistically to characterise the sediment type and particle size homogeneity.

The proportion of organic matter present in each sediment sample was determined by loss on ignition at 440 °C.

Full details of methodologies are found in Appendix B and the full particle size analysis results and size distribution graph for each station are displayed in Appendix D.

5.2 Results

Particle size statistics for the current survey area are shown in Table 5.1 and the spatial variation in sediment composition (proportions of gravel, sand, silt and clay material) is presented in Figure 2.1.

Sediments across the survey area had a mean particle size ranging from 7.7 µm (station S07) to 156.1 µm (station S03) and a mean of 64.5 µm, showing a high level of variation (relative standard deviation (RSD) of 127%). Three stations (S01, S03 and S05) had a higher proportion of sand content ranging from 72.9% to 76.9% and were described using the folk classification as slightly gravelly, muddy sand. Three stations (S02, S08 and S09) had mixed sand and mud sediment with sand content ranging from 50.7% to 53.3% and mud content from 46.9% to 49.3%. Two stations were predominantly mud with some sand content, described as sandy mud (S04) and mud (S07). All samples were described as very poorly sorted. Gravel content across the survey area was low with a range between 0.0% and 0.6%.

The current survey data have been compared to those obtained previously from the Bay of Bengal (Fugro, 2016). Higher proportions of gravels were recorded at some stations during this previous survey, with proportions reaching 50.5% at one gravel dominated station. Sand and fines proportions were similar to that seen in the current survey, but the composition of fines consisted of a reduced proportion of clay and a greater proportion of silt.

The total organic matter (TOM) content of the sediments ranged from 0.40% (station S05) to 1.43% (station S02) with a mean of 0.86%, also showing a moderate level of variation (RSD 40%). Total organic carbon (TOC) levels were below detectable limits of <0.5% at four stations and reached a maximum of 0.68% at station S08.

Table 5.1: Sediment Particle Size Distribution and Organics Data

Station	Depth [m]	Sorting	Mean Phi ø	Mean µm	Fractional Composition			Fines		Folk Description	Organics	
					Gravel [%]	Sand [%]	Fines [%]	Silt [%]	Clay [%]		TOC [%]	TOM [%]
S01	37	Very Poorly Sorted	3.75	74.2	0.4	72.9	26.7	16.0	10.7	Slightly Gravelly Muddy Sand	0.64	0.90
S02	36	Very Poorly Sorted	4.86	34.4	0.0	50.7	49.3	20.2	29.2	Muddy Sand	<0.5	1.43
S03	37	Very Poorly Sorted	2.68	156.1	0.3	76.9	22.8	5.8	17.1	Slightly Gravelly Muddy Sand	<0.5	0.46
S04	37	Very Poorly Sorted	6.35	12.2	0.0	22.4	77.6	37.6	40.0	Sandy Mud	0.89	1.17
S05	35	Very Poorly Sorted	2.76	147.5	0.1	74.4	25.4	6.9	18.5	Slightly Gravelly Muddy Sand	<0.5	0.40
S07	24	Very Poorly Sorted	7.02	7.7	0.0	6.1	93.9	26.2	67.7	Mud	<0.5	0.96
S08	21	Very Poorly Sorted	4.89	33.8	0.0	53.3	46.7	20.1	26.7	Muddy Sand	0.68	0.75
S09	15	Very Poorly Sorted	4.32	50.1	0.6	52.5	46.9	21.1	25.8	Slightly Gravelly Muddy Sand	0.61	0.84
Min	**-**	**-**	**2.68**	**7.7**	**0.0**	**6.1**	**22.8**	**10.7**	**22.8**	**-**	**<0.5**	**0.40**
Mean	**-**	**-**	**4.58**	**64.5**	**0.2**	**51.2**	**48.7**	**29.5**	**48.7**	**-**	**0.48**	**0.86**
Max	**-**	**-**	**7.02**	**156.1**	**0.6**	**76.9**	**93.9**	**67.7**	**93.9**	**-**	**0.89**	**1.43**
SD	**-**	**-**	**1.56**	**57.8**	**0.2**	**25.5**	**25.6**	**17.8**	**25.6**	**-**	**0.26**	**0.34**
%RSD	**-**	**-**	**34**	**90**	**127**	**50**	**53**	**60**	**53**	**-**	**54**	**40**
2016 Environmental Baseline Survey, Bay of Bengal (Fugro EMU, 2016)												
Min	-	-	**-0.91**	**6**	**0.0**	**2.0**	**15.3**	**10.6**	**4.7**	-	**0.485**	**2.08**
Mean	-	-	**5.67**	**204**	**5.1**	**19.1**	**75.8**	**52.1**	**23.7**	-	**0.958**	**13.3**
Max	-	-	**7.30**	**1880**	**50.5**	**72.5**	**98.0**	**68.4**	**34.7**	-	**1.50**	**27.7**
SD	-	-	**2.59**	**588**	**16.0**	**23.4**	**31.2**	**21.1**	**10.5**	-	**0.334**	**9.90**
%RSD	-	-	**46**	**288**	**316**	**122**	**41**	**40**	**44**	-	**35**	**75**

Notes:
Gravel = > 2 mm; Sand = 62.5 µm to 2 mm

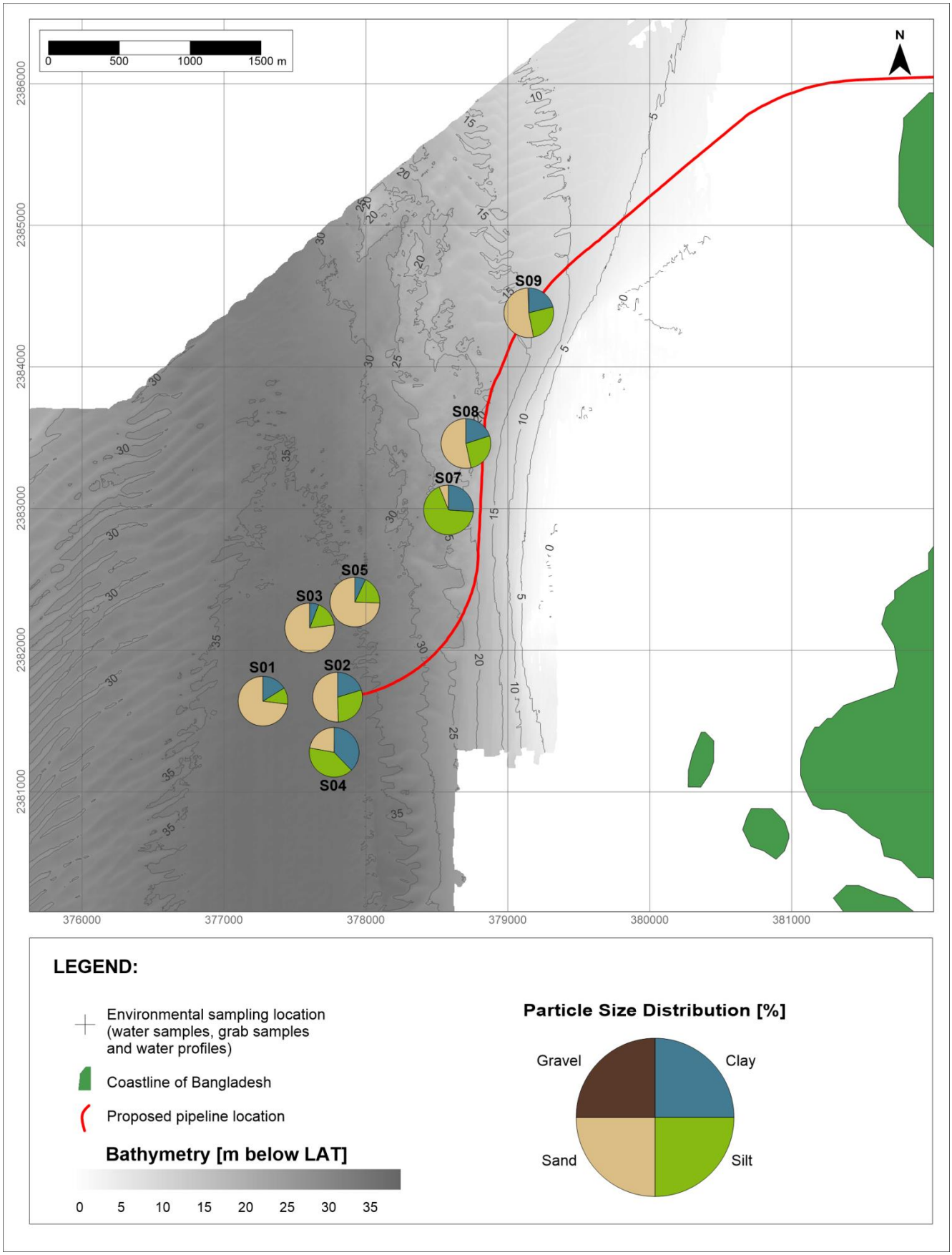


Figure 5.1: Sediment composition of samples across the survey area

5.3 Multivariate Statistical Analysis

A more detailed analysis of the fractional composition of the sediment samples acquired was undertaken by means of CLUSTER analysis using the PRIMER V6 software. This analysis was used to identify similarities between the sampling stations, based on fractional data differentiated at 1 phi intervals.

The dendrogram in Figure 5.2 identifies groupings of stations that have statistically significantly similar particle size distributions. Similarity was measured using the Euclidean distance measure and the statistical significance of differences between groupings assessed using the SIMPROF algorithm; statistically significant splits ($P<0.01$) are shown as black lines and non-significant splits are shown as red lines. Two groups were identified from this analysis with a statistical significance ($P<0.01$).

The dendrogram (Figure 5.2) shows the levels of 'similarity' within the clusters differentiated. This is perhaps, better demonstrated by the Non-metric Multidimensional Scaling (nMDS) ordination in Figure 5.3, which shows substantial multidimensional distances within cluster B, but very close association between the constituent stations of cluster A. The low stress value of the ordination (0.01) indicates an excellent two-dimensional representation of the dataset, in which multidimensional relationships have undergone minimal distortion.

Cluster A comprised three of the stations sampled (S01, S03 and S05) all of which were shown to have predominantly sand sediments from the previous interpretation. The more mixed sediment stations (S02, S08 and S09).and mud dominated stations were differentiated into cluster B

The mean fractional composition of the three clusters is tabulated in Table 5.2and presented graphically in Figure 5.4, alongside example sample photographs. The sediments of the cluster A stations were shown to have a unimodal particle size distribution, peaking around 2 phi (medium sand). Cluster B had a trimodal particle distribution with three weak peaks around 2 phi, (medium sand) 6 phi (medium silt) and >10 phi (clay).

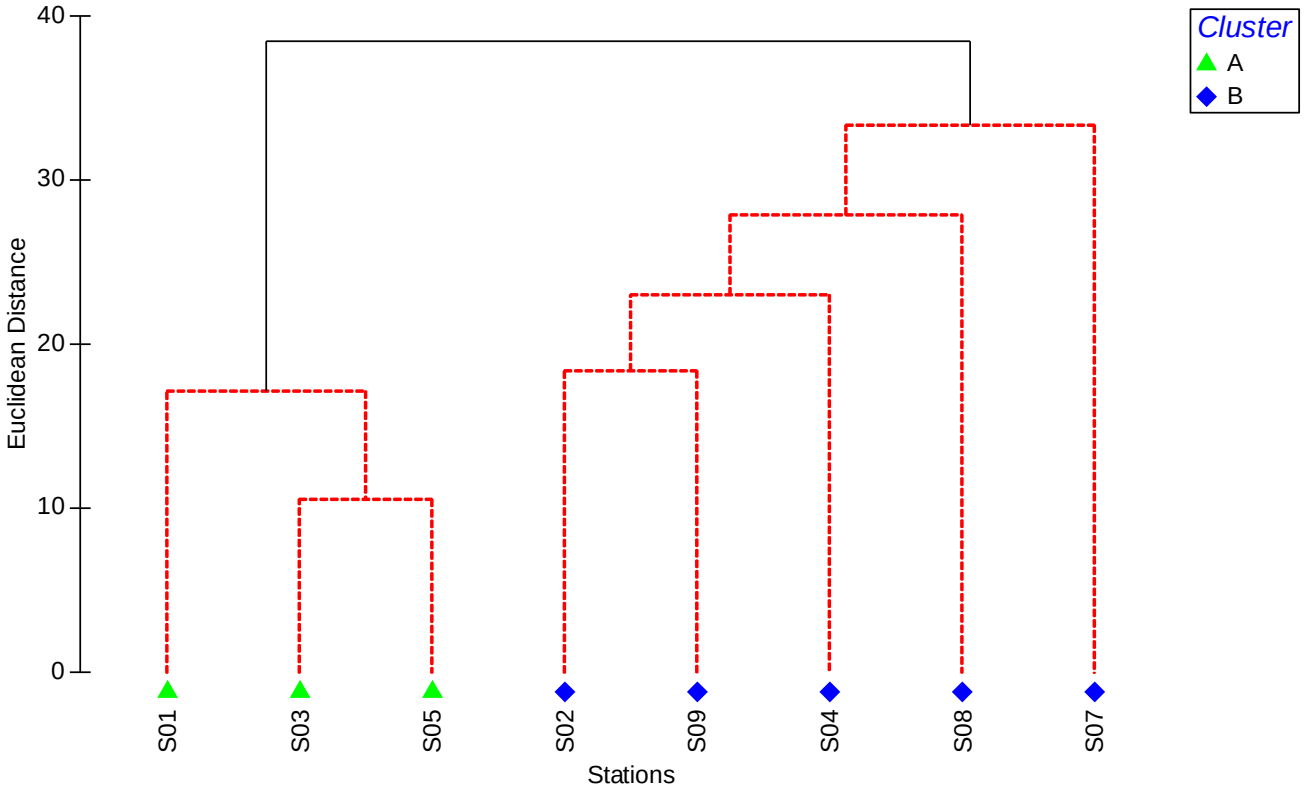


Figure 5.2: Dendrogram of particle size data using the Euclidean distance measure

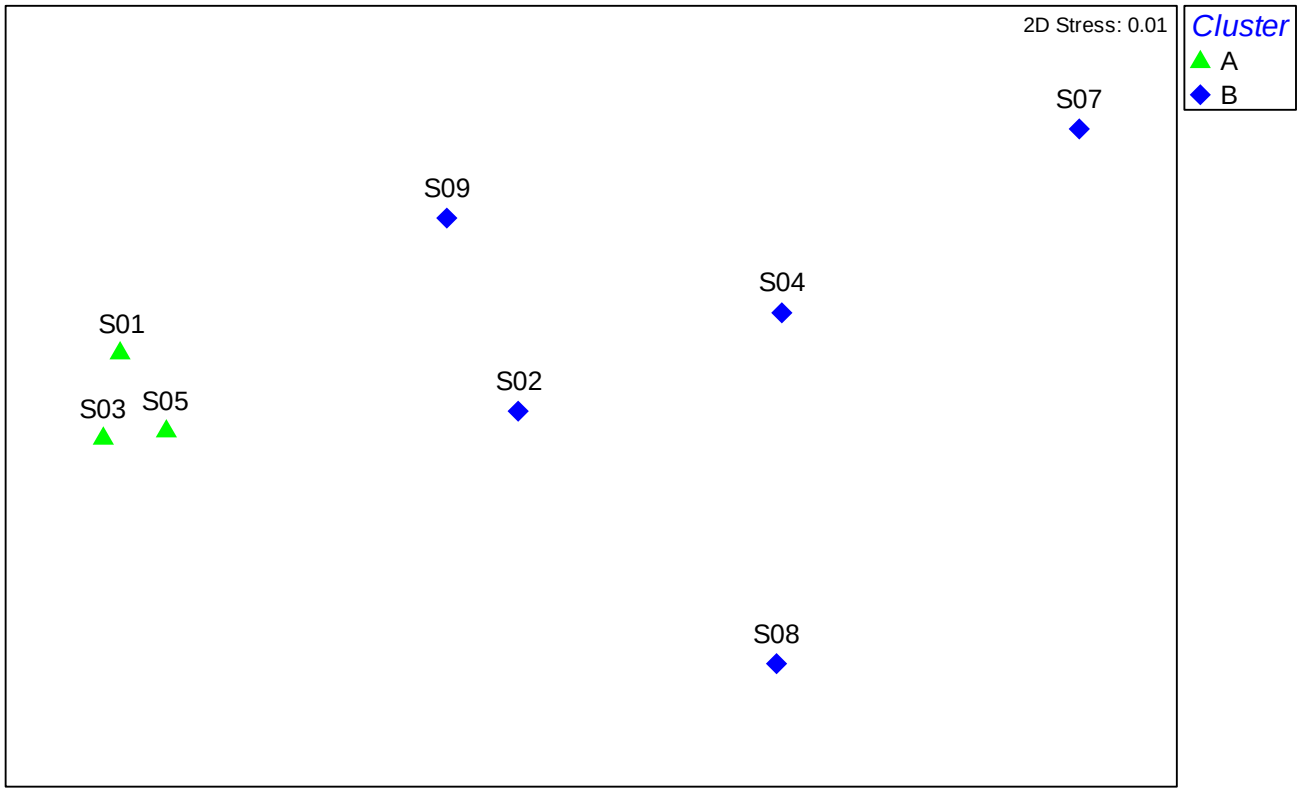
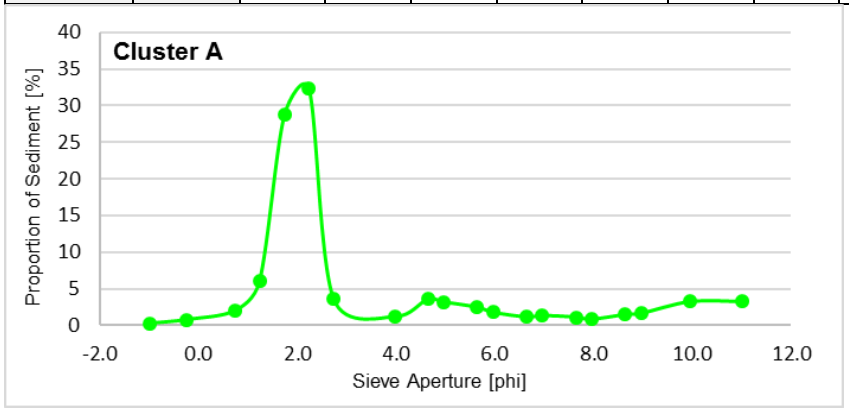


Figure 5.3: nMDS ordination of particle size data using the Euclidean distance measure

Table 5.2: Mean Fractional Composition for Particle Size Multivariate Clusters

Clusters		Sieve Aperture [phi]																			
		-1	-0.2	0.7	1.2	1.7	2.2	2.7	4.0	4.6	5.0	5.6	6.0	6.6	7.0	7.6	8.0	8.6	9.0	10.0	>10.0
Cluster A	Mean	0.27	0.79	2.02	6.04	28.74	32.33	3.57	1.19	3.57	3.19	2.48	1.78	1.15	1.34	1.11	0.83	1.48	1.63	3.25	3.25
	SD	0.12	0.15	0.73	3.13	6.45	5.51	1.00	0.38	2.33	3.35	2.03	1.22	0.88	0.78	0.72	0.67	1.04	0.94	1.82	1.82
Cluster B	Mean	0.11	1.01	1.39	2.25	7.57	10.61	6.70	7.43	2.53	2.23	2.81	10.26	6.04	5.42	5.42	3.18	4.48	4.68	6.03	9.86
	SD	0.26	1.27	1.28	3.22	8.09	7.83	5.72	7.99	0.84	1.46	1.03	10.18	3.79	2.45	2.45	1.25	2.92	2.84	2.97	3.80



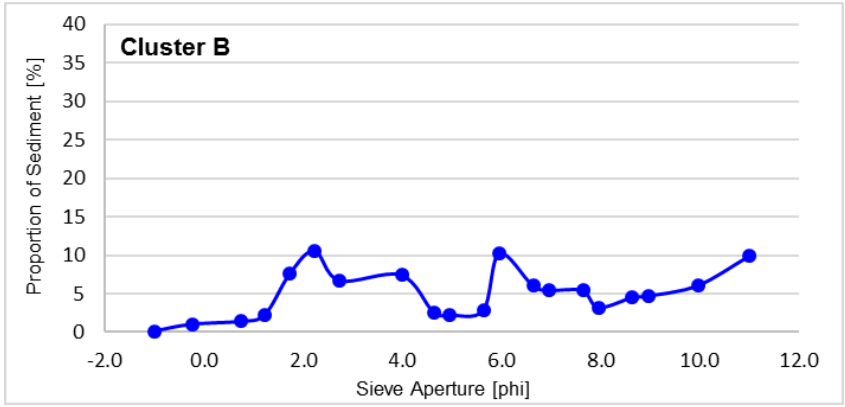


Figure 5.4: Mean particle size distributions for multivariate clusters with example sample photographs

6. SEDIMENT HYDROCARBONS

6.1 Introduction and Methods

The seabed sediments collected from eight sampling stations in water depths ranging from approximately 15 m to 39 m were analysed for hydrocarbon content, including polycyclic aromatic hydrocarbons.

Total Petroleum Hydrocarbons (TPH) were analysed using gas chromatography and flame ionisation detection (GC-FID); full details of all the analytical techniques employed are included in Appendix B.

6.2 Results

6.2.1 Total Petroleum Hydrocarbons

A summary of total petroleum hydrocarbon (TPH) analysis is provided in Table 6.1. TPH ranged from below detectable limits (of <0.2 μgg^{-1}) at station S03 to 37.4 μgg^{-1} at station S07.

6.2.2 Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbon (PAH) content was quantified using gas chromatography with mass spectrometry (GC-MS).

The United States Environmental Protection Agency (EPA) has identified a list of 16 priority PAH congeners (known as the EPA 16). These 16 compounds are routinely tested for by environmental studies and internationally recognised standards have been set to allow assessment of whether levels of the compounds may have adverse effects on the environment, or on human health. Concentrations of EPA 16 PAH are provided in Table 6.1, where they are contrasted with effects range low (ERL) criteria, as originally defined by the US National Oceanographic and Atmospheric Administration (NOAA) and later adopted in Europe as part of the Oslo-Paris Commission (OSPAR) Coordinated Environmental Monitoring Programme (CEMP).

With the exception of Benzo(a)pyrene, which was recorded at detectable concentrations from 5 of the 8 samples obtained, levels of EPA 16 pollutants were present at levels below the limit of detection from all samples. Where Benzo(a)pyrene was detected, it ranged in concentration from 0.012 μgg^{-1} to 0.049 μgg^{-1}, well below ERL criterion of 0.430 μgg^{-1} (Table 6.1).

Table 6.1: Sediment Sample Total Petroleum Hydrocarbons and EPA 16 Polycyclic Aromatic Hydrocarbon Concentrations [µgg^{-1}]

Stations	Depth [m MSL]	Total Petroleum Hydrocarbons	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(123cd)pyrene	Benzo(ghi)perylene	Dibenzo(ah)anthracene
S01	37	9.94	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
S02	36	34.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.049	<0.01	<0.01	<0.01
S03	37	<2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
S04	37	8.35	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.027	<0.01	<0.01	<0.01
S05	35	5.63	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
S07	24	37.4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.048	<0.01	<0.01	<0.01
S08	21	31.6	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.017	<0.01	<0.01	<0.01
S09	15	17.6	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.012	<0.01	<0.01	<0.01
Min	**15**	**<2**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
Mean	**30**	**18.2**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.021**	**<0.01**	**<0.01**	**<0.01**
Max	**37**	**37.4**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.049**	**<0.01**	**<0.01**	**<0.01**
SD	**9**	**14.2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.019**	**-**	**-**	**-**
%RSD	**29**	**78**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**90**	**-**	**-**	**-**
International Standards*																		
ERL	-		0.160	0.044	0.016	0.019	0.240	0.085	0.600	0.665	0.261	0.384	-	-	0.430	0.240	0.085	0.063

Notes:
ERL= Effects Range Low. *Standards from Buchman (2008) and BODC (2015).

7. SEDIMENT METALS

7.1 Introduction and Methods

Seabed sediments collected from the eight of the nine proposed locations. Samples were homogenised and subjected to microwave digestion with a mixture of nitric and hydrochloric acids. The resulting digests were then analysed by inductively coupled plasma - optical emission spectroscopy (ICP-OES), with levels of target analytes quantified by reference to standards of known metal concentrations. Further details on these methodologies are listed in Appendix B.

All metals occur naturally in the marine environment. Mercury, cadmium and lead are generally considered to be toxic without having any biological function and are therefore often the focus of environmental studies (e.g. OSPAR, 2014). Cadmium and lead are liable to bio-accumulate so there is a concern for both the overall health of the environment and for human consumption of seafood. Mercury is an extremely rare element in the earth's crust but does occur naturally in young geologically active areas (volcanic regions). It is extremely toxic to humans and biota and can be transformed once in the environment into more toxic organometallic compounds (OSPAR, 2009). Results have been compared with NOAA ERL and ERM values (Buchman, 2008).

7.2 Results

The concentrations of metals measured in the seabed sediments are listed in Table 7.1. The relationship between the sediment metals and the other environmental variables and how the concentrations recorded compare with other marine datasets will be discussed in Section 12.4.

Heavy metal concentrations were variable across the site with RSD values for metals ranging from 21% to 60%. Stations S03 and S05 showed lower concentrations than other stations for most metals (barium, cadmium, chromium, copper, iron, nickel, lead, vanadium and zinc). The highest concentrations for most metals were observed at station S02, although levels were often high at station S07 as well. The exception was Manganese where the highest concentrations were seen at stations S03 and S05 and ranged from 288 μgg^{-1} at station S08 and 975 μgg^{-1} at station S05.

Nickle exceeded the NOAA ERL (21 μgg^{-1}) at five of the eight stations and ranged from 6.5 μgg^{-1} to 30.7 μgg^{-1}. High levels of nickel had been recorded within the Bay of Bengal in a previous study (Fugro, 2016). All other metals concentrations were below the NOAA ERL values.

Example spatial distributions of metal concentrations are shown for iron, nickel and zinc in Figure 7.1 to Figure 7.3.

