Environmental Impact Assessment

NFE SOUTH HOLDINGS LIMITED LNG TERMINAL AND PIPELINE PROJECT, OLD HARBOUR, ST. CATHERINE

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ENVIRONMENTAL IMPACT ASSESSMENT FOR THE NEW FORTRESS ENERGY MARINE TERMINAL AND PIPELINE PROJECT, OLD HARBOUR, ST. CATHERINE

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A	AADT	Annual average daily traffic
	ACGIH	American Conference of Industrial Hygienists
	ADO	Automotive Diesel Oil
	AMC	Antecedent moisture conditions
	amsl	Above mean sea level
B	BA	Basal area
C	C	Celsius
	CBD	Convention on Biological Diversity
	CDMP	Caribbean Disaster Mitigation Project
	CN	Curve number
	CO	Carbon Monoxide
	CO_2	Carbon Dioxide
D	DAFOR	Dominant, Abundant, Frequent, Occasional, Rare
	dBA	A-weighted sound level (decibel)
	DBH	Diametre at breast height
	DEM	Digital elevation model
	DO	Dissolved oxygen
	DCS	Distributed control system
E	E	East/ Easting
	EIA	Environmental Impact Assessment
	EMP	Environmental Monitoring Programme
	ESRI	Environmental Systems Research Institute
	FHA	Federal Highway Administration
	FOG	Fats Oil and Grease
F	ft	Feet
	FSU	Floating Storage Unit (
G	g/l	Grams per litre
	GIS	Geographic information system
	GOJ	Government of Jamaica
	GPS	Global Positioning System
H	HA	Hectares
	HDD	Horizontal Directional Drilling
	hr	Hour
	Hz	Hertz
I	IPCC	Intergovernmental Panel on Climate Change
	IUCN	International Union for Conservation of Nature
J	JAD 2001	Jamaica Grid 2001
	JGQ	Jamaica Gypsum and Quarries Limited
	JNHT	Jamaica National Heritage Trust
K	km	Kilometre
L	Leq	Time-average sound level

	Lj	jth sound level
	LNG	Liquefied Natural Gas Carrier
	LNGC	Liquefied Natural Gas Carrier
M	m	Metre
	m/s	Metres per second
	m^3/sec	Cubic metres per second
	mg/l	Milligrams per litre
	mg/m^3	Milligrams per cubic metre
	min	Minute (s)
	mm	Millimetre
	MMBTU	Million Metric British Thermal Units
	mS/cm	milli Siemens per cm
	MSDS	Material Safety Data Sheets
N	N	North/ Northing
	NAAQS	National Ambient Air Quality Standards
	NEPA	National Environment and Planning Agency
	NG	Natural Gas
	NMIA	Norman Manley International Airport
	NO_2	Nitrogen Dioxide, Nitrite
	NO_3	Nitrate
	NOx	Nitrogen Oxides
	NRCA	Natural Resources Conservation Act
	NSWMA	National Solid Waste Management Authority
	NTU	Nephelometric turbidity units
	NWA	National Works Agency
	NWC	National Water Commission
O	ODPEM	Office of Disaster Preparedness and Emergency Management
	OSHA	Occupational Safety and Health Administration
P	PCQ	Point-Centred Quarter
	PEL	Hearing Conservation and Permissible Exposure Limit
	PIF	Project Information Form
	PM10	Particulate matter smaller than 10 microns in diametre, respirable particulate matter
	PM2.5	Particulate matter smaller than 2.5 microns in diametre, fine particulate matter
	ppm	parts per million
	ppt	parts per thousand
Q	QSP II	Quest suite Professional II
S	s	Second
	SCS	US Soil Conservation Service
	SIA	Social Impact Area
	SO2	Sulfur Dioxide, sulfite
	SO4	Sulfate
	SOx	Sulfur Oxides

	STATIN	Statistical Institute of Jamaica
T	TCP Act	Town and Country Planning Act
	TDS	Total dissolved solids
	TSS	Total Suspended Solids
	TCL	Trinidad Cement Limited
U	USEPA	United States Environmental Protection Agency
W	WHO	World Health Organization
	WRA	Water Resources Authority
Y	yr	Year

1.0 EXECUTIVE SUMMARY

INTRODUCTION

The Jamaica Public Service Company Limited (JPS) has selected NFE South Holdings Limited (NFE) to supply natural gas to Old Harbour Power Station Plant. Additionally, natural gas will be provided to potential future industrial users. The main objective is to provide the Jamaica Public Service Company's Old Harbour Plant with a cleaner and more cost effective fuel in furtherance of the goals of the National Energy Policy.

COMPREHENSIVE DESCRIPTION OF THE PROPOSED PROJECT

This project proposes to construct a marine terminal facility comprised of a vessel berth and off-shore offloading and regasification platform at the general location approved by the Port Authority of Jamaica in the Portland Bight area of Jamaica. This facility will accommodate a Floating Storage Unit (FSU) vessel for Liquid Natural Gas (LNG) storage and a LNG carrier delivering LNG to the FSU. The FSU is a LNG carrier refitted for use as a storage vessel. LNG will be delivered by ship from various potential locations in the United States or other locations. The platform would contain equipment to regasify LNG as well as related process and safety equipment. The liquid gas from the FSU would be carefully regasified and the gas would then be released into an undersea pipeline which will be mostly directionally drilled in basically a straight line from the platform to the vicinity of the JPS plant. This submerged line will minimize environmental impacts since it will be directionally mostly drilled in a relatively straight line. The gas pipeline would then be mostly directionally drilled on shore to a small receiving facility on shore near the proposed gas power plant that JPS is constructing where it can be metered and then sent to the power plant. In addition, the project will construct a new, or refurbish an existing Automotive Diesel Oil (ADO) line from storage tanks to the renovated power plant in order to enhance the reliability of the facility in case of LNG delivery interruptions.

Project Infrastructure, Effluent, and Emissions

The proposed LNG offloading facility location was selected after consideration of environment, operations, and constructability. The facility will be constructed in approximately 14 meters of water in the northwestern region of Portland Bight near the Old Harbour Power Plant. Phase 1 of the project includes one vessel berth consisting of an unloading and regasification platform, metering and pig launch platform, four (4) breasting dolphins and six (6) mooring dolphins. The dolphins and the process platforms are connected for access using nine truss spans and four catwalks. Phase 2 of the project includes a second berth, an extension to the Phase 1 unloading and regasification platform and installation of four (4) additional breasting dolphins.

The structures will be constructed using steel pipe piles, steel framing, steel superstructure and concrete deck slabs on the platforms. The dolphins will include a fender system and quick release hooks for vessel mooring and berthing. The berths are designed for LNG vessel sizes ranging from 140,000 m^3 up to 175,000m^3 capacity with an approximate vessel length of 280m to 300m and draft of approximately 12.5m. The structures are designed to resist mooring and berthing loads under operational conditions, as well as seismic and hurricane/tropical storm conditions.

The platform will be sized to include the following critical components of an LNG offloading and regasification facility; an unloading area, control room, power distribution centre, boil-off-gas compressor skid, LNG pump skid, vaporizer and process skid, flare skid including drain tank and igniter, flare, nitrogen generator skid, seawater pumps, mixing tank, air burst system, crane, and launcher area. The onshore facilities will have equipment for both the natural gas and the ADO systems. The natural gas pipeline will be mostly directionally drilled using a horizontal directional drill (HDD) from the planned fuel skid at the JPS plant to offshore for a distance of approximately 5,410 meters. The length of the HDD will allow the proposed pipeline to go under the coral and the ship channel. A new or refurbished up to 8-inch (20.32 cm) ADO pipeline will run from the existing power plant to either existing ADO tanks or the existing multipoint mooring buoys.

International standards and guidelines will be used during both the construction and operational phases of the project.

Associated Facilities and Environmental Issues

Impacts from the construction and operation of the proposed project will potentially arise and it is imperative to consider these likely impacts and assess the vulnerability of environmental features in proximity to the project location, as well as on a national scale. The following Environmental Impact Assessment was prepared following NEPA guidelines to more fully describe the project, analyse its environmental and social impacts as well as measures taken to reduce and mitigation those impacts, and finally to describe measures that will be taken to ensure that a facility is constructed and operated that is safe for the environment, the nearby community, and workers while providing this important new energy source for Jamaica.

The main potential impacts to the marine environment and shoreline during construction include; sedimentation and temporary displacement of some species such as commercially important fish species, marine turtles and crocodiles. Terrestrial impacts include the direct removal of vegetation (including mangroves) for onshore facilities. This may also result in habitat loss and fragmentation for avifauna, invertebrates and reptiles. However, mitigation measures have been proposed that reduce these impacts.

Socio-economic surveys suggest there was a general feeling among respondents (who are primarily fishermen dependent on the OHB Area for their livelihood) that the project could have a negative impact on their fish catch. Notwithstanding the potential impact of the project on the fish catch the majority of respondents, 74.2%, thought the proposed project site was appropriate.

Project Construction

Figure 3-12 shows the schedule for project construction and Figure 3-13 details the pipeline construction schedule. It is anticipated that NG will be ready to be delivered to the JPS 190 MW Power Plant by the second quarter of 2018.

Platform

The proposed marine structures will be constructed utilizing jack-up and floating equipment. The primary in-water construction activity is installing the steel pipe piles for the marine structures. Following pile installation, pre-fabricated steel frames will be lowered onto the piles and welded in place to form the substructure of the platform. Modular precast deck slabs will be installed on the frame to form the platform deck. The four breasting dolphins and the six mooring dolphins consist of steel pipe piles with a steel frame and steel superstructure. Construction activities for the process equipment and skids will consist of first off-loading equipment/skids/materials/components from barges or vessels followed by setting up of equipment/skids on the platform table-top.

Natural Gas and ADO Pipelines – Horizontal Directional Drilling (HDD)

The Natural Gas Pipeline will be mostly horizontally drilled. It is initiated onshore and exits at a point beyond the coral reef along the predetermined pipeline route. The straight line path for the natural gas line is approximately 5,410 km (3.36 miles). The HDD depth is estimated to be approximately 12 m (40 feet) below the coral. The remaining pipeline length will be trenched to the platform. The ADO pipeline will originate at the existing mooring field and will be directionally drilled as well. Both pipelines (ADO and NG) will be mostly directionally drilled and be at least 25 feet (7.62 m) beneath the ground at the onshore location. Therefore, there will be no need for a cleared maintenance corridor for either pipeline on shore.

Employment

It is estimated that during site clearance and preparation, approximately 20 persons will be employed. The actual number of persons employed may vary depending on the timing and exact design of the construction, however it estimated that a total of between 225 persons (average) and 250 persons (peak)will be employed during the project construction.

During operations, it is estimated that approximately up to 40 persons will be hired primarily to work on the FSU, as well as the platform and land.

Project Operation and Maintenance

Sea water will be pumped from the ocean using submersible column mounted pumps. The pump columns will extend from the platform operating deck to below the minimum sea level. Column intakes will be provided with screens to prevent suction of marine life/vegetation and/or debris. Cooled sea water will be returned to the ocean (below sea level) at a temperature no more than 5 degree C below the intake temperature via a sea water return pipe.

Maintenance will be minor at the off shore platform and will consist of routine inspections and special inspections following severe weather in order to ensure the structural integrity of the platform. Routine maintenance may include steel coating repair, or concrete defect repair. The Floating Storage Unit fleet shall follow a risk-based approach to maintenance management, whereby equipment shall be maintained (inspected, monitored, overhauled, and renewed) to achieve the level of reliable operation required to reduce and manage the risk to personnel, equipment, and the environment.

POTENTIAL DIRECT AND INDIRECT IMPACTS AND RECOMMENDED MITIGATION

Impact matrices for the impacts of construction and operation were developed and are available in the EIS. These matrices describe the receptor, activity, impact, direct/indirect nature of the impact, the direction of the impact (positive, none, or negative), the impact's duration, and the impact's magnitude. These matrices guided the analysis of potential impacts and the recommended mitigation to manage the impacts as described below.

Site Preparation and Construction

Physical

1. NOISE

Site clearance for the construction of the metering facility necessitates the use of heavy equipment to carry out the job. Construction noise can result in short-term impacts of varying duration and magnitude. To gain a general insight into potential construction noise impacts that may result from the project, the typical noise levels associated with various types of construction equipment were identified.

Recommended Mitigation for Noise

i. Use equipment that has low noise emissions as stated by the manufacturers.
ii. Use equipment that is properly fitted with noise reduction devices such as mufflers.
iii. Operate noise-generating equipment during regular working hours (e.g. 7 am – 7 pm) to reduce the potential of creating a noise nuisance during the night.
iv. Construction workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.
v. Management controls will be used to mitigate the potential noise impacts along the access route. These are;
    a. Trucks and other heavy duty vehicles will be required to travel at no more than 30 km/h along the access route.
    b. Truck and heavy duty vehicles should travel along the access route only during day time hours 7 am – 5 pm.

2. VIBRATION

Construction activities can result in various degrees of ground vibration. This is dependent on the type of equipment used and the methodologies employed. The closest receptors to the onshore LNG Metering Facility are: a wooden shack (211m away) and a house made of block and steel (310m away). The vibration impact was predicted on these receptors with the use of ten (10) pieces of construction equipment. The results show that both structures (wooden shack and house made of block and steel) will be unaffected by vibrations as a result of the onshore construction activity.

Recommended Mitigation for Vibration

i. Avoid night time construction activities. People are more aware of vibration in their homes during the night time hours.
ii. Have regular meetings or devise a communication strategy to inform the residents nearby of construction activities.

3. NOISE AND VIBRATION - TERRESTRIAL AND MARINE MAMMALS AND REPTILES

The construction/installation of the proposed project has the potential to have a negative impact on terrestrial and marine mammals and reptiles albeit on a short term basis.

Recommended Mitigation for Terrestrial and Maine Mammals and Reptiles for Noise and Vibration

i. A soft start procedure can be used to cause marine animals to leave the immediate area of the piling. This involves starting the energy of the impact at approximately 1/10th of the desired level and progressively increasing the energy of the impact until the desired impact energy is achieved. The ramp up time should be determined by the time it would take the aquatic animal of interest to leave the high impact area.
ii. Impact cushions of plywood, nylon or other material can be placed between the top of the pile and the hammer. These cushions can reduce the sound pressure level by between 4-26dB at the cost of requiring slightly more impacts to achieve the same penetration depth.
iii. Bubble curtains may be used should noise mitigation be required for protection of marine animals. A bubble curtain is a vertical 'curtain' of bubbles that completely surrounds the pile while driving is in progress. The bubbles present an impedance mismatch which results in transmission loss of between 320dB. Bubble curtains are less effective in areas where there are strong currents or high turbulence as the transmission loss depends on the whole pile being encased in the bubble curtain.
iv. Use vibropiling where possible
v. Reduce piling during breeding season

4. STORAGE OF RAW MATERIALS AND EQUIPMENT

Any raw materials used in construction of the onshore metering facility will be stored onsite. There will be a potential for them to become air or waterborne. Stored fuels and the repair of construction equipment has the potential to leak hydraulic fuels, oils etc.

Recommended Mitigation for Storage of Raw Materials and Equipment

i. A central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of chemicals into the sediment.
ii. Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne.
iii. Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.
iv. Raw material should be placed on hardstands surrounded by berms.
v. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff.

vi. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage.

5. TRANSPORTATION OF RAW MATERIALS AND EQUIPMENT

The transportation and use of heavy equipment and trucks is required during construction. Trucks will transport raw materials and heavy equipment. This has the potential to directly impact traffic flow along local roads.

Recommended Mitigation for Transportation of Raw Materials and Equipment

i. Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
ii. Adequate and appropriate road signs should be erected to warn road users of the construction activities. For example, signs which require reduced speed near the construction site.
iii. Raw materials such as marl and sand should be adequately covered within the trucks to prevent any escaping into the air and along the roadway.
iv. The trucks should be parked on the proposed site until they are off loaded.
v. Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
vi. The use of flagmen should be employed to regulate traffic flow.

6. LIGHT

The platform and on-shore facility will be designed to minimize light pollution through the use of LED lights and shielding as required to minimize the spread of light in the nearby environment.

7. AIRCRAFT

Any impacts on aircraft will be minimal since the platform and on-shore facilities are in remote locations. In addition, the tallest structure will be the flare which will be under 30.5 m (100 ft) above the platform deck.