Table 7.1: Sediment Sample Heavy and Trace Metals Analysis (concentrations expressed as µgg^{-1} Dry Sediment)

Station	As	Ba	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sr	V	Zn
S01	4.64	14.3	0.14	13.6	13.5	15133	0.13	919	17.8	9.74	19.6	16.4	27.0
S02	4.74	22.5	0.26	23.9	22.3	24218	0.072	677	30.7	11.9	19.0	24.0	46.9
S03	6.01	2.09	<0.06	3.51	4.00	7307	0.093	932	6.51	6.72	16.5	8.19	7.85
S04	5.19	16.4	0.17	17.0	15.7	18216	0.053	723	21.8	9.76	16.1	18.2	33.2
S05	5.86	2.92	<0.06	4.94	4.87	7913	0.045	975	7.94	6.84	17.3	8.68	9.28
S07	4.71	12.3	0.2	23.6	12.1	22932	0.062	530	30.6	9.46	33.0	19.4	47.2
S08	2.83	8.2	0.15	15.9	8.12	17353	0.039	288	21.0	6.34	17.6	13.1	29.4
S09	4.39	11.8	0.14	16.3	12.7	16853	<0.03	530	22.1	8.52	19.2	15.8	30.6
Min	**2.83**	**2.1**	**0.0**	**3.5**	**4.0**	**7307**	**<0.03**	**288**	**6.5**	**6.3**	**16.1**	**8.19**	**7.85**
Mean	**4.80**	**11.3**	**0.1**	**14.8**	**11.7**	**16241**	**0.064**	**697**	**19.8**	**8.7**	**19.8**	**15.5**	**28.9**
Max	**6.01**	**22.5**	**0.3**	**23.9**	**22.3**	**24218**	**0.130**	**975**	**30.7**	**11.9**	**33.0**	**24.0**	**47.2**
SD	**0.99**	**6.8**	**0.1**	**7.5**	**6.0**	**6145**	**0.035**	**241**	**9.0**	**1.9**	**5.5**	**5.4**	**14.7**
%RSD	**21**	**60**	**56**	**51**	**51**	**38**	**56**	**35**	**45**	**22**	**28**	**35**	**51**
2016 Environmental Baseline Survey, Bay of Bengal (Fugro EMU, 2016)													
Min	**3.52**	**20.7**	**0.033**	**51.2**	**11.4**	**-**	**0.017**	**-**	**23.1**	**12.6**	**-**	**51.2**	**24.0**
Mean	**5.91**	**30.0**	**0.090**	**100**	**22.8**	**-**	**0.036**	**-**	**88.0**	**16.6**	**-**	**88.1**	**81.4**
Max	**8.77**	**57.3**	**0.216**	**121**	**29.6**	**-**	**0.047**	**-**	**107.0**	**18.4**	**-**	**113**	**97.4**
SD	**1.69**	**10.9**	**0.071**	**23.0**	**6.8**	**-**	**0.010**	**-**	**27.6**	**2.1**	**-**	**19.8**	**23.0**
%RSD	**29**	**36**	**79**	**23**	**30**	**-**	**29**	**-**	**31**	**13**	**-**	**23**	**28**
CEMP (OSPAR, 2014)													
ERL	**-**	**-**	**1.2**	**81**	**34**	**-**	**0.15**		**-**	**47**	**-**	**-**	**150**
NOAA Effects Range (Buchman, 2008)													
ERL	**8.2**	**-**	**1.2**	**81**	**34**	**-**	**0.15**		**21**	**47**	**-**	**-**	**150**
ERM	**70.0**	**-**	**9.6**	**370**	**270**	**-**	**0.71**		**52**	**218**	**-**	**-**	**410**

Notes:

As – Arsenic , Ba – Barium , Cd – Cadmium, Cr – Chromium , Cu – Copper, Fe – Iron , Hg – Mercury, Mn – Manganese , Ni – Nickel, Pb – Lead
Sr – Strontium, V – Vanadium , Zn – Zinc
ERL – Effects Range Low ERM – Effects Range Medium

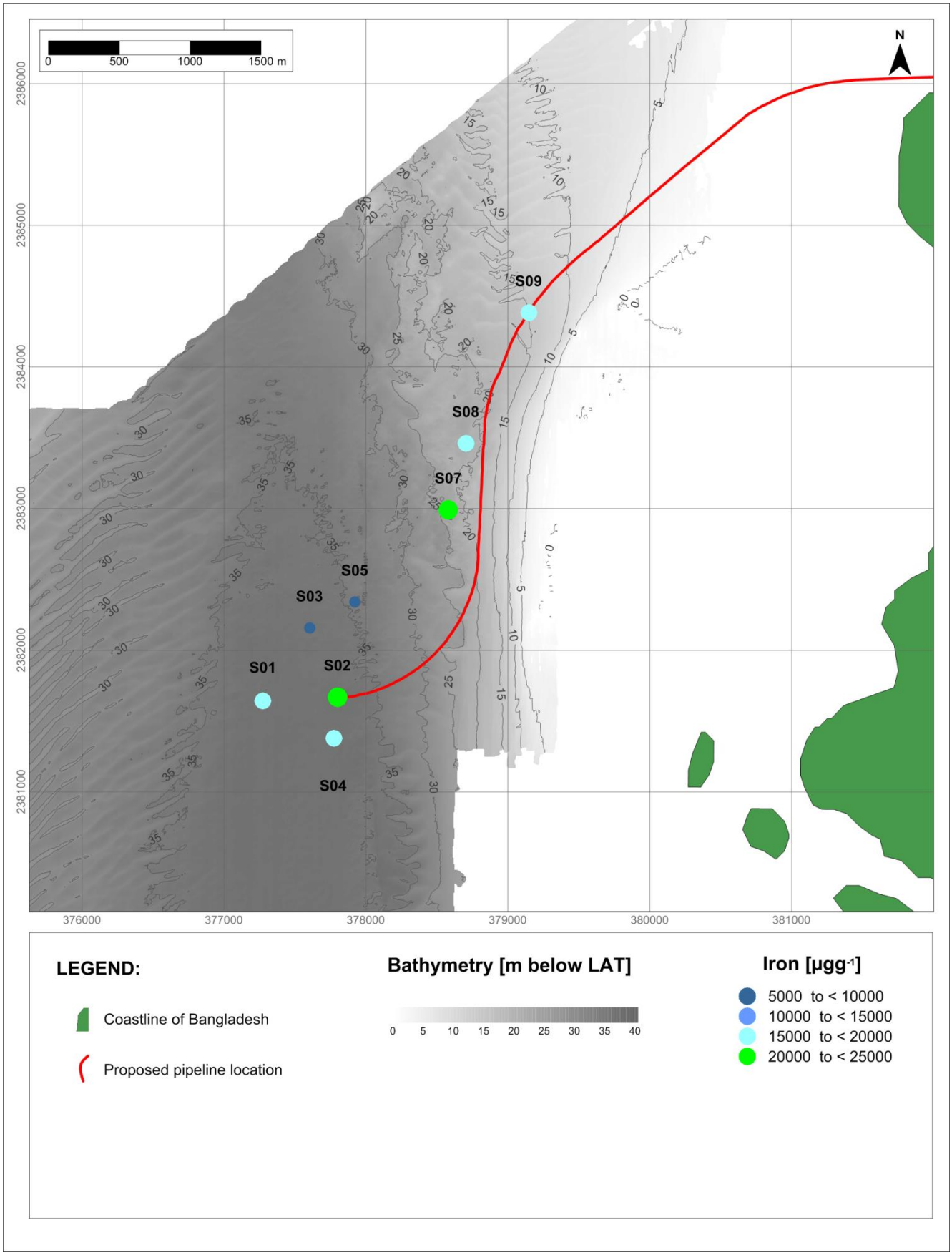


Figure 7.1: Spatial distribution of iron concentrations in sediment [µgg^{-1}]

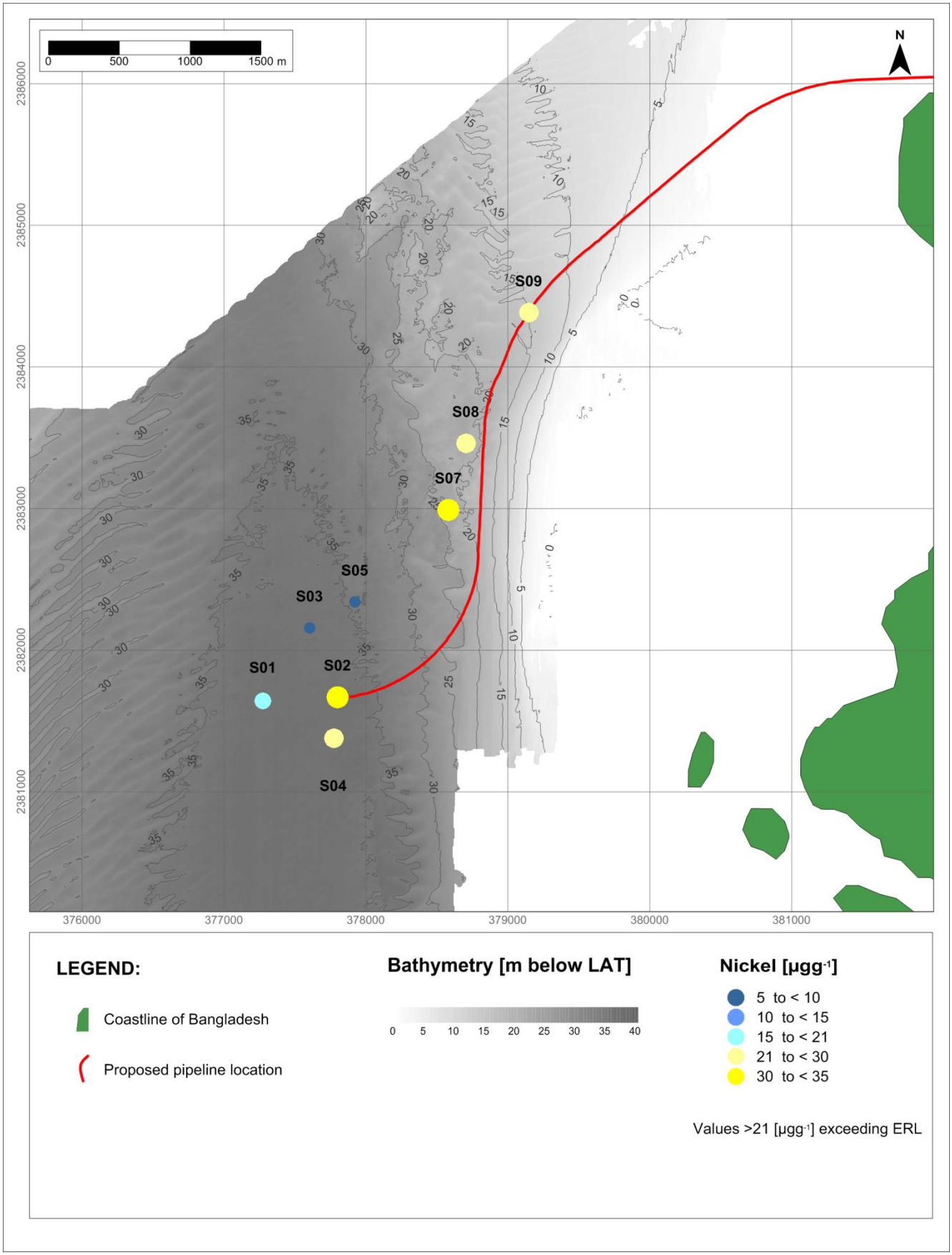


Figure 7.2: Spatial distribution of nickel concentrations in sediment [µgg^{-1}]

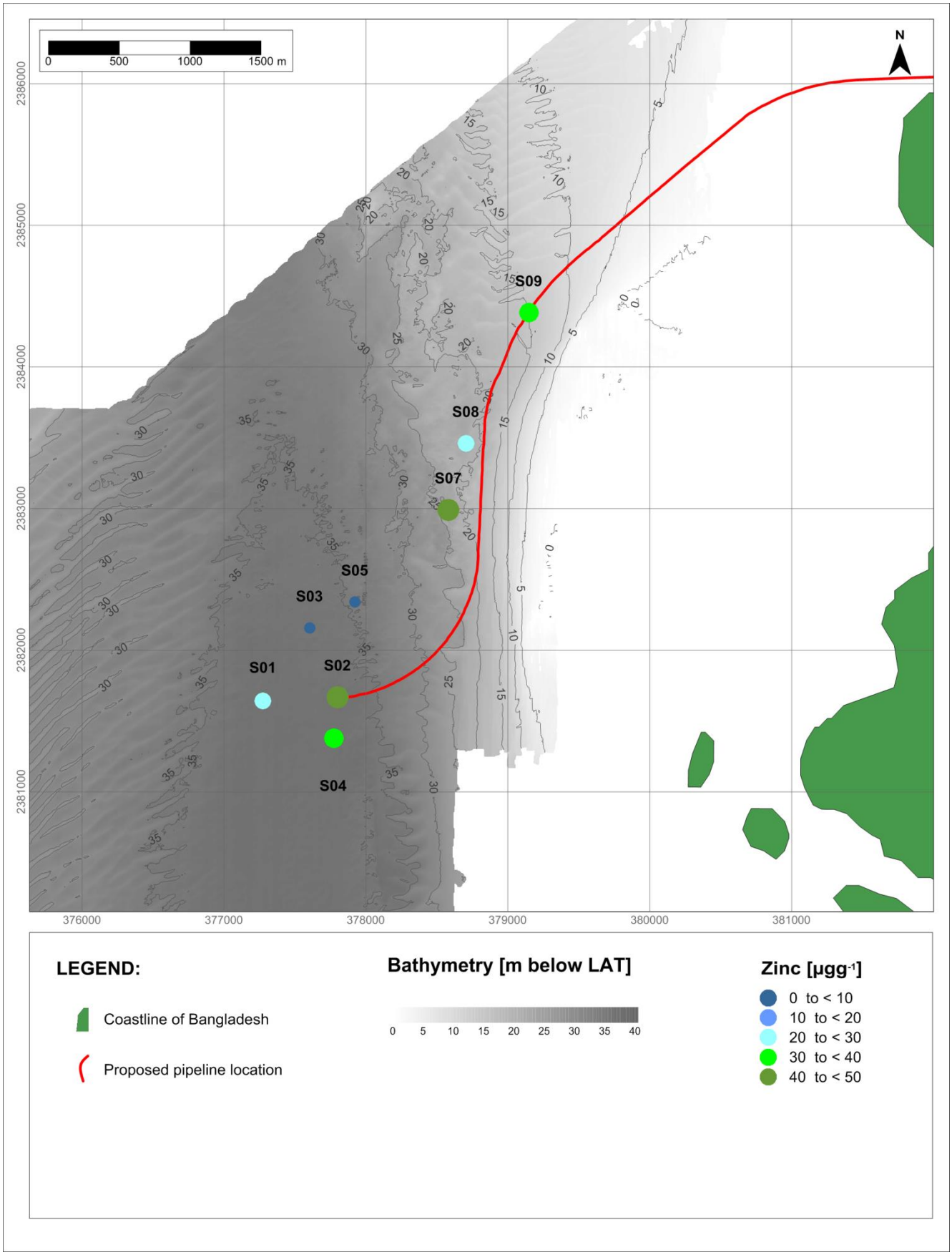


Figure 7.3: Spatial distribution of zinc concentrations in sediment [µgg^{-1}]

8. SEDIMENT MACROFAUNA

8.1 Introduction and Methods

Six of the eight proposed stations were sampled successfully using a dual 0.1 m^2 van Veen grab with two samples (FA and FB) from each station analysed to determine macrofaunal community structure. Sampling was unsuccessful at stations S07 and S08. A third sample (FC) was acquired at five of the six stations where sampling was successful, but analysis of these samples was not required.

The sediment macrofauna is defined here as those animals living in or on the seabed and which are retained on a sieve mesh of greater than 0.5 mm. Intrastation variability for the survey area ranged from high to low with the maximum similarity between each of the two replicates ranging from 0% (stations S01, S03 and S04) to 42 % (station S09).

The data from replicate samples for each station were combined to obtain numbers of taxa and individuals per 0.2 m^2 for each station, as well as diversity indices. The purpose of combining individual replicate data is to achieve a more accurate representation of the mean numbers of taxa and individuals present in a given area of the seabed. This is accepted practice within marine benthic monitoring.

The results of the macrofaunal analysis are presented in the form of figures and tables; the main features of the communities identified are highlighted in the text. A full list of taxa and the number enumerated (numbers per 0.1 m^2) from the survey area are presented in Appendix E.

8.2 Results

The results of the statistical analyses of the dataset are presented in Sections 8.2.1 to 8.2.5. Figure 8.1 and Figure 8.2 show phyletic composition of taxa and individuals, respectively, the top ten taxa identified from each station are shown in Table 8.1, dominant taxa in Table 8.2, community statistics in Table 8.3 and species accumulation in Figure 8.5. Multivariate analyses of community structure are provided in Section 8.2.5, with a cluster plot and nMDS shown in Figure 8.6 and Figure 8.7**Error! Reference source not found.**, respectively. An interpretation of the results in the context of the physico-chemical environment and other survey data is given in Section 12.5.

8.2.1 Phyletic Composition

A total of 32 taxa were identified from the samples. Of these taxa, 4 were used to record juveniles, and ciliates (protozoans). To avoid spurious enhancement of diversity indices, the dataset was rationalised and these 4 taxa removed prior to statistical analysis (see Appendix B.3).

Results show that of the 28 taxa included in the analysis, 16 (57 %) were annelids, 9 (32 %) were arthropods, 1 (4 %) were molluscs and 2 (7 %) were of other phyla, including nemerteans (ribbon worms) and sipunculids (peanut worms); no echinoderm taxa were recorded. A total of 104 individual animals were identified in the data, of which 60 (58 %) were annelids, 32 (31 %) were arthropods, 10 (10 %) were molluscs and 2 (2 %) were other phyla.

Figure 8.1 and Figure 8.2 illustrate the phyletic composition of taxa and individuals, respectively; these have been calculated for each station for ease of comparison, and show the variation between

stations across the survey area. The composition of taxa and individuals was varied across the site. Polychaetes were the dominant phylum overall, however arthropods were dominant at station S04. molluscs were not present at S09 and arthropods were not present at station S03.

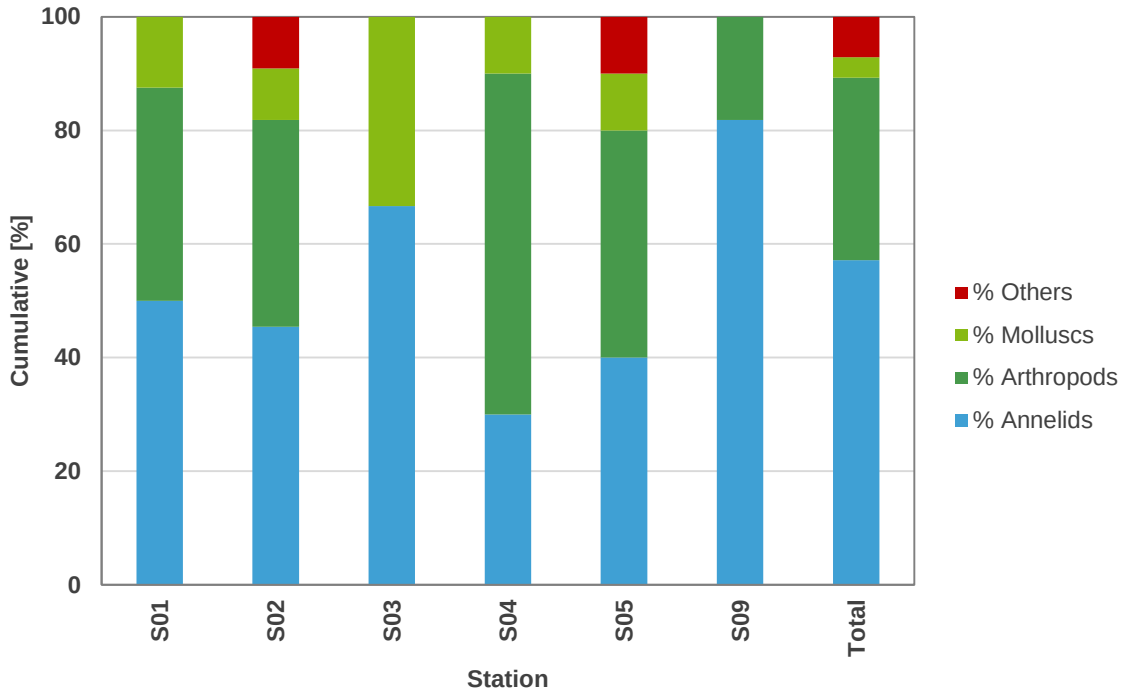


Figure 8.1: Phyletic composition of taxa

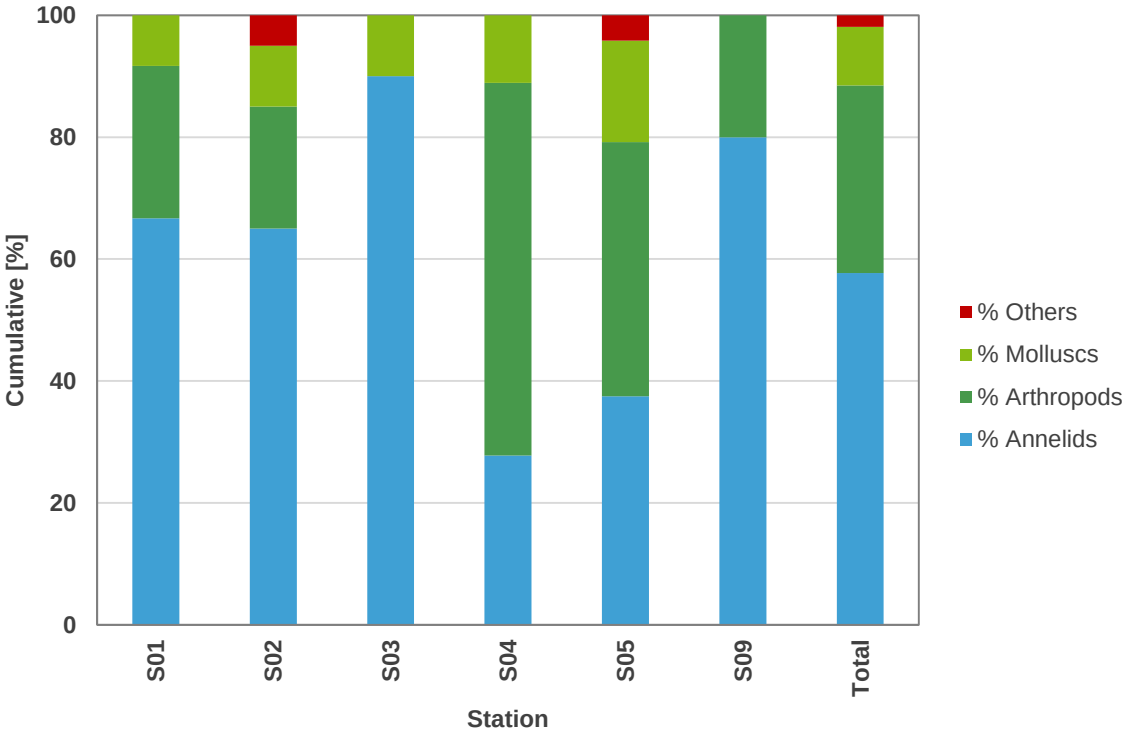


Figure 8.2: Phyletic composition of individuals

8.2.2 Faunal Composition

The ten most abundant taxa of the rationalised dataset at each station are listed in Table 8.1 along with their cumulative percentage abundances.

Table 8.1 shows that the top ten abundant taxa varied between each station, with the most abundant taxon different at each station. It also shows that there were only eight taxa present at station S01 and only three taxa at station S03.

By ranking the taxa recorded at each station in terms of density and summing the rank scores for all samples to give the overall rank dominance for each taxon, it is possible to examine which species were consistently dominant throughout the survey area. This method is less susceptible to bias caused by the species that occur in high densities, in only a few of the samples analysed. The ten most dominant taxa of the rationalised dataset are listed in Table 8.2 with their rank abundance, mean abundance and frequency of occurrence. It demonstrates that the most dominant taxa were usually the most abundant taxa. The most dominant taxa, *Amandia* (Type A) was also the most abundant species and it was present at five of the six stations (83% frequency of occurrence). Aside from the top three dominant species (*Armandia* (Type A), Tellinidae (Type A) and Copepoda) all other species were present in 50% or less of the samples.

Table 8.1: Most Abundant Taxa at Each Station

S01*	**No. 0.2 m²**	**Cum %**	**S02**	**No. 0.2 m²**	**Cum %**
Armandia (Type A)	4	33.3	*Armandia* (Type A)	4	20.0
Notomastus	2	50.0	*Magelona crenulifrons*	3	35.0
Aricidea (Type A)	1	58.3	*Mediomastus*	3	50.0
Cirrophorus (?)	1	66.7	*Glycera macrobranchia*	2	60.0
Perioculodes	1	75.0	Tellinidae (Type A)	2	70.0
Nematopalaemon karnafuliensis	1	83.3	SIPUNCULA (Type A)	1	75.0
Pinnotheridae (Type A)	1	91.7	*Notomastus*	1	80.0
Tellinidae (Type A)	1	100.0	COPEPODA	1	85.0
			Indischnopus herdmani	1	90.0
			Phoxocephalidae (Type A)	1	95.0
S03*	**No. 0.2 m²**	**Cum %**	**S04**	**No. 0.2 m²**	**Cum %**
Armandia (Type A)	8	80.0	Phoxocephalidae (Type A)	5	27.8
Spionidae (dam.)	1	90.0	*Armandia* (Type A)	3	44.4
Tellinidae (Type A)	1	100.0	COPEPODA	2	55.6
			Tellinidae (Type A)	2	66.7
			Magelona crenulifrons	1	72.2
			Kirkegaardia	1	77.8
			Indischnopus herdmani	1	83.3
			Perioculodes	1	88.9
			Urothoe ruber	1	94.4
			Gammaridea (Type A)	1	100.0
S05	**No. 0.2 m²**	**Cum %**	**S09**	**No. 0.2 m²**	**Cum %**
Xenanthura orientalis	5	20.8	*Scoloplos (Leodamus) gracilis*	4	20.0
Notomastus	4	37.5	*Kirkegaardia*	3	35.0
Tellinidae (Type A)	4	54.2	*Magelona crenulifrons*	2	45.0
Armandia (Type A)	3	66.7	*Capitellethus*	2	55.0
COPEPODA	3	79.2	COPEPODA	2	65.0
NEMERTEA	1	83.3	*Indischnopus herdmani*	2	75.0
Glycera macrobranchia	1	87.5	*Glycera macrobranchia*	1	80.0
Lumbrineris cf. *cingulata*	1	91.7	*Goniada japonica*	1	85.0
Perioculodes	1	95.8	*Onuphis eremita* (agg.)	1	90.0
Phoxocephalidae (Type A)	1	100.0	*Levinsenia*	1	95.0

Note:
Less than 10 taxa were recorded stations S01 and S03.

Table 8.2: Dominant Taxa by Dominance and Abundance Rank

Taxon	Rank Dominance	Frequency [%]	Rank Abundance	Mean Abundance [0.2 m^2]
Armandia (Type A)	1	83	1	3.67
Tellinidae (Type A)	2	83	2	1.67
COPEPODA	3	67	3	1.33
Magelona crenulifrons	4	50	6	1.00
Notomastus	5	50	4	1.17
Phoxocephalidae (Type A)	6	50	4	1.17
Scoloplos (Leodamus) gracilis	7	17	8	0.67
Kirkegaardia	7	33	8	0.67
Glycera macrobranchia	9	50	8	0.67
Mediomastus	9	17	12	0.50

8.2.3 Community Statistics

The numbers of taxa and individuals identified from each station, along with several commonly used diversity and evenness statistics, are listed in Table 8.3. The number of taxa and individuals recorded are displayed spatially in Figure 8.3 and Figure 8.4, respectively.

The number of taxa recorded per 0.2 m^2 ranged from 3 (station S03) to 11 (station S09), with a mean of 9 taxa. The total number of individuals ranged from 10 (station S03) to 24 (station S05), with a mean of 17 individuals. The variation across the stations was moderate for both number of taxa (RSD 35%) and number of individuals (RSD 31%). Diversity across the stations ranged from very low to moderate, with the Simpsons diversity index (D) ranging from 0.34 (station S03) to 0.89 (station S09) with a mean of 0.77 and low variation (RSD 28%). The Brillion's (Hb) index ranged from 0.45 (station S03) to 1.73 (station S09) with moderate variation (35 %) and Shannon Weiner (Hs) index ranged from 0.92 (station S03) to 3.28 (station S09) with moderate variation (RSD 33%). Pielou's evenness (J) showed lower variation (RSD 16%) across the community, ranging from 0.58 (station S03) to 0.95 (station S09).

The minima for all indices were calculated for station S03, which had the lowest number of taxa and abundance of the stations sampled. The main reason that the derived diversity indices were lower at this station was the dominance of a single species, *Armandia* (Type A), which contributed 80% of the total faunal abundance recorded and therefore supressed community equitability (evenness).