8. WATER IMPACTS FROM OPERATIONS AND SPILLS

There are several potential pollution sources that have the potential to generate sediment plumes in the marine environment, both nearshore and offshore. They include; directional drilling nearshore for the pipeline, and driving of piles to build the offshore LNG platform. There will be no dredging or associated spoil disposal or reclamation activities for this project. Therefore, no dredge related impacts are expected. In terms of ballast water, it will only be released in accordance with international and Jamaican standards. Only LNG spills apply to the LNG Re-Gas Facility at the platform. In the event of a spill, the LNG will immediately begin to vaporize.

Recommended Mitigation from Water Impacts

Turbidity barriers/silt screens are recommended to be used around LNG platform construction activities and pipeline directional drilling activities nearshore. These should be placed so as to reduce/contain the resultant sediment plume during these activities. Activities should only continue when these barriers are fully operational, that is; placed correctly; calm to moderate sea conditions;

without damage. These barriers are particularly important when operations occur near or may influence sensitive ecosystems and species such as coral reefs and seagrass beds and or filter feeding organisms and fish. The silt screens should encircle the areas and be deep enough to contain the plumes so that plumes will not travel in the direction of the prevailing currents.

9. AIR IMPACTS

Site preparation for the onshore metering facility has the potential to have a two-folded direct negative impact on air quality of the surrounding residential area. The first impact is air pollution generated from the construction equipment and transportation. The second is from fugitive dust from the proposed construction areas and raw materials stored on site.

Recommended Mitigation for Air Impacts

i. Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance. On hotter days, this frequency should be increased.
ii. Minimize cleared areas to those that are needed to be used.
iii. Cover or wet construction materials such as marl to prevent a dust nuisance.
iv. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.

<u>Biological</u>

1. ALONG PIPELINE ROUTE

The pipeline will be directionally drilled several feet underground, below the seafloor and topsoil layers. Using this method of pipe installation, the impacts to the biological community are expected to be minimal. Impacts were examined for marine invertebrates, terrestrial invertebrates, fish and filter feeders, reptiles, avifauna, marine mammals, coral reef and seagrass communities, mangrove, salina/salt marsh and thorn savanna.

Recommended Mitigation for Pipeline route

i. Silt screens or other turbidity barriers should be used in any working area where a sediment plume may occur.
ii. No work activities should occur in unfavourable or unsafe weather conditions. These include high winds, rough seas, heavy rainfall and any other natural event which may increase the risk of accidents or render silt screens and other mitigation tools ineffective.
iii. No lights should be pointed out to sea or illuminate sections of the beach so as to cause confusion and disorientation of turtles or any other species that maybe affected by lunar activity.
iv. Fixtures in direct line-of-sight from the beach should be shielded down-light only fixtures or recessed fixtures having low wattage (i.e. 450 lumens or less) "bug" type bulbs and non-reflective interior surfaces.
v. Fixtures mounted as low in elevation as possible through use of low-mounted wall fixtures, low bollards and ground level fixtures.
vi. Floodlights, up-lights or spotlights for decorative and accent purposes that are directly visible from the beach or which indirectly or cumulatively illuminate the beach shall not be used.

vii. For high intensity lighting applications such as providing security and similar applications shielded low-pressure sodium vapour lamps and fixtures shall be used.

viii. Avoid contact with sensitive, protected or hazardous species. These include turtles and crocodiles. Any unavoidable interaction with these species should be handled by the regulatory Agency and any incidents should also be reported to the Agency.

ix. Temporary fencing or relocation maybe needed in working areas if crocodiles are present and or any other recommendations by the Agency.

x. Workers should be sensitized to existence of hazardous animals as well as the procedure if one is encountered. Works should be properly educated to ensure no animals are caught, harmed, teased or otherwise harassed. Works should be aware of the reporting procedure in the event of an encounter with a protected species.

xi. Limit the vegetation clearance when possible. Mangroves and other large, protected or endemic species should not be removed.

2. OFFSHORE FACILITY

Impacts for the off shore facility were described for marine invertebrates, fish and filter feeders, marine mammals, and coral reef and seagrass communities.

Recommended Mitigation for the off shore facility

i. Avoid or relocate macrofauna such as starfish and sea cucumbers in working areas.

ii. Silt screens or other turbidity barriers should be used in any working area where a sediment plume may occur. Further to this, special care should be taken in the placement of these screens around these systems, in particular where seagrass beds occur near to shoreline areas. Small sections of seagrass were found within the footprint near the shoreline. These areas should be avoided where possible.

iii. No work activities should occur in unfavourable or unsafe weather conditions. These include high winds, rough seas, heavy rainfall and any other natural event which may increase the risk of accidents or render silt screens and other mitigation tools ineffective.

iv. Night time activities should be limited or avoided when possible. No lights should be pointed out to sea confusion and disorientation of turtles or any other species that maybe affected by lunar activity.

v. Fixtures should have low wattage (i.e. 450 lumens or less) "bug" type bulbs and non-reflective interior surfaces.

vi. Fixtures mounted as low in elevation as possible through use of low-mounted wall fixtures, low bollards and ground level fixtures.

vii. For high intensity lighting applications such as providing security and similar applications shielded low-pressure sodium vapour lamps and fixtures shall be used.

viii. Avoid contact with sensitive, protected or hazardous species. These include turtles and crocodiles. Any unavoidable interaction with these species should be handled by the regulatory Agency and any incidents should also be reported to the Agency.

ix. Workers should be sensitized to existence of sensitive and protected species as well as the procedure if one is encountered. Works should be properly educated to ensure no animals are caught, harmed, teased or otherwise harassed. Works should be aware of the reporting procedure in the event of an encounter with a protected species.

3. ONSHORE FACILITY

Impacts were described for terrestrial invertebrates, reptiles, avifauna and mangrove, salina/salt marsh and thorn savanna.

Recommended Mitigation for the on shore facility

i. A mangrove relocation exercise should be conducted with the use of nursery grown plants in an area approved by the Agency as a mitigation for the removal of mangroves as a result of the construction activities.
ii. No lights should be pointed out to sea to cause confusion and disorientation of turtles or any other species that maybe affected by lunar activity.
iii. Fixtures in direct line-of-sight from the beach should be shielded down-light only fixtures or recessed fixtures having low wattage (i.e. 450 lumens or less) "bug" type bulbs and non-reflective interior surfaces.
iv. Fixtures mounted as low in elevation as possible through use of low-mounted wall fixtures, low bollards and ground level fixtures.
v. Floodlights, up-lights or spotlights for decorative and accent purposes that are directly visible from the beach or which indirectly or cumulatively illuminate the beach shall not be used.
vi. For high intensity lighting applications such as providing security and similar applications shielded low-pressure sodium vapour lamps and fixtures shall be used.
vii. Avoid contact with sensitive, protected or hazardous species. These include turtles and crocodiles. Any unavoidable interaction with these species should be handled by the regulatory Agency and any incidents should also be reported to the Agency.
viii. Temporary fencing or relocation maybe needed in working areas if crocodiles are present and or any other recommendations by the Agency.
ix. Workers should be sensitized to existence of hazardous animals as well as the procedure if one is encountered. Works should be properly educated to ensure no animals are caught, harmed, teased or otherwise harassed. Works should be aware of the reporting procedure in the event of an encounter with a protected species.
x. Limit the vegetation clearance when possible.

<u>Human/Social</u>

1. MARINE OPERATIONS

The presence of marine vessels associated with offshore LNG platform construction and pipeline deployment activities has the potential to cause conflict with other marine vessels in the area.

Recommended Mitigation for Marine Operations

i. A safety plan should be developed in conjunction with NFE South Holdings Limited and the Port Authority of Jamaica.

ii. The use of marker buoys demarcating an exclusion zone should be used to keep out other marine traffic from the work area during construction and pipeline deployment activities.
iii. Ample notice must be placed in public media concerning the conducting of offshore construction and pipeline deployment activities.

2. EMPLOYMENT

There is the potential for increased employment during the pre-clearance, construction phases, and operation phases. Therefore, the construction of the facility will provide an additional source of jobs in the immediate area. No mitigation is recommended for employment.

3. SOLID WASTE GENERATION

During the construction phase of the onshore metering facility, solid waste generation may occur mainly from: From the construction campsite. From construction activities such as site clearance and excavation (vegetative debris), construction materials packaging (cardboard, plastics, fencing material, wooden pallets, containers etc.)

Recommended Mitigation for Solid Waste Generation

i. Skips and bins should be strategically placed within the campsite and construction site.
ii. The skips and bins at the construction campsite should be adequately designed and covered to prevent access by vermin and to minimise odour.
iii. The skips and bins at both the construction campsite should be emptied regularly to prevent overfilling.
iv. Disposal of the contents of the skips and bins should be done at an approved disposal site.

4. WASTEWATER GENERATION AND DISPOSAL

With every construction campsite comes the need to provide construction workers with showers and sanitary conveniences. The disposal of the wastewater generated at the construction campsite has the potential to have a minor negative impact on groundwater.

Recommended Mitigation for Wastewater Generation and Disposal

i. Provide portable sanitary conveniences for the construction workers for control of sewage waste. A ratio of approximately 25 workers per chemical toilet should be used.
ii. Showers should be provided for the workers.

5. HOUSING

It is not expected that the structure of housing will be adversely impacted and as such relocation of residents is not a foreseen measure. No mitigation is required.

6. AESTHETICS

Solid waste generation during the construction period can have a potential negative impact on visual aesthetics if improperly collected and stored on site. There is also the potential for vermin infestation if discarded food and food containers are present.

Recommended Mitigation for Aesthetics

i. Skips and bins should be strategically placed within the campsite and construction site.
ii. The skips and bins at the construction campsite should be adequately designed and covered to prevent access by vermin and minimise odour.

Operations

Physical

1. GEOTECHNIAL CONSIDERATIONS

i. Shift Structures away from Borehole Locations 1 and 2.
ii. For detail study of the area it is critical that further testing be performed in the vicinity of the proposed structures.
iii. Excavate and remove the TOP1soils in the vicinity of Boreholes 3 and 4 and replace with 0.7m of river shingle for pore pressure dissipation and 1m of compacted granular fill or to design level (invert) whichever is thicker. Use Shallow Mat/Raft foundation above the fill. Note excavation below the water table is anticipated.
iv. Use short driven or cast in place pile foundation to a depth sufficient to safely carry the anticipated loads for the structures with pile caps interconnected to mitigate differential deformation.

2. SOIL

No impacts are expected on the soil for the onshore metering facility.

3. NOISE

The predicted noise from the proposed LNG Regassification project was determined by using SoundPlan version 7.4. The noise spectrum for the major equipment provided by the manufacturer was used to calibrate the model. The predicted noise generated from the proposed LNG Terminal and Regassification project are shown on figures in the EIA.

- Landside Noise - The noise model was used to generate the night time limit lines for Industrial facilities (70 dBA) and residential areas (50 dBA). This was done to determine the potential noise impact from the operation of the LNG Storage and Regasification Project. The residential and industrial noise limit lines are depicted in figures in the EIA.
- Marine Infrastructure - The night time industrial noise standard (70 dBA) is met close to the equipment generating the noise resulting in the noise levels generated meeting the NEPA noise standard within the property boundary or on the regas facility (marine side) (Table 7-14 and Figure 7-4). When the NEPA night time noise standard was examined the noise limit line for the landside fell within the property and no residential areas were impacted. The noise

level for the marine side fell within the NEPA night time standard (50 dBA) for residential areas within approximately 207 m of the marine facility.

- Impact on Terrestrial and Marine Mammals and Reptiles- Based on this analysis as described in the EIA, No mitigation required as the frequency of LNG delivery is inconsequential (1 ship per month), therefore, the potential to significantly increase the noise climate in the area is negligible. The operation of the pumps on the platform will not adversely influence the noise climate
- Sensitive Receptors - Sensitive receptors (schools, churches and clinics) within 6 km were mapped. Note that this list is not exhaustive. The noise attributed to the operation of the LNG Terminal and Regassification Project alone at the various receptors was predicted using both the General Prediction Model. All predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guidelines. Therefore, no mitigation is required.

4. STORM SURGE HAZARD

During a 1:50yr storm event, the mooring area is expected to experience wave heights of up to 3.16m while during a 100yr event, wave heights up to 3.41 will be observed. For the proposed LNG site on land, the vulnerability to storm surge was also investigated. It was determined that the expected storm surge inundation levels for the 50yr and 100yr events is 3.14m and 3.26m respectively.

Recommended Mitigation for Storm Surge Hazard

i. The floor levels can be set to 0.5m above the 50 or 100yr storm event, all critical components should be at a minimum elevation of 0.5m above the expected flood level for the 1 in 100 year rainfall event.
ii. All coastal protective works should be employed to protect the seaward edges of the site. Due consideration should be given to overtopping and direct wave damage. Such coastal protection works should be constructed to elevations determined by the 95% confidence limits of the storm surge re-analysis.

5. TSUMANI HAZARD

Modeling suggests that the tsunami waves are expected to arrive at the Old Harbour Bay fishing village, Jamaica Public Service (JPS) power plant and JAMALCO (Salt River Bay) in approximately 135, 120 and 108 minutes after the earthquake, respectively.

Recommended Mitigation for Tsunami Hazards

i. Regulatory authorities should not only implement but enforce early and public warning systems inclusive of evacuation routes and assembly points throughout the Old Harbour Bay area.
ii. The implementation of coastal protection such as tsunami breakwaters, dikes and revetments.

6. HURRICANE WAVE CLIMATE

Various scenarios of hurricane waves, water level setups, locally generated waves, and sea level rise (2050 and 2100 projections) were made for the various components of the project. The results of these models are shown in the EIA. Results of these models were incorporated into project design as appropriate.

7. WAVE OVERTOPPING PLATFORM

The modelling analysis indicates that, in a worst case scenario the mooring platform will see wave heights of up to 5.33m and 5.63m for the 50year and 100year respectively. Platform design will manage this wave scenario.

8. STORMWATER

On-shore stormwater potential will be minimal since the footprint of the metering facility is small. Stormwater from the off-shore platform and FSU will also be minimal and not result in violation of water quality standards at this location.

Recommended Mitigation for Stormwater

i. Appropriately sized stormwater management will be incorporated into the design of this on shore facility to manage stormwater runoff. The drainage design criteria for this project will be guided by local requirements for permitting and international standards.

9. WATER QUALITY INCLUDING THERMAL OUTFALL

During construction, the immediate areas around the NG pipeline will have the potential to have reduced water quality. The effluent of the power plant will be discharged through a thermal outfall. The effluent is expected to be of a lower temperature than the ambient surroundings. Additionally, these areas could be affected by wave action and currents resulting in the farfield dispersion of this thermal effluent. Regulations stipulate that the effluent from the thermal outfall must be mixed with the seawater until the temperature differences are within NEPA and EPA limits (< 2^{o}C below ambient temperature) within a radius of 100m from the outfall.

Recommended Mitigation for Water Quality

i. Once the effluent temperature adheres to the standards prescribed by the statutory authorities (NEPA, EPA, World Bank), no specific management measures will be required. Salinity changes are expected to be within 38 ppt, hence impact of salinity and temperature on the marine biota is expected to be minimal.
ii. However, it is recommended that good practices be implemented for inlet and outfall management in order to protect the marine environment.

10. SEDIMENT TRANSPORT AND COASTAL DYNAMICS

There will be no structures built along the shoreline/coastline so no changes in the nearshore sediment transport (erosion and accretion) or wave patterns are anticipated. The offshore facility will be comprised of pilings, a floating platform and the FSU. Therefore, no changes in wave or current patterns are anticipated. Therefore, no mitigation is required.

11. ADO SPILLAGE

According to the National Oceanic and Atmospheric Administration (NOAA), diesel oil has a very low viscosity and is readily dispersed into the water column with moderate winds (5 -7 knots) or with breaking waves.

Recommended Mitigation for ADO spillage

i. Pressure in the subsea ADO pipeline will be continuously monitored and recorded at the onshore pipeline facility. When a vessel is delivering ADO to the tanks, JPS, or both, the flow rate and pressure will be monitored both onshore and on the ship located at the offshore single point mooring (SPM). In the event of a sudden drop in flow rate or pressure, the vessel will be immediately contacted to stop delivering ADO into the pipeline and all isolation valves will be closed.
ii. An automated block valve in the proximity of the beach will be located onshore and will be used for isolation and emergency shutdown purposes. Automated block valves will be located at the inlet of the meter skid and at each inlet to each regulator skid and the tanks. In the event of a pipeline leak, the automated block valves will close to stop transportation of ADO to the onshore storage tanks and/or to the power plant and isolate the pipeline.
iii. The ADO storage tanks on land will each be located inside containment bunds sufficient to hold 110% of the volume of one tank. Each tank will have instrumentation to automatically shut down to prevent overfilling.
iv. In the event of a storm/hurricane, the pipeline will be shut down and the isolation valves will be closed

12. AIR IMPACTS

An air dispersion modelling analysis was undertaken to determine the impact of the air pollutants from the proposed facility on ambient air quality. A determination was also made whether a significant air quality impact will be created based on the incremental contribution of the proposed facility to the cumulative air quality impact. Section 7.2.1.3 of the EIA describes the modelling process, model inputs, meteorological data, and the model domain.