Table 8.3: Macrofaunal Community Statistics (0.2 m^2)

Station	Taxa	Individuals	Simpsons [D]	Brillion's [Hb]	Shannon-Weiner [Hs]	Pielou [J]
S01	8	12	0.82	1.34	2.75	0.92
S02	11	20	0.88	1.71	3.25	0.94
S03	3	10	0.34	0.45	0.92	0.58
S04	10	18	0.85	1.58	3.04	0.91
S05	10	24	0.86	1.67	3.04	0.91
S09	11	20	0.89	1.73	3.28	0.95
Min	**3**	**10**	**0.34**	**0.45**	**0.92**	**0.58**
Mean	**9**	**17**	**0.77**	**1.41**	**2.71**	**0.87**
Max	**11**	**24**	**0.89**	**1.73**	**3.28**	**0.95**
SD	**3**	**5**	**0.21**	**0.49**	**0.90**	**0.14**
%RSD	35	31	28	35	33	16

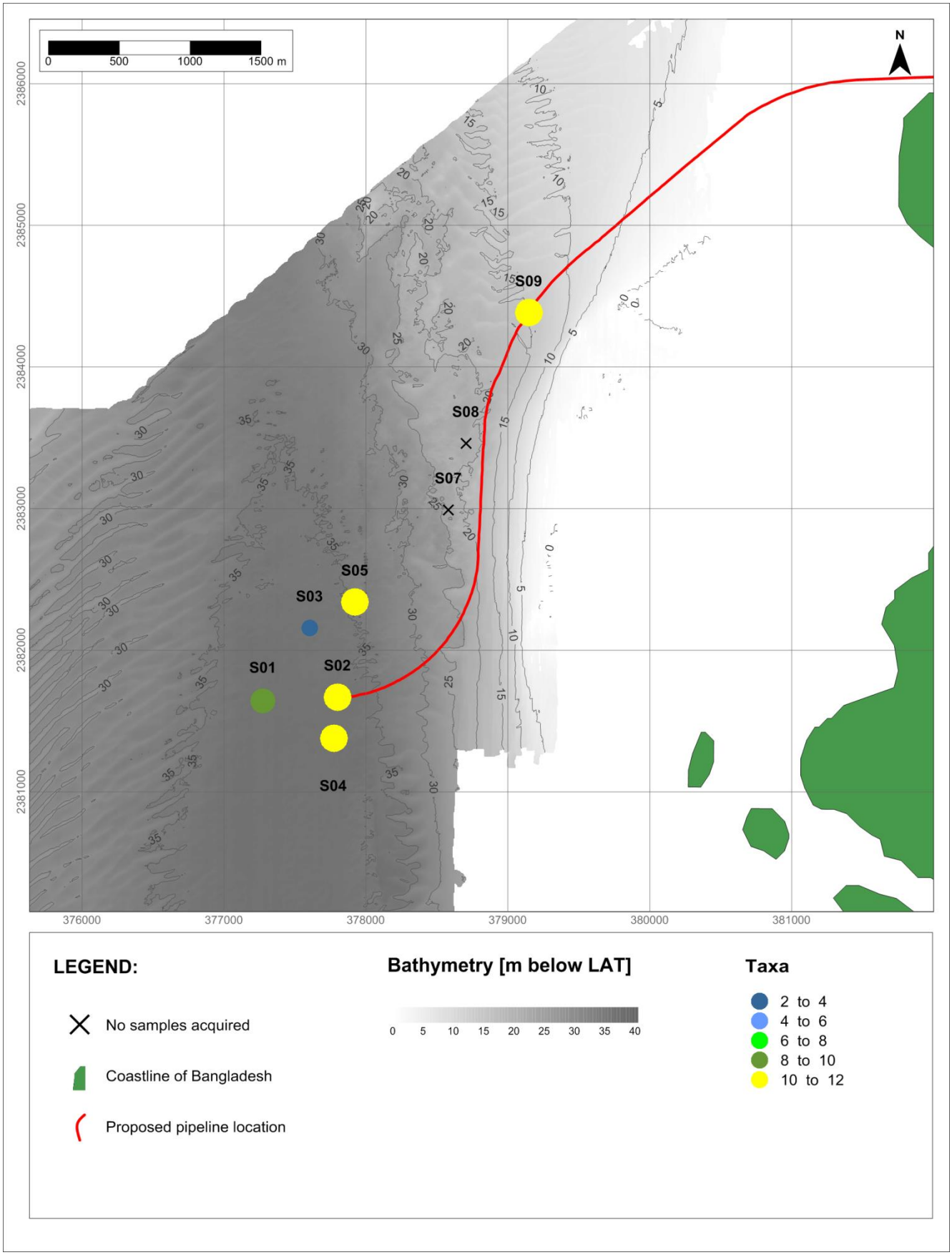


Figure 8.3: Spatial distribution of the number of taxa across the survey area

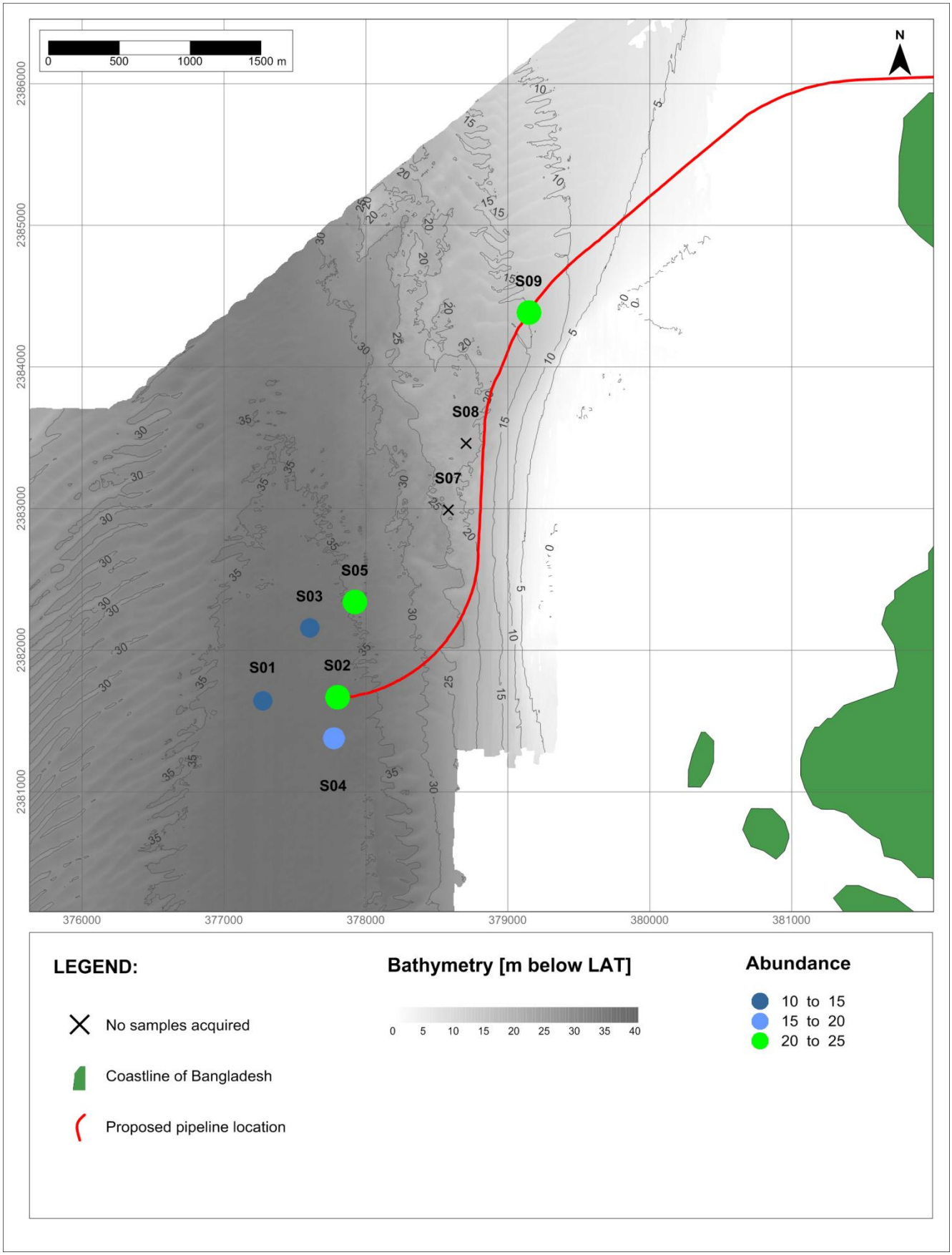


Figure 8.4: Spatial distribution of abundance across the survey area

8.2.4 Species Accumulation and Richness Estimation

The species accumulation plot is displayed in Figure 8.5 was generated using sample data (0.1 m^2) in PRIMER v6.0. The observed number of taxa obtained through repeated sampling (Sobs) were cumulatively plotted, as were richness estimates from repeated sampling as calculated by the Chao1, Chao2, Jacknife1 and Jacknife2 formulae (see Chao (2005) for further discussion of these indices). All of the displayed curves were smoothed (by random permutation of the data points) to aid interpretation

The observed species accumulation curve shows Sobs and Jacknife 1 and Jacknife 2 still rising steadily while Chao 1 rising steeply indicating that not all species/taxa have been detected during the current survey. The richness estimators suggest that the survey area had not been fully described, with estimates for the total macrofauna diversity ranging from 41 taxa (Jacknife 1) to 70 taxa (Chao 1), in comparison to the 28 taxa observed (Sobs). These estimates suggest that between 40% and 68% of the total faunal diversity had been detected by the sampling and there could be around 32% to 60% more diversity not described by the current survey. The wide range of predicted abundance is largely due to the number of 'rare' (single representatives of taxa in a sample) species present in the samples.

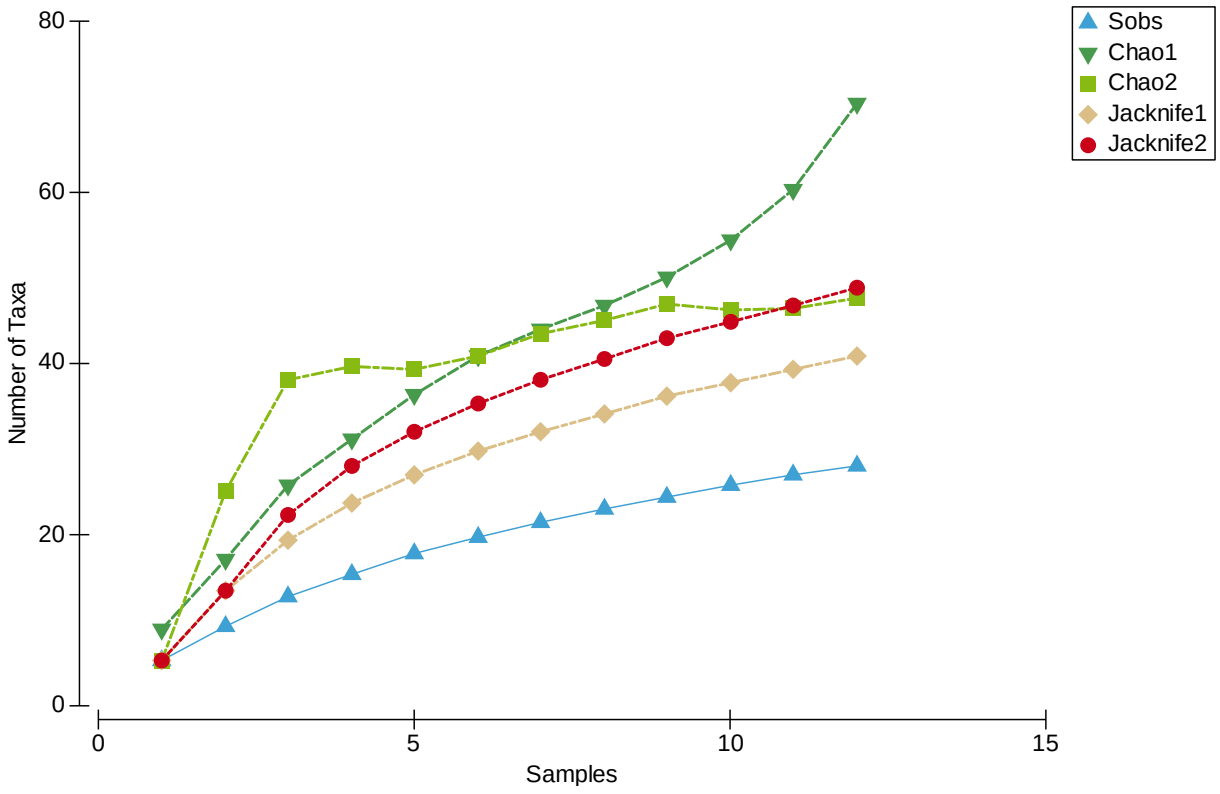


Figure 8.5: Species accumulation plot for sample data (0.1 m^2)

8.2.5 Investigation of Faunal Similarities

Univariate statistics can summarise large and complex datasets (see Appendix A) to a certain extent, however, multivariate techniques will condense a large data matrix to a much more manageable form and compare each variable with all other in the process. In doing so, subtle trends in the data may be elucidated by multivariable analyses.

Various multivariable techniques were applied to the survey area data to investigate such patterns of similarity within the macrobenthic community, which were then further considered with the results from the univariate analyses.

Cluster analysis groups replicates/samples or stations according to their faunal similarity (see Appendix A) and the results are presented in the form of a dendrogram. Due to the intrastation variability at some stations being quite high, multivariate analyses were applied to sample data (0.1 m^2). The dendrogram displayed in Figure 8.6 shows a pattern of similarity of square root transformed sample data. The SIMPROF algorithm was used to identify statistically significant (P=0.05) differences between samples, with significant splits shown as black lines and non-significant splits as red lines. The analysis shows a high level of variation between samples, including those that were acquired at the same stations. Sample S03 FB had 0 % similarity with the other samples, while the highest similarity was seen between station S02 FA and S04 FB at 68 %. A single statistically significant split was identified within the dataset, differentiating sample S03 FB from the remaining samples (grouped within cluster A).

Non-metric multi-dimensional scaling (nMDS) is an ordination technique, which arranges samples in a two-dimensional plot, which best fits the multi-dimensional distances between data points. The ordination shown has a stress value of 0.01, which indicates an excellent representation with no prospect of misinterpretation (Clarke and Warwick, 2001). The outlying sample S03 FB is clearly offset from the remaining samples (cluster A) in the ordination. An nMDS subset analysis was undertaken to investigate similarities/differences within the cluster A samples (inset on Figure 8.7). This accurate ordination of the data (stress value of 0.06) clearly shows the lack of clear spatial structure within the cluster A community, with none of the samples acquired at the same stations shown to be clearly associated with each other.

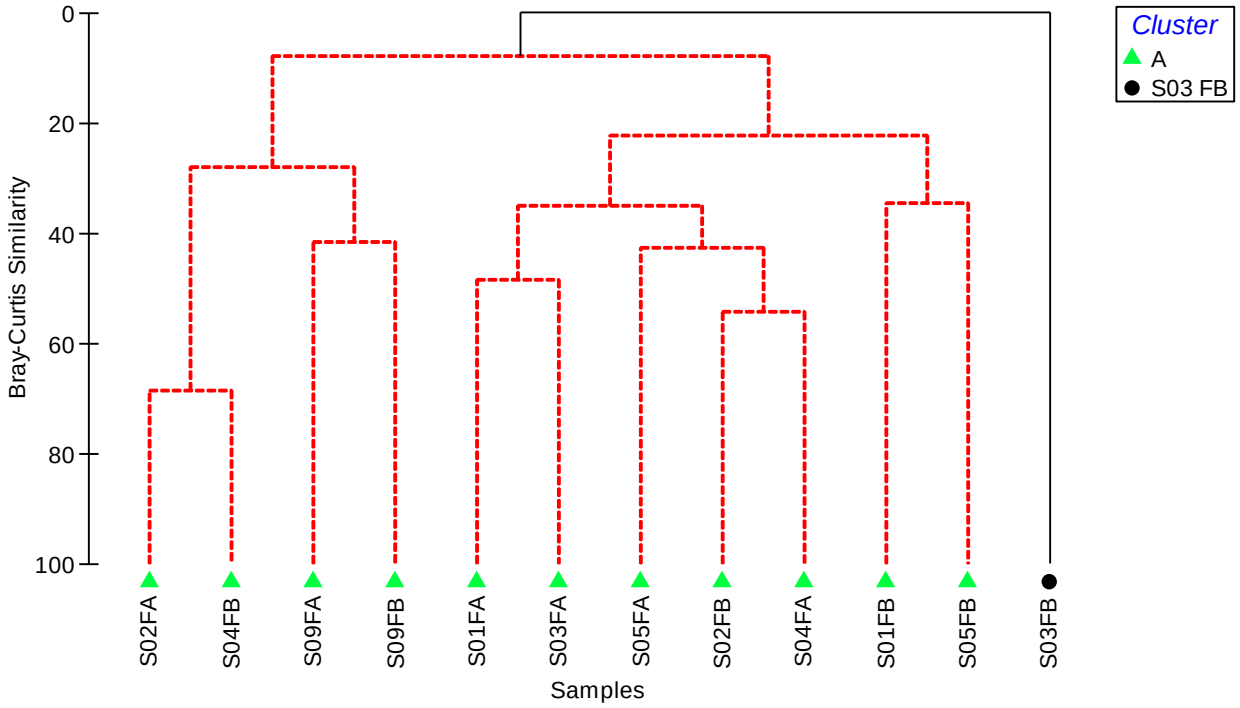


Figure 8.6: Dendrogram of sample (0.1 m^2) macrofaunal abundance data using Bray Curtis similarity

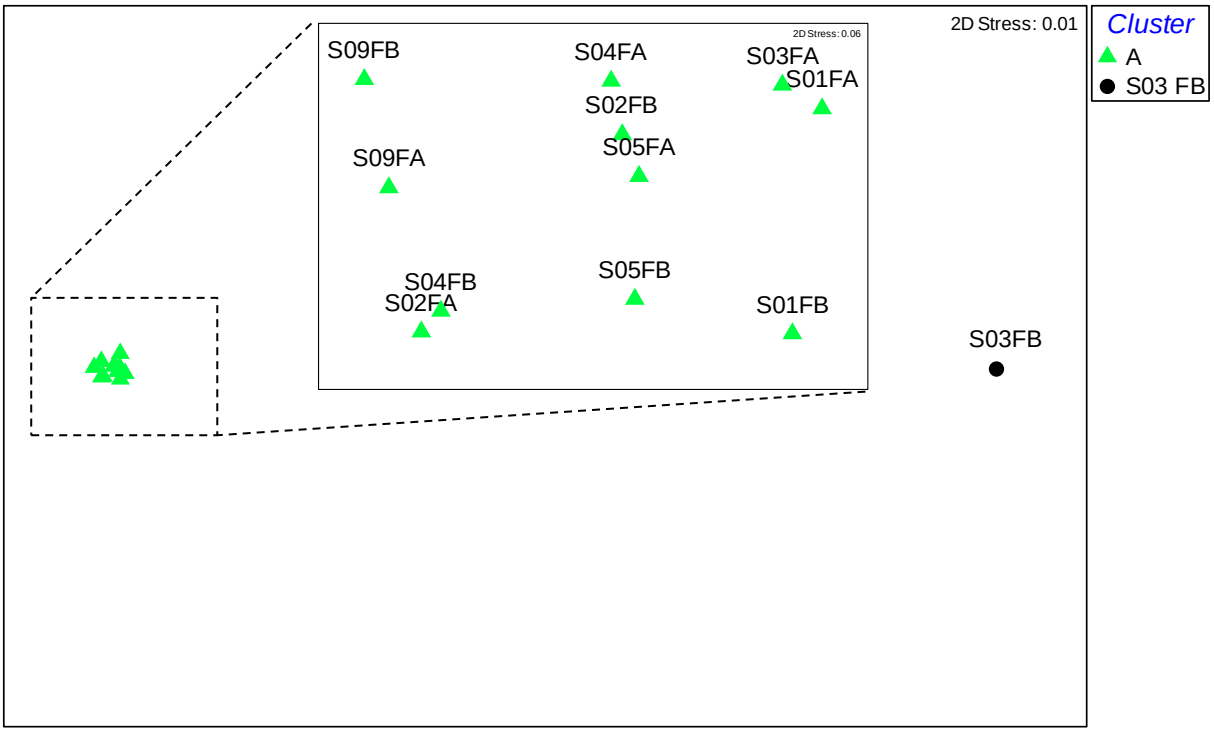


Figure 8.7: nMDS ordination of sample (0.1 m^2) macrofaunal abundance data using Bray Curtis similarity

9. WATER PROFILES

9.1 Introduction and Methods

A Hydrolab Series 5 multi-parameter probe and water samplers were deployed at eight of the nine proposed sampling locations. As the water depth was too shallow to use a USBL beacon, the plasma rope was measured out and marked to indicate water depth and used to determine when to trigger the water sampler for 'Top' and 'Middle' water column samples. A clump weight attached 2 m below the water profiler and water sampler was used to indicate when the 'bottom' sample was to be triggered from when it made contact with the seabed.

The data within some profiles were rationalised in order to remove spurious data to allow a clearer indication of the overall trends.

9.2 Results

Water profiles were successfully acquired at eight of the proposed nine sampling stations. The water profiles are shown together for comparison in Figure 9.1 with all individual profiles provided in Appendix H.

9.2.1 Temperature

The temperature profiles across the site are displayed in Figure 9.1 providing a profile of temperature ranges down to approximately 39 m. All water temperature profiles showed a well-mixed water column with very little change in temperature throughout the water column.

The surface water temperatures recorded at each station to a depth of 2 m ranged between 26.63 °C (station S09) and 27.97 °C (station S04). These temperatures remained consistent throughout the water column and no thermocline was apparent. The minimum temperature of 26.61 °C was observed at station S09 between 2.6 m and 4.4 m. The maximum temperature of 28.06 °C was observed at station S02 between 38.0 and 38.6 m which was the maximum depth to which the profiler was deployed.

Some variability in temperature was present across the survey area, which related to the order in which the profiles were taken, indicating a decrease in water temperature during the survey period. A similar trend is seen for pH and, to a lesser extent, salinity, with their values increasing during the survey period (see Section 12.6 and Figure 12.1:).

9.2.2 Salinity

Generally, salinity profiles across the site showed minimal change throughout the water column. Some variation was seen between the profiles however with station S02 and S04 having a lower salinity than the other six stations.

The sea surface salinity was between 28.80 psu (station S02) and 29.54 psu (station S09). Salinity was consistent throughout the water column with salinity near seabed ranging from 28.6 psu at 37.0 m (station S04) to 29.5 psu at 16.2 m (station S09). The salinity profiles from all stations are displayed in Figure 9.1.

9.2.3 Turbidity

Turbidity was very variable across the site and through the water column. Surface levels of turbidity ranged from 4.0 NTU to 30.3 NTU with the exception of station S03 which showed a higher turbidity level on the surface of 75.5 NTU. Levels of turbidity were shown to increase with depth in all water profiles. However only a slight increase of 3.3 NTU was observed at S02 from 19.9 NTU at surface to 23.2 NTU at seabed. Stations S01, S07, S08 showed the greatest change in turbidity throughout the water column with a maximum value of 167.9 NTU at station S01, 291.0 NTU at station S07 and 174.9 NTU for station S08. Turbidity profiles are shown in Figure 9.1.

9.2.4 pH

Generally, pH profiles showed minimal change in pH from the surface to the seabed, although some variation was observed between profiles. The variation between stations trends with time during the survey period (Figure 12.1:) indicting temporal rather than spatial variation. The inverse of this relationship is seen with temperature. The profiles for pH are displayed in Figure 9.1.

Average sea surface pH levels ranged from 8.29 (station S02) to 8.43 (station S09) with no consistent change of increase or decrease with depth observed in the profiles from each station.

9.2.5 Dissolved Oxygen

Dissolved oxygen profiles from all stations are displayed in Figure 9.1. All but one water profile showed a well-mixed water column with little variation in DO concentration. Station S09 showed some variability throughout the water profile and a subsurface increase in dissolved oxygen at approximately 10 m.

Surface water DO levels were fairly consistent across most profiles, ranging between 94.4% saturation (station S03) and 97.2% (station S07), with the exception of S09 where surface concentrations were 99.3%. As water depth increased DO levels at S09 rose to a maximum of 100.7% while all other profiles showed little variation. At a depth of 10 m DO levels at station S09 decreased until reaching a similar level to that seen in the other profiles. The range of DO recorded near seabed was between 94.5% (station S03) and 96.8% (station S09). At the maximum depth the profiler was deployed to 38.5 m at S02 the DO was 95.6%.

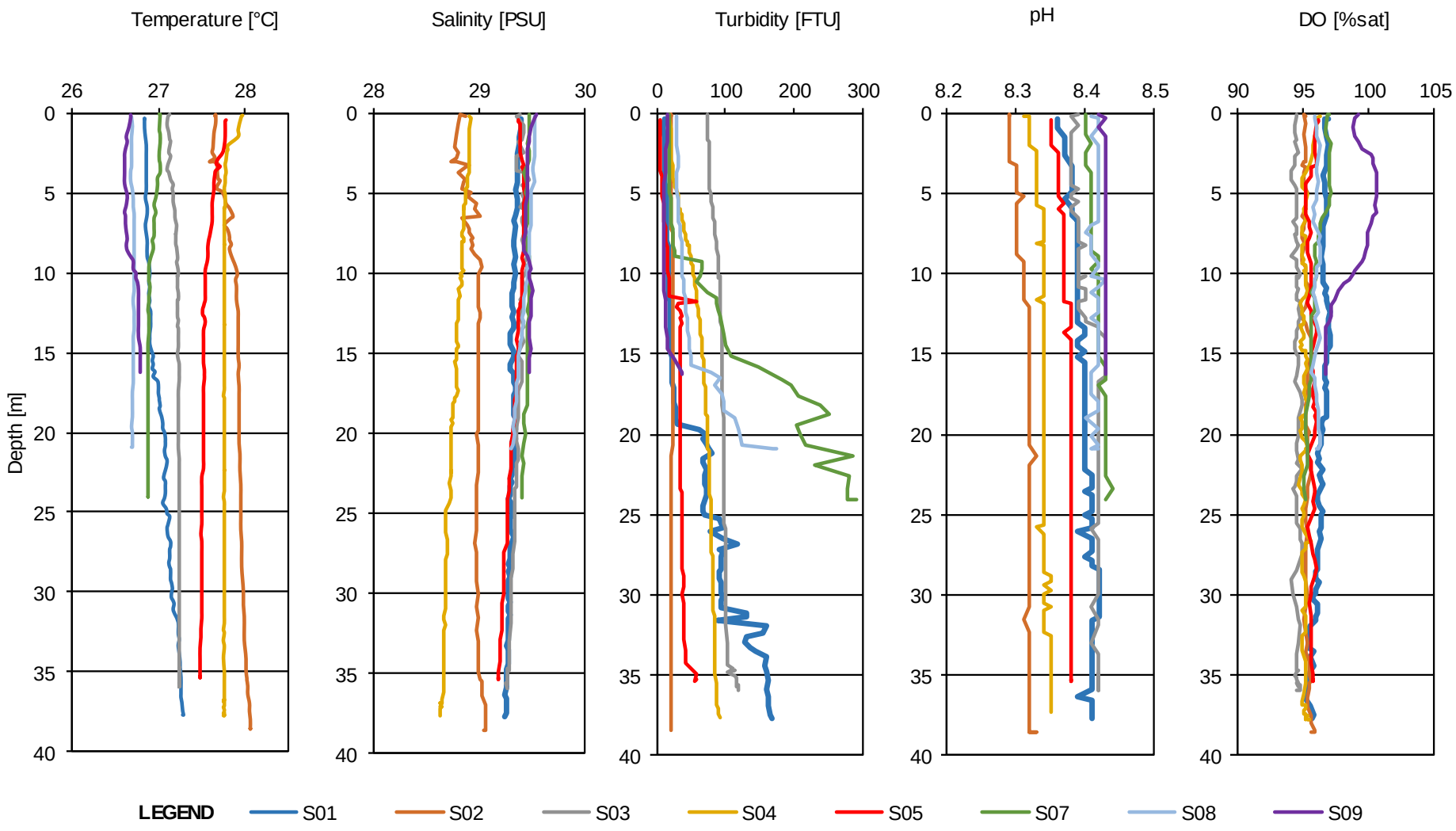


Figure 9.1: Water profiles showing temperature, salinity, turbidity, pH and dissolved oxygen

10. WATER QUALITY

10.1 Introduction and Methods

Seawater samples for the analysis of key indicators of water quality were collected at eight of the nine proposed location. A 'TOP' sample, taken 2 m below sea surface, and 'BOTTOM' sample, taken 2 m above seabed, were acquired at every sampling station. At five stations deeper than 30 m an additional 'MIDDLE' sample was taken from mid water column depth. However, as the water profiles showed a well-mixed water column only the TOP and BOTTOM samples were analysed and reported here.

Results are compared to appropriate marine water quality standards where available. The specific standards used to assess the data include criteria maximum concentration (CMC) and criterion continuous concentration (CCC) developed by the US EPA (United States Environmental Protection Agency). The CMC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The CCC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

10.2 Results

10.2.1 Hydrocarbons

Total Petroleum Hydrocarbons (TPH) concentrations were consistently low throughout the survey area (Table 10.1), with all values below detectable limits (<0.1 $\mu g l^{-1}$).

Concentrations of US Environmental Protection Agency (EPA) priority PAHs (the EPA 16) are provided in Table 10.1 where they are contrasted with internationally recognised water quality standards. All EPA 16 PAH were below the limit of detection.