The model predictions for the LNG Terminal revealed compliance with the CO, PM10, NO2 and SO2 ambient air quality standards and the priority air pollutant guideline concentrations for the applicable averaging periods. The incremental impact of the criteria air pollutants was also less than the established values that would have created a significant air quality impact.

<u>Biological</u>

1. LIGHTING

Lights will be placed on the platform as a security feature so as to prevent other marine vessels from collision during night time or low visibility situations. Some amount of lighting will also be present by the onshore metering facility.

Recommended Mitigation for Lighting Impacts

i. Lighting on the offshore platform should be minimal and only placed where necessary and should be of low intensity.
ii. Fixtures should have low wattage (i.e. 450 lumens or less) "bug" type bulbs and non-reflective interior surfaces.
iii. Fixtures mounted as low in elevation as possible through use of low-mounted wall fixtures, low bollards and ground level fixtures.
iv. For high intensity lighting applications such as providing security and similar applications shielded low-pressure sodium vapour lamps and fixtures shall be used.
v. No lights should be pointed out to sea or illuminate sections of the beach so as to cause confusion and disorientation of turtles or any other species that maybe affected by lunar activity.
vi. Floodlights, up-lights or spotlights for decorative and accent purposes that are directly visible from the beach or which indirectly or cumulatively illuminate the beach shall not be used.
vii. Staff will be sensitized about the sensitive species in the area. Special precautions will be taken during turtle nesting season, this will include logging and reporting of all turtle sightings to the Agency.

2. COOLING WATER SYSTEM

Seawater cooling has been used in more than 50% of the LNG plants built since the 1960s (Birtwell, 2001). This is primarily attributed to the fact that use of seawater is more efficient, less expensive, and generates less noise than air cooling or other mechanical means of cooling. These impacts are described in the EIA.

Recommended Mitigation for Cooling Water System

i. Once the effluent temperature adheres to the standards prescribed by the statutory authorities (NEPA, EPA, World Bank), no specific management measures will be required. Salinity changes are expected to be within 38 ppt, hence impact of salinity and temperature on the marine biota is expected to be minimal.
ii. However, it is recommended that good practices be implemented for inlet and outfall management in order to protect the marine environment.

<u>Human/Social</u>

1. MARITIME OPERATIONS

With the presence of marine vessels associated with offshore LNG platform as well as the LNG platform itself, exists the potential for accidents with other marine vessels in the area.

Recommended Mitigation for Maritime Operations

i. There will be a marine security zone of 500 meters enforced around the off-shore mooring facility and clearly marked with buoys where boat access will be restricted and strictly controlled for safety reasons. In addition, there will be a hazard zone of 1000 meters from the platform where shipping will be restricted as clearly marked by additional buoys. The 500m security zone will be enforced using patrol and safety boats. When an LNCG is at the terminal the tug will additionally assist with the enforcement of the safety zone. The safety zone will be published and broadcast as a notice to mariners. No vessel will be permitted to enter the zone without authorization from the Terminal Operators.

ii. Due to usage of the area by fishers and concerns expressed during stakeholder consultation, we are willing to reduce the 500m restricted/exclusion zone to 200m so as to accommodate the local fisherfolk only.
iii. The terminal will be lighted per the Illuminating Engineer Society (IES) recommendations and applicable Occupational Safety and Health Administration (OSHA) standards. The platform lighting will utilize high efficiency LED lighting, minimizing power consumption. Design considerations will be taken to reduce the risk of light pollution such as unwanted spill lighting and sky glow.

2. EMPLOYMENT

Approximately highly trained 40 workers will be needed to permanently operate the facility (on-shore and off-shore). These positions will likely be a mix of off and on-island individuals. No mitigation is required for this impact.

3. SOLID WASTE

It is expected that solid waste will be generated by the facility, at both the platform and on board the ships. The facility may periodically generate hazardous waste (typically less than 100 kilograms per month), including spent solvents, chemical cleaning wastes, and other wastes.

Recommended Mitigation for Solid Waste

i. Any domestic (non-hazardous) garbage from the ship will be collected and taken to shore for proper disposal. All food waste which is from locally obtained produce will also be collected and taken to shore for proper disposal. Hazardous waste will be managed according to applicable rules and regulations

4. WASTEWATER

Sewage and wastewater loads will be minimal for the on-shore facility and offshore platform.

Recommended Mitigation for Wastewater

ii. Domestic wastewater from the on shore terminal control room will be collected in a septic tank and drain field to be constructed within the boundaries of the plant.
iii. The facility will not result in the generation of process wastewater. The regasification process will utilize seawater which will result in the discharge of cooled water into the sea near the mooring facility using a mixing process to ensure that there is no more than 5^{o} C change in temperature. This effect will be carefully modelled and monitored to ensure that there are no negative effects on marine life in the vicinity.
iv. There will be no effluent discharge from the FSU. Effluent is treated onboard in a three stage process and the effluent and waste will be collected by a waste handling company to discharge in accordance with MARPOL Requirements. The waste handling company is responsible for

the handling and final disposal of the wastes and providing the Ship's Agent with a disposal certificate.

v. The following additional parameters will assist in avoiding pollution:
   a. No oil or mixture containing oil shall be discharged or allowed to escape from a vessel while at the terminal.
   b. No garbage or other materials, either liquid or solid, shall be discharged overboard from a vessel, but shall be retained in suitable receptacles on board for proper disposal on land.

Carrying Capacity-

Carrying capacity refers to the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural, social, cultural and economic environment for present and future generations.

- Social Environment- Based on the analysis described in the EIA, It is anticipated that proposed project will not negatively impact the social carrying capacity of the area.
- Natural Environment - - Based on the analysis described in the EIA, It is anticipated that proposed project will not negatively impact the natural environment's carrying capacity of the area.

LNG Specific Impacts and Mitigation

International standards and guidelines will be used during both the construction and operational phases of the project. These standards and guidelines include identification of potential impacts and suggested mitigation for the biological and physical environment as well as general occupational health and safety. Industry sector were used together with the IFC General EHS Guidelines to provide guidance to users on common EHS issues potentially applicable to all industry sectors in order to address the following issues in the EIA.

1. MARINE ENVIRONMENT, SHORELINE AND TERRESTRIAL HABITATS

Potential impacts to the marine environment and shoreline during construction include; trenching for of pipelines and pile driving for the offshore facility.

Recommended Mitigation measures are as follows:

For LNG facilities located near the coast (e.g. coastal terminals marine supply bases, loading / offloading terminals), guidance for protecting marine and shoreline environments is provided in the IFC EHS Guidelines for Ports, Harbours, and Terminals, which includes the use of siltscreens. Ballast water from international ships should not be discharged in the neashroe environment. This should be monoitored by the facility as well as marine police and coast guard patrols. This should reduce the risk of a species introduction.

It is important to design an LNG facility that will protect the public from a credible, major release or incident. The following provides an outline of the design concepts and elements:

- Each landed storage tank is surrounded by a bund which is designed to contain at least 110% of the storage tank capacity (not applicable to floating storage.
- Areas outside the bund are provided with drainage and catch basins which will contain any LNG release from the process area.
- The LNG tanks have no penetrations above the maximum liquid levels such that the only way LNG can leave the tank is to be pumped out or to have a collapse of the tank integrity.
- There must be an extensive hazard detection system and continuous monitoring from the control room.
- There will be an emergency shutdown system which will secure the facility in case a hazardous event occurs.

2. CRYOGENIC IMPACTS IN THE BIOLOGICAL ENVIRONMENT

Negative long-term environmental impact from an LNG release is virtually non-existent. LNG is colourless, odourless, non-toxic and leaves no residue after evaporation. LNG and LNG vapour are not soluble in water, therefore ruling out water contamination. Potential damage to environmental and socio-economic components is limited to short-term hazards.

Recommended Mitigation - Pipeline Placement

Pipelines should be placed in areas with little to no sensitive systems such as; seagrass beds, patch reefs, mangroves or other rare or endemic species, where possible. If pipelines must be placed through these ecosystems, then some sort of relocation or rehabilitation mitigation plan must be included.

3. HAZARDOUS MATERIAL MANAGEMENT –

LNG is a highly flammable material (due to its characteristic boil-off-gas-BOG) - as a result the storage, transport and transfer of LNG poses risks of fires and explosions.

Recommended Mitigation – Hazardous Material Management

- LNG storage tanks and components should meet international standards for structural design integrity and operational performance. Applicable international standards may include provisions for Overfill protection, Secondary containment, Metering and flow control,
- Fire protection (including flame arresting devices),
- Grounding (to prevent electrostatic charge).
- Storage tanks and components should undergo periodic inspection for corrosion and structural integrity and be subject to regular maintenance and replacement of equipment.
- A cathodic protection system should be installed to prevent or minimize corrosion, as necessary.
- Loading / unloading activities should be conducted by properly trained personnel according to pre-established formal procedures to prevent accidental releases and fire / explosion hazards. Procedures should include all aspects of the delivery or loading operation from arrival to departure, connection of grounding systems, verification of proper hose connection and disconnection.

- Adherence to no-smoking and no-naked light policies for personnel and visitors
- A formal spill prevention and control plan should be developed in coordination with local regulatory agencies that addresses significant scenarios and magnitude of releases. The plan should be supported by the necessary resources and training. Spill response equipment should be conveniently available to address all types of spills, including small spills.
- The facility should be equipped with a system for the early detection of gas releases, designed to identify the existence of a gas release and to help pinpoint its source so that operator-initiated ESDs can be rapidly activated, thereby minimizing the inventory of gas releases.
- An Emergency Shutdown and Detection (ESD/D) system should be available to initiate automatic transfer shutdown actions in case of a significant LNG leak;
- For unloading / loading activities involving marine vessels and terminals, preparing and implementing spill prevention procedures for tanker loading and off-loading according to applicable international standards and guidelines which specifically address advance communications and planning with the receiving terminal;
- Onshore storage tanks should be designed with adequate secondary containment. Facilities should provide grading, drainage, or impoundment able to contain the largest total quantity of flammable liquid that could be released from a single transfer in 10 minutes.
- Material selection for piping and equipment that can be exposed to cryogenic temperatures should follow international design standards;

4. EXTERNAL FIRES

The possibility of an LNG release/fire caused by external events, such as a forest fires or adjacent oil storage fire is extremely remote because the facility is built from non-combustible materials, mostly steel and concrete. The facility should also be designed to contain vapour dispersion and thermal radiation within its boundaries.

5. FLAMMABLE VAPOUR DISPERSION

The primary hazard from the storage and handling of LNG is the possibility of a fire from the ignition of LNG vapours mixed with air. The two limiting conditions are an LNG release with and without immediate ignition.

Dispersion modelling has been completed to determine the flammable vapour hazard footprint for a hypothetical accidental release from the proposed LNG facility. The modelling process is described in the EIA. The results of the vapour dispersion modeling are shown on figures in the EIA for the LNG carrier breach and the unloading arm failure. The vapor cloud footprints show the maximum extent of the flammable cloud, at LFL (Lower Flammable Limit) and at 50%-LFL even though the LFL is the physical limit below which ignition is not possible, the 50%-LFL threshold is typically considered for regulator purposes in order to allow for modeling uncertainties. The figures show that the flammable vapor cloud for both release scenarios dissipates below 50%-LFL before reaching the shoreline.

6. THERMAL RADIATION

If the vapours from an LNG spills such as described above are ignited close to the source, a pool fire will ensue on top of the liquid pool. Since an LNG pool over water is unconfined, its size will change over time and therefore the size of the fire (and the distance at which thermal radiation hazards can extend) also varies over time. For the purpose of this study, the thermal radiation hazards were calculated considering the largest size reached by the LNG pool during the spill scenario.

Recommended Mitigation for Thermal Radiation

Exclusion zones will be enforced around terminal platform.

7. VAPOUR DISPERSION

When a release occurs, the LNG will vapourise as it comes into contact with the relatively warm surfaces and atmosphere. The initial hazard following a release comes from the LNG spreading over the surface and vapourizing as it absorbs heat.

Recommended Mitigation – Vapour Dispersion

Canadian Standards Association (CSA Z-276-2007) requires that the isopleth (range or dispersion path) for a (Lower Flammable Limit)LFL vapour cloud must not go beyond the LNG facility boundaries or property that cannot or will not have occupancies and thus result in a distinct hazard to the public. The hazard is not the vapour itself, but the possibility that it could be ignited. If ignited, the vapour cloud will not expand any further, but instead, will burn back to the vapour source. The LNG fire will continue to burn until the fuel is consumed or the fire extinguished.

8. FROSTBITE

Low temperatures (frostbite) may occur, but only in the immediate area of the release and would be confined to the site.

Recommended Mitigation for Frostbite

Employees of the facility must be trained and instructed as to a safe course of action to follow in the event of an emergency as required by the codes covering the facility.

9. WASTEWATER

Cooling water and cold water streams for revapourization heating at LNG receiving terminals may result in significant water use and discharge streams. Other wastewater streams generated at LNG facilities include; drainage, sewage water, tank bottom water (e.g. from condensation in LNG storage tanks), fire water, equipment and vehicle wash water, and general oily water.

Recommended Mitigation for Wastewater

- Water conservation opportunities should be considered for LNG facility cooling systems. The proposed project will utilize a seawater cooling system and reduce the water demand. Other options include air cooled heat exchangers in place of water cooled heat exchangers and opportunities for the integration of cold water discharges with other proximate industrial or power plant facilities). The selection of the preferred system should balance environmental benefits and safety implications of the proposed choice.
- Cooling or cold water should be discharged to surface waters in a location that will allow maximum mixing and cooling of the thermal plume;

- There will be no effluent discharge from the FSU. Effluent is treated onboard in a three stage process and the effluent and waste will be collected by a waste handling company to discharge in accordance with MARPOL Requirements. The waste handling company is responsible for the handling and final disposal of the wastes and providing the Ship's Agent with a disposal certificate.
- The following additional parameters will assist in avoiding pollution:
  - No oil or mixture containing oil shall be discharged or allowed to escape from a vessel while at the terminal.
  - No garbage or other materials, either liquid or solid, shall be discharged overboard from a vessel, but shall be retained in suitable receptacles on board for proper disposal on land.

10. AIR EMISSIONS

Air emissions (continuous or non-continuous) from LNG facilities include combustion sources for power and heat generation (e.g. for dehydration and liquefaction activities at LNG regasification activities at LNG receiving terminals). Sources of emissions from the on shore facility, exhaust gases, venting and flaring and fugitive emissions are described in the EIA.

Recommended Mitigation for Air Emissions

- Air emission specifications should be considered during all equipment selection and procurement.
- The overall objective should be to reduce air emissions and evaluate cost-effective options for reducing emissions that are technically feasible. Significant (>100,000 tons CO_2 equivalent per year) greenhouse gas (GHG) emissions from all facilities and support activities should be quantified annually as aggregate emissions in accordance with internationally recognized methodologies and reporting procedures.
- Flaring or venting should be used only in emergency or plant upset conditions. Continuous venting or flaring of boil-off gas under normal operations is not considered good industry practice and should be avoided.
- BOG should be collected using an appropriate vapour recovery system (e.g. compressor systems). For LNG plants (excluding LNG carrier loading operations), the vapour should be returned to the process for liquefaction or used on-site as a fuel; on board LNG carriers BOG should be re-liquefied and returned to the storage tanks or used as a fuel; for regasification facilities (receiving terminals), the collected vapours should be returned to the process system to be used as a fuel on-site, compressed and placed into the sales stream/pipeline, or flared.
- Methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of facilities. The selection of appropriate valves, flanges, fittings, seals, and packings should be based on their capacity to reduce gas leaks and fugitive.

11. WASTE MANAGEMENT

Non-hazardous and hazardous wastes routinely generated at LNG facilities include various sources outlined in the EIA.

Recommended Mitigation for Waste Management

Waste materials should be segregated into non-hazardous and hazardous wastes and considered for re-use /recycling prior to disposal. A waste management plan should be developed that contains a waste tracking mechanism from the originating location to the final waste reception location. Storage, handling and disposal of hazardous and non-hazardous waste should be conducted in a way consistent with good EHS practice for waste management.