Table 10.1 Water Sample Total Petroleum Hydrocarbon and EPA 16 Polycyclic Aromatic Hydrocarbons

Stations	Samples	Depth [m MSL]	Total Petroleum Hydrocarbons [mgl^{-1}]	Concentrations Expressed as µgl^{-1}															
				Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(123cd)pyrene	Benzo(ghi)perylene	Dibenzo(ah)anthracene
S01	TOP	2	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
	BOTTOM	37	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
S02	TOP	2	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
	BOTTOM	36	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
S03	TOP	2	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
	BOTTOM	37	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
S04	TOP	2	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
	BOTTOM	37	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
S05	TOP	2	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
	BOTTOM	35	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
S07	TOP	2	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
	BOTTOM	24	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
S08	TOP	2	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
	BOTTOM	21	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
S09	TOP	2	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
	BOTTOM	15	<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
Min			<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
Mean			<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
Max			<0.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<2	<2	<2	<2	<2
SD			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Standards*																			
Chronic effect				1.40*	N/A	0.04*[1]	N/A	0.0046*[2]	N/A	0.011*[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Acute effect				2.35	0.3	0.97	0.3	0.0077*[2]	0.300	0.040	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Notes: International standards from Buchman (2008). Unless stated all acute (short term effect) standards are current EPA Ambient Water Quality Criteria. Chronic (long term effect) standards from:
* Canadian Water Quality Guidleines; *[1] EPA EcoUpdate; *[2] Provisional EPA.

10.2.2 Metals

Heavy/trace metals are natural constituents of the aquatic environment and are generally found in very low concentrations. Current environmental interest in metals in seawater is mainly focussed on arsenic, cadmium, copper, mercury and zinc, with environmental quality standards derived for these parameters (EPA, 2016). The concentrations of heavy/trace metals in the seawater are presented in Table 10.2, with concentrations of copper plotted in Figure 10.1:.

Concentrations of Cadmium were below the limit of detection of 0.1 μgl^{-1} at all stations. Mercury and nickel were also below the limit of detection (0.1 μgl^{-1} and 0.6 μgl^{-1}, respectively) at several stations. All metals with the exception of copper were below the EPA saltwater quality standards (EPA,2015). Copper exceeded the CCC of 3.1 μgl^{-1} at four stations.

Concentrations of heavy and trace metal values for previous studies (Fugro EMU, 2016 and TEPSCO, 2013) compared to the current study are provided in Table 10.3. Levels of lead exceeded EPA CMC during the 2016 survey in the Bay of Bengal and the 2013 survey off the coast of Matabari Island. Levels of mercury, zinc and copper were all recorded in high concentrations off the coast of Matabari Island, exceeding the EPA CMC.

Table 10.2: Water Sample Heavy and Trace Metal Analysis

Concentrations Expressed as μgl^{-1}															
Station	**Sample**	**Depth [m]**	**As**	**Ba**	**Cd**	**Cr**	**Fe**	**Pb**	**Hg**	**Zn**	**Cu**	**Mn**	**Ni**	**Sr**	**V**
S01	TOP	2	1.74	11.3	<0.1	1.29	461	1.17	<0.1	30.3	3.07	17.4	1.08	6018	2.80
	BOTTOM	35	1.89	43.9	<0.1	2.36	1299	1.83	0.21	18.7	4.10	47.0	2.71	6120	4.14
S02	TOP	2	1.34	12.0	<0.1	1.45	446	0.48	0.20	42.6	3.03	14.9	1.35	5903	2.95
	BOTTOM	36	1.72	12.5	<0.1	2.60	1752	1.93	0.32	18.0	3.63	65.4	3.38	5914	4.87
S03	TOP	2	1.9	11.3	<0.1	1.72	415	1.04	<0.1	27.3	2.57	17.7	1.19	6051	2.92
	BOTTOM	37	1.68	11.7	<0.1	1.91	1179	1.57	0.33	13.5	2.78	47.4	2.05	5997	4.08
S04	TOP	2	1.35	10.4	<0.1	0.97	213	0.27	0.19	31.8	1.92	7.05	<0.6	6056	2.49
	BOTTOM	37	1.42	10.1	<0.1	1.05	284	0.27	0.32	13.6	0.96	9.70	<0.6	6115	2.81
S05	TOP	2	1.28	11.4	<0.1	1.35	256	0.93	<0.1	30.0	2.03	8.47	<0.6	6102	2.58
	BOTTOM	35	1.61	11.1	<0.1	2.18	1135	1.59	0.18	15.5	2.29	39.0	1.91	6093	3.81
S07	TOP	2	1.28	11.7	<0.1	1.47	276	0.29	0.12	16.1	1.73	9.95	1.06	6061	2.50
	BOTTOM	24	1.36	10.2	<0.1	1.33	643	0.73	0.16	11.8	1.65	24.8	1.36	6091	3.23
S08	TOP	2	1.31	11.1	<0.1	1.03	192	0.49	<0.1	21.2	3.58	6.60	<0.6	6092	2.39
	BOTTOM	21	1.42	10.9	<0.1	1.44	678	0.65	0.25	9.7	1.70	26.0	1.29	6145	3.22
S09	TOP	2	1.46	10.4	<0.1	1.17	214	1.20	0.13	27.5	4.26	7.70	1.04	6130	2.38
	BOTTOM	15	1.3	10.5	<0.1	1.54	392	1.55	<0.1	19.8	1.60	13.7	1.19	6183	2.93
Minimum		**-**	**1.28**	**10.1**	**<0.1**	**0.97**	**192**	**0.27**	**<0.1**	**9.7**	**0.96**	**6.6**	**<0.6**	**5903**	**2.38**
Mean		**-**	**1.50**	**13.2**	**<0.1**	**1.55**	**615**	**1.00**	**0.17**	**21.7**	**2.56**	**22.7**	**1.30**	**6067**	**3.13**
Maximum		**-**	**1.90**	**43.9**	**<0.1**	**2.60**	**1752**	**1.93**	**0.33**	**42.6**	**4.26**	**65.4**	**3.38**	**6183**	**4.87**
SD		**-**	**0.22**	**8.2**	**-**	**0.48**	**473**	**0.57**	**0.10**	**9.0**	**0.98**	**17.8**	**0.87**	**77**	**0.73**
%RSD		**-**	**15**	**63**	**-**	**31**	**77**	**57**	**61**	**41**	**38**	**79**	**67**	**1**	**23**
US EPA Saltwater Quality Standards (EPA, 2015)															
CMC			**-**	**-**	**33**	**-**	**-**	**210**	**1.8**	**90**	**4.8**	**-**	**74**	**-**	**-**
CCC			**-**	**-**	**7.9**	**-**	**-**	**8.1**	**0.94**	**81**	**3.1**	**-**	**8.2**	**-**	**-**

Table 10.3: Water Sample Heavy and Trace Metal Analyses compared to Previous Data

Concentrations Expressed as $\mu g l^{-1}$											
	As	**Ba**	**Cd**	**Cr**	**Fe**	**Pb**	**Hg**	**Zn**	**Cu**	**Ni**	**V**
2017 Environmental Baseline Survey, Coast of Moheshkhali Island											
Minimum	1.28	10.1	<0.1	0.97	192	0.27	<0.1	9.7	0.96	<0.6	2.38
Mean	1.5	13.2	<0.1	1.55	615	1	0.17	21.7	2.56	1.3	3.13
Maximum	1.9	43.9	<0.1	2.6	1752	1.93	0.33	42.6	4.26	3.38	4.87
Std Deviation	0.22	8.2	-	0.48	473	0.57	0.1	9	0.98	0.87	0.73
%RSD	15	63	-	31	77	57	61	41	38	67	23
2016 Environmental Baseline Survey, Bay of Bengal (Fugro EMU, 2016)											
Minimum	-	<100	<0.03	<0.5	-	<0.04	<0.0001	1.6	<0.2	<0.3	<20
Mean	-	<100	-	-	-	1.37	-	8.2	-	0.43	<20
Maximum	-	<100	0.097	4.01	-	25	0.0001	40.6	1.73	0.561	<20
Std Deviation	-	-	-	-	-	5.29	-	8.8	-	0.099	-
%RSD	-	-	-	-	-	387	-	107	-	23	-
2013 Environmental Impact Assessment, Coast of Island (Coal Power Generation Company of Bangladesh Limited, 2013)											
Minimum	5	-	<1	-	2970	10	5	50	<100	-	-
Mean	6.73	-	<1	-	19791	17.67	14	110	223.33	-	-
Maximum	12	-	<1	-	45200	60	29	210	580	-	-
SD	2.19	-		-	12546	13.18	7.01	55.03	179.83	-	-
%RSD	32	-		-	63	75	50	50	81	-	-
US EPA Saltwater Quality Standards (EPA, 2015)											
CMC	-	-	**33**	-	-	**210**	**1.8**	**90**	**4.8**	**74**	**-**
CCC			**7.9**			**8.1**	**0.94**	**81**	**3.1**	**8.2**	

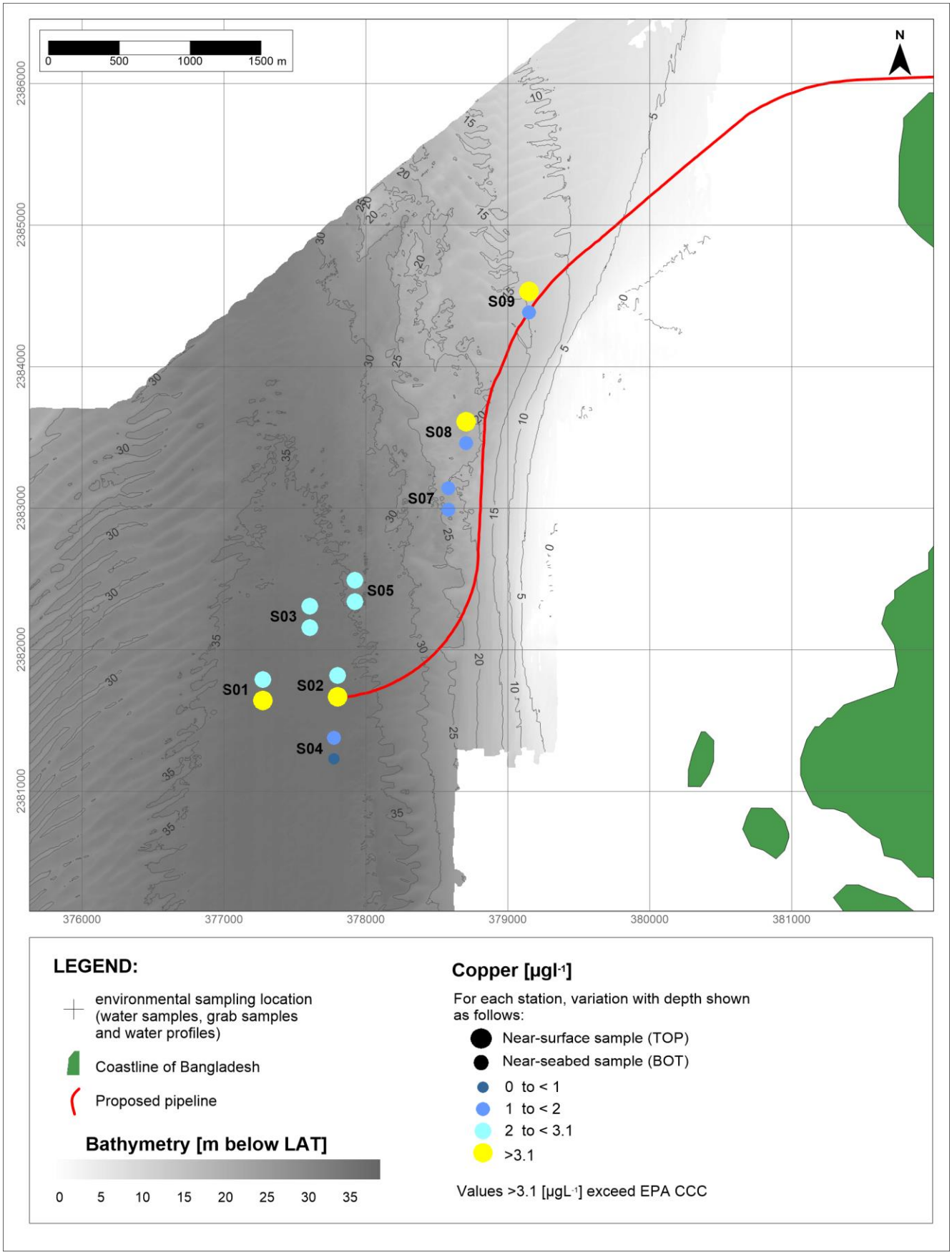


Figure 10.1: Spatial distribution of copper concentrations in water [µgl^{-1}]

10.2.3 Suspended Solids, Chlorophyll and Nutrients

Total suspended solids, chlorophyll and nutrient concentrations are provided in Table 10.4.

Total suspended solids concentrations showed an increase between surface and bottom samples at all stations. Surface total suspended solid concentrations ranged from 11.1 mgl^{-1} to 28.1 mgl^{-1}, while near-seabed concentrations ranged from 14.0 mgl^{-1} to 75.0 mgl^{-1}. This trend was mirrored in the turbidity profiles acquired at each station.

Chlorophyll concentrations were consistently below the limit of detection (<5 mgl^{-1}) from all the samples obtained.

Nitrite concentrations were below or close to the limit of detection ranging from <0.0l mgl^{-1} to 0.044 mgl^{-1}. Nitrate was consistently detectable, ranging in concentration from 0.52 mgl^{-1} to 1.48 mgl^{-1}; higher concentrations were clearly evident from station S04, with the TOP and BOTTOM samples both exceeding 1.0 mgl^{-1}. Ammoniacal nitrogen levels were consistent and low, ranging from 0.021 mgl^{-1} to 0.042 mgl^{-1}. Orthophosphate levels were low and displayed little variation, ranging from 0.017 mgl^{-1} to 0.023 mgl^{-1}. Silicate concentration ranged between 0.28 $mgl^{-1}$and 0.78 mgl^{-1}. None of the nutrients quantified were shown to clearly trend with depth.

Table 10.4: Water Sample Nutrient Analysis and Total Suspended Solids

Concentrations expressed as mgl^{-1}										
Station		**Depth [m]**	**Total Suspended solids**	**Chlorophyll-a**	**Ammoniacal as N**	**Nitrate as NO_3**	**Nitrite as NO_2**	**Nitrogen: Total Oxidised as N**	**Orthophosphate as PO_4-P**	**Silicate as SiO2**
S01	TOP	2	28.1	<5	0.037	0.68	0.040	0.54	0.022	0.38
	BOTTOM	35	47.1	<5	0.021	0.55	<0.01	0.38	0.023	0.28
S02	TOP	2	19.1	<5	0.021	0.68	0.041	0.79	0.020	0.29
	BOTTOM	36	75.0	<5	0.022	0.63	0.022	0.63	0.023	0.45
S03	TOP	2	20.5	<5	0.026	0.58	<0.01	0.65	0.023	0.63
	BOTTOM	37	48.4	<5	0.026	0.64	<0.01	0.44	0.021	0.49
S04	TOP	2	11.5	<5	0.035	1.18	0.044	0.71	0.018	0.30
	BOTTOM	37	14.0	<5	0.042	1.48	<0.01	0.70	0.021	0.41
S05	TOP	2	11.1	<5	0.030	0.70	0.042	0.57	0.019	0.69
	BOTTOM	35	56.0	<5	0.022	0.52	0.042	0.35	0.021	0.33
S07	TOP	2	14.5	<5	0.023	0.61	<0.01	0.49	0.020	0.78
	BOTTOM	24	35.3	<5	0.026	0.54	0.028	0.43	0.021	0.57
S08	TOP	2	11.4	<5	0.023	0.62	<0.01	0.43	0.017	0.59
	BOTTOM	21	43.5	<5	0.025	0.56	<0.01	0.49	0.020	0.46
S09	TOP	2	11.7	<5	0.023	0.57	<0.01	0.44	0.022	0.62
	BOTTOM	15	17.8	<5	0.023	0.56	<0.01	0.45	0.021	0.46
Minimum		**-**	**11.1**	**<5**	**0.021**	**0.52**	**<0.01**	**0.35**	**0.017**	**0.28**
Mean		**-**	**29.1**	**<5**	**0.026**	**0.69**	**0.019**	**0.53**	**0.021**	**0.48**
Maximum		**-**	**75.0**	**<5**	**0.042**	**1.48**	**0.044**	**0.79**	**0.023**	**0.78**
SD		**-**	**19.6**	**-**	**0.006**	**0.26**	**0.017**	**0.13**	**0.002**	**0.15**
%RSD		**-**	**67**	**-**	**24**	**38**	**91**	**25**	**8**	**31**

11. INCIDENTAL OBSERVATIONS

11.1 Fishing Activity

A lot of fishing activity was recorded around the survey vessel during the period of the survey. At almost every station there were one to two fishing boats with fishing gear in the water. At station GEO-PR1 five fishing boats were recorded on site and operations had to be delayed. The high level of fishing activity caused several incidents where nets became entangled with the vessel and anchor chains. A summary of the incidents is recorded in Table 11.1. Example photographs of the vessels and equipment used are shown in Plate 11.1.

During the geophysical survey 67 sonar contacts were identified, 54 of which were associated with fishing activity. A total of 58 magnetic anomalies were observed within the survey area, 26 of which were associated with fishing gear on the seabed. Fishing stakes were also present to the north east of the survey area (Figure 4.1:) which prevented some geophysical data acquisition.

Table 11.1: Summary of Fishing Net Incidents

Location	Description
PLEM	A total of 1.5 hours of standby time were incurred for cutting and removing the fishing net from starboard side of the vessel.
CAN-PA7 CAN-PA8	A total of 1.6 hours of standby time were incurred for cutting and removing the fishing net from port side of the vessel.
CAN-PA1	A total of 1.4 hours of standby time were incurred for cutting and removing the fishing net caught by the moonpool door.
GEO-PR1	A total of 8.4 hours of standby time were incurred due to extensive fishing activities within the anchor spread. Standby till daylight.

11.2 Marine and Terrestrial Fauna

Throughout the survey the area was monitored for marine and terrestrial fauna. Despite being in close proximity to the shore very few species were observed. Species recorded include the occasional needle fish (Belonidae), unidentified seabird and bat (Chiroptera). No other marine mammals, fish or reptiles were seen.

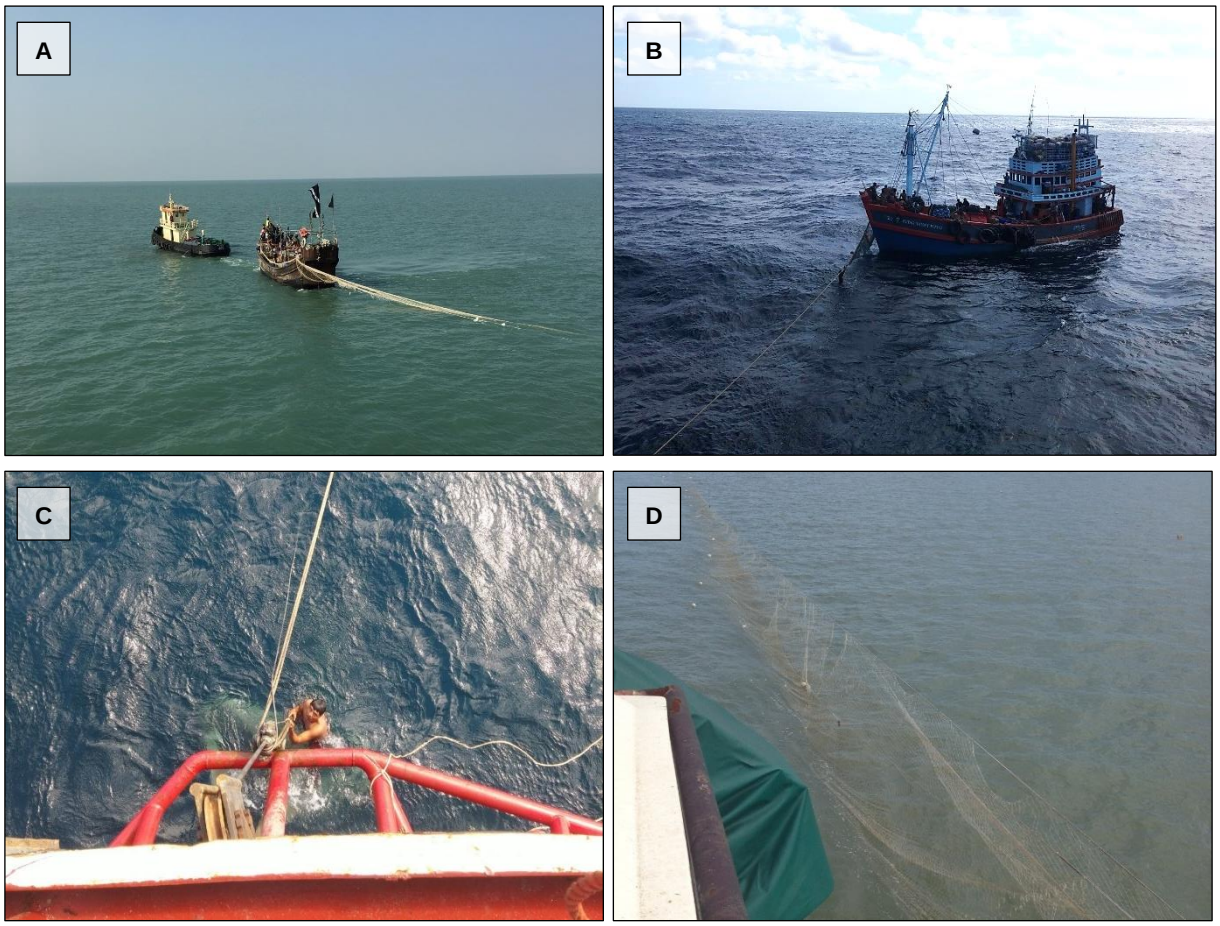


Photo A: Fishing vessels with gill net deployed
Photo B: Fishing vessel with gill net deployed and caught on survey vessel anchor
Photo C: Releasing caught fishing gear from anchor
Photo D: A deployed gill net

Plate 11.1 Example of fishing vessel and gear encountered during survey

12. DISCUSSION

12.1 Introduction

This survey was undertaken to establish the current biological and physico-chemical conditions of the seabed sediments in the survey area off the coast of Moheshkhali Island in the Bay of Bengal, Bangladesh. The surface (0 cm to 2 cm) sediment samples collected (Section 2.2.1) were analysed for selected physical characteristics, total organic carbon, hydrocarbons and heavy and trace metal content. Water profiles were acquired at each station, along with water samples that were analysed for hydrocarbons, heavy metal content, nutrients and total suspended solids.

The previous sections of the report (Sections 4 to 10) have presented the data generated from the analysis programme, with the aid of data tables and graphics. This discussion section will review data with respect to historic and regional survey results where available. Due to a lack of regional background information for environmental surveys in the Bay of Bengal, background European (North sea) and North American levels have been utilised to support interpretation including reports such as the combined Oslo and Paris Commissions (OSPAR, 2000 and 2010), US NOAA standards (O'Conner, 2004) along with appropriate sediment quality (Buchman, 2008) and water quality guidelines (WFD, 2010; EPA, 2015). In addition, a previous environmental survey completed in the Bay of Bengal has been used for comparison data (Fugro, 2016) as well as an EIA for a coal field plant that involved five water sampling stations 14 km from the survey area (TEPSCO, 2013).

In addition to the comparison of the analytical data against available references, statistical correlations of the sediment parameters recorded with the chemical and biological determinands in the survey are summarised (for the main environmental parameters) in Appendix G. The statistical analysis chosen was the Spearman's rank correlation coefficient (Spearman, 1904), sometimes referred to as Spearman's rho. This coefficient is used to test the association between two measured values for statistical dependence. It is a measure of rank correlation, or the similarity of the orderings of the data when ranked by each of the values. Correlations can only suggest a relationship and do not prove a causal link between parameters tested. Correlations occur as both positive and negative, they are positive when both values measured increase or decrease in unison. Negative correlations indicate that as one value increases the other value decreases and vice-versa. Commonly observed positive correlations would include such variables as total hydrocarbon content and polycyclic aromatic hydrocarbons whereas common negative correlations would typically include factors such as distance from oil and gas infrastructure and total hydrocarbon content, i.e. the further from a platform (point source) the lower the level of contamination observed.

The key correlations in this study were as follows:

- Depth had no correlation with nearly all metals in sediment, the exception was mercury which showed moderate correlation ($P<0.05$),
- The proportion of fines content was noted to have a strong positive correlation ($P<0.01$) with several of the metals (chromium, iron and zinc) and a moderate positive correlation ($P<0.05$) with organic matter, TPH, cadmium, nickel and vanadium (no correlation with arsenic, barium, copper, mercury, manganese, lead and strontium),

- The proportion of organic matter had a strong positive correlation (P<0.01) with several of the of the metals (barium, cadmium, copper and vanadium) and a moderate positive correlation (P<0.05) with chromium, iron, lead, nickel and zinc (no correlation with arsenic, mercury, manganese and strontium),
- The proportion of TSS in the water samples showed a strong correlation (P<0.01) with many metals (chromium, iron, manganese, nickel and vanadium) and a moderate positive correlation with depth as well as arsenic, lead and mercury and a moderate negative correlation (P<0.05) with zinc.
- Depth of water samples had a strong correlation (P=0.01) with several metals (iron, mercury, manganese and vanadium), moderate correlation (P=0.05) with TSS and nickel and strong negative correlation (P=-0.01) with zinc.
- No correlation was observed between number of taxa, number of individuals, diversity indices and any environmental parameter

These correlations will be discussed further in the relevant sections of the discussion below.

12.2 Sediment Characterisation

The general physical and chemical characteristics of sediment particles have a significant effect on how other chemical components and biological species interact with seabed sediments. Granulometry data can therefore be critical when interpreting chemical and biological data obtained in this type of benthic study.

Sediment composition across the survey area showed a high level of inter-station variability in mean diameter (µm) and also in the proportion of sand and fine material with no clear correlation to water depth. Gravel was absent from all but four of the samples and even then present in very small amounts (0.1% to 0.6%). The variability in particle size across the survey area, and lack of depth-driven trends in granulometry, is considered indicative of an energetic environment, with dynamic erosional and depositional processes which vary over relatively short timescales. The area receives considerable fluvial inputs which may be deposited during periods of reduced tidal flow, but eroded when flows increase. The high turbidity seen near seabed from water profiles provides evidence of this (see Section 9.2.3), as do the visible variations in turbidity seen from the vessel during operations (see Plate 11.1).

Particles of various types and sizes, notably the silt/clay fraction, are known to adsorb petroleum hydrocarbons/heavy metals from seawater and through this pathway, these chemicals become incorporated into the sediment system (Meyers and Quinn, 1973). Strong positive correlations (P<0.01) were observed between fine sediment with several of the metals (chromium, iron, and zinc) and a moderate positive correlation (P<0.05) with cadmium, nickel and vanadium.

12.3 Sediment Hydrocarbons

12.3.1 Total and Aliphatic Hydrocarbons

Marine sediments contain hydrocarbons derived from many sources which enter the marine environment via three general processes (Farrington and Meyer, 1975; Myers and Gunnerson, 1976): biosynthesis (marine and land organisms biosynthesise hydrocarbons), geochemical processes

(submarine and coastal/terrestrial oil-seeps) and anthropogenic sources (from accidental or intentional discharge of fossil fuel). The latter obviously includes hydrocarbon exploration, production and associated shipping; these and other sources of contaminants are assessed in the reports NSTF (1993) and OSPAR (2000, 2010).

The total hydrocarbon concentrations recorded in the seabed samples ranged from below detectable levels (<2 μgg^{-1}) to 37.4 μgg^{-1} and were influenced by the physical characteristics of the sediment present. The highest TPH concentrations were recorded in samples composed mainly of silt and clay particles with the lowest values being found in samples containing high proportions of sand sediment. This is also observed in the correlation results where a moderate positive correlation ($P<0.05$) was seen between TPH and fines content. While the sources of hydrocarbons present in the survey area could not be identified from the analysis undertaken, these are likely to contain a mixture of anthropogenic inputs (from both marine activity and terrestrial run-off) and biogenic sources. In an area of high fluvial input and coastal mangrove swamp, long chain length n-alkanes (nC_{29-31}) from plant cuticular waxes may form a significant part of sedimentary hydrocarbon load.