12. NOISE

The main noise emission sources in LNG facilities include pumps, compressors, generators and drivers, compressor suction / discharge, recycle piping, air dryers, heaters, vapourizers used during regasification, and general loading / unloading operations of LNG carriers / vessels.

Recommended Mitigation for Noise

Atmospheric conditions that may affect noise levels include humidity, wind direction, and wind speed. Vegetation, such as trees, and walls can reduce noise levels. Installation of acoustic insulating barriers can be implemented, where necessary on land. On the off shore platform, personal protective equipment will be made available to reduce worker exposure to unacceptable noise levels

13. LNG TRANSPORT

Common environmental issues related to vessels and shipping include; hazardous materials management (risk of spills); wastewater and other effluents (ballast water and sewage); fires and explosions, contamination of marine waters and other water sources; air emission; solid waste generation of LNG tankers / carriers.

Recommended Mitigation for LNG Transport

Recommendations for their management are covered in the EHS Guidelines for Shipping. Measures to Avoid, Minimize, or Mitigate Environmental Risk.

- LNG vessel design, construction and operations should comply with international standards and codes; relating to hull requirements (e.g. double hulls with separation distances between each layer), cargo containment, pressure / temperature controls, ballast tanks, safety systems, fire protection, crew training,
- Guidelines include; International Maritime Organization's (IMO) International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, known as the International Gas Carrier Code (IGC Code).
- Further guidance is provided in the standards, codes of practices, principles and guidelines issued by the Society of International Gas Tanker and Terminal Operators (SIGTTO).

14. SHIPPING HAZARDS – GROUNDING AND COLLISION

The risk and environmental impacts of LNG shipping are different compared to the receiving (off shore and on shore) facilities. In principle, the hazards are similar (fire from LNG release), however the potential causes of a release are different and the area potentially affected by the release will move along the route of a ship. These hazards are described in the EIA.

Recommended Mitigation for Shipping Hazards

As the ship approaches the facility, it will be under control of a licensed pilot. The manoeuvring for berthing and turning of the ship will be assisted by tugboats. The tugboats will be able to control the movement of the ship and prevent grounding. The potential for damage in the event of grounding would be further mitigated by the ship's reduced speed as it approaches the offloading berth and its double hull. The energy required to cause a release of cargo during a grounding incident is very large and would require both high ship speed and a hard, penetrating bottom.

Maritime regulations should be set regarding clearance areas between ships and smaller vessels. Regardless of the very low probability of a collision, it is the general practice to establish a safety or security moving zone for the LNG carriers. This also

15. LNG RELEASE DUE TO EQUIPMENT OR SYSTEM FAILURE

The most credible type of release is the result of equipment or system leakage, such as a leaking valve seal or flange gasket. This type of release is typically small and non-threatening.

Recommended Mitigation for LNG Release due to equipment or system failure

The LNG facility should be equipped with an extensive array of gas detection and flame detection equipment. Small leaks will be detected either visually, by trained personnel working in the facility, or by the detection equipment. Small leaks and/or fires should be easily handled by facility personnel, with assistance from the Fire Department if necessary.

Any release will be contained and directed to a sump, thus mitigating the extent of vapour dispersion. Should the vapour ignite, the thermal radiation will be mitigated by containment in the sump. The fire will continue until the fuel is consumed or the fire is extinguished. Damag Damage will be confined to the terminal boundaries, including any controlled areas outside the property lines

16. TERRORISM AND SABOTAGE

A successful act of terrorism will require a high level of training and must be capable of being planned and initiated without detection. This limits the size of the weapon that can be used in the attack and therefore limits the credible threats.

Recommended Mitigation for Terrorism and Sabotage

- Terminal and shipping personnel will be screened by the terminal before hiring.
- Ship crews and plant operators tend to be very stable as the jobs are considered to be monetarily attractive. There is very little turnover in terminal staffing and hence a low possibility for unscrupulous persons to work aboard the vessels.

- All authorized persons and vehicles will be subject to search before entering the facility. All unauthorized persons will be turned back.
- LNG facilities should be required by law to have significant security features built into the facility.
- LNG ship's double hull plus separate cargo tanks prevent significant damage which may cause a LNG release given a terrorist attack.
- The LNG ship's cargo tanks are surrounded by insulation within the double hull construction of the ship. The tops of the tanks have an outer cover above the main deck, called the weather dome. The weather dome should absorb most of the blast from any explosion and any damage to the cargo tank will be reduced.
- The credibility of the threat of a small boat with explosives is greatly reduced by the fact that the LNG ship will be located in restricted waters with security provisions in the berth area. The security provisions are normally for protection of the LNG vessel, other ships or a secondary benefit of the security craft as a deterrent of sabotage in the waterway.
- Terrorists are more interested in "high profile" targets with strong symbolic value, or targets that can cause mass casualties or severe economic damage. In general, LNG terminals are not attractive targets due to their "low political profile", difficulty of attack, and high level of security.

17. NATURAL DISASTERS

The possibility of a LNG release resulting from an act of nature such as hurricane, earthquake and tsunami is remote, as design standards should take seismic, wind and weather factors into account. Should an act of nature cause a release, the result will be the same or less than other scenarios previously stated.

Recommended Mitigation for Natural Disasters

- The tanks should be designed to take into account the wind loads (both typical and maximum) for the region and must be able to withstand a Category 5 hurricane. Equipment and structures must also be designed to withstand the harshest recorded environment for the region.
- It is also important to ensure that the ship's automatic disconnection.

CUMULATIVE IMPACTS AND RECOMMENDED MITIGATION

1. TRAFFIC

Traffic to and from the on shore facility will be minimal except during construction since LNG will be piped directly to the metering station on shore rather than using trucks. There will be some minimal traffic for on shore staffing at shift changes. Boat traffic to the platform will also be minimal after construction is complete and will mainly consist of daily staffing changes which will be minimal since only a small number of staff are needed to conduct offshore operations. Therefore, the cumulative impact of traffic and site access will be minimal during operation of the facility. During construction (especially of the off-shore facility and laying of the pipeline), there will be a temporary increase in boat traffic.

Recommended Mitigation

i. Construction traffic entering or leaving Old Harbour Bay may be scheduled for off peak hours to minimize additional congestion and or disruptions in the regular traffic flow.
ii. Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
iii. Adequate and appropriate road signs should be erected to warn road users of the construction activities.
iv. The trucks should be parked within the proposed area unless they are in use.
v. Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
vi. The use of flagmen should be employed to regulate traffic flow.
vii. Efforts will be made with the Port Authority of Jamaica to coordinate this required work effort in order to minimize conflicts with normal port marine vessel traffic.

2. RAW MATERIALS AND EQUIPMENT

Some of the materials to construct the on-shore facility will be acquired locally but the materials and equipment for the off-shore platform and pipelines (as well as the equipment for the on-shore facility) will have to be acquired off island due to their specialized nature.

Recommended Mitigation

i. Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
ii. A central area should be designated for the storage of raw materials. This area should be lined or fenced in order to prevent the leakage of chemicals into the sediment/water.
iii. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental runoff.

3. STORAGE OF FUELS AND CHEMICALS

It is anticipated that refuelling and maintenance of large machinery will take place on the construction site; except for the LNG stored on the FSU (there will be minimal storage of fuel and lubricants on site).

Recommended Mitigation

i. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored.
ii. In addition, these containers should be placed on hard, impermeable surfaces and surrounded by bunds to contain the volume being stored in case of accidental spillage.
iii. LNG on the FSU will be carefully managed in order to ensure its safe delivery via pipeline to the on-shore facility and the JPS plant.
iv. Careful metering of the pipelines will ensure that any leaks are detected quickly and properly managed.

4. MARINE WATER QUALITY

Cumulative impacts on water quality from the facility will be from the small on-shore facility as well as the off-shore platform and associated FSU. With respect to the on-shore facility, there will be some stormwater runoff from the facility as well as runoff during construction. The off shore facility and associated FSU will have some potential water quality impacts mainly from stormwater runoff, discharge of water used to warm the LNG before it is discharged into the pipeline, and domestic wastewater from the platform and FSU from the staff required to maintain these facilities

Recommended Mitigation

i. Stormwater from the facility will be managed through on-site stormwater management and construction of Best Management Practices and use of capture strategies to avoid direct discharge into the bay.
ii. The discharge of heating water will be done in such a manner as to meet all NEPA water quality requirements.
iii. All domestic wastewater from the staff for the platform or FSU will be treated to meet all NEPA requirements before discharge.
iv. Care should be taken during connection and disconnection of pipeline ends to avoid or reduce the amount of residual spillage of fuel during delivery.

5. NOISE

The cumulative noise impact takes into account all the existing background noise sources which include the existing Jamaica Public Service Old Harbour power plant, the Jamaica Energy Partners Doctor Bird I and II Barges, Jamaica Ethanol, Operations at Port Esquivel, Hi Pro Feed Mill, and other anthropogenic activities such as night noises. The predicted noise from the new noise source (the proposed LNG Terminal and Regassification Project) is then added to the existing noise levels to determine what, if any impact this new development would have on the surrounding community. This is considered a worst case scenario as the existing Jamaica Public Service Old Harbour power plant will be decommissioned once the new 190 MW plant becomes operational. After this analysis all predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guidelines. Therefore, no mitigation is required.

6. AIR QUALITY

As part of the air dispersion modeling analyses, a determination of the impact of the existing sources on the ambient air quality was made, as well as the cumulative impact with the addition of the air pollutant sources associated with the proposed 190 MW power plant and the consequent retirement of the existing oil-fired 190 MW JPS facility, as well as the sources of the proposed LNG Terminal. From these results it can be concluded that the replacement of the implementation of the LNG Terminal and the associated combustion of LNG at a new 190 MW power plant to replace the existing JPS oil-fired power plant will significantly improve the prevailing SO_2 ambient air quality concentration within the air shed. Therefore, no mitigation is required.

7. EMPLOYMENT

About 20 workers will be needed for the site preparation work for the project for the on-shore facility, 225 to 250 workers for construction of the on-shore and off-shore facilities as well as construction of the pipelines, and about 40 workers to permanently operate the facility (on-shore and off-shore). These positions will likely be a mix of off and on-island individuals with much of the construction being done by locally contracted individuals. It is anticipated that persons from the community will be employed directly with other persons benefiting indirectly. This has the potential to be a significant positive impact. Therefore, no mitigation is required.

COST BENEFIT ANALYSIS

This analysis was conducted using the following approach. The approach for this analysis uses a five stage methodology as described in the EIA:

1) Calculation of financial profitability measured at market prices.
2) Obtaining the net bene t of the project measured in terms of economic prices.
3) Adjustment for the impact of the project on savings and investment.
4) Adjustment for the impact of the project on income distribution.
5) Adjustment for the impact of the project on merit goods and demerit goods

Based on this analysis, the final NPV of the project after application of Social Cost Benefit Analysis turns out to be US $953,410,000. Hence, the project should be undertaken as it has multiple social benefits which are reflected in the final positive NPV of the project.

ENVIRONMENT, HEALTH AND SAFETY MANAGEMENT AND MONITORING PLAN

An environment, health and safety management and monitoring plan has been prepared as part of the EIA. This plan provides detailed plans for the FSU and regas facility, underwater pipeline, and on-shore pipeline both during site preparation/construction and operation. In addition, reporting requirements are discussed for noise and water quality for the project.

EMERGENCY PREPAREDNESS AND RESPONSE

Measures to address emergency preparedness and response are addressed in the EIA. These measures are outlined for the following topics: Off-shore loading facility, Natural Gas Pipeline, ADO Pipeline, and the On-Shore Facility. Measures for the pipelines include pressure monitoring, block valves, subsea block valves, tanks, and measures for hurricanes and tropical storms.

RISK ASSESSMENT

A Risk Assessment of the project was also undertaken. The following aspects of the project were evaluated for their risk to the environmental and human health – LNG Off-Loading Facility (cryogenic hazards, fire hazards, severe weather, and power outage), NG Pipeline, and ADO Pipeline. In general, the probability of these incidences were low with severe weather risks (hurricanes and tropical storms) was moderate. Measures were described to manage the severe weather risks.

SUMMARY OF IMPACTS

Item	Size*	Description
Off-shore platform	1,358 m^2	Total area of platform
Off-shore platform	300 m^2(100 m^2 each)	Mooring footprint
Off-shore NG pipeline	100 m	On sea bed near platform
Off-shore NG pipeline	2,362 m	Length, conventional lay
Off-shore NG pipeline	3,048 m	Length, directionally drilled
On-shore NG pipeline	800 m	Trenched on site to JPS plant.
Off-shore ADO pipeline	100 m	On sea bed at exit point near mooring
Off-shore ADO pipeline	2,012 m	Length, directionally drilled
On-shore ADO pipeline	800 m	Trenched on site to JPS plant
On-shore facility	15,000 m^2	Total footprint
On-shore facility	7,150 m^2	Impact to mangroves

Up to this size

SUMMARY OF MITIGATION

- 500-meter exclusion zone around platform (However, due to usage of the area by fishers and concerns expressed during stakeholder consultation, we are willing to reduce the 500m restricted/exclusion zone to 200m so as to accommodate the local fisherfolk only).
- Mangrove mitigation – 10,400 m^2 impacted area (3,041 plantings)
- Stormwater – on site management
- Numerous safety measures – operational and spill related (see EIA for details).

2.0 INTRODUCTION

2.1 BACKGROUND

The Jamaica Public Service Company Limited (JPS) has selected NFE South Holdings Limited (NFE) to supply natural gas to Old Harbour Power Station Plant. Additionally, natural gas will be provided to potential future industrial users, including power generators. To meet the needs of JPS and other future users, Liquefied Natural Gas (LNG) will be transported to Jamaica from the U.S. or another location to a new LNG Off-Shore Terminal. The new fuel supply will be regasified and distributed by a new natural gas pipeline from the off shore facility via an undersea gas pipeline to the JPS Old Harbour 190 MW Power Plant.

Impacts from the construction and operation of the proposed project will potentially arise and it is imperative to consider these likely impacts and assess the vulnerability of environmental features in proximity to the project location, as well as on a national scale. In order to evaluate these impacts, an Environmental Impact Assessment (EIA) is required by the National Environment and Planning Agency for the proposed project. The specific tasks, as outlined by the Terms of Reference (TORs) (Appendix 1) have been executed by the contracted entity, CL Environmental Co. Ltd., and this report serves to compile and present the findings of the EIA.

2.2 LIQUEFIED NATURAL GAS (LNG)

LNG is the liquid form of natural gas, which is primarily methane, the lightest and cleanest burning of all the fossil fuels. Natural gas originates from reservoirs beneath the earth's surface and once captured, can be stored and transported over long distances as a gas in pipelines or in a liquid form (LNG) in cryogenic tanks on trucks, trains and ships. To return LNG to a gaseous state, it is regasified[1] by warming in a controlled environment. LNG is more economical to transport because its volume is approximately 600 times less than natural gas.

2.3 PROJECT OVERVIEW

This project proposes to construct a marine terminal facility comprised of a vessel berth and off-shore offloading and regasification platform at the general location approved by the Port Authority of Jamaica in the Portland Bight area of Jamaica. This facility will accommodate a Floating Storage Unit (FSU) vessel for LNG storage and a LNG carrier delivering LNG to the FSU. The FSU is a LNG carrier refitted for use as a storage vessel. LNG will be delivered by ship from various potential locations in the United States or other locations. The platform (as described) would contain equipment to regasify LNG as well as related process and safety equipment. The liquid gas from the FSU would be carefully regasified and the gas would then be released into an undersea pipeline which will be mostly directionally drilled

[1] "Regasification" is the process of turning a liquefied gas (like "Liquefied Natural Gas") into a gas for ease of transport or use.

in basically a straight line from the platform to the vicinity of the JPS plant. This mostly submerged line will minimize environmental impacts since it will be mostly directionally drilled in a relatively straight line. It follows a route parallel to the general route of an existing Automotive Diesel Oil (ADO) line which runs from the existing mooring facility to the JPS plant in Old Harbour. The gas pipeline would then be mostly directionally drilled on shore to a small receiving facility on shore near the proposed gas power plant that JPS is constructing where it can be metered and then sent to the power plant. In addition, the project will construct a new ADO line to storage tanks in close proximity to the new power plant in order to enhance the reliability of the facility in case of LNG delivery interruptions.

2.4 JUSTIFICATION OF THE STUDY AREA BOUNDARY

The boundary of the study area (2 km buffer around the Marine Terminal and Land side facilities) was defined by analysing various areas of potential impacts. These were based on:

1. Air emissions,
2. Noise emissions,
3. Potential area for water quality pollution,
4. Potential for thermal radiation and explosion potential; and
5. The communities and potential livelihoods that potentially may be impacted by the construction and operation of the proposed Project.

3.0 COMPREHENSIVE DESCRIPTION OF THE PROPOSED PROJECT

3.1 PROJECT CONCEPT AND DESCRIPTION

3.1.1 The Proponent

NFE South Holding Limited is an affiliate of New Fortress Energy and sponsored by Fortress Investment Group. Fortress Investment Group is a highly diversified global asset management firm with approximately $70.64 billion of assets under management and an experienced investor in transportation, infrastructure, & energy assets around the world.

- Founded in 1998, Fortress Investment Group LLC (NYSE:FIG) was the first New York Stock Exchange listed alternative asset manager
- Headquartered in New York, Fortress has 1,130 employees across 15 offices worldwide

3.1.2 Project Location and Siting

The FSU vessel and regasification platform is to be located on the south coast of Jamaica, approximately 56.1 kilometres (≈ 30.3 nautical miles) southwest of the Port of Kingston (Figure 3-1). It is approximately 5.7 km south west from the Old Harbour fishing beach. The proposed natural gas pipeline will run south of the entrance to the Port Esquivel channel and then be directionally drilled to a location just southwest of the existing JPS Old Harbour facility, and the privately owned diesel power plant (Doctor Bird I & II) (Figure 3-2).

The community of Old Harbour Bay, located on the southwestern coast of Jamaica in the parish of St. Catherine, was estimated to have a total population of 5,471 in 2011. Located approximately 5 km from the town of Old Harbour, the Old Harbour Bay community consists of twenty-four (24) small communities, which include Blackwood Gardens, Kelly Pen, Thompson Pen, Bay Bottom, Terminal, Dagger Bay, More Pen Lane, Peter's Land, Sal Gully, Cross Road and Panton Town. Bordered by the Colbeck Castle community to the east and Bourkesfield to the southeast, the Old Harbour Bay community is one of many residential fishing villages found along the coast in Jamaica, and is considered the largest fishing village on the island. The other industries and sources of employment include mining, manufacturing, small retail shops and subsistence farming.

The location of the off-shore mooring facility was chosen with the assistance of the Port Authority of Jamaica staff in order to lessen impacts on existing marine facilities in the Portland Bight. The NG pipeline route was selected to be mostly directionally drilled from the on shore facility to the off shore platform in a relatively straight line in order to lessen the potential for impact to the seabed from this line. Similarly, the new ADO line route was selected to be mostly directionally drilled in a straight line from shore to the existing ADO location in order to minimize environmental impacts and also provide the most direct route to the JPS plant. Both pipelines are planned to run underneath the degraded coral reef community to minimize environmental impacts.

Delivery of LNG will take place approximately once every twenty five (25) days. The offloading of each ship is expected to take a maximum of forty hours (40).

The majority of the marine facility will be largely assembled outside of Jamaica and therefore many of the components will arrive in the island by sea and be installed directly on site offshore and not pass through a port facility. To the extent equipment and materials need to be delivered through a port, the preference will be Port Esquivel because of its proximity to the site. Materials may also be brought in through other port facilities such as Rocky Point and Kingston as the logistics favour those movements (small size, existing trade routes, delivery schedule, existing off-loading equipment, etc.

3.1.3 Rationale and Objectives

This proposed Project fits in with the National Energy Policy which seeks to develop a modern, efficient, diversified and environmentally sustainable energy sector providing affordable and accessible energy supplies, with long-term energy. The proposed Project forms the basis of providing a more diversified and environmentally friendly fuel source that has the potential to reduce the cost of electricity to the country and improve electricity supply reliability. The main objective is to provide the Jamaica Public Service Company's Old Harbour Plant with a cleaner and more cost effective fuel in furtherance of the goals of the National Energy Policy.

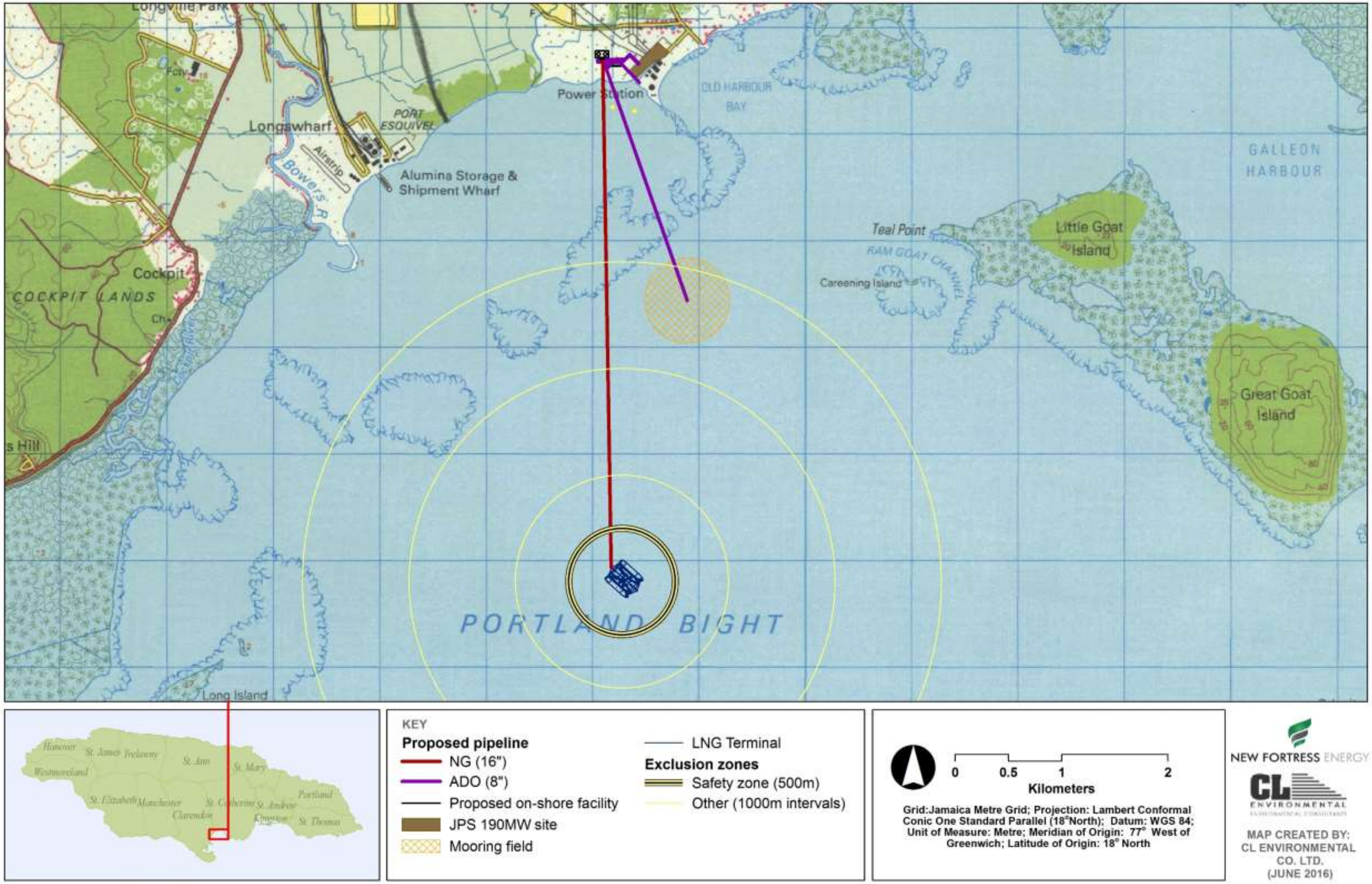

Figure 3-1 Location of proposed project and pipeline route

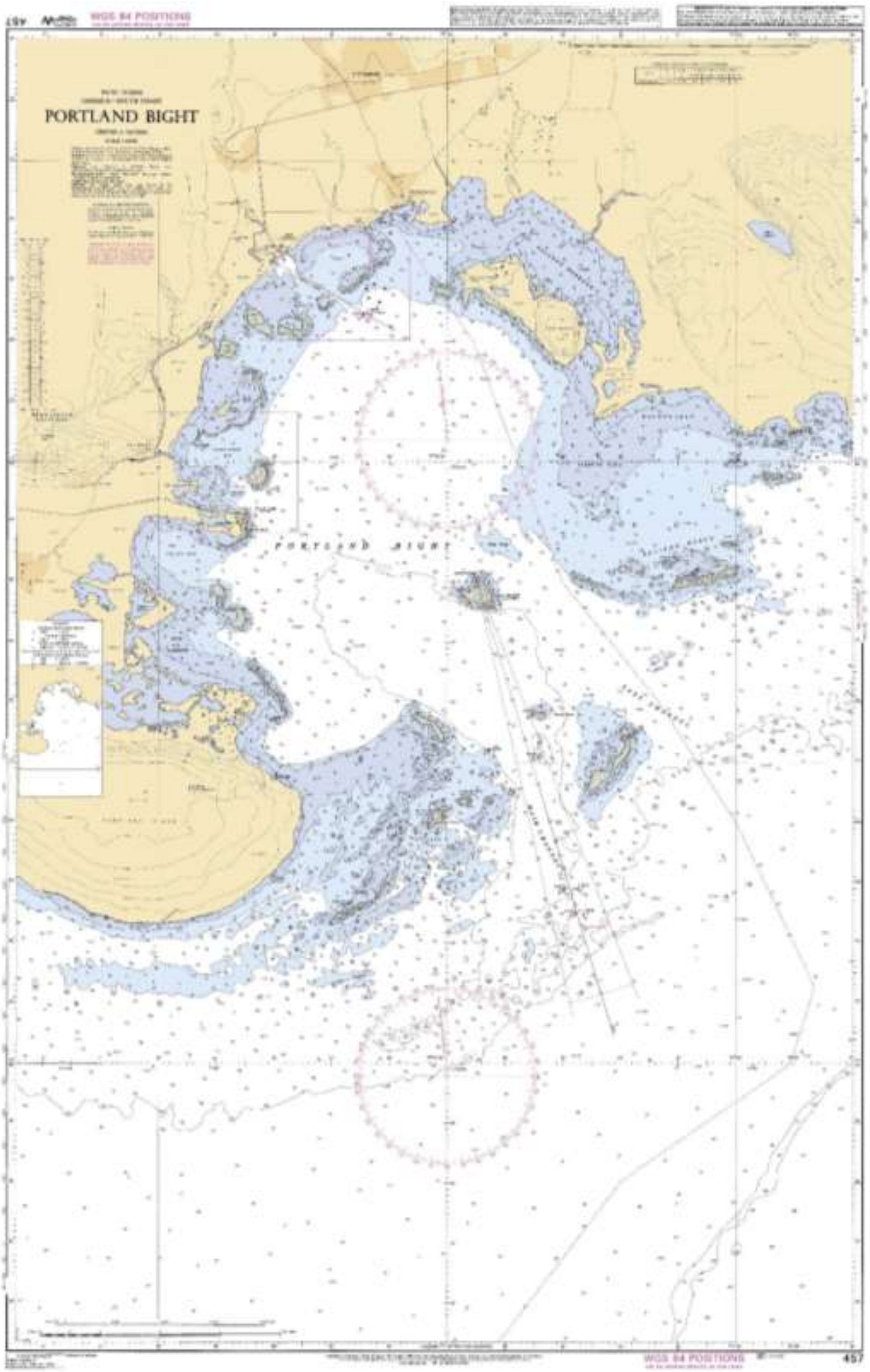

Figure 3-2 Shipping Channels in Portland Bight area.

3.2 PROJECT INFRASTRUCTURE, EFFLUENT AND EMISSIONS

3.2.1 Off Shore Berth and Regasification Platform

The proposed marine facility location was selected after consideration of environment, operations, and constructability. The marine facility will be constructed off-shore in the western side of Portland Bight, at a distance about 200 meters from the shipping channel to Port Esquivel in approximately 14 meters of water depth. This location offers sufficient depth to berth the FSU and the LNG carrier vessels without the need for dredging, yet has sufficient protection from storm wave impacts as a result of the shape of the Bight. This general location was reviewed by staff of the Port Authority of Jamaica and does not interfere with on-going marine activities in the area.

Coordinates of the proposed platform are: LAT: N017.8564; LON: W077.1093.

This facility will contain an unloading area, control room, power distribution center, boil-off-gas compressor skid, LNG pump skid, vaporizer and process skid, flare skid including drain tank and igniter, flare, nitrogen generator skid, seawater pumps, mixing tank, air burst system, crane, and launcher area. The facility will be designed so it can be readily expanded as demand for LNG grows in the region.

The project is organized in 2 phases. The elements for each phase and general construction materials are outlined below:

- Phase 1 of the project includes one vessel berth consisting of an unloading and regasification platform, metering and pig launch platform, four (4) breasting dolphins and six (6) mooring dolphins. The dolphins and the process platforms are connected for access using nine truss spans and four catwalks.
- Phase 2 of the project includes a second berth, an extension to the Phase 1 unloading and regasification platform and installation of four (4) additional breasting dolphins.

The structures will be constructed using steel pipe piles, steel framing, steel superstructure and concrete deck slabs on the platforms. The dolphins will include a fender system and quick release hooks for vessel mooring and berthing. The berths are designed for LNG vessel sizes ranging from 140,000 m^3 up to 175,000m^3 capacity with an approximate vessel length of 280m to 300m and draft of approximately 12.5m. The structures are designed to resist mooring and berthing loads under operational conditions, as well as seismic and hurricane/tropical storm conditions. The tallest structure or piece of equipment on the Platform is likely to be the crane which could be +/- 7.6 m (25 ft) above the deck (the deck elevation is + 10m). The Flare Stack, which will be located on one of the mooring dolphins is +/- 13.7 m (45 ft) tall. Therefore, no structure or equipment will extend more than 17.6 m in height above the horizon and will not be visually obtrusive from shore or from the sea.

The offshore facilities will be buffered by a 500 m safety exclusion zone (international guideline) in which navigation will be restricted. A 2008 study by Sandia National Laboratories looked at LNG tankers that transport from 125,000 to 145,000 cubic meters of LNG in multiple (separated) cargo tanks on a single ship. The study concluded that "*Even with the increase in thermal hazard distances from pool fires for the larger ships, the most significant impacts to public safety and property are still within approximately 500 m of a spill, with lower public health and safety impacts at distances beyond approximately 1600 m*."

All safety and navigational lighting will be in place 24/7 in an effort to ensure sufficient navigational warning for vessels using this area.

The facility will contain mooring provisions for LNG ships to dock at the facility at varying intervals depending on demand for the gas. The ships will then off-load the LNG which will be stored in the FSU and regasified on the facility constructed on the platform and sent to the shoreside distribution facilities. Under normal operation, a Boil off Gas compressor will compress boil-off gas from the FSU to pipe line pressure and into the product pipeline. In the event of an emergency shut-down of the system, boil-off gas will be diverted to a flare designed to handle the full rate of boil-off gas from the FSU. The flare will be located on one of the dolphins furthest from the platform. The flare tip will be at a height that will result in acceptable radiation levels to allow emergency egress of personnel. The flare is designed to combust 5.64MMSCFD. The flare will be operated for short periods during initial start-up and in the event of an emergency shut-down. We do not anticipate more than a few occurrences per year after initial start-up.

Please see Figure 3-3 through to Figure 3-8 for associated project drawings.