12.3.2 Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) and their alkyl homologues have been found in a wide range of marine sediments (Laflamme and Hites, 1978; Neff, 1979; Youngblood and Blumer, 1975). These compounds consist of two or more fused benzene rings in linear, angular or cluster arrangements containing, by definition, only carbon and hydrogen atoms. However, nitrogen, sulphur and oxygen atoms may be readily substituted into the benzene ring to form heterocyclic compounds which are found in significant amounts in petroleum and refined products.

Monitoring of aromatic hydrocarbon type and content is important due to the particularly toxic nature (mutagenic/carcinogenic) of several PAHs even at very low concentrations. The US EPA has identified 16 priority PAHs to be measured and the OSPAR CEMP specifies 9 PAH of specific concern, which primarily reflect inputs from manmade combustion sources (further alkylated and parent compounds are normally studied because of the information they provide on PAH origin and fate). Many PAHs have long been recognised as universal environmental pollutants with the heavier molecular weight PAHs (mainly 4 to 6 ring PAH) generally being regarded as carcinogens and mutagens. Indeed, 11 of 40 PAHs ranging from 3 to 6 ring structures have been listed as being strongly carcinogenic or mutagenic with a further 10 listed as weakly carcinogenic or mutagenic (Edwards, 1983).

As previously stated, PAHs are widely spread in the environment (e.g. Butler et al., 1984) with natural sources occurring primarily as a result of synthesis by plants (Sims and Overcash, 1983; Neff, 1979), related to natural seeps of petroleum (NRC, 1985; Kennicutt et al., 1988) and formation during natural forest and prairie fires (Youngblood and Blumer, 1975; Wakeham et al., 1979). By far the greatest amounts of PAHs released into the environment are formed during fossil fuel combustion and man-made, forest and agricultural fires (e.g. Sims and Overcash, 1983; Edwards, 1983). Once released into the atmosphere the PAHs may be carried long distances adsorbed to particulate material, e.g. soot and flyash (Windsor and Hites, 1979). Upon deposition in the environment the particulate may undergo further transport e.g. by rivers/currents in the oceans before final deposition in the sediments. Because of their low solubility and hydrophobic nature, PAHs tend to be adsorbed by the inorganic

and organic particulate matter in the water column, which gradually settles out. Once deposited in the sediment PAHs are less susceptible to photochemical and biological degradation and may accumulate to relatively high concentrations.

Petroleum sources are rich in aromatic hydrocarbons, particularly 1 to 3 ring compounds (benzenes, naphthalenes and phenanthrenes); the levels of 4 to 6 ring compounds being relatively low. In addition, significant concentrations of organosulphur compounds (dibenzothiophenes) are normally present (Friocourt et al., 1982). The relative proportion of these compounds will vary between crude oils and refined petroleum.

The many possible origins of PAHs in marine sediments have been briefly discussed in this section. The source of the PAHs may be determined from the study of the relative proportions of individual PAH concentrations (e.g. Neff, 1979; Garrigues et al., 1995; Budzinski, 1997) as well as examining the overall distributions of parent and alkylated PAHs present. Pyrogenically (or pyrolytic) derived PAHs signatures (i.e. forest fires, etc.) are dominated by higher molecular weight compounds (mainly 4 to 6 ring) and are predominantly unsubstituted. In contrast, PAH formed during the slow geological maturation of petroleum, are dominated by alkylated, low molecular weight (mainly 1 to 3 ring) compounds (e.g. Neff, 1979).

The potential environmental effects of the PAH compounds present was assessed by comparison with indicative effects range low threshold concentrations (ERL) for a range of specific PAH compounds (OSPAR, 2014). All PAH levels were below the limit of detection except for benzo(a)pyrene and the levels recorded for this PAH were still below the ERL criterion (Table 6.1), indicating that the PAH present in the sediment would not be expected to have a major detrimental effect on sediment dwelling biota. The only detectable PAH, benzo(a)pyrene, is a product of incomplete combustion. Degradation of high molecular weight PAHs such as benzo(a)pyrene is limited by the relatively few genera which are capable of breaking the compound down and therefore once present in a system it takes longer for the levels to decrease compared to low weight PAHs (Juhasz, 2000).

12.4 Sediment Metals

Metals occur naturally in the marine environment, and are widely distributed in both dissolved and sedimentary forms. Some are essential to marine life while others may be toxic to numerous organisms (Paez Osuna and Ruiz-Fernandez, 1995). Rivers, coastal discharges, and the atmosphere (the principal route by which lead enters offshore areas (Schaule and Patterson, 1983) are the principal modes of entry for metals to the marine environment, with anthropogenic input occurring primarily as components of industrial and municipal wastes.

Trace metal contaminants in the marine environment tend to form associations with the non-residual phases of mineral matter, such as iron and manganese oxides and hydroxides, metal sulphides, organics and carbonates. Metals associated with these non-residual phases are prone to various environmental interactions and transformations (physical, chemical and biological) potentially increasing their biological availability (Tessier et al., 1979). Residual trace metals are defined as those which are part of the silicate matrix of the sediment and that are located mainly in the lattice structures of the component minerals. Non-residual trace metals are not part of the silicate matrix and have been

incorporated into the sediment from aqueous solution by processes such as adsorption and organic complexation and may include trace metals originating from sources of pollution.

In this study, an analytical procedure involving digestion of sediment in aqua regia (nitric and hydrochloric acids) was employed to analyse the elemental content of the sediments. This technique does not completely dissolve the sediment matrix and only releases the 'non-residual' heavy metals (the proportion that is potentially available for biological uptake) for analysis.

The individual concentrations of the metals in the sediment collected are presented in Table 7.1. The majority of the metals results displayed moderate to high inter-station variability, ranging from 21% to 60% RSD, primarily derived from the different metals levels of the sediment collected from stations S03 and S05. Lower concentration values were observed for most metals at stations S03 and S05, with this attributable to the lower levels of fine material (silt and clay) present at these stations. The skewing effects of these stations may have influenced the correlation analysis, which indicated that positive correlation ($P<0.01$) was observed between fines and several metals (chromium, iron and zinc) and a moderate positive correlation ($P=0.05$) with cadmium, nickel and vanadium. Conversely however, levels of arsenic and at stations S03 and S05 were higher than at other stations with finer grained sediments; this suggested some affinity between arsenic and manganese and sand material within the area.

The recorded concentrations of most metals were below the ERL values indicating that the metals present would be unlikely to cause any adverse effects on sediment biota. The exception was nickel, which was present at concentrations that slightly exceeded in the ERL value, but below the ERM; elevated nickel was also observed in the previous survey in the Bay of Bengal (Fugro EMU, 2016) and may reflect higher background concentrations across the region.

There is no indication of any major spatial variability in the metals present in the survey area that could indicate the presence of specific point sources of contamination and the concentrations were lower than those recorded in the baseline survey of a site located in the Bay of Bengal conducted in 2016 (Fugro, 2016). The recorded results can therefore be considered indicative of typical background concentrations for the potential development area.

12.5 Macrofaunal Communities

Seabed sediments provide support, protection and the food source for many macrofaunal species. The sediment macrofauna, most of which are infaunal (living within the sediment), are therefore particularly vulnerable to external influences which alter the sediments' physical, chemical or biological nature.

Such infaunal animals are largely sedentary and are thus unable to avoid unfavourable conditions. Each species has its own response and degree of sensitivity to changes in the physical and/or chemical environment and consequently the species composition and their relative abundance in a particular location provides a reflection of the health and condition of the immediate environment, both current and historical. The recognition that aquatic contaminant inputs may alter sediment characteristics, together with the relative ease of obtaining quantitative samples from specific

locations, has led to the widespread use of infaunal communities in monitoring the impact of disturbances to the marine environment over a long period of time.

The community across the survey area was observed to be highly variable between samples, with considerable variation also noted between pairs of samples which had been acquired at the same stations. Overall faunal richness (the number of taxa and abundance) was low and univariate measures of diversity were very low to moderate, with most stations demonstrating a sparse, but equitable benthic assemblage, but station S03 being shown to have an assemblage dominated by a single taxon (*Armandia* Type A). No correlation was observed between any physico-chemical factors and number of individuals, number of taxa or diversity indices.

The data acquired was considered indicative of the presence of a single, inherently species poor and patchy community throughout the survey area. This was consistent with the results of the geophysical survey and the granulometric analysis of particle size data, which suggested that the seabed environment in the area has extremely dynamic erosional and depositional processes. Several of the species characteristic of the community sampled, including the numerically dominant opheliid polychaete *Armandia* (Type A), the amphipod Phoxocephalidae (Type A) and bivalve Tellinidae (Type A), are relatively large bodied and robust organisms, well-adapted to mobile sediment habitats. Along with the natural disturbance evident within the survey area (wave and tidal action), fishing activity in the area was observed to be high (Section 11), which may have introduced an element of anthropogenic physical disturbance.

12.6 Water Profiling

The water profiles showed well mixed waters throughout the water column and no thermoclines or haloclines were apparent from the water profile data. A potential oxycline was present at S09, the shallowest station. The subsurface increase in dissolved oxygen is likely due to the increased turbulence in the water column form tidal and wave action closer to shore.

There was variability across the site with water temperatures ranging from 26.61 °C (S09) to 28.06 °C (S02). When the average temperature was plotted against the date the profile was acquired (Figure 12.1:) a trend is apparent with water temperatures decreasing during the survey period and a corresponding increase in average pH value from 8.31 to 8.43 during the survey. A period of heavy rain preceded survey operations which may have contributed to the lower pH observed, with increasing fluvial inputs of fresh water, which has lower alkaline salt levels, possibly occurring for some time after this period of rainfall

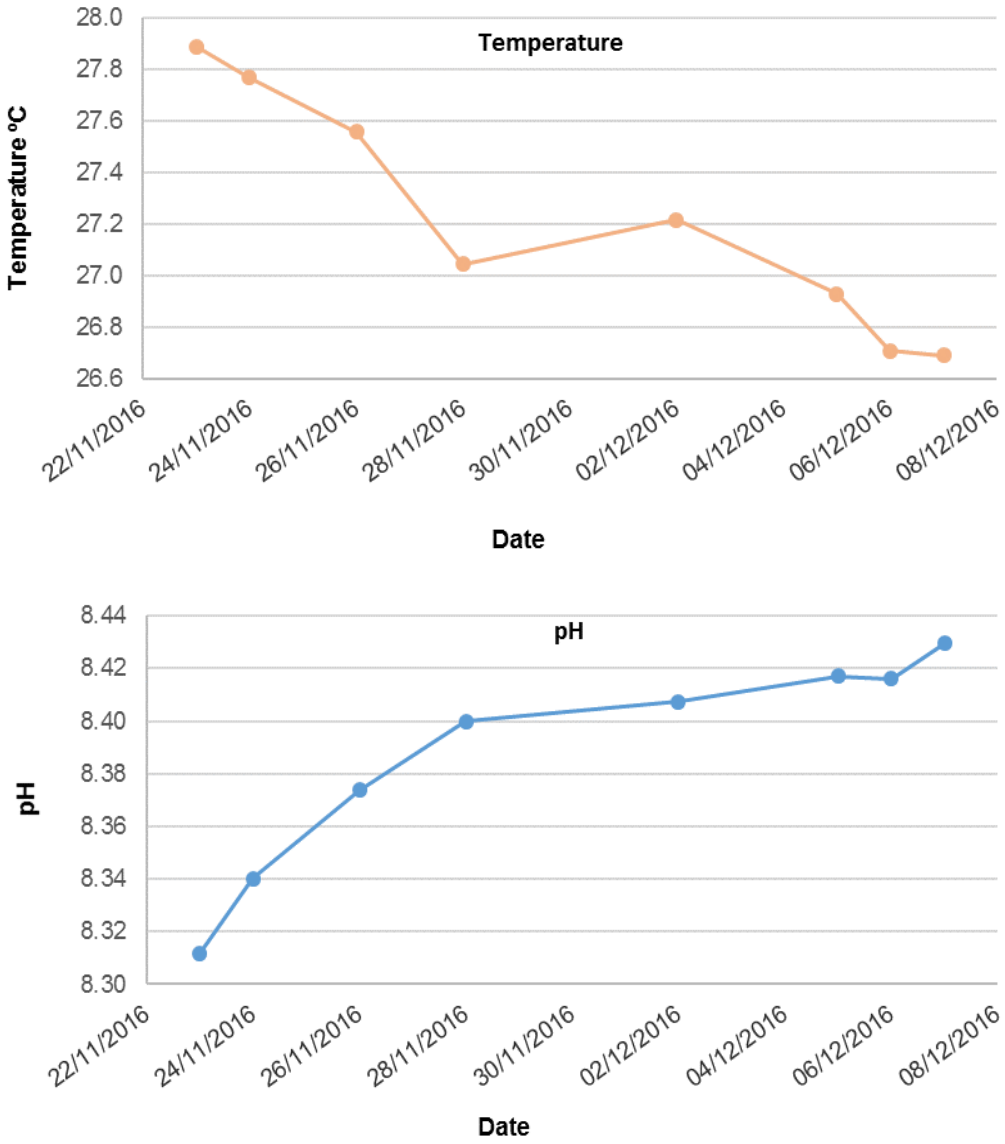


Figure 12.1: Temperature and pH average values during survey period

Turbidity showed the most variability across the site and throughout the water column and an increase in turbidity with depth was observed at every station. Stations S07, S08 and S01 showed the largest changes of turbidity throughout the water column. Turbidity reached a maximum value of 291 NTU at station S07. Observations made from the survey vessel noted very strong current throughout the survey which caused visible areas of increased turbidity see Plate 12.1. The areas of increased surface turbidity moving across the site accounts for the high variability between stations and why some stations had little change in turbidity (stations S02, S03) while other stations showed a large change throughout the water column (stations S01, S07, S08).

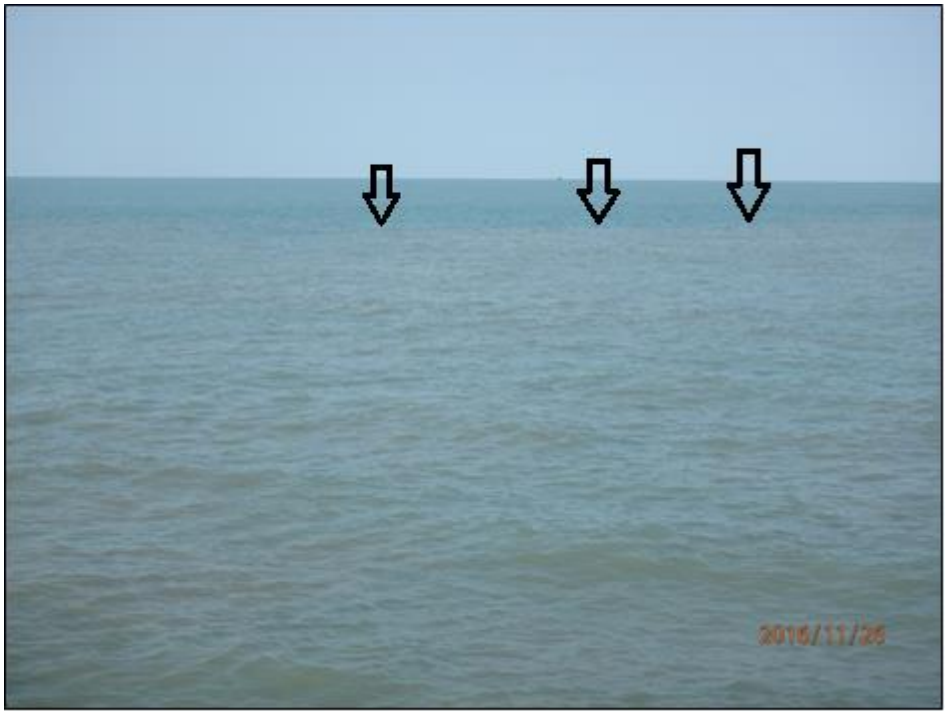


Plate 12.1 Example photograph from station S05 showing areas of increased turbidity observed from survey vessel

12.7 Water Quality

The Bay of Bengal receives large amounts of freshwater via river discharges, especially during the monsoon season. These inputs transport large quantities of nutrients and suspended solids (and potentially organic and inorganic contaminants) into the marine environment.

The concentrations of TPH were below the 0.1 μgl^{-1} detection limit for TPH. The PAH 16 were also present in concentrations that were below the limit of detection (1 μgl^{-1} for Naphthalene, Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene and 2 μgl^{-1} for Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(123cd)pyrene, Benzo(ghi)perylene).

Metals concentrations in the water column samples were generally low and below the available water quality threshold values (Table 10.2). Copper was the exception as it exceeded the US EPA CCC (3.1 μgl^{-1}) at four stations; the potential source of copper to the area is unknown.

The concentration of certain metals were compared with data from the Bay of Bengal (Fugro, 2016) and off the coast of Matabari Island (TEPSCO, 2013) in Table 10.3. Levels of mercury, zinc and copper exceeded the EPA CMC in the survey completed off the coast of Matabari Island which is located 14 km north of the current survey. The results cannot be directly compared however due to different methods being used during the analyses of the water samples. The EIA used electrothermal atomic absorption spectrometric method (APHA 3113.B) for chromium lead and cadmium, cold vapour atomic absorption spectrometric method (APHA 3112.B) for mercury, direct air-acetylene flame

method (APHA 3111.B) for copper, iron and zinc and continuous hydroid generic/atomic absorption spectrometry method (APHA 3114.C) for arsenic.

Water depth had a strong correlation (P<0.01) with total suspended solids and several metals (iron, mercury, manganese and vanadium), moderate correlation (P<0.05) with nickel and strong negative correlation (P<0.01) with zinc. The proportion of total suspended solids in the water samples also showed a strong correlation (P<0.01) with many of the metals (arsenic, chromium, iron, lead, manganese, nickel and vanadium) moderate positive correlation with mercury and a moderately negative correlation (P<0.05) with zinc. These correlations suggested that much the metal load detected in the water column was bound to particles suspended in it, rather than dissolved.

No clear patterns of spatial variation were observed within the water column hydrocarbon and metals datasets. The results can therefore be considered as providing a reasonable indication of typical background concentrations in this area at this time of year and there was no evidence to indicate the presence of any localised point source inputs of these compounds/elements in the area.

Water sample analyses showed that the concentration of chlorophyll and nutrients (nitrate, nitrite, total oxidised nitrogen, orthophosphate and silicate) were generally low with many of the results falling below the analytical detection limits. The highest concentrations of nitrogen compounds were recorded from station S04 to the south of the survey area; this station was not located in closer proximity to any likely input of nutrient rich water (e.g. river mouth) and, as such, the variation evident was considered temporal, rather than spatial.

12.8 Incidental Observations

Fisheries are an important part of Bangladesh's economy and provide the population with livelihoods and the majority of its animal protein. Inshore fisheries are dominant, with marine fisheries only responsible for 16.3% of annual fish production (Hussain, 2016).

The majority of fish production comes from artisanal fisheries with industrial fisheries making up only 14.1% of annual marine fish production. There are estimated to be 68,000 mechanised and non-mechanised boats that make up Bangladesh's artisanal fisheries (Hussain, 2016). The artisanal fisheries are characterised by their use of traditional methods and fishing gear.

Bangladesh has a multispecies fish resource with shrimp, demersal and pelagic fish being targeted with a variety of gear, including gillnets, set bagnets, trammel nets and bottom longlines. Alternative gear is used in shallow waters less than 10 m in depth, including beach seine, *char pata jal*, cast nets, push nets, fixed bagnets and dragnets. Marine fisheries target shrimps or demersal fish and stock of both commercially viable fish and shrimp species have dramatically declined with overfishing (Khan, 2003).

During the survey a lot of fishing activity was observed and several times it affected survey operations resulting in a total of 12.9 hours of downtime due to entanglement in fishing gear or fishing vessels operating at borehole locations which delayed the vessel getting into position. All the fishing vessels observed were utilising gill nets.

The geophysical survey also recorded a lot of fishing gear on the seabed with 57 sonar contacts and 26 magnetic anomalies attributed to fishing gear.

The amount of marine life observed during the survey (e.g. seabirds and pelagic fish) was minimal. Overfishing, and the consequently limited food supply for larger marine fauna, may explain this.

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APPENDICES

A. GUIDELINES ON USE OF REPORT

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F. CORRELATIONS

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A. GUIDELINES ON USE OF REPORT

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B. METHODOLOGIES

B.1 LABORATORY ANALYSIS FOR SEDIMENT SAMPLES

B.1.1 Particle Size Analysis

Particle size distribution analysis was undertaken by Marchwood Laboratory Services Pte Limited using a method based on BS1377: 1990: Part 2, which comprised dry sieving and hydrometer analyses. Results from the two analyses were each expressed as a percentage of the subsample analysed and rationalised to determine the percentage particle size distribution for the original bulk sample.

B.1.1.1 Dry Sieve Analysis

Representative material was split from the bulk sample and oven dried at 105 ±5°C to constant weight before sieving through a series of sieves with apertures ranging between 10 mm and 0.063 mm (63 µm). The weight of the sediment fraction retained on each mesh was subsequently measured and recorded, with this expressed as a percentage of the total sample weight analysed.

B.1.1.2 Hydrometer Analysis

Approximately 25 g to 50 g of oven-dried sample (dependent on sediment type) was accurately weighed and added to a flask with dispersant solution; this mixture was agitated to allow the particles present to fully disperse. The resultant suspension was screened through a 63 µm sieve into a measuring cylinder. A hydrometer was immersed in the suspension and its specific gravity (R_h) measured at intervals over a 24 h period. The proportion of particles of any given size which had settled from the solution was calculated from R_h, applying corrections for the specific gravity of the dispersant solution, temperature and hydrometer design.

B.1.2 Organic Carbon

Total organic matter (TOM) and total organic carbon (TOC) were analysed by Marchwood Laboratory Services Pte Limited.

Prior to both analyses an appropriate mass subsample was oven dried at 50 ±2.5°C, cooled in a desiccator, screened and pulverised to produce material which would pass through a 425 µm mesh sieve.

B.1.2.1 Total Organic Matter (TOM)

Analysis of TOM was undertaken using a method based on BS1377: 1990: Part 3.

A subsample of the dried, ground sediment was placed in a crucible and ignited in a muffle furnace at 440 ±25°C for a minimum of 3 h, or until constant mass was achieved. Total organic matter content was expressed as percentage weight loss during the ignition process.

B.1.2.2 Total Organic Carbon (TOC)

Analysis of TOM was undertaken using a method based on BS EN13137.

A pre-dried aliquot of the sediment was weighed and then treated with hydrochloric acid to remove inorganic carbon in the form of carbonate. Fresh acid was added until all effervescence ceased; the

sediment was then washed over a glass-fibre filter and the residue dried to a constant weight before being ignited in a muffle furnace at 600 ±25°C for 2 hours. The organic content of the sediment was then calculated using the weight difference from the original dry weight to the ignited residue (taking into account the loss of carbonate).

B.1.3 Hydrocarbon Analysis in Sediments

Hydrocarbon analysis of sediments was performed by Marchwood Laboratory Services Pte Limited.

Sediment samples were solvent extracted and appropriate analytical standards added to allow quantification of target analytes. All extraction solvents and standards were reagent grade.

Total hydrocarbon (THC) concentration was analysed using a method based on USEPA 8015C. This utilised gas chromatography with flame ionisation detection (GC-FID) to quantify THC in the range nC_{10-40} using response factors calculated from the analysis of mixed oil standard solutions over this range.

The USEPA 16 PAH were quantified using an in house method which utilised gas chromatography with mass spectroscopy (GC-MS).

B.1.4 Heavy and Trace Metals in Sediments

Heavy and trace metals analysis of sediments was performed by Marchwood Laboratory Services Pte Limited using an extraction method based on USEPA 3051 and detection in accordance with APHA 3120B.

Samples were homogenised and subjected to microwave digestion with a mixture of nitric and hydrochloric acids. This acid mixture resulted in a strong partial digestion of metals from the sediment and was expected to liberate all metals adsorbed onto sediment surfaces, but not those mineralised within particles. The resulting digests were then analysed by inductively coupled plasma - optical emission spectroscopy (ICP-OES), with levels of target analytes quantified by reference to standards of known metal concentrations.

B.2 LABORATORY ANALYSIS FOR WATER SAMPLES

B.2.1 Hydrocarbon Analysis in Water Samples

Hydrocarbon analysis of sediments was performed by Marchwood Laboratory Services Pte Limited.

Total hydrocarbon (THC) concentration was analysed using a method based on USEPA 8015C. This utilised gas chromatography with flame ionisation detection (GC-FID) to quantify THC in the range nC_{10-40} using response factors calculated from the analysis of mixed oil standard solutions over this range.

The USEPA 16 PAH were quantified using an in house method which utilised gas chromatography with mass spectroscopy (GC-MS).

B.2.2 Heavy and Trace Metals in Water Samples

Heavy and trace metal analyses were undertaken by Marchwood Laboratory Services Pte Limited in accordance with APHA Method 3125 B.

All metals were analysed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) following matrix elimination.

B.2.3 Chlorophyll in Water Samples

Nutrient analyses were undertaken by Marchwood Laboratory Services Pte Limited in accordance with APHA Method 10200 H.

The filter was ground and steeped in acetone before being centrifuged. The supernatant was analysed in a spectrophotometer, with absorbance measured at 750 nm and 664 nm wavelengths.

B.2.4 Nutrients in Water Samples

Nutrient analyses were undertaken by Marchwood Laboratory Services Pte Limited in accordance with APHA Methods.

Nitrite was analysed using APHA method 4500-NO_2 and nitrate by APHA method 4500-NO_3. Concentrations of nitrite were determined through formation of a reddish purple azo dye produced at pH 2.0 to 2.5 by coupling diazotized sulfanilamide with N-(1-naphthyl)-ethylenediamine dihydrochloride (NEDD). Levels of nitrate were determined by first reducing nitrate to nitrite in the presence of cadmium, then reacting the resultant sample with the same reagents. Colour responses were measured colorimetrically. Ammonia was determined by APHA method 4500-NH_3 and nitrogen by APHA method 4500-N. Both methods react samples in the presence of sulphuric acid, potassium sulphate and cupric sulphate to produce ammonium, levels of which are quantified colorimetrically.

Orthophosphate was quantified using APHA method 4500-P (G) in which orthophosphate ions react with a solution containing molybdic ions, ascorbic acid, trivalent antimony ions and hydrogen ions to form a 1,2 molybdo-phosphoric acid which is reduced by ascorbic acid to a blue heteropoly compound (phosphomolybdenum blue) in which antimony is incorporated. The acid conditions used may cause

partial hydrolysis of condensed phosphates and/or some of the more labile organic phosphates in the sample will contribute to the result. The blue colour formed was measured colorimetrically.

Silicate was determined by APHA method 4500-SiO_2 where samples are reacted with ammonium molybdate at pH approximately 1.2 and the intensity of the yellow colouring response measured colorimetrically.

B.2.5 Total Suspended Solids in Water Samples

Total Suspended Solids (TSS) analysis was completed Marchwood Laboratory Services Pte Limited in accordance with APHA Method 2540D.

A measured volume of sample was filtered through a pre-weighed glass fibre filter paper with a particle size retention of 1.2 microns, which was subsequently re-dried for a specific time (1 h) and temperature (103-105°C). The filter paper was then re-weighed and the increase in weight represents the total suspended solids.

B.3 STATISTICAL ANALYSIS

B.3.1 Correlation Analysis

Depth, crude granulometric data, chemical data and univariate indices of community structure were correlated using Spearman's Rank Correlation Coefficient. This is calculated as follows:

$$\rho = \frac{\sum(x - \overline{x})\,(y - \overline{y})}{\sqrt{\sum(x - \overline{x})^2 \sum(y - \overline{y})^2}}$$

Where x and y are ranked vales for each variable.

The resultant test statistic (ρ) will range from -1 to 1, with -1 indicating a very strong negative correlation, 0 no correlation and 1 a very strong positive correlation. Significance levels were taken from tabulated vales for a two-tail test at 5% and 1%.

B.3.2 Multivariate Statistical Analysis

A range of multivariate statistical analyses were conducted on the granulometric data. These were undertaken with the statistical package Plymouth Routines in Multivariate Ecological Research (PRIMER) v6.0 (Clarke & Gorley, 2006).