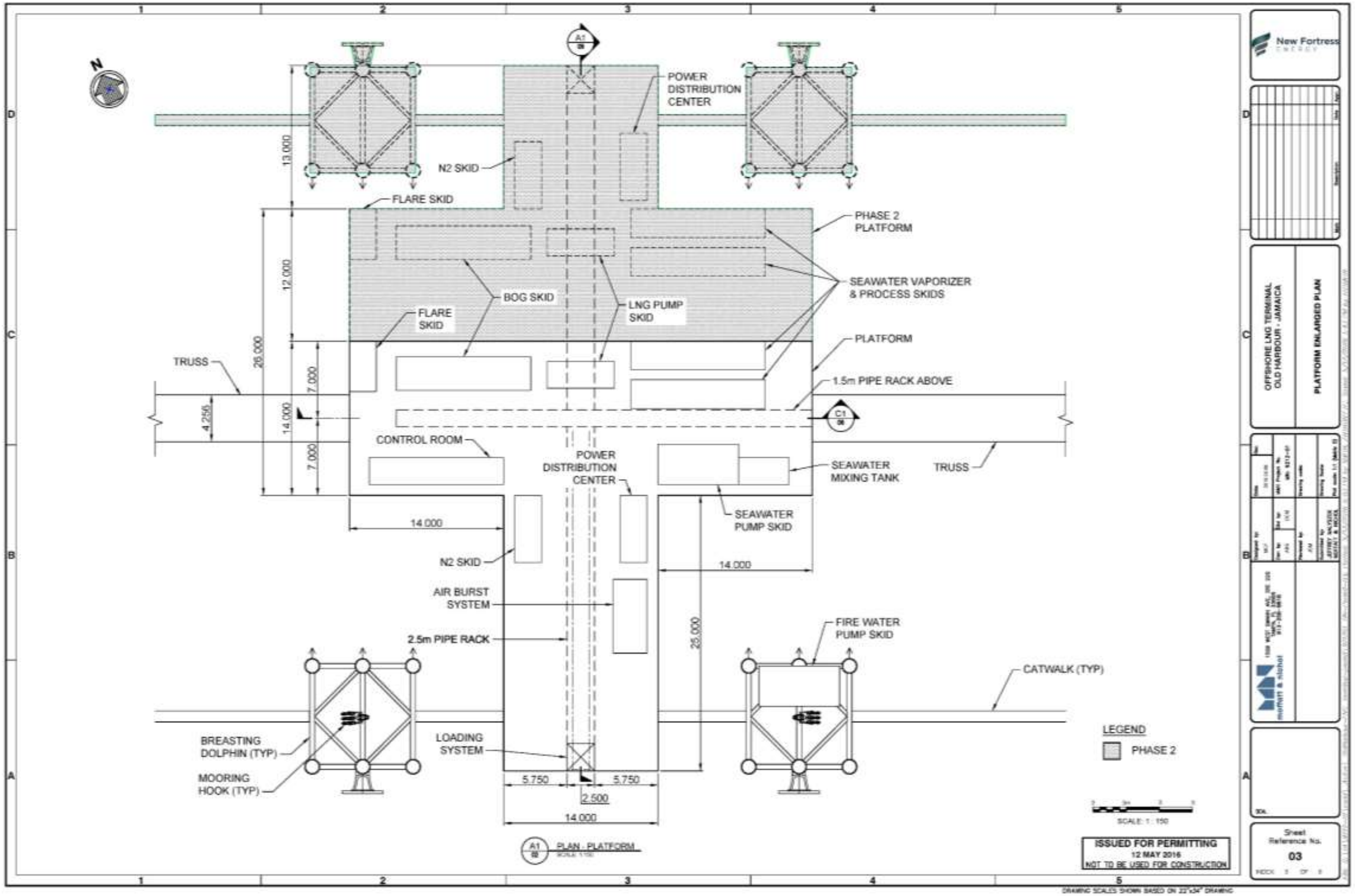

Figure 3-3 Plan view of the offshore LNG platform

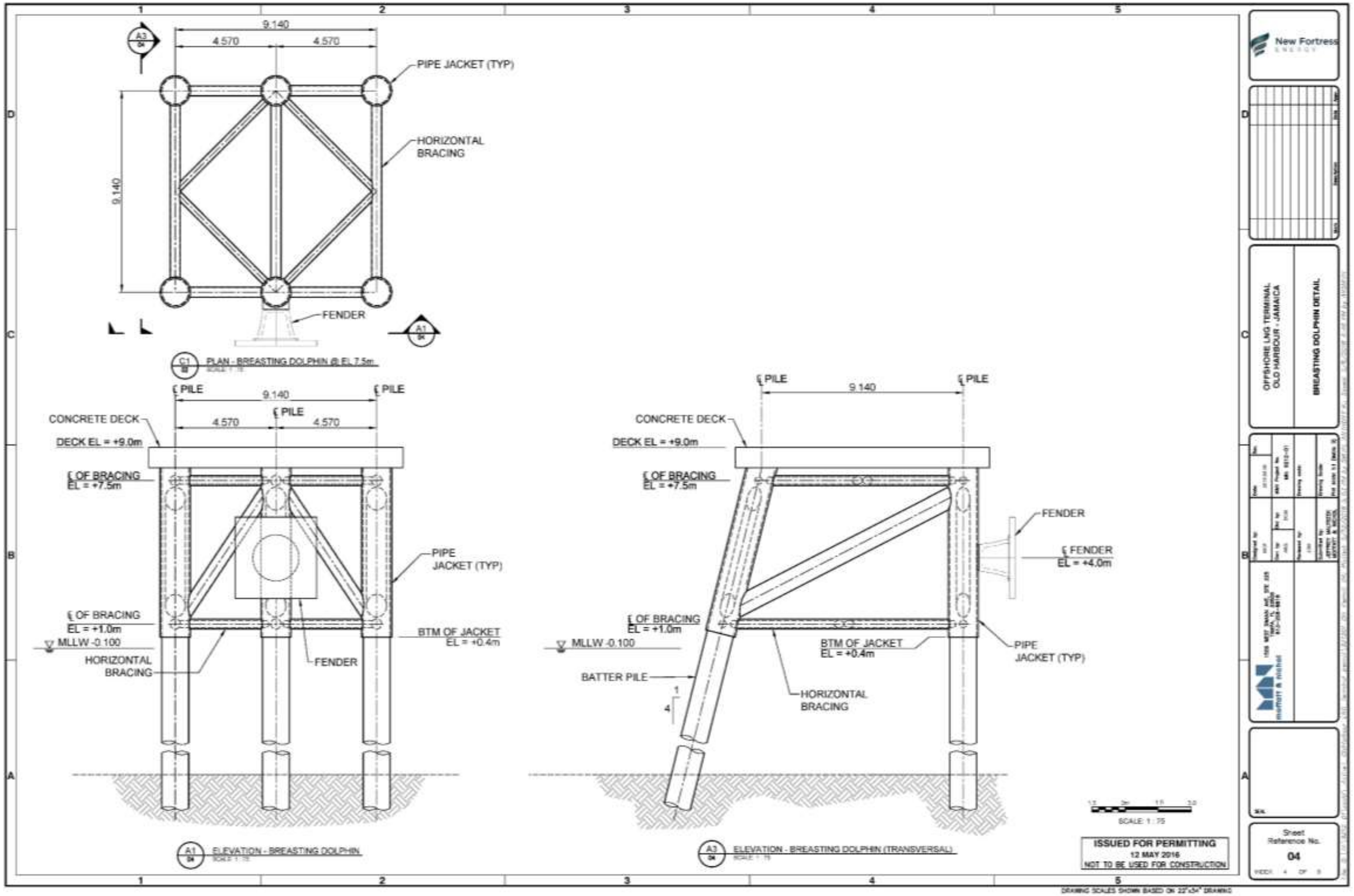

Figure 3-4 Elevation drawing of the breasting dolphins of the offshore LNG terminal

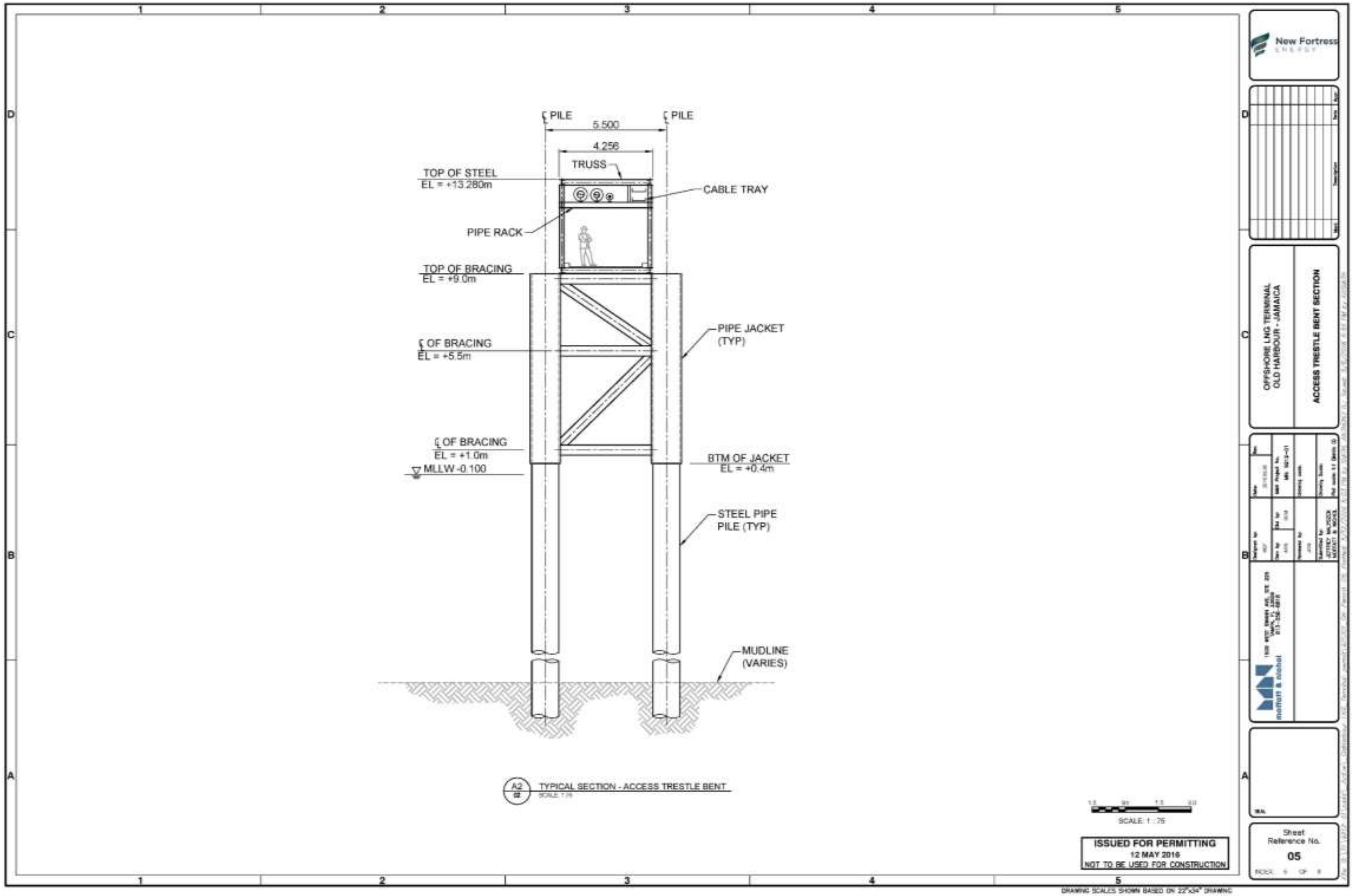

Figure 3-5 Access trestle of the offshore LNG Terminal

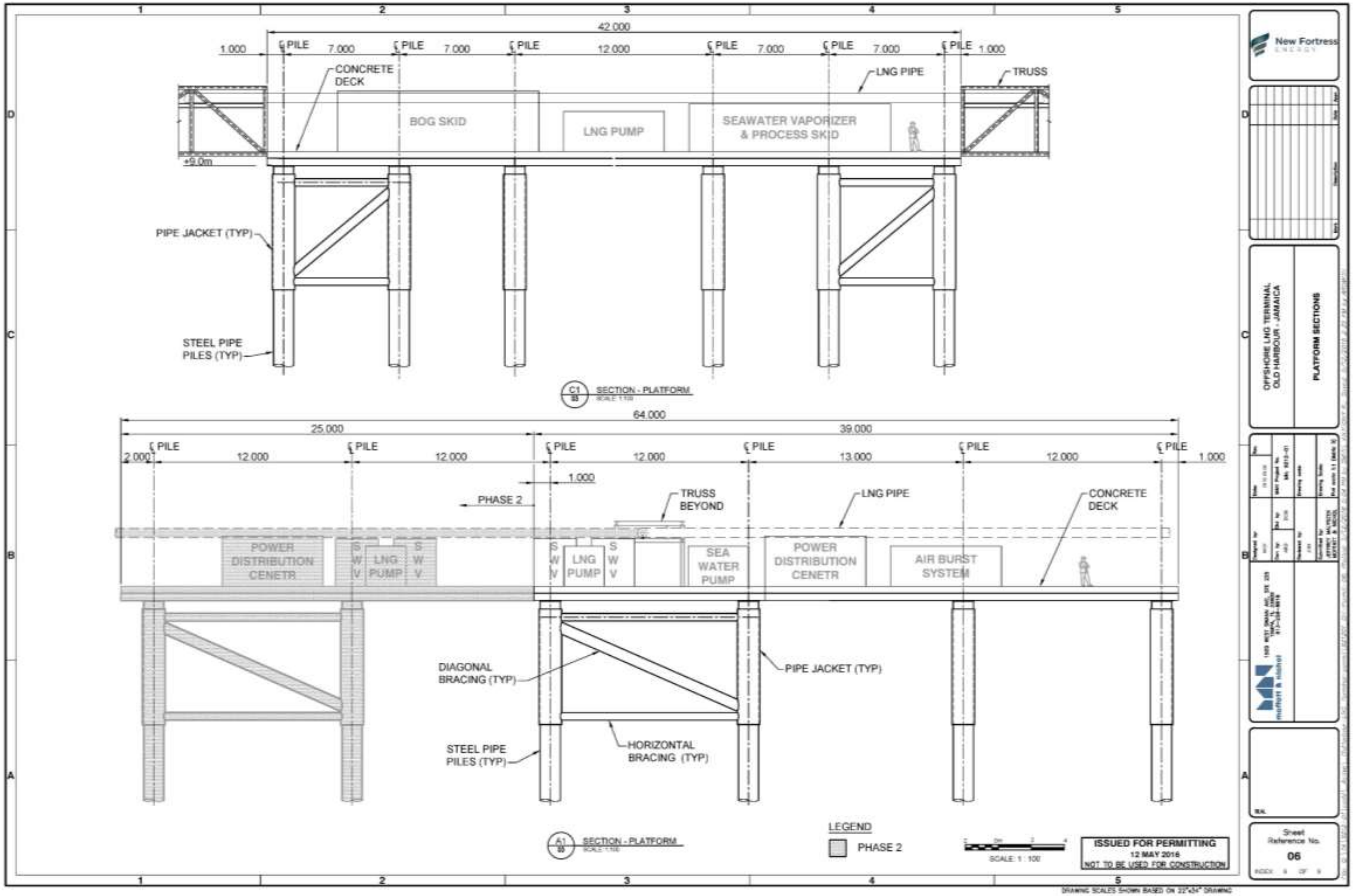

Figure 3-6 Platform section of the offshore LNG Terminal

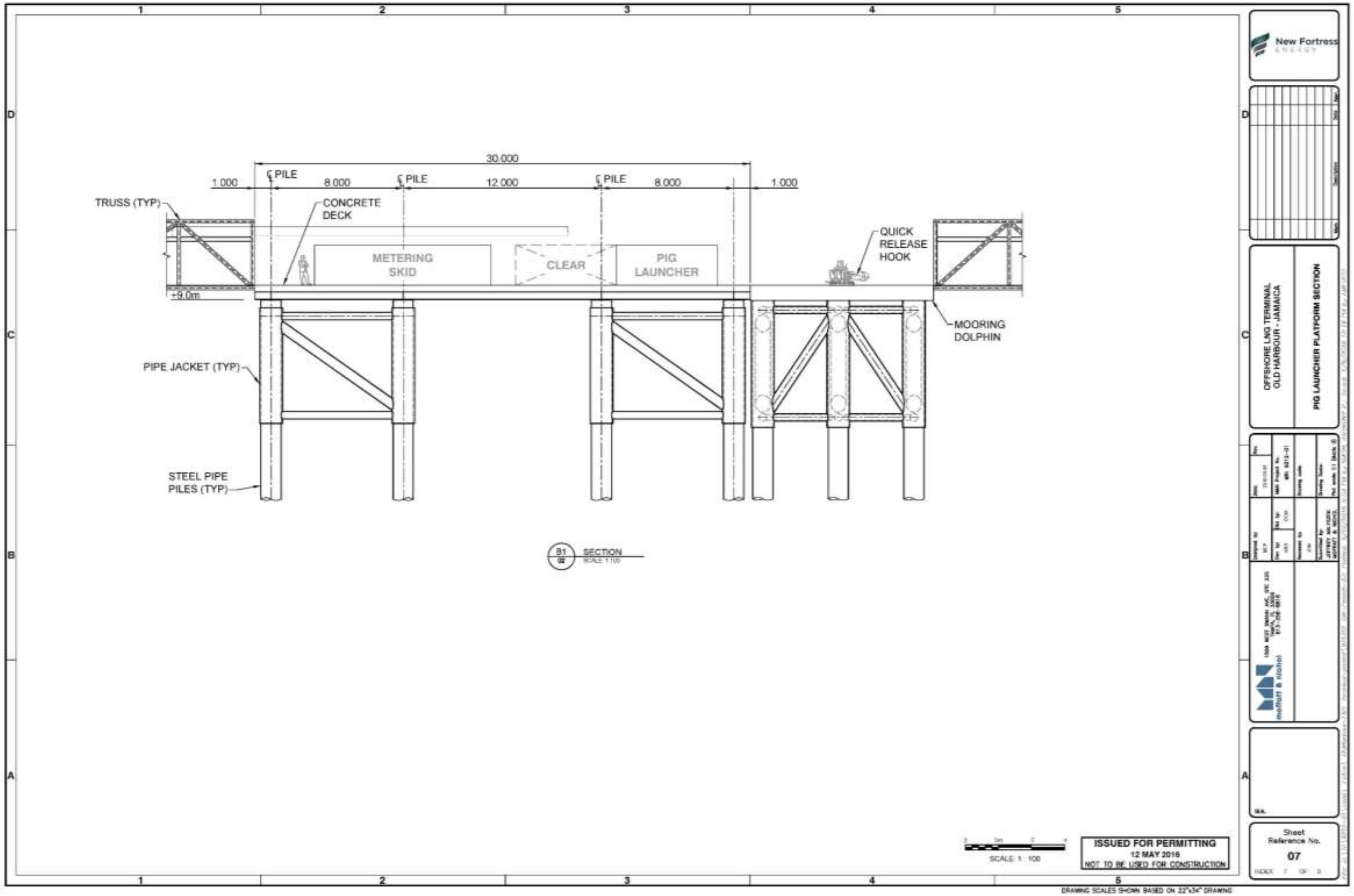

Figure 3-7 Pig launcher platform section

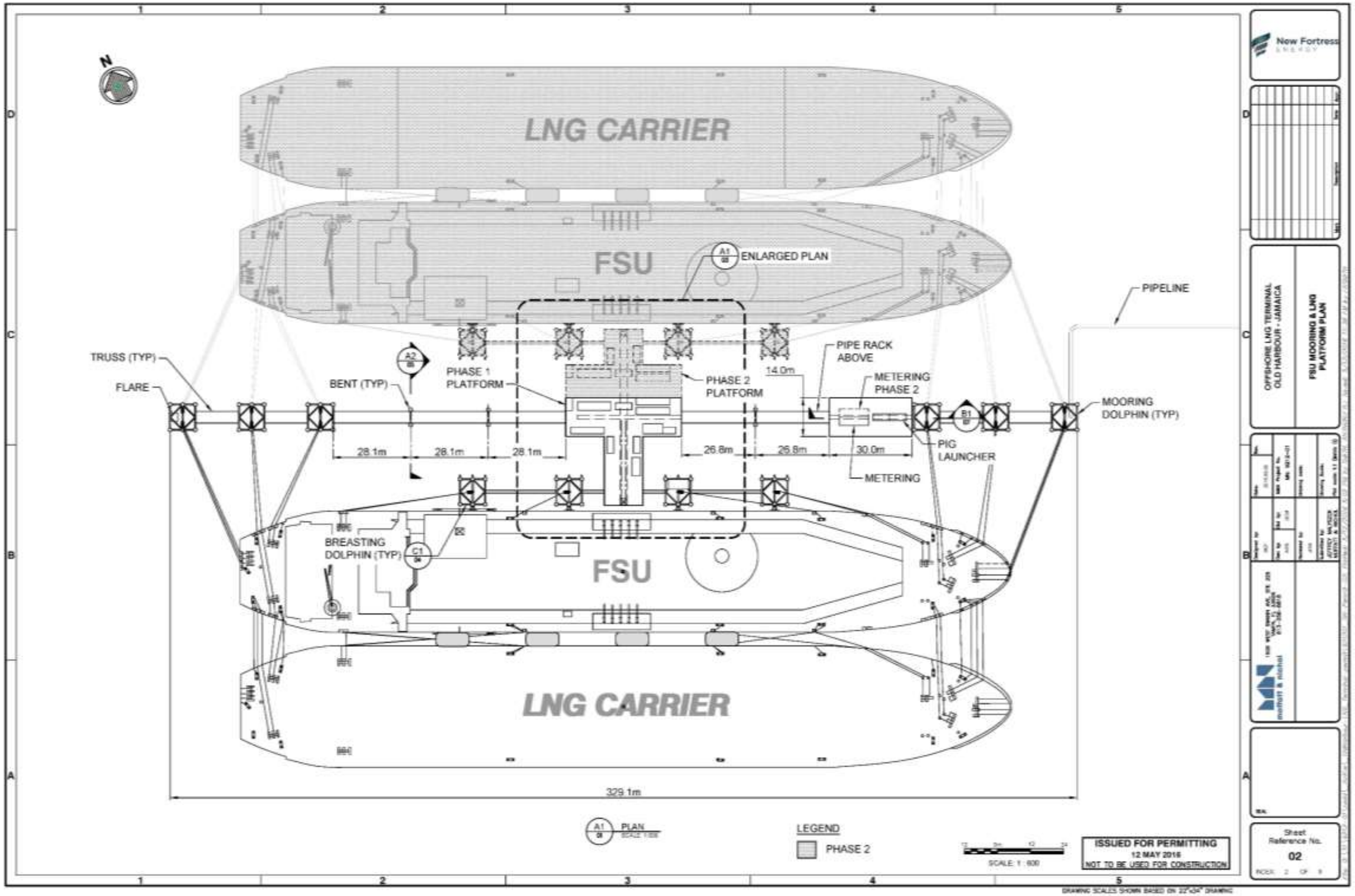

Figure 3-8 Floating Storage Unit (FSU) mooring and LNG platform plan

3.2.1.1 Floating Storage Unit

The FSU will be designed to allow storage of LNG prior to being regasified at the off-shore facility and before it is then sent to the mainland via the subsea pipeline. It is anticipated that this FSU will be moored at the off-shore facility but it will be able to undock and move to shelter in case of pending hurricane conditions.

3.2.1.2 Regasification System

LNG is pumped from the FSU tanker via marine loading arms to the LNG booster pumps located on the regasification platform. The pumps boost the pressure of the LNG to approximately 650 psig and send it to vaporizers which use warm sea water to vaporize the LNG and heat it to a temperature in excess of freezing point to prevent ice formation on the outside of the pipe. Vaporized gas proceeds to a metering skid and to the undersea, off shore pipeline. Seawater pumps are used to pump seawater to the vaporizer. Seawater flowing out of the vaporizer is mixed with warm seawater to stabilize water temperature, which then discharges back into the ocean.

A boil-off-gas compressor will be located on the regasification platform to collect surplus boil-off-gas generated by the FSU and compress to about 650 psig to join vaporized gas. A flare, drain tank and igniter is included to provide a means to flare off gas in case of an emergency. A nitrogen generation system, which produces nitrogen from air, is installed on the regasification platform to be used to operate valves and for purging.

In relation to gas flaring, the quantifiable maximum is assumed to be the condition dealing with boil-off gas only, in that case, there is 4.7 mmscf/d. CO_2 emissions from the flared gas assume ~117lb/mmbtu or about 381 lbs of CO_2/min. The relevant standards are local air emissions standards, of which this level of emissions is below the applicable standard. Note that as part of the manufacturing process for LNG, impurities are stripped from the feedgas, therefore consisting of mostly methane.

3.2.2 Natural Gas (NG) Pipeline

The natural gas (NG) pipeline will run southwards from the proposed on-shore metering facility to the offshore mooring berth and is located so as to not jeopardize the integrity of the existing line or the anchors for the buoys. The total length of this pipeline is approximately 5,410 meters. An undersea, off shore, carbon steel pipeline (up to 16 inches in outside diameter (40.64 cm)) will be constructed to run from the regasification platform to the shore at the JPS plant. The pipelines are to be directionally drilled in straight lines between the following points:

- Origin at platform:
  - LAT: N 017.857451
  - LONG: W077.110489
- At on-shore tie-in:
  - LAT: N07.900010
  - LONG: W077.110769

The design of the pipeline will be in accordance with ASME B31.8. A seismic analysis of the pipeline will be performed during detailed design. The pipe joints will be 12.2-meter long. The pipe will be coated with a corrosion coating and where applicable either an abrasive resistant overlay coating or a concrete weight coating (see below). The concrete weight coating is to ensure on-bottom pipeline stability under environmental loading (wave, current, and buoyancy). The concrete coating will also provide impact protection. Bracelet type aluminum alloy anodes will be installed on the pipe to provide corrosion protection in addition to the corrosion coating. These anodes will be installed at predetermined locations along the pipeline length.

The natural gas pipeline will be mostly directionally drilled using a horizontal directional drill (HDD) from the planned metering facility at the JPS plant to offshore for a distance of approximately 5,410 meters. The length of the HDD will allow the proposed pipeline to go under the coral and the ship channel. The pipe lay for the HDD will start close to the open water HDD exit point and in line with the HDD. A shallow water lay barge will be used. The pipe for the HDD will be coated with a corrosion coating and an abrasion resistant overlay (ARO). The pipe will be welded together on the lay barge to install a pipe string onto the seabed. After the HDD bore has been drilled, the drill pipe will be connected to a pull head on the pipe string. The pipe string will be pulled into the drill hole using the HDD or other installation equipment. A length of pipe string approximately 100 meters in length will be left on the seabed at the HDD exit point.

The pipe lay for the remaining pipeline will start after the HDD pipe string is installed in the HDD drill hole. The free end of the approximately 100 meters of pipe at the HDD exit point will be lifted back to the lay barge. The lay barge will weld pipe joints to the HDD pipe and commence to lay it on the seabed. The lay barge will continue welding on pipe joints, laying the pipe to the seabed, and moving along a predetermined route ending close to the FSU platform location. The pipe for the offshore pipe lay will be coated with a corrosion coating and concrete coating.

To provide additional protection for the pipeline, it is proposed to trench it to at least a depth of 1 meter (measured from the existing seabed to the top of the pipe). The trenching will be performed at least after the pipeline has been installed on the seabed and will start at a point near the open water HDD exit point and stop close to the FSU platform location.

3.2.3 On-shore Metering Facility

A metering facility will be constructed at the on-shore end of the pipeline to measure the gas before it enters the JPS facility. This facility will be constructed to allow additional connections for gas distribution to future customers as demand requires.

Coordinates of the on-shore facilities are as follows: LAT: N017.898946; LON: W077.110665.

Please see Figure 3-9 and Figure 3-10.

3.2.4 Automotive Diesel Oil (ADO) Facilities

A new (or refurbished) up to 8-inch (20.32 cm) ADO pipeline will run from the existing power plant and end at the pipeline end termination near the existing multipoint mooring buoys. This pipeline will be mostly directionally drilled from the shore and under the coral to a point near the mooring field.

Coordinates for the ADO line are as follows:

- Origin at mooring location:
  - LAT: N017.880062
  - LONG: W077.103760
- At on-shore tie-in:
  - LAT: N017.898946
  - LONG: W077.110665

The onshore facility will include up to two 50,000 barrel storage tanks with approximately 55,000 barrels of containment in close proximity to the proposed new 190 MW power plant to be operated by JPS. This ADO line will provide a back-up fuel source to the JPS plant in case of interruptions in LNG delivery due to storms or other factors. The ADO will likely be supplied around once a year by ship and off loaded using a process similar to the existing process that the JPS plant uses.

Please see Figure 3-11.