B.3.2.1 Measurement of Similarity

A triangular similarity matrix was then produced from the proportional granulometric data, by calculating the Euclidean distance between every pair of samples.

B.3.2.2 CLUSTER Analysis and SIMPROF

The CLUSTER programme uses the similarity matrix to successively fuse samples into groups and groups into clusters according to their level of similarity. The end point of this process is a single cluster containing all the samples, which is displayed by means of a dendrogram with distance displayed on one axis and samples on the other.

Similarity profile permutation tests (SIMPROF) were also be performed, to look for evidence of genuine statistically significant clusters, in samples which are *a-priori* unstructured (i.e. with no prior statistical design), as typically seen for a baseline survey such as this. By combining this significance testing with the CLUSTER function, dendrograms are produced indicating those clusters which are statistically significant. Statistically significant splits in dendrograms are illustrated as solid black lines, while nonsignificant splits are shown as dotted red lines.

B.3.2.3 Non-metric Multidimensional Scaling (nMDS)

A two dimensional representation of the multidimensional particle size dataset was generated iteratively. The degree of distortion within the two-dimensional representation (i.e. how accurately it represents the multidimensional Euclidean distances calculated) was indicated by a stress value. Typically, stress values of less than 0.10 indicate an accurate ordination which closely represents the actual Euclidean distances between samples. Values in the range 0.10 to 0.20 indicate a useful ordination, but one in which fine detail may have been lost and values of greater than 0.20 indicate an ordination in which data point are arbitrarily distributed.

C. LOGS

C.1 SURVEY LOG

Date	Time [UTC +6.30]	Transect/ Station	Type	Sample Rep/ Still No.	Water Depth [m]	Proposed Location		Actual Location		Offset [m]	Notes
						Easting [m]	Northing [m]	Easting [m]	Northing [m]		
23/11/2016	03:50	S02	DVV	FA	38.0	377 800.00	2 381 669.00	377 808.65	2 381 683.52	16.9	
23/11/2016	03:50	S02	DVV	PC	38.0	377 800.00	2 381 669.00	377 808.65	2 381 683.52	16.9	
23/11/2016	04:10	S02	DVV	FB	38.0	377 800.00	2 381 669.00	377 808.65	2 381 683.52	16.9	
23/11/2016	04:10	S02	DVV	FC	38.0	377 800.00	2 381 669.00	377 808.65	2 381 683.52	16.9	
23/11/2016	05:15	S02	WS	TOP, MID,BOT	38.0	377 800.00	2 381 669.00	377 808.65	2 381 683.52	16.9	
23/11/2016	09:20	S02	WP	-	38.0	377 800.00	2 381 669.00	377 795.15	2 381 638.22	31.2	
24/11/2016	09:00	S04	DVV	FA	37.0	377 775.97	2 381 379.51	377 784.76	2 381 393.29	16.3	
24/11/2016	09:00	S04	DVV	PC	37.0	377 775.97	2 381 379.51	377 784.76	2 381 393.29	16.3	
24/11/2016	09:20	S04	DVV	FB	37.0	377 775.97	2 381 379.51	377 784.76	2 381 393.29	16.3	Branch/stick in DVV caused sed. to leak.
24/11/2016	09:30	S04	DVV	FC	37.0	377 775.97	2 381 379.51	377 784.76	2 381 393.29	16.3	3rd drop
24/11/2016	10:05	S04	WS	TOP, MID, BOT	37.0	377 775.97	2 381 379.51	377 784.76	2 381 393.29	16.3	
24/11/2016	14:00	S04	WP	-	37.0	377 775.97	2 381 379.51	377 771.26	2 381 347.99	31.9	
26/11/2016	08:25	S05	DVV	NS	35.0	377 921.99	2 382 340.11	377 913.33	2 382 326.48	16.2	No grab
26/11/2016	08:30	S05	DVV	PC	35.0	377 921.99	2 382 340.11	377 913.33	2 382 326.48	16.2	
26/11/2016	08:50	S05	DVV	NS	35.0	377 921.99	2 382 340.11	377 913.33	2 382 326.48	16.2	No grab
26/11/2016	08:55	S05	DVV	FA	35.0	377 921.99	2 382 340.11	377 913.33	2 382 326.48	16.2	
26/11/2016	08:55	S05	DVV	FB	35.0	377 921.99	2 382 340.11	377 913.33	2 382 326.48	16.2	
26/11/2016	09:05	S05	DVV	NS	35.0	377 921.99	2 382 340.11	377 913.33	2 382 326.48	16.2	No grab
26/11/2016	09:15	S05	DVV	NS	35.0	377 921.99	2 382 340.11	377 913.33	2 382 326.48	16.2	No grab
26/11/2016	09:45	S05	WS	TOP, MID, BOT	35.0	377 921.99	2 382 340.11	377 913.33	2 382 326.48	16.2	
26/11/2016	10:50	S05	WP	-	35.0	377 921.99	2 382 340.11	377 926.83	2 382 371.78	32.0	
28/11/2016	19:25	S01	DVV	FA	37.0	377 274.19	2 381 640.70	377 264.58	2 381 627.52	16.3	
28/11/2016	19:25	S01	DVV	PC	37.0	377 274.19	2 381 640.70	377 264.58	2 381 627.52	16.3	
28/11/2016	19:45	S01	DVV	FB	37.0	377 274.19	2 381 640.70	377 264.58	2 381 627.52	16.3	
28/11/2016	19:45	S01	DVV	FC	37.0	377 274.19	2 381 640.70	377 264.58	2 381 627.52	16.3	
28/11/2016	20:15	S01	WS	TOP, MID, BOT	37.0	377 274.19	2 381 640.70	377 264.58	2 381 627.52	16.3	

Date	Time [UTC +6.30]	Transect/ Station	Type	Sample Rep/ Still No.	Water Depth [m]	Proposed Location		Actual Location		Offset [m]	Notes
						Easting [m]	Northing [m]	Easting [m]	Northing [m]		
28/11/2016	20:45	S01	WP		37.0	377 274.19	2 381 640.70	377 278.08	2 381 672.82	32.4	
02/12/2016	16:20	S03	DVV	FA	37.0	377 603.48	2 382 157.55	377 609.13	2 382 172.07	15.6	One bucket viable
02/12/2016	16:20	S03	DVV	PC	37.0	377 603.48	2 382 157.55	377 609.13	2 382 172.07	15.6	One bucket viable
02/12/2016	16:35	S03	DVV	FB	37.0	377 603.48	2 382 157.55	377 609.13	2 382 172.07	15.6	One bucket viable
02/12/2016	16:40	S03	DVV	NS	37.0	377 603.48	2 382 157.55	377 609.13	2 382 172.07	15.6	No grab
02/12/2016	16:45	S03	DVV	NS	37.0	377 603.48	2 382 157.55	377 609.13	2 382 172.07	15.6	No grab
02/12/2016	16:50	S03	DVV	NS	37.0	377 603.48	2 382 157.55	377 609.13	2 382 172.07	15.6	No grab
02/12/2016	19:15	S03	DVV	FC	37.0	377 603.48	2 382 157.55	377 609.13	2 382 172.07	15.6	
02/12/2016	19:50	S03	WS	TOP, MID, BOT	37.0	377 603.48	2 382 157.55	377 609.13	2 382 172.07	15.6	
02/12/2016	20:15	S03	WP	-	35.5	377 603.48	2 382 157.55	377 604.05	2 382 125.08	32.5	Current too strong and going under the vessel, waited until following morning
05/12/2016	10:15	S07	DVV	NS	24.0	378 581.63	2 382 990.50	378 572.26	2 382 976.17	17.1	No grab
05/12/2016	10:20	S07	DVV	NS	24.0	378 581.63	2 382 990.50	378 572.26	2 382 976.17	17.1	No grab
05/12/2016	10:35	S07	DVV	PC	24.0	378 581.63	2 382 990.50	378 572.26	2 382 976.17	17.1	No grab. Instead, took PC samples from both buckets.
05/12/2016	11:15	S07	WS	TOP, BOT	24.0	378 581.63	2 382 990.50	378 572.26	2 382 976.17	17.1	
05/12/2016	14:00	S07	WP	-	24.0	378 581.63	2 382 990.50	378 586.37	2 383 021.27	31.1	
06/12/2016	17:20	S08	DVV	NS	21.0	378 704.52	2 383 459.66	378 713.41	2 383 473.49	16.4	No grab
06/12/2016	17:35	S08	DVV	NS	21.0	378 704.52	2 383 459.66	378 713.41	2 383 473.49	16.4	No grab
06/12/2016	17:40	S08	DVV	PC	21.0	378 704.52	2 383 459.66	378 713.41	2 383 473.49	16.4	No grab. Instead, took PC samples from both buckets.
06/12/2016	18:05	S08	WS	TOP, BOT	21.0	378 704.52	2 383 459.66	378 713.41	2 383 473.49	16.4	
06/12/2016	21:20	S08	WP	-	21.0	378 704.52	2 383 459.66	378 700.01	2 383 428.17	31.8	
07/12/2016	17:40	S09	DVV	PC	15.0	379 147.46	2 384 382.35	379 132.62	2 384 391.77	17.6	
07/12/2016	17:55	S09	DVV	FA	15.0	379 147.46	2 384 382.35	379 132.62	2 384 391.77	17.6	
07/12/2016	17:55	S09	DVV	FB	15.0	379 147.46	2 384 382.35	379 132.62	2 384 391.77	17.6	
07/12/2016	18:10	S09	DVV	FC	15.0	379 147.46	2 384 382.35	379 132.62	2 384 391.77	17.6	
07/12/2016	18:25	S09	WS	TOP, BOT	15.0	379 147.46	2 384 382.35	379 132.62	2 384 391.77	17.6	

Date	Time [UTC +6.30]	Transect/ Station	Type	Sample Rep/ Still No.	Water Depth [m]	Proposed Location		Actual Location		Offset [m]	Notes
						Easting [m]	Northing [m]	Easting [m]	Northing [m]		
07/12/2016	17:25	S09	WP	-	15.0	379 147.46	2 384 382.35	379 117.10	2 384 347.13	46.5	

C.2 SAMPLE LOG

Date	Time [UTC +6:30]	Station	Sample Rep	Sample Depth/ Volume	Temp [˚C]	Redox [mV]	pH	Sediment Description (inc. stratigraphy)				Comments (fauna, smell, bioturbation, debris)	Sampling Personnel
								Depth [cm]	Sediment Type	Sediment Description	Colour (inc. Munsell Colour, if used)		
23/11/2016	03:50	S02	FA	17cm	26.5	198	7.97	17.0	M	Muddy clay	10YR 4.2		AG
23/11/2016	03:50	S02	PC	17cm	26.6	217	8.03	17.0	M	Muddy clay	10YR 4.2		AG
23/11/2016	04:10	S02	FB	15cm	26.2	224	7.96	15.0	S	Fine sand with shell fragments	7.5YR 5.2		AG
23/11/2016	04:10	S02	FC	15cm	26.6	152	7.94	15.0	S	Fine sand with shell fragments	7.5YR 5.2		AG
24/11/2016	09:00	S04	FA	14.5cm	27.7	213	7.86	14.5	mS	Sand with small amounts of clay	5YR 4.3		AG
24/11/2016	09:00	S04	PC	14.5cm	28.4	228	8.53	14.5	mS	Sand with small amounts of clay	5YR 4.3		AG
24/11/2016	09:20	S04	FB	13.5cm	28.7	203	7.70	13.5	S	Fine sand	5YR 4.2		AG
24/11/2016	09:30	S04	FC	14cm	28.5	209	8.77	14.0	S	Fine sand	2.5YR 4.3		AG
26/11/2016	08:25	S05	-									No grab	AG
26/11/2016	08:30	S05	PC	10cm	27.0	-46	7.89	10.0	S	Sand with shell fragments	2.5YR 4.4		AG
26/11/2016	08:50	S05	-									No grab	AG
26/11/2016	08:55	S05	FA	13.5cm	28.0	159	8.03	13.5	S	Sand with shell fragments	2.5YR 4.4		AG
26/11/2016	08:55	S05	FB	13.5cm	27.8	158	7.99	13.5	S	Sand with shell fragments	2.5YR 4.4		AG
26/11/2016	09:05	S05	-									No grab	AG
26/11/2016	09:15	S05	-									No grab due to sedimentary rock getting stuck in the buckets (see photos)	AG
28/11/2016	19:25	S01	FA	15cm	26.7	191	7.94	15.0	S	Sand with shell fragments	5YR 4.3		AG
28/11/2016	19:25	S01	PC	15cm	26.3	207	7.73	15.0	S	Sand with shell fragments	5YR 4.3		AG
28/11/2016	19:45	S01	FB	10.5cm	26.9	175	7.99	10.5	mS	Muddy sand	5YR 4.2		AG
28/11/2016	19:45	S01	FC	12cm	26.8	179	8.02	12.0	mS	Muddy sand	5YR 4.2		AG
02/12/2016	16:20	S03	FA	10cm	26.9	205	8.10	10.0	S	Sand with shell fragments	2.5YR 5.3		AG
02/12/2016	16:20	S03	PC	15cm	26.9	204	7.83	15.0	S	Sand with shell fragments	2.5Yr 5.3		AG
02/12/2016	16:35	S03	FB	13cm	26.9	183	8.12	13.0	S	Sand with shell fragments	2.5YR 5.2		AG
02/12/2016	16:40	S03	-									No grab	AG
02/12/2016	16:45	S03	-									No grab	AG

Date	Time [UTC +6:30]	Station	Sample Rep	Sample Depth/ Volume	Temp [˚C]	Redox [mV]	pH	Sediment Description (inc. stratigraphy)				Comments (fauna, smell, bioturbation, debris)	Sampling Personnel
								Depth [cm]	Sediment Type	Sediment Description	Colour (inc. Munsell Colour, if used)		
02/12/2016	16:50	S03	-									No grab	AG
02/12/2016	19:15	S03	FC	12cm	26.6	192	8.09	12.0	S	Sand with shell fragments	5YR 5.2		AG
05/12/2016	10:15	S07	-									No grab	AG
05/12/2016	10:20	S07	-									No grab	AG
05/12/2016	10:35	S07	PCi	5cm	27.4	58	7.64	5.0	M	Firm clay	10GY 5.1	No grab. Instead, took PC replicates.	AG
05/12/2016	10:35	S07	PCii	5cm	27.4	10	7.96	5.0	M	Firm clay	10GY 5.1	No grab. Instead, took PC replicates.	AG
06/12/2016	17:20	S08	-									No grab	AG
06/12/2016	17:35	S08	-									No grab	AG
06/12/2016	17:40	S08	PCi	3cm	26.1	136	7.85	3.0	M	Firm clay	GLEY1 4	No grab. Instead, took PC replicates.	AG
06/12/2016	17:40	S08	PCii	3cm	26.2	52	8.10	3.0	M	Firm clay	GLEY1 4	No grab. Instead, took PC replicates.	AG
07/12/2016	17:40	S09	PC	10cm	26.4	168	8.16	10.0	sM	Sandy clay	10Y 4.2		AG
07/12/2016	17:55	S09	FA	10cm	26.3	109	8.13	10.0	sM	Clay with sand	10Y 4.2		AG
07/12/2016	17:55	S09	FB	9cm	26.4	101	8.09	9.0	sM	Sandy clay	2.5YR 4.2		AG
07/12/2016	18:10	S09	FC	15cm	26.3	146	8.16	15.0	sM	Sandy clay	2.5YR 4.3		AG

D. SEDIMENT PARTICLE SIZE AND GRAB PHOTOS

STATION S01

Easting: 377264.58 mE	Depth: 37 m
Northing: 2381627.52 mN	Sediment type: Slightly Gravelly Muddy Sand

Easting: 377264.58 mE	Depth: 37 m
Northing: 2381627.52 mN	Sediment type: Slightly Gravelly Muddy Sand

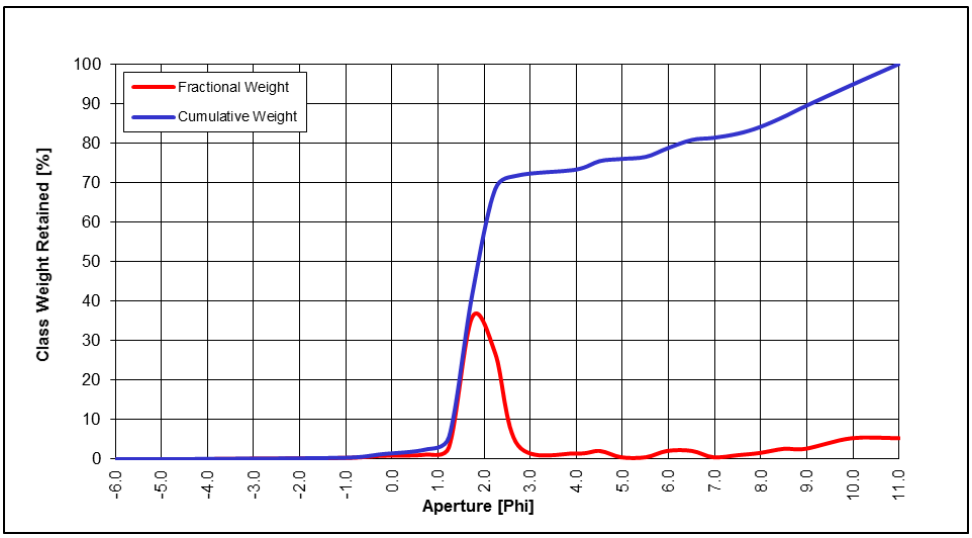
FRACTIONAL DATA

Aperture	Aperture	Fractional	Cumulative
63000	-6.0	0.0	0.0
50000	-5.6	0.0	0.0
35000	-5.1	0.0	0.0
2000	-1.0	0.4	0.4
1180	-0.2	0.9	1.3
600	0.7	1.2	2.5
425	1.2	3.1	5.6
300	1.7	35.9	41.5
212	2.2	26.8	68.3
150	2.7	3.5	71.8
63	4.0	1.5	73.3
40	4.5	2.1	75.4
32	5.0	0.5	75.9
20	5.5	0.5	76.5
16	6.0	2.1	78.6
10	6.5	2.1	80.7
8	7.0	0.5	81.3
5	7.5	1.1	82.3
4	8.0	1.6	84.0
3	8.5	2.7	86.6
2	9.0	2.7	89.3
1	10.0	5.3	94.7
<1	11.0	5.3	100.0
TOTAL		100.0	100.0

STATISTICS

Sorting	3.02	Very Poorly Sorted
Skewness	0.84	Very Fine Skewed
Kurtosis	1.23	Leptokurtic
Mean [µm]	74.2	Very Fine Sand
Mean [phi]	3.75	
Median [µm]	268.7	Medium Sand
Median [phi]	1.90	
Gravel [%]	0.4	Slightly Gravelly Muddy Sand
Sand [%]	72.9	
Mud [%]	26.7	

PARTICLE SIZE DISTRIBUTION



Based on Wentworth (1922) Grain Size Classification. Statistics based on Folk and Ward (1957)

STATION S02

Easting: 377808.65 mE	Depth: 38 m
Northing: 2381683.52mN	Sediment type: Muddy Sand

Easting: 377808.65 mE	Depth: 38 m
Northing: 2381683.52mN	Sediment type: Muddy Sand

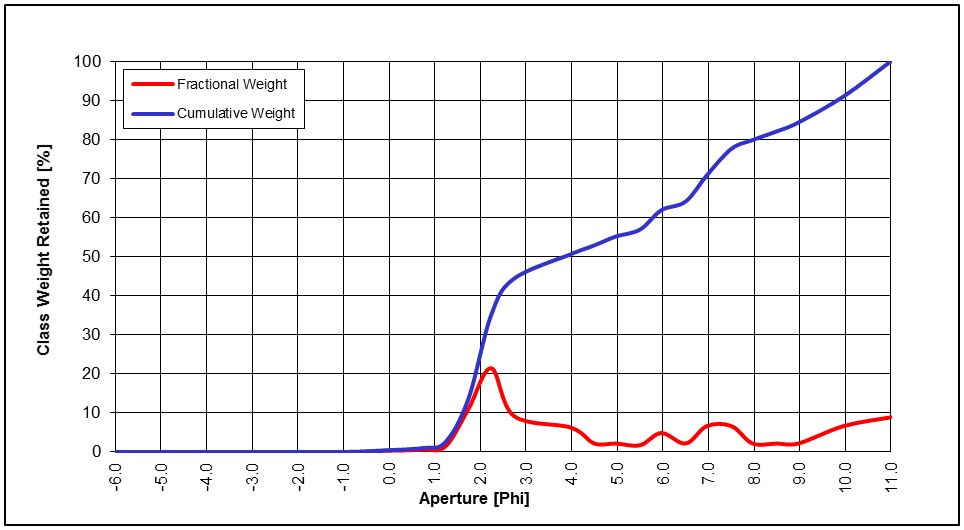
FRACTIONAL DATA

Aperture	Aperture	Fractional	Cumulative
63000	-6.0	0.0	0.0
50000	-5.6	0.0	0.0
35000	-5.1	0.0	0.0
2000	-1.0	0.0	0.0
1180	-0.2	0.3	0.3
600	0.7	0.7	1.0
425	1.2	1.5	2.5
300	1.7	11.0	13.5
212	2.2	21.5	35.0
150	2.7	9.3	44.3
63	4.0	6.3	50.6
40	4.5	2.2	52.9
32	5.0	2.2	55.1
20	5.5	1.8	56.9
16	6.0	4.9	61.8
10	6.5	2.2	64.1
8	7.0	6.7	70.8
5	7.5	6.7	77.6
4	8.0	2.2	79.8
3	8.5	2.2	82.0
2	9.0	2.2	84.3
1	10.0	6.7	91.0
<1	11.0	9.0	100.0
TOTAL		100.0	100.0

STATISTICS

Sorting	3.31	Very Poorly Sorted
Skewness	0.46	Very Fine Skewed
Kurtosis	0.77	Platykurtic
Mean [µm]	34.4	Coarse Silt
Mean [phi]	4.86	
Median [µm]	68.6	Very Fine Sand
Median [phi]	3.86	
Gravel [%]	0.0	Muddy Sand
Sand [%]	50.6	
Mud [%]	49.4	

PARTICLE SIZE DISTRIBUTION



Based on Wentworth (1922) Grain Size Classification. Statistics based on Folk and Ward (1957)

STATION S03

Easting: 377609.13mE	Depth: 37 m
Northing: 2382172.07mN	Sediment type: Slightly Gravelly Muddy Sand

Easting: 377609.13mE	Depth: 37 m
Northing: 2382172.07mN	Sediment type: Slightly Gravelly Muddy Sand

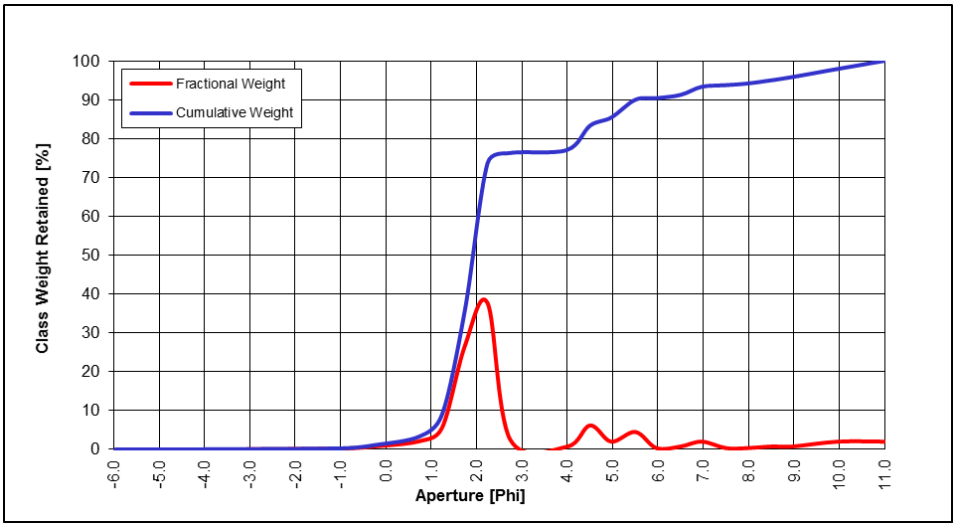
FRACTIONAL DATA

Aperture	Aperture	Fractional	Cumulative
63000	-6.0	0.0	0.0
50000	-5.6	0.0	0.0
35000	-5.1	0.0	0.0
2000	-1.0	0.3	0.3
1180	-0.2	0.9	1.2
600	0.7	2.2	3.4
425	1.2	5.7	9.0
300	1.7	26.8	35.8
212	2.2	37.8	73.7
150	2.7	2.6	76.3
63	4.0	0.8	77.1
40	4.5	6.3	83.3
32	5.0	2.1	85.4
20	5.5	4.6	90.0
16	6.0	0.4	90.4
10	6.5	0.8	91.2
8	7.0	2.1	93.3
5	7.5	0.4	93.7
4	8.0	0.4	94.2
3	8.5	0.8	95.0
2	9.0	0.8	95.8
1	10.0	2.1	97.9
<1	11.0	2.1	100.0
TOTAL		100.0	100.0

STATISTICS

Sorting	2.02	Very Poorly Sorted
Skewness	0.70	Very Fine Skewed
Kurtosis	3.32	Extremely Leptokurtic
Mean [µm]	156.1	Fine Sand
Mean [phi]	2.68	
Median [µm]	263.4	Medium Sand
Median [phi]	1.92	
Gravel [%]	0.3	Slightly Gravelly Muddy Sand
Sand [%]	76.8	
Mud [%]	22.9	

PARTICLE SIZE DISTRIBUTION



Based on Wentworth (1922) Grain Size Classification. Statistics based on Folk and Ward (1957)

STATION S04

Easting: 377784.76 mE	Depth: 37 m
Northing: 2381393.29 mN	Sediment type: Sandy Mud

Easting: 377784.76 mE	Depth: 37 m
Northing: 2381393.29 mN	Sediment type: Sandy Mud

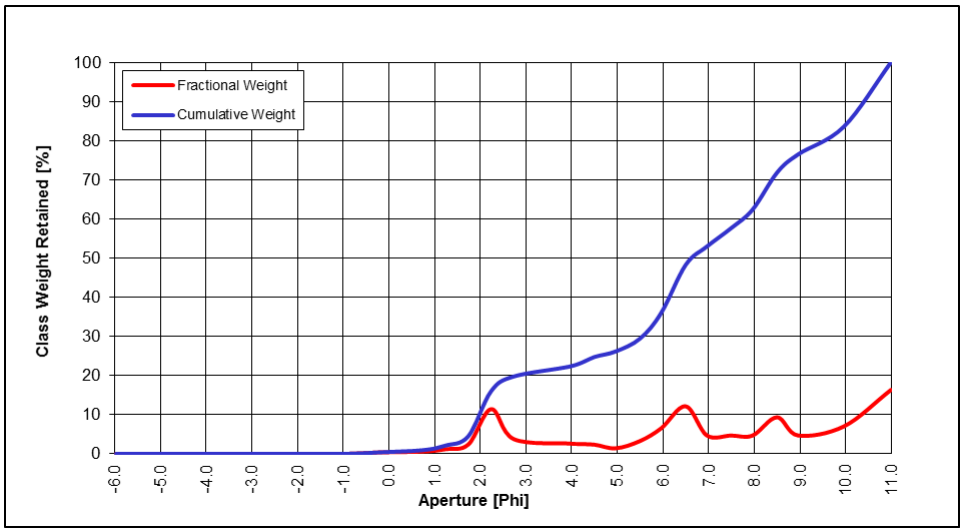
FRACTIONAL DATA

Aperture	Aperture	Fractional	Cumulative
63000	-6.0	0.0	0.0
50000	-5.6	0.0	0.0
35000	-5.1	0.0	0.0
2000	-1.0	0.0	0.0
1180	-0.2	0.3	0.3
600	0.7	0.6	0.9
425	1.2	1.2	2.1
300	1.7	2.4	4.5
212	2.2	11.5	16.0
150	2.7	3.8	19.8
63	4.0	2.6	22.4
40	4.5	2.4	24.7
32	5.0	1.4	26.1
20	5.5	3.3	29.4
16	6.0	6.6	36.0
10	6.5	12.2	48.2
8	7.0	4.7	53.0
5	7.5	4.7	57.7
4	8.0	4.7	62.4
3	8.5	9.4	71.8
2	9.0	4.7	76.5
1	10.0	7.1	83.5
<1	11.0	16.5	100.0
TOTAL		100.0	100.0

STATISTICS

Sorting	3.55	Very Poorly Sorted
Skewness	-0.05	Symmetrical
Kurtosis	1.04	Mesokurtic
Mean [µm]	12.2	Fine Silt
Mean [phi]	6.35	
Median [µm]	9.2	Fine Silt
Median [phi]	6.76	
Gravel [%]	0.0	Sandy Mud
Sand [%]	22.4	
Mud [%]	77.6	

PARTICLE SIZE DISTRIBUTION



Based on Wentworth (1922) Grain Size Classification. Statistics based on Folk and Ward (1957)

STATION S05

Easting: 377913.33 mE	Depth: 35 m
Northing: 2382326.48 mN	Sediment type: Slightly Gravelly Muddy Sand

Easting: 377913.33 mE	Depth: 35 m
Northing: 2382326.48 mN	Sediment type: Slightly Gravelly Muddy Sand

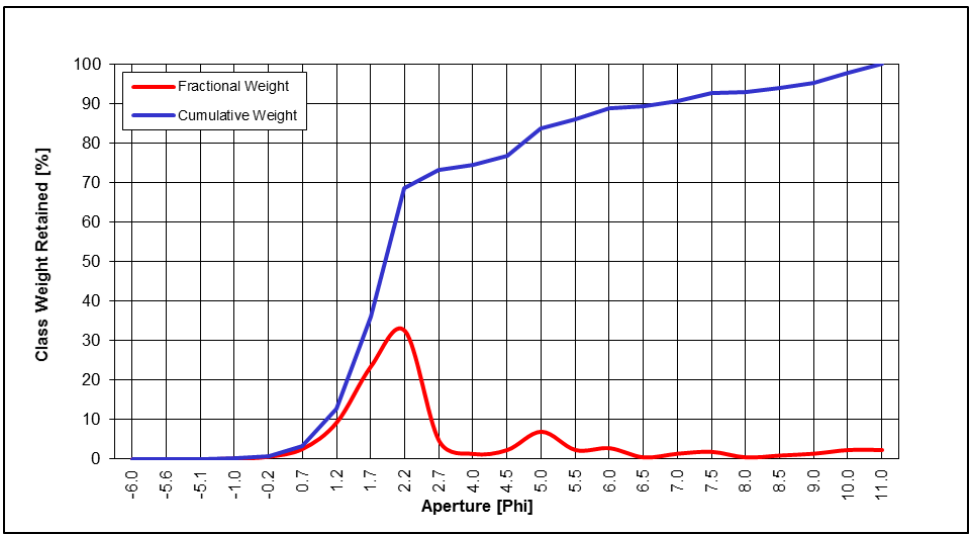
FRACTIONAL DATA

Aperture	Aperture	Fractional	Cumulative
63000	-6.0	0.0	0.0
50000	-5.6	0.0	0.0
35000	-5.1	0.0	0.0
2000	-1.0	0.1	0.1
1180	-0.2	0.6	0.8
600	0.7	2.6	3.4
425	1.2	9.3	12.7
300	1.7	23.5	36.2
212	2.2	32.4	68.6
150	2.7	4.6	73.2
63	4.0	1.3	74.5
40	4.5	2.3	76.8
32	5.0	6.9	83.8
20	5.5	2.3	86.1
16	6.0	2.8	88.9
10	6.5	0.5	89.3
8	7.0	1.4	90.7
5	7.5	1.9	92.6
4	8.0	0.5	93.1
3	8.5	0.9	94.0
2	9.0	1.4	95.4
1	10.0	2.3	97.7
<1	11.0	2.3	100.0
TOTAL		100.0	100.0

STATISTICS

Sorting	2.15	Very Poorly Sorted
Skewness	0.69	Very Fine Skewed
Kurtosis	1.26	Leptokurtic
Mean [µm]	147.5	Fine Sand
Mean [phi]	2.76	
Median [µm]	258.8	Medium Sand
Median [phi]	1.95	
Gravel [%]	0.1	Slightly Gravelly Muddy Sand
Sand [%]	74.4	
Mud [%]	25.5	

PARTICLE SIZE DISTRIBUTION



Based on Wentworth (1922) Grain Size Classification. Statistics based on Folk and Ward (1957)

STATION S07

Easting: 378572.26 mE	Depth: 24 m
Northing: 2382976.17 mN	Sediment type: Mud

No Photograph Available

Easting: 378572.26 mE	Depth: 24 m
Northing: 2382976.17 mN	Sediment type: Mud

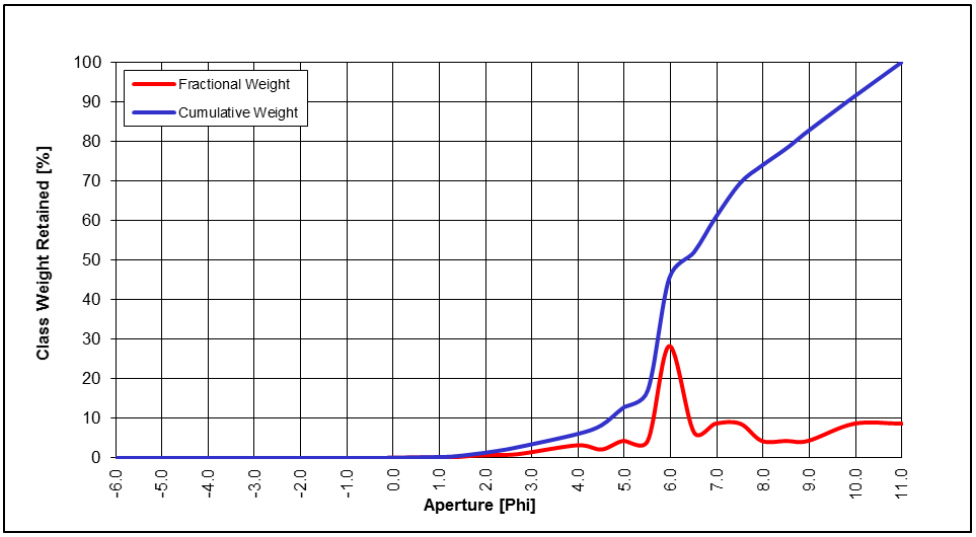
FRACTIONAL DATA

Aperture	Aperture	Fractional	Cumulative
63000	-6.0	0.0	0.0
50000	-5.6	0.0	0.0
35000	-5.1	0.0	0.0
2000	-1.0	0.0	0.0
1180	-0.2	0.0	0.0
600	0.7	0.2	0.2
425	1.2	0.1	0.4
300	1.7	0.6	1.0
212	2.2	0.8	1.8
150	2.7	1.1	2.9
63	4.0	3.3	6.1
40	4.5	2.2	8.3
32	5.0	4.4	12.7
20	5.5	4.4	17.0
16	6.0	28.4	45.4
10	6.5	6.6	52.0
8	7.0	8.7	60.7
5	7.5	8.7	69.4
4	8.0	4.4	73.8
3	8.5	4.4	78.2
2	9.0	4.4	82.5
1	10.0	8.7	91.3
<1	11.0	8.7	100.0
TOTAL		100.0	100.0

STATISTICS

Sorting	2.10	Very Poorly Sorted
Skewness	0.37	Very Fine Skewed
Kurtosis	1.33	Leptokurtic
Mean [µm]	7.7	Very Fine Silt
Mean [phi]	7.02	
Median [µm]	11.5	Fine Silt
Median [phi]	6.44	
Gravel [%]	0.4	Mud
Sand [%]	72.9	
Mud [%]	26.7	

PARTICLE SIZE DISTRIBUTION



Based on Wentworth (1922) Grain Size Classification. Statistics based on Folk and Ward (1957)

STATION S08

Easting: 378713.41 mE	Depth: 21 m
Northing: 2383473.49 mN	Sediment type: Muddy Sand

No Photograph Available

Easting: 378713.41 mE	Depth: 21 m
Northing: 2383473.49 mN	Sediment type: Muddy Sand

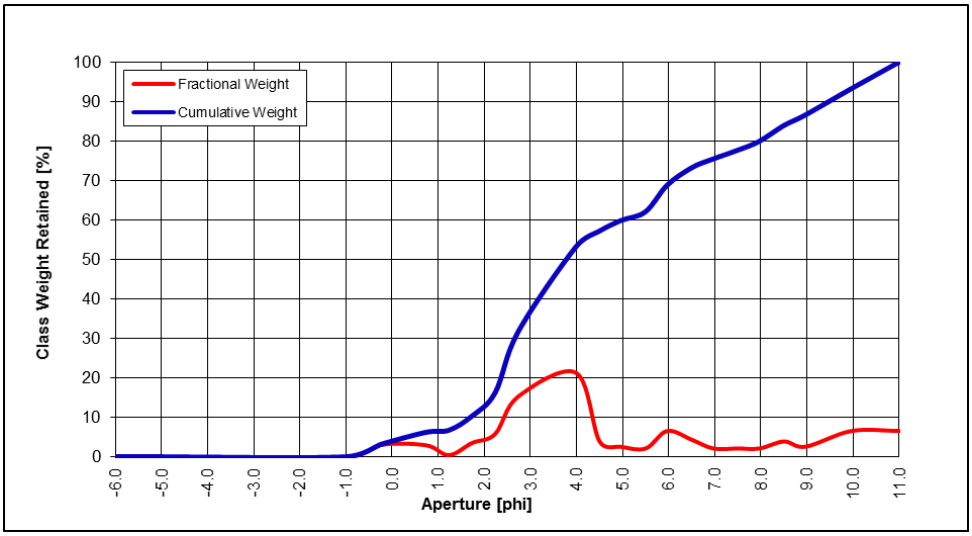
FRACTIONAL DATA

Aperture	Aperture	Fractional	Cumulative
63000	-6.0	0.0	0.0
50000	-5.6	0.0	0.0
35000	-5.1	0.0	0.0
2000	-1.0	0.0	0.0
1180	-0.2	3.2	3.2
600	0.7	3.1	6.2
425	1.2	0.5	6.7
300	1.7	3.6	10.3
212	2.2	5.9	16.3
150	2.7	15.4	31.7
63	4.0	21.5	53.2
40	4.5	4.0	57.2
32	5.0	2.7	59.9
20	5.5	2.2	62.1
16	6.0	6.7	68.8
10	6.5	4.5	73.3
8	7.0	2.2	75.5
5	7.5	2.2	77.7
4	8.0	2.2	79.9
3	8.5	4.0	84.0
2	9.0	2.7	86.6
1	10.0	6.7	93.3
<1	11.0	6.7	100.0
TOTAL		100.0	100.0

STATISTICS

Sorting	3.19	Very Poorly Sorted
Skewness	0.42	Very Fine Skewed
Kurtosis	0.98	Mesokurtic
Mean [µm]	33.8	Coarse Silt
Mean [phi]	4.89	
Median [µm]	71.7	Very Fine Sand
Median [phi]	3.80	
Gravel [%]	0.0	Muddy Sand
Sand [%]	53.2	
Mud [%]	46.8	

PARTICLE SIZE DISTRIBUTION



Based on Wentworth (1922) Grain Size Classification. Statistics based on Folk and Ward (1957)

STATION S09

No Available Photographs

Easting: 379132.62 mE	Depth: 15 m
Northing: 2384391.77 mN	Sediment type: Slightly Gravelly Muddy Sand

No Available photographs

Easting: 379132.62 mE	Depth: 15 m
Northing: 2384391.77 mN	Sediment type: Slightly Gravelly Muddy Sand

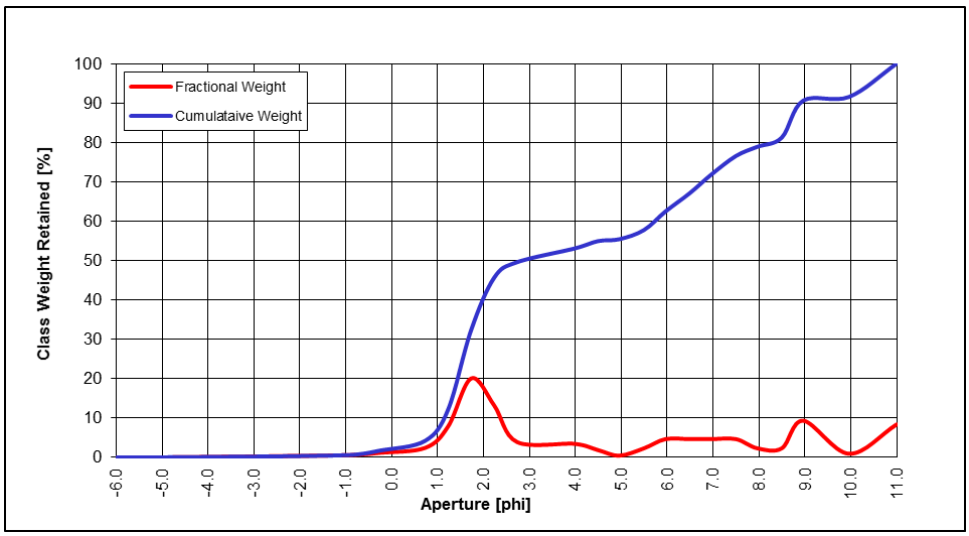
FRACTIONAL DATA

Aperture	Aperture	Fractional	Cumulative
63000	-6.0	0.0	0.0
50000	-5.6	0.0	0.0
35000	-5.1	0.0	0.0
2000	-1.0	0.6	0.6
1180	-0.2	1.2	1.8
600	0.7	2.5	4.2
425	1.2	7.9	12.2
300	1.7	20.2	32.4
212	2.2	13.3	45.6
150	2.7	3.9	49.6
63	4.0	3.5	53.1
40	4.5	1.9	54.9
32	5.0	0.5	55.4
20	5.5	2.3	57.8
16	6.0	4.7	62.4
10	6.5	4.7	67.1
8	7.0	4.7	71.8
5	7.5	4.7	76.5
4	8.0	2.3	78.9
3	8.5	2.3	81.2
2	9.0	9.4	90.6
1	10.0	0.9	91.6
<1	11.0	8.4	100.0
TOTAL		100.0	100.0

STATISTICS

Sorting	3.45	Very Poorly Sorted
Skewness	0.59	Very Fine Skewed
Kurtosis	0.74	Platykurtic
Mean [µm]	50.1	Coarse Silt
Mean [phi]	4.32	
Median [µm]	135.0	Fine Sand
Median [phi]	2.89	
Gravel [%]	0.6	Slightly Gravelly Muddy Sand
Sand [%]	52.5	
Mud [%]	46.9	

PARTICLE SIZE DISTRIBUTION



Based on Wentworth (1922) Grain Size Classification. Statistics based on Folk and Ward (1957)

E. MACROFAUNAL DATA

The following taxa were included in the statistical analyses of macrofaunal community structure

Taxon	Authority	S01FA	S01FB	S02FA	S02FB	S03FA	S03FB	S04FA	S04FB	S05FA	S05FB	S09FA	S09FB	Total
NEMERTEA	-									1				1
SIPUNCULA (Type A)	-				1									1
Glycera macrobranchia	Moore, 1911				2						1	1		4
Goniada japonica	Izuka, 1912												1	1
Onuphis eremita (agg.)	Audouin & Milne Edwards, 1833											1		1
Lumbrineris cf. *cingulata*	Ehlers, 1897									1				1
Scoloplos (Leodamus) gracilis	Pillai, 1961											2	2	4
Aricidea (Type A)	Webster, 1879		1											1
Cirrophorus (?)	Ehlers, 1908		1											1
Levinsenia	Mesnil, 1897												1	1
Spionidae (dam.)	Grube, 1850						1							1
Magelona crenulifrons	Gallardo, 1968			1	2				1			1	1	6
Kirkegaardia	Blake, 2016							1				3		4
Capitellethus	Chamberlin, 1919											1	1	2
Heteromastus	Eisig, 1887											1		1
Mediomastus	Hartman, 1944			2	1									3
Notomastus	M. Sars, 1851	2			1					1	3			7
Armandia (Type A)	Filippi, 1861	4			4	8		3		3				22
COPEPODA	Milne Edwards, 1840			1					2	1	2	2		8
Indischnopus herdmani	(Walker, 1904)				1			1					**2**	4
Perioculodes	G.O. Sars, 1892		1					1			1			3
Urothoe ruber	Giles, 1888							1						1
Phoxocephalidae (Type A)	G.O. Sars, 1891				1			5		1				7
Gammaridea (Type A)	Latreille, 1802				1			1						2
Xenanthura orientalis	Barnard, 1935									5				5
Nematopalaemon karnafuliensis	(Ali Azam Khan, Fincham & Mahmood, 1980)	1												1
Pinnotheridae (Type A)	De Haan, 1833		1											1
Tellinidae (Type A)	Blainville, 1814		1		2	1		2		2	2			10
Number of taxa		**3**	**5**	**3**	**10**	**2**	**1**	**8**	**2**	**8**	**5**	**8**	**6**	**28**
Abundance		**7**	**5**	**4**	**16**	**9**	**1**	**15**	**3**	**15**	**9**	**12**	**8**	**104**

The following taxa were excluded from the analysis

Taxon	Authority	S01FA	S01FB	S02FA	S02FB	S03FA	S03FB	S04FA	S04FB	S05FA	S05FB	S09FA	S09FB	Total
Folliculinidae	Dons, 1914	P	P		P		P	P	P	P	P		P	P
Nephtyidae (juv.)	Grube, 1850												1	1
Gastropoda (juv.)	Cuvier, 1795										1	1		2
Tellinidae (juv.)	Blainville, 1814												1	1
Number of taxa		**1**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**2**	**1**	**3**	**4**
Abundance		**P**	**P**	**0**	**P**	**0**	**P**	**P**	**P**	**P**	**1**	**1**	**2**	**4**

F. CORRELATIONS

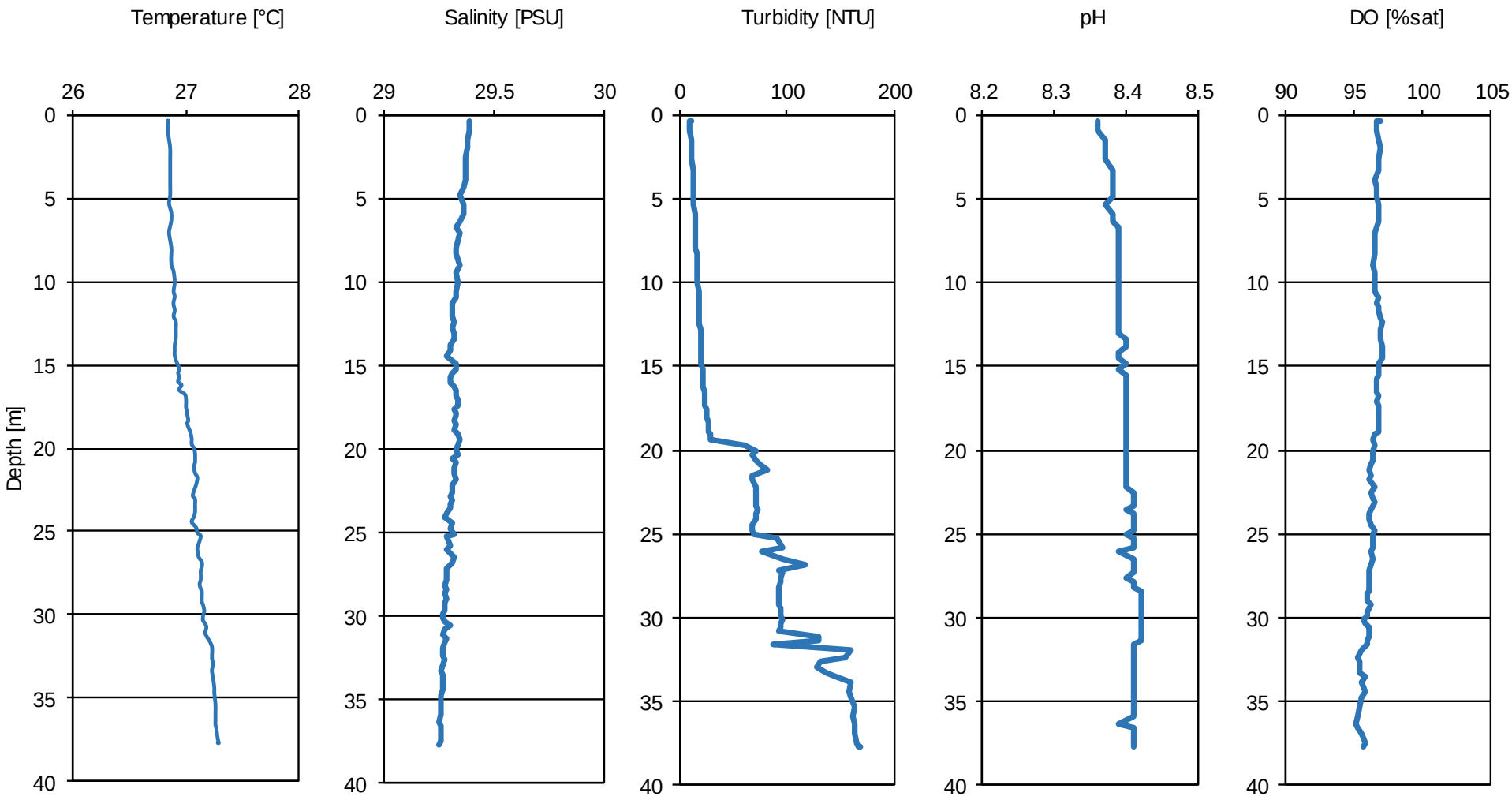
	Depth	PSD Mean [µm]	Gravel	Sand	Silt	Clay	Fines	Total Organic Carbon	Organic Matter as LOI	TPHs C10-C40	Benzo(a)pyrene	Arsenic as As	Barium as Ba	Cadium as Cd	Chronium as Cr	Copper as Cu	Iron as Fe	Mercury as Hg	Manganese as Mn	Nickel as Ni	Lead as Pb	Strontium as Sr	Vanadium as V	Zinc as Zn	Taxa	Individuals	Simpsons [D]	Brillouins [Hb]	Shannon-Weiner [Hs]	Pielou [J]
Depth																														
PSD Mean [µm]	0.030																													
Gravel	-0.277	0.464																												
Sand	0.030	1.000	0.464																											
Silt	-0.152	-0.943	-0.203	-0.943																										
Clay	-0.213	-0.829	-0.638	-0.829	0.771																									
Fines	-0.030	-1.000	-0.464	-1.000	0.943	0.829																								
Total Organic Carbon	0.355	-0.577	0.092	-0.577	0.698	0.213	0.577																							
Organic Matter as LOI	0.273	-0.829	-0.464	-0.829	0.657	0.543	0.829	0.395																						
TPHs C10-C40	-0.395	-0.657	0.000	-0.657	0.600	0.371	0.657	0.152	0.714																					
Benzo(a)pyrene	-0.161	-0.880	-0.554	-0.880	0.759	0.880	0.880	0.161	0.820	0.698																				
Arsenic as As	0.395	0.486	-0.464	0.486	-0.600	-0.086	-0.486	-0.455	-0.429	-0.829	-0.334																			
Barium as Ba	0.091	-0.886	-0.522	-0.886	0.714	0.600	0.886	0.395	0.943	0.771	0.820	-0.486																		
Cadium as Cd	0.063	-0.912	-0.478	-0.912	0.765	0.677	0.912	0.375	0.971	0.794	0.907	-0.500	0.971																	
Chronium as Cr	-0.152	-0.943	-0.464	-0.943	0.829	0.771	0.943	0.334	0.886	0.829	0.941	-0.543	0.943	0.971																
Copper as Cu	0.091	-0.886	-0.522	-0.886	0.714	0.600	0.886	0.395	0.943	0.771	0.820	-0.486	1.000	0.971	0.943															
Iron as Fe	-0.152	-0.943	-0.464	-0.943	0.829	0.771	0.943	0.334	0.886	0.829	0.941	-0.543	0.943	0.971	1.000	0.943														
Mercury as Hg	0.820	0.257	-0.058	0.257	-0.429	-0.543	-0.257	0.030	0.257	-0.143	-0.273	0.200	0.086	0.029	-0.200	0.086	-0.200													
Manganese as Mn	0.334	0.714	-0.116	0.714	-0.771	-0.543	-0.714	-0.334	-0.657	-0.829	-0.759	0.771	-0.600	-0.736	-0.771	-0.600	-0.771	0.314												
Nickel as Ni	-0.395	-0.829	-0.203	-0.829	0.771	0.657	0.829	0.213	0.771	0.943	0.880	-0.714	0.829	0.883	0.943	0.829	0.943	-0.314	-0.886											
Lead as Pb	0.091	-0.886	-0.522	-0.886	0.714	0.600	0.886	0.395	0.943	0.771	0.820	-0.486	1.000	0.971	0.943	1.000	0.943	0.086	-0.600	0.829										
Strontium as Sr	-0.334	0.086	0.638	0.086	-0.029	-0.486	-0.086	0.030	0.086	0.600	-0.152	-0.771	0.143	0.088	0.086	0.143	0.086	0.143	-0.314	0.314	0.143									
Vanadium as V	0.091	-0.886	-0.522	-0.886	0.714	0.600	0.886	0.395	0.943	0.771	0.820	-0.486	1.000	0.971	0.943	1.000	0.943	0.086	-0.600	0.829	1.000	0.143								
Zinc as Zn	-0.152	-0.943	-0.464	-0.943	0.829	0.771	0.943	0.334	0.886	0.829	0.941	-0.543	0.943	0.971	1.000	0.943	1.000	-0.200	-0.771	0.943	0.943	0.086	0.943							
Taxa	-0.750	-0.647	-0.149	-0.647	0.647	0.677	0.647	-0.031	0.412	0.794	0.750	-0.588	0.559	0.606	0.765	0.559	0.765	-0.677	-0.736	0.883	0.559	0.235	0.559	0.765						
Individuals	-0.832	-0.232	-0.191	-0.232	0.232	0.406	0.232	-0.277	-0.116	0.348	0.277	-0.203	0.174	0.104	0.319	0.174	0.319	-0.754	-0.116	0.406	0.174	0.116	0.174	0.319	0.746					
Simpsons [D]	-0.880	-0.486	0.029	-0.486	0.543	0.543	0.486	-0.091	0.200	0.714	0.577	-0.600	0.371	0.412	0.600	0.371	0.600	-0.771	-0.657	0.771	0.371	0.314	0.371	0.600	0.971	0.812				
Brillouins [Hb]	-0.880	-0.486	0.029	-0.486	0.543	0.543	0.486	-0.091	0.200	0.714	0.577	-0.600	0.371	0.412	0.600	0.371	0.600	-0.771	-0.657	0.771	0.371	0.314	0.371	0.600	0.971	0.812	1.000			
Shannon-Weiner [Hs]	-0.801	-0.609	-0.015	-0.609	0.667	0.638	0.609	0.031	0.319	0.754	0.678	-0.638	0.464	0.522	0.696	0.464	0.696	-0.754	-0.754	0.841	0.464	0.261	0.464	0.696	0.985	0.735	0.986	0.986		
Pielou [J]	-0.616	-0.493	0.309	-0.493	0.551	0.232	0.493	0.154	0.435	0.928	0.493	-0.928	0.522	0.552	0.638	0.522	0.638	-0.348	-0.812	0.841	0.522	0.725	0.522	0.638	0.806	0.441	0.812	0.812	0.824	

Notes: Significance:

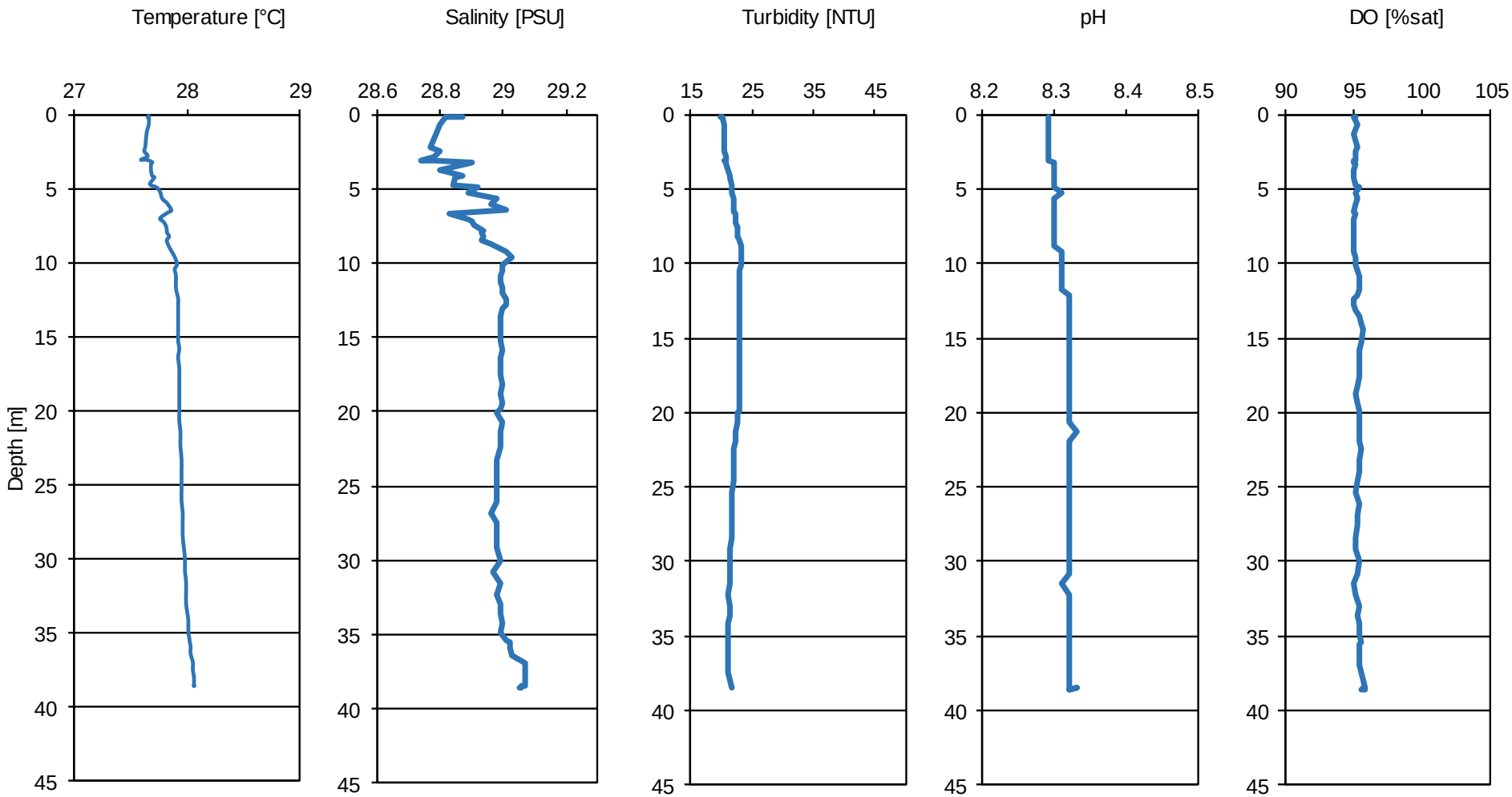
P=0.05 at 0.886 (n=6)

P=-0.05 at -0.886 (n=6)

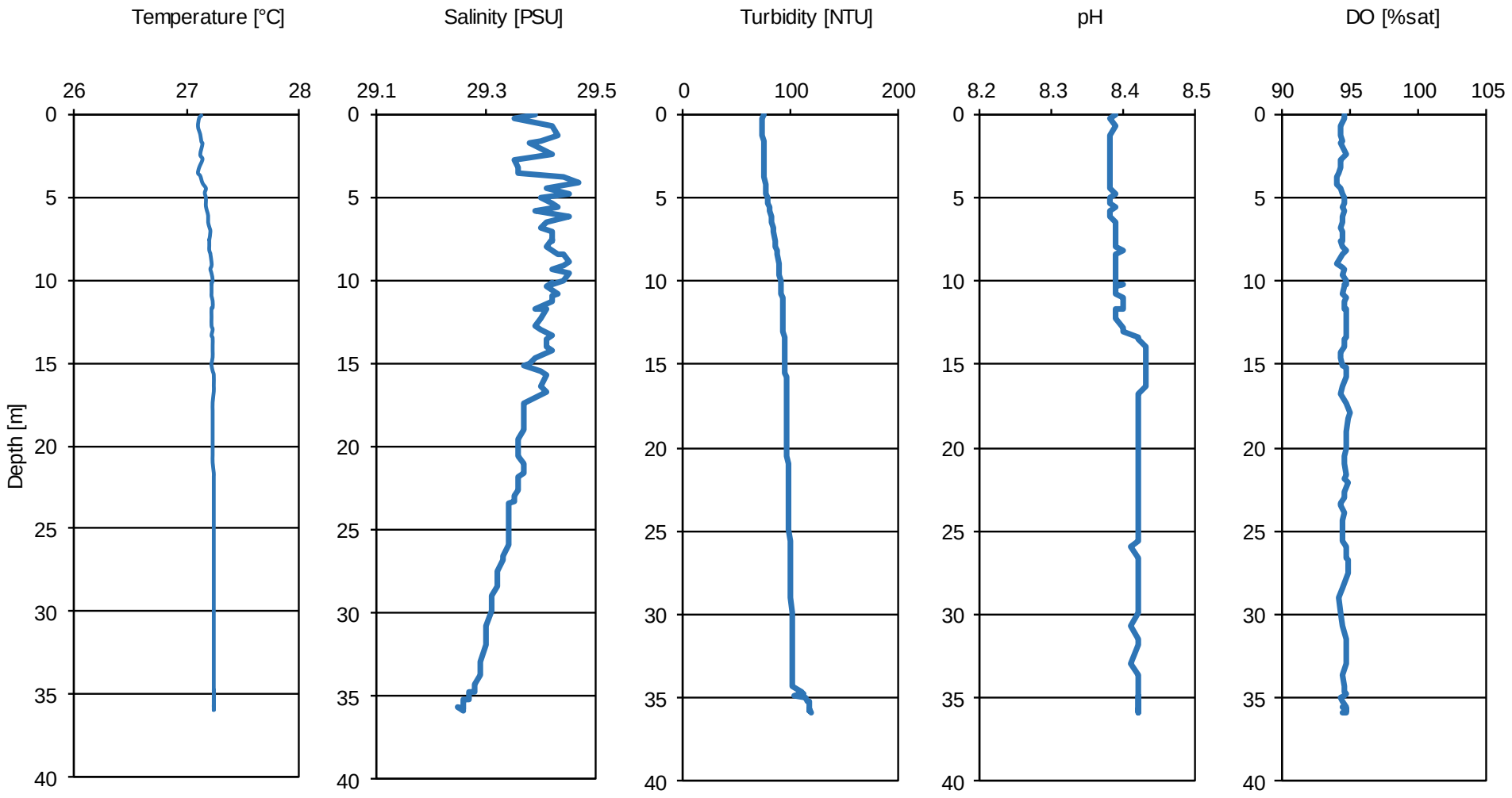
G. WATER PROFILES


Temperature [°C]
Salinity [PSU]
Turbidity [NTU]
pH
DO [%sat]
Depth [m]
26
27
28
29
29.5
30
0
100
200
8.2
8.3
8.4
8.5
90
95
100
105
0
5
10
15
20
25
30
35
40

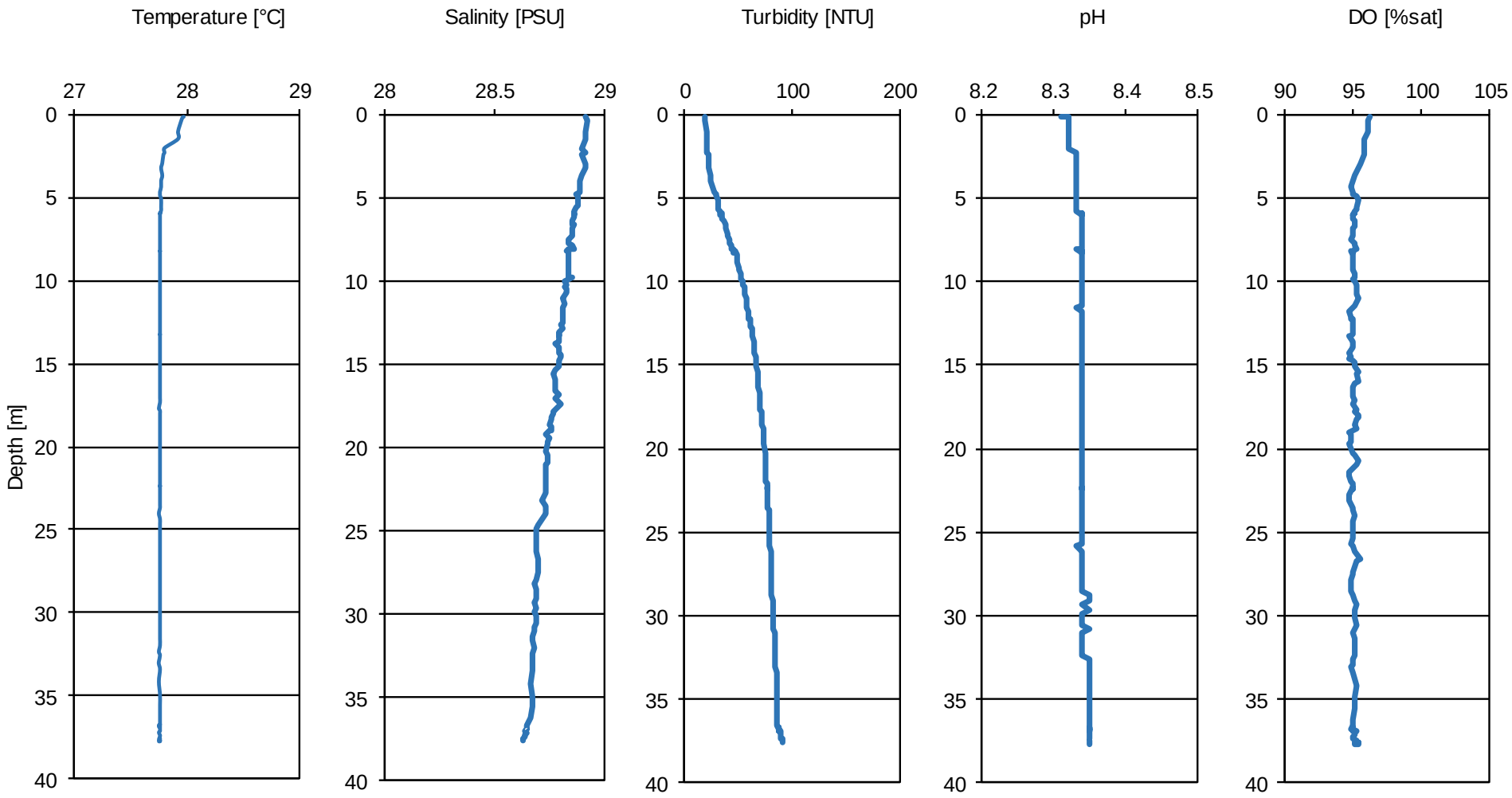
S01


Temperature [°C]
Salinity [PSU]
Turbidity [NTU]
pH
DO [%sat]
Depth [m]
27
28
29
28.6
28.8
29
29.2
15
25
35
45
8.2
8.3
8.4
8.5
90
95
100
105
0
5
10
15
20
25
30
35
40
45

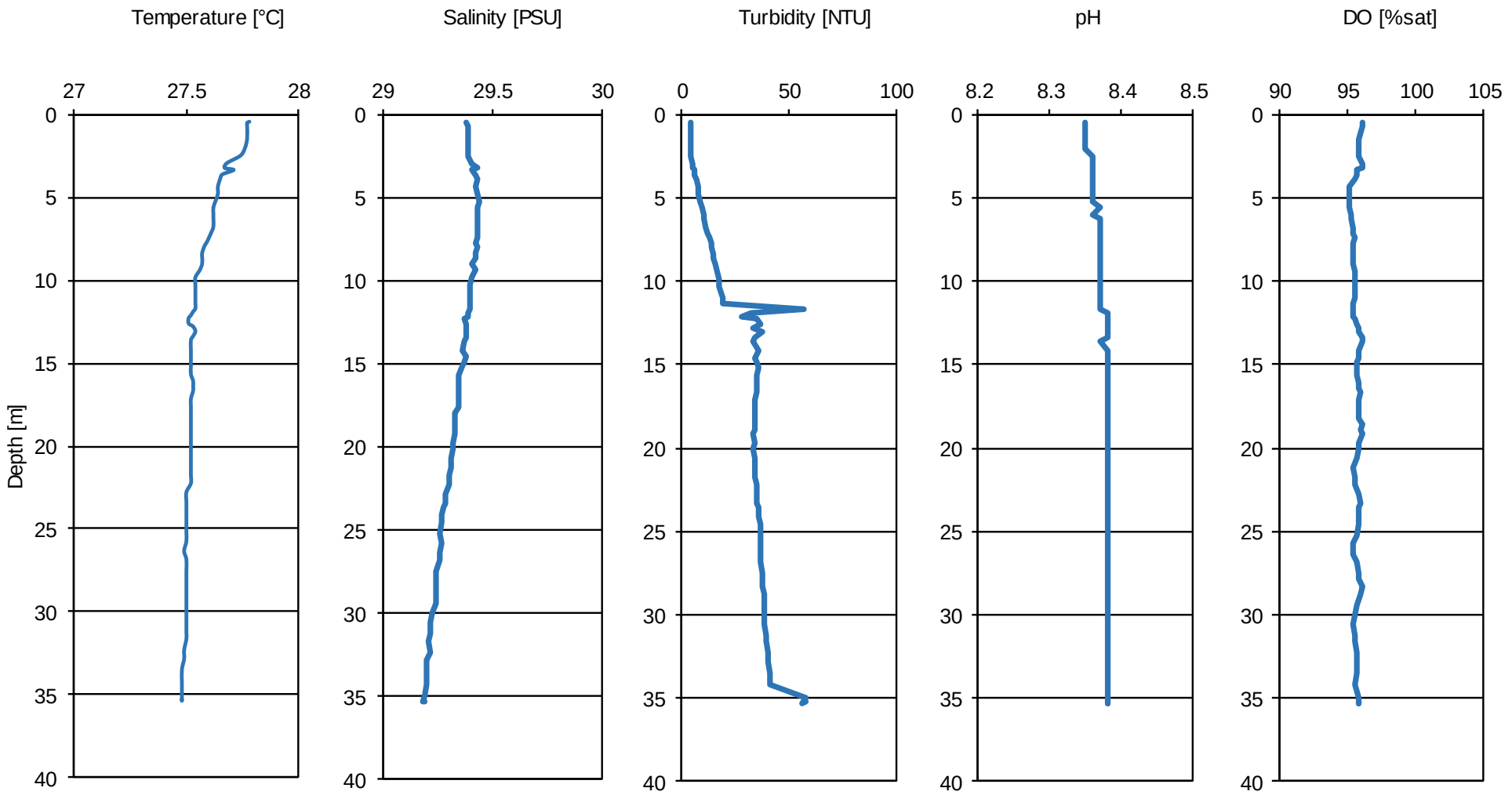
S02


Temperature [°C]
Salinity [PSU]
Turbidity [NTU]
pH
DO [%sat]
Depth [m]
26
27
28
29.1
29.3
29.5
0
100
200
8.2
8.3
8.4
8.5
90
95
100
105
0
5
10
15
20
25
30
35
40

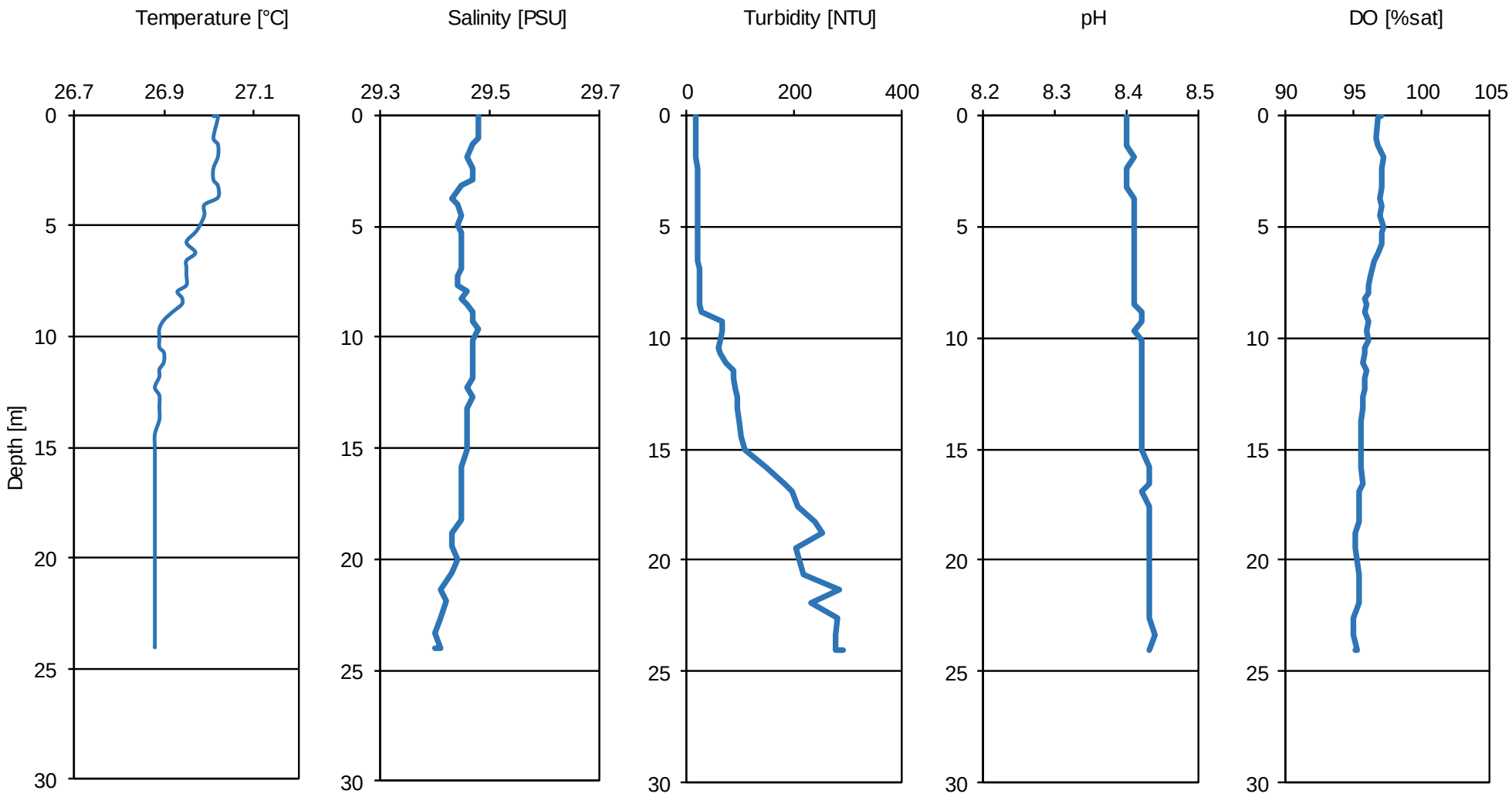
S03


Temperature [°C]
Salinity [PSU]
Turbidity [NTU]
pH
DO [%sat]
Depth [m]
27
28
29
28
28.5
29
0
100
200
8.2
8.3
8.4
8.5
90
95
100
105
0
5
10
15
20
25
30
35
40

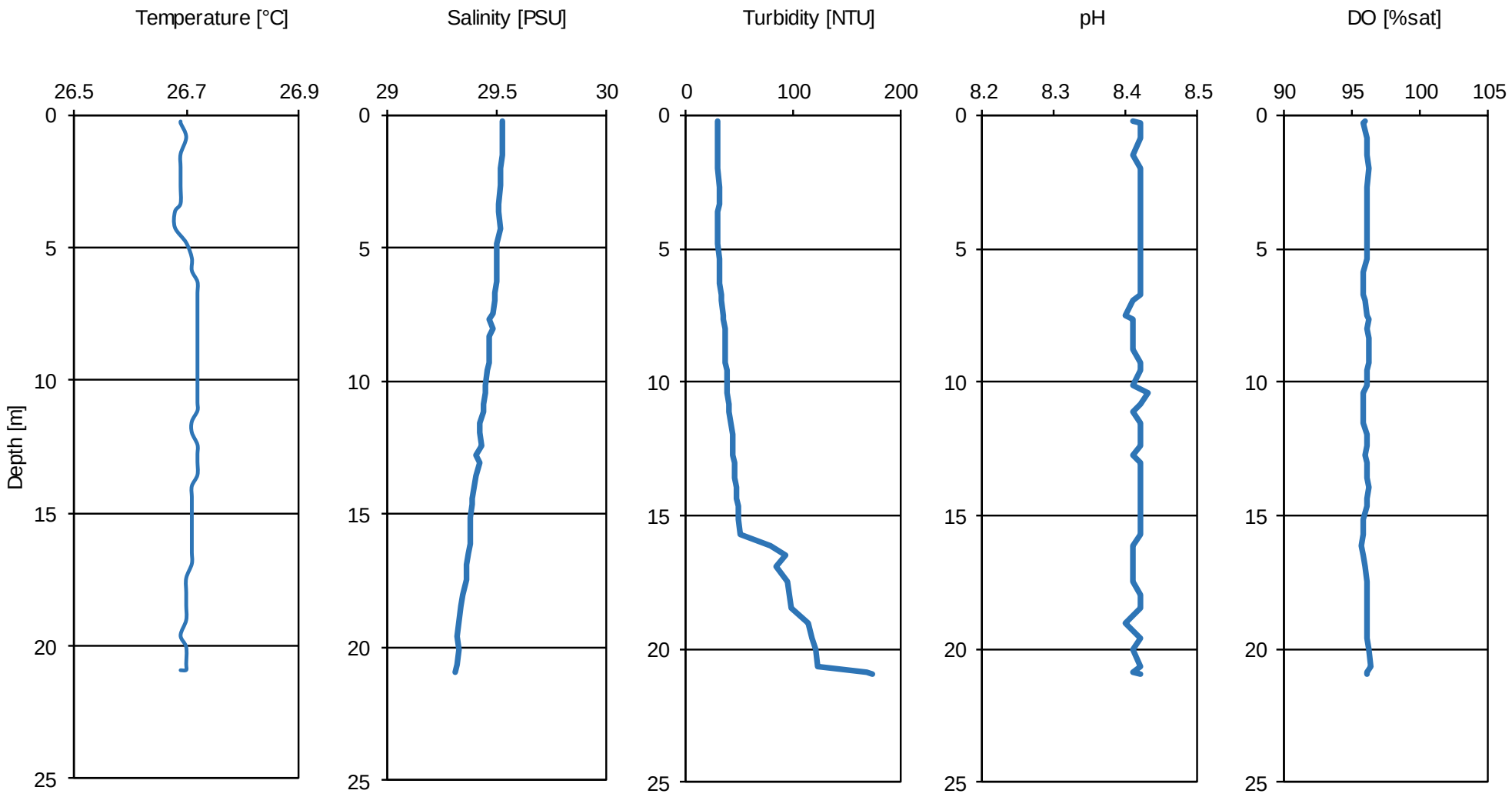
S04


Temperature [°C]
Salinity [PSU]
Turbidity [NTU]
pH
DO [%sat]
Depth [m]
27
27.5
28
29
29.5
30
0
50
100
8.2
8.3
8.4
8.5
90
95
100
105
0
5
10
15
20
25
30
35
40

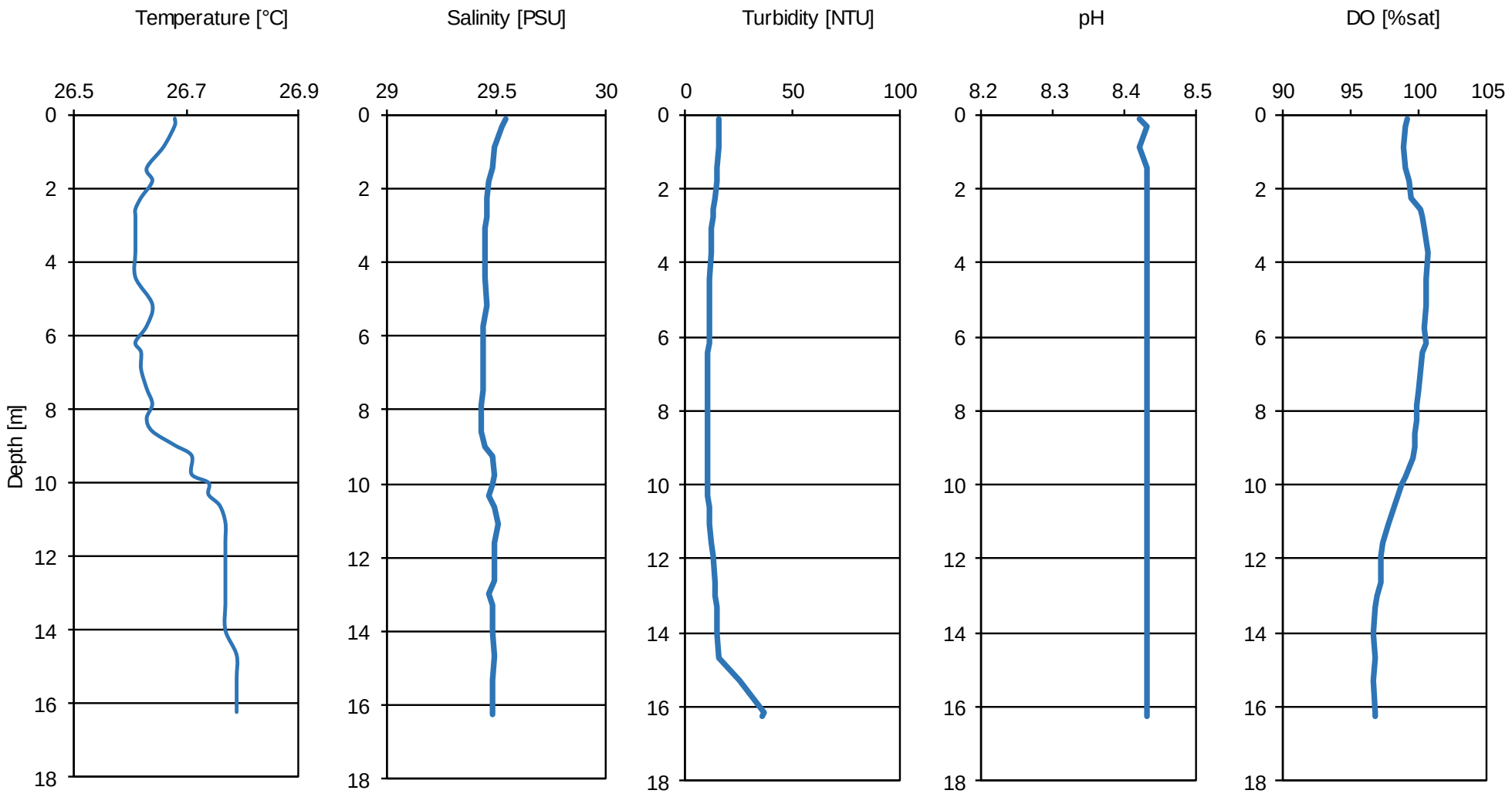
S05


Temperature [°C]
Salinity [PSU]
Turbidity [NTU]
pH
DO [%sat]
Depth [m]
26.7
26.9
27.1
29.3
29.5
29.7
0
200
400
8.2
8.3
8.4
8.5
90
95
100
105
0
5
10
15
20
25
30

S07


Temperature [°C]
Salinity [PSU]
Turbidity [NTU]
pH
DO [%sat]
Depth [m]
26.5
26.7
26.9
29
29.5
30
0
100
200
8.2
8.3
8.4
8.5
90
95
100
105
0
5
10
15
20
25

S08


Temperature [°C]
Salinity [PSU]
Turbidity [NTU]
pH
DO [%sat]
Depth [m]
26.5
26.7
26.9
29
29.5
30
0
50
100
8.2
8.3
8.4
8.5
90
95
100
105
0
2
4
6
8
10
12
14
16
18

S09