Figure 3-9 Onshore facility layout plan

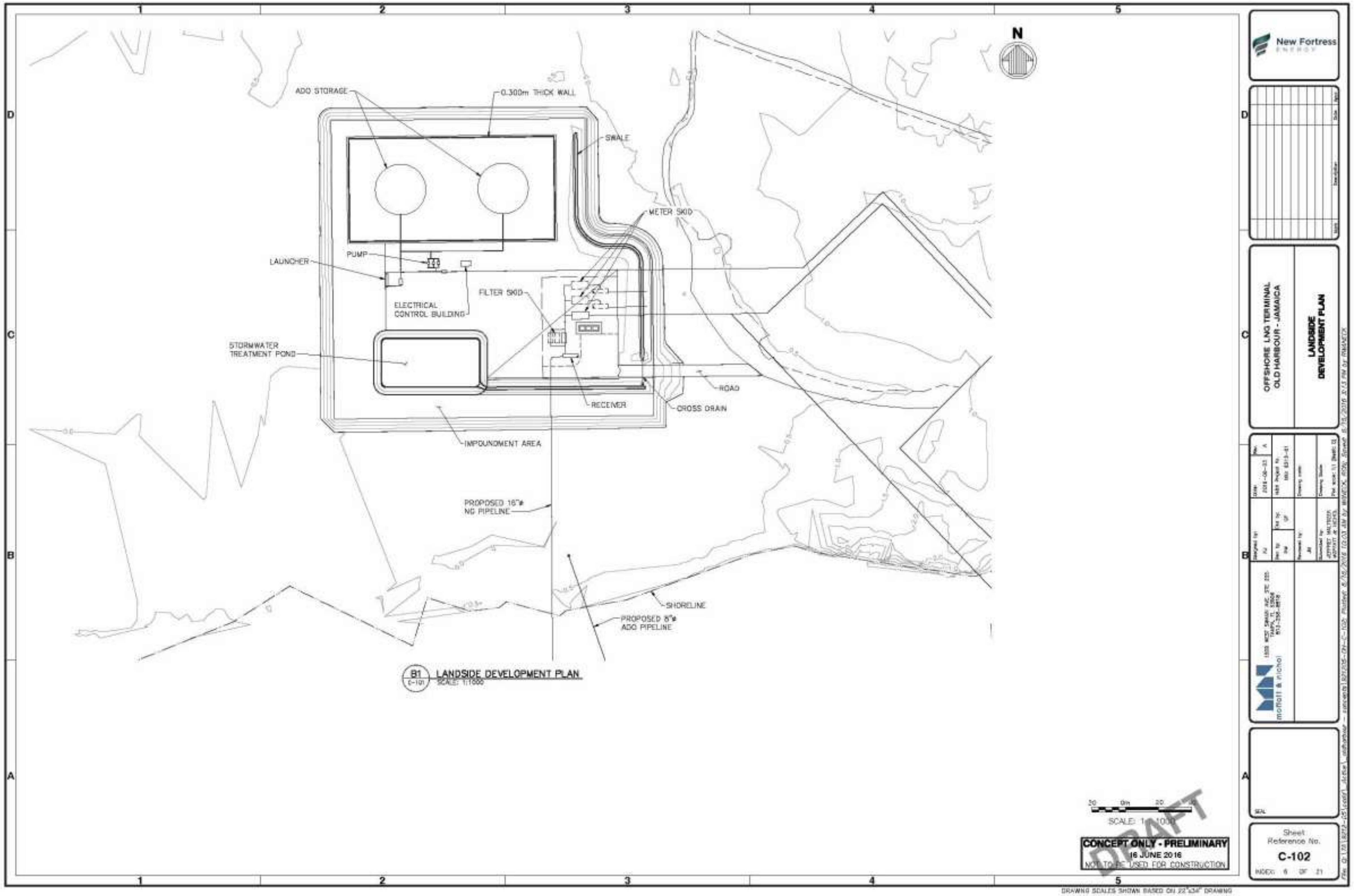

Figure 3-10 Landside development plan

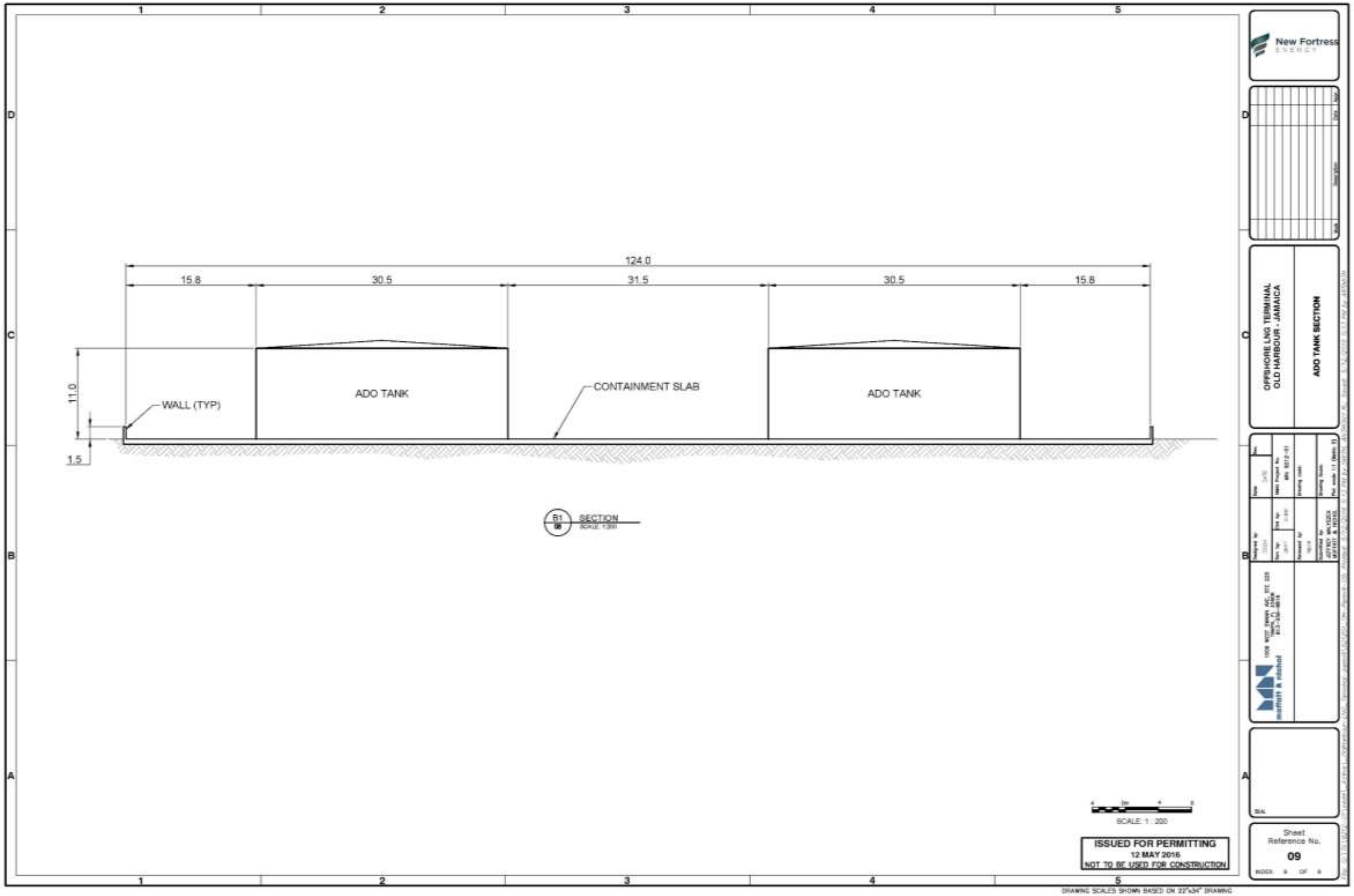

Figure 3-11 ADO tank section

3.3 ASSOCIATED FACILITIES AND ENVIRONMENTAL ISSUES

3.3.1 Power Generation

Power for the on-shore metering facility will be supplied by JPS through existing electrical transmission and distribution infrastructure. Power at the off shore platform will be supplied from the FSU or in certain cases from a generator on the platform (with potential redundancy provided by onshore power). In addition, one back-up diesel generator on the off-shore platform will power the emergency shutdown (ESD) and associated critical items. Another generator will provide back-up power to a main water pump. Generally, the platform equipment will have the capability to run on natural gas.

3.3.2 Diesel

Electricity will be provided by the ships or in certain cases from a generator on the platform. Diesel will be used as fuel for the emergency generator for the off-shore mooring facility and as back-up fuel for the main water pumps. Up to two diesel tanks will be stored on-site with capacities of 2 m^3 each. These pumps will also be designed to run on natural gas.

3.3.3 Potable Water

Utility provisions for the facility will be provided by a potable water source located on-site for the on-shore metering facility and will be provided at the off-shore facility for the staff. Potable water is used for domestic purposes at safety showers and eye wash purposes.

3.3.4 Wastewater Treatment

Sewage and wastewater loads will be minimal for the on-shore facility. Domestic wastewater from the terminal control room will be collected in a septic tank and drain field to be constructed within the boundaries of the plant.

The facility will not result in the generation of process wastewater. The regasification process will utilize seawater which will result in the discharge of cooled water into the sea near the mooring facility using a mixing process to ensure that there is no more than 5^{o} C change in temperature. This effect will be carefully modelled and monitored to ensure that there are no negative effects on marine life in the vicinity.

There will be no effluent discharge from the FSU. Effluent is treated on board in a three stage process and the effluent and waste will be collected by a waste handling company to discharge in accordance with MARPOL Requirements. The waste handling company is responsible for the handling and final disposal of the wastes and providing the Ship's Agent with a disposal certificate.

The following additional parameters will assist in avoiding pollution:

1. No oil or mixture containing oil shall be discharged or allowed to escape from a vessel while at the terminal.
2. No garbage or other materials, either liquid or solid, shall be discharged overboard from a vessel, but shall be retained in suitable receptacles on board for proper disposal on land.

While the FSU is permanently berthed, the basis is that there will be no discharge of waste or contaminated water to sea. As part of the FSU operations; (a) Bilge, grey water, sludge and sewage will be collected in holding tanks on-board the FSU, emptied periodically and sent to an external authorized treatment plant, and (b) All solid and semi-solid waste will be collected and disposed by sending them to an external authorized company.

3.3.5 Solid Waste

Solid waste will be generated by the facility, at both the platform and on board the ships. Any domestic (non-hazardous) garbage from the ship will be collected and taken to shore for proper disposal. All food waste which are from locally obtain produce will also be collected and taken to shore for proper disposal. All generating wastes will be reused or recycled to the maximum extent possible. The facility may periodically generate hazardous waste (typically less than 100 kilograms per month), including spent solvents, chemical cleaning wastes, and other wastes. Hazardous waste will be managed according to applicable rules and regulations.

3.3.6 Noise

Noise is a product of the various components of the offshore and onshore facility while it is operating. Table 3-1 lists the types of equipment whose normal operation will result in noise from the facility. In general, equipment will be purchased with sound attenuation consisting of enclosures (generators) or lagging (pumps and exchangers) to limit noise levels to 85 dB at 5 ft. from the perimeter of the module or skid.

Table 3-1 Estimated noise level by system

Line Item #	System	Line Size / Qty	Estimated dBA	Estimated Flow Rate / Pump hp
1	NG	2	80	2 MMSCFD
2	NG	4	98	29.1 MMSCFD/meter
3	NG	6	93	58.2 MMSCFD
4	NG	16	69	58.2 MMSCFD
5	ADO Pumps	2	70	5

Notes:

- *All flow and dBA values based on preliminary designs/data*
- *Two (2) of the three (3) ADO Pumps will operate simultaneously*
- *No sound attenuation devices are included in the values above.*
- *NG - Natural Gas System*
- *ADO - Automotive Diesel Oil System*

3.3.7 Storm Water

On-shore stormwater potential will be minimal since the footprint of the facility is small. Appropriately sized stormwater management will be incorporated into the design of this facility to manage stormwater runoff. The drainage design criteria for this project will be guided by local requirements for permitting and international standards, including National Works Agency's (NWA's) guidelines for preparing hydrologic & hydraulic design reports for drainage systems of proposed development applications, (guidelines) June 2015, the Government of Jamaica (GOJ) development and investment manual, (manual), volume 3, section 1 and the methodology of U.S. Department of Agriculture (soil conservation service technical release no. 55 (tr-55)), urban hydrology for small watersheds. Stormwater from the off-shore mooring facility and FSU will also be minimal and not result in violation of water quality standards at this location.

3.3.8 Onshore Erosion Control

On-shore erosion potential will be minimal since the on-shore pipeline will be mostly directionally drilled rather than using an open cut. There is some potential for erosion during construction at the small on-shore metering facility but proper erosion and sedimentation control measures such as silt fences should suffice to manage this risk.

3.3.9 Plant Control Philosophy

The facility will utilize a distributed control system (DCS) that will supply continuous information to the control room on both the off-shore and on-shore facilities. Fire detection (smoke, heat, or flame) will produce equipment shutdown. Manual actuation of fire suppression systems and emergency shutdown (ESD) will be provided to site personnel via manual call stations. The FGS (fire & gas detection and alarm system) and ESD philosophy is to utilize a multiple detector voting logic.

3.3.10 Safety and Fire Protection

The project will be designed, constructed, and operated in accordance, and in reference to, the National Fire Protection Association (NFPA) 59a, where appropriate, for the production, storage, and handling of LNG. The offshore mooring facility will have a specialized system that safeguards the facility against potential upset conditions and fires by utilizing early warning detection and emergency shutdown systems. In the event of an emergency within the process area, the systems will detect the emergency via fire and gas detection alarms, alert operators, and automatically shut down the process. Manual activation of fire suppression and emergency shutdown will also be provided to site personnel via manual call stations. Water based hydrants and monitors along with special hazard (dry chemical) suppression systems will be included at the off-shore terminal. Additional safety measures will be constructed at the small on-shore metering facility.

3.3.11 Firewater Description

The fire protection system is controlled and monitored by the fire and gas detection system and monitoring panels and sensors. Dedicated firewater pumps will supply seawater from the ocean as the influent. Firewater monitors and hydrants will be located on the offshore facility as well as the onshore metering facility.

3.3.12 Seawater Intake System

Sea water to vaporize the LNG will be pumped from the ocean using submersible column mounted pumps. The pump columns will extend from the platform operating deck to below the minimum sea level. Column intakes will be provided with screens to prevent suction of marine life/vegetation and/or debris. Pump discharge will be at the top of the column which will be manifolded with other pump columns into a single distribution header. The distribution header will provide sea water for LNG regasification which occurs by indirect contact of the seawater with the LNG in a shell and tube heat exchanger.

3.3.13 Auxiliary Heat Exchanger and Discharge

Cooled sea water will be returned to the ocean (below sea level) at a temperature no more than 5 degrees C below the intake temperature via a sea water return pipe. In order to optimize the size of the re-gasification exchangers, some of the sea water flow will bypass the exchangers. This bypass stream will be remixed with the cooled sea water exiting the exchangers prior to returning to the sea. The mixing process will be carried out in a mixing tank. In-line mixers are being considered in lieu of mixing tanks. Three pumps will be required for Phase I. Two pumps will be added to support Phase II as demand for LNG grows in the area.

3.3.14 Storage of Chemicals

The chemicals used or stored on the platform or the on-shore facility include the drilling mud for the directional drill during construction, and nitrogen used on the platform. Other than these there will be no other chemicals stored or used during normal operations other than the NG and ADO. Constituents of the drilling mud cannot be finalized until the actual work has begun as the drilling contractor will determing the most appropriate constitents to be used based on soil conditions.

3.3.15 Other Safety-related Measures

The planned undersea pipeline will have a leak detection system which contains numerous pressure, flow, and acoustic detector devices to provide instantaneous feedback as to the presence and location of a leak. The instantaneous feedback of the leak detection system may be used to initiate a system shutdown per operating procedures and/or local requirements. There will be a marine security zone of 500 meters enforced around the off-shore mooring facility and clearly marked with buoys where boat access will be restricted and strictly controlled for safety reasons. The Purpose of a safety zone is to reduce risks to public safety and property. In addition, there will be a hazard zone of 1000 meters from the platform where shipping will be restricted as clearly marked by additional buoys.

The 500m security zone will be enforced using patrol and safety boats, as well as electronic surveliance and monitoring technology. When a LNG delivery vessel is at the terminal, the tug will additionally assist with the enforcement of the safety zone. The safety zone will be published and broadcast as a notice to mariners. No vessel will be permitted to enter the zone without authorization from the Terminal Operators. The offshore terminal will be lighted per the Illuminating Engineer Society (IES) recommendations and applicable Occupational Safety and Health Administration (OSHA) standards. The platform lighting will utilize high efficiency LED lighting, minimizing power consumption. Design considerations will be taken to reduce the risk of light pollution such as unwanted spill lighting and sky glow. It is anticipated that the illuminance at the Terminal will be on average 53.81 - 64.58 lux (5 – 6 foot candles (fc)), with a minimum of approximately 13.99 lux to a maximum of 161.46 lux (1.3 – 15 fc).

3.3.16 Carbon Footprint

3.3.16.1 Carbon Emissions for Existing JPS Facility

Using USEPA* greenhouse gas emission factors for the existing Oil-Fired Utility Boilers and a total oil consumption of 306,099,807 L/y, the following emission rates were calculated for the JPS 190 MW power plant that this project will supply natural gas (Table 3-2):

Table 3-2 Carbon Emission rates for Oil-fired Utility Boilers

Facility	Pollutant	Emission Factor, lb/10^3 gal	Emission Factor, kg/L	Facility Emission Rate, tonne/y
Oil-Fired Utility Boilers	CO_2	24,400	2.928	896,260.2
	CH_4	0.28	0.0000336	10.3

United States Environmental Protection Agency. May 2010. Emission Factor Documentation for AP-42: External Combustion Sources, Tables 1.3-3, 1.3-8 and 1.3-12. Office of Air Quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle, North Carolina.

3.3.16.2 Carbon Emissions for NG Fired 190 MW Power Plant

Using USEPA* greenhouse gas emission factors for LNG-Fired Stationary Gas Turbines and the heat consumption rate of 1.383 x 10^9 kJ/h for the LNG to be used, the following emission rates were calculated (Table 3-3):

Table 3-3 Carbon Emission rates for 190 MW Power Plant

Facility	Pollutant	Emission Factor, lb/MMBtu	Facility Emission Rate, tonne/y
LNG-Fired Combustion Turbine	CO_2	110	573,000
	CH_4	0.0086	44.8

United States Environmental Protection Agency. July 1998. Emission Factor Documentation for AP-42: Stationary Gas Turbines. Office of Air Quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle, North Carolina.

The use of natural gas to fire the new JPS 190 MW power plant will result in a reduction of ≈ 36.06% in carbon dioxide and a 334.95% increase in methane generated by the power plant facility per year.

3.4 ENGINEERING AND DESIGN DETAILS FOR OLD HARBOUR LNG PROJECT

3.4.1 Reception (FSU to Re-Gas Facility)

The transfer of LNG from FSU to Re-gas facility will be continuous via articulating LNG arms. There will be one liquid supply line, one vapor return line and one spare that is manifolded such that it can be used either as back-up vapor or liquid line. Arm diameter is maximum 16". Unloading pressure is 5.2 bar at the loading arms, LNG composition is 85%+ methane.

3.4.2 Storage

The loading from LNG tanker to FSU will be at a rate of ~12,000 m^3/hr. The capacity of the FSU is expected to be up to 170,000 m^3 with 4 to 5 tanks depending on the selected FSU. The tanks are expected to be low pressure membrane type with storage temperature (°C) -160 (+/- 3F) and storage pressure of ~5 mbar. Isolation valves and cold detection system would be included;

3.4.3 Processing

The processing system will include up to four (4) vaporizers, boil off gas management system, and controls that comprise the regasification system. Each vaporizer will have capacity of up to 225 m^3/hr, operating pressure of ~42 bar, outlet temperature (°C) ~27 C;

3.4.4 Transportation

3.4.4.1 NG Transportation Network

The natural gas would be transported to shore via a ~5.41 km pipeline with an operating pressure of 41.4 barg, and design pressure of 49.6 barg. The pipeline is proposed to be buried at least 1m to top of pipe below natural seabed level. The pipeline is expected to have a diameter of up to 16 inches comprised of material similar to API 5L Grade X65 PSL2 and a preliminary thickness of 21.4 mm. The final wall thickness will be determined based on pressure requirement, buoyancy, and seismic analysis, type of cathodic protection system, and other factors. The proposed leak detection system is a HIMA LDS that uses Enhanced Pressure Wave (EPW), Compensated Volume Balance (VBM), and Pressure Drop (PDM) and leak detection methods to provide instantaneous feedback as to the presence and location of a leak.

3.4.4.2 ADO Transportation Network

The ADO would be transported via a ~2.91 km pipeline with an operating pressure of 6.9 barg, and design pressure of 18.9 barg. The pipeline is proposed to be buried at least 1m to the top of pipe below natural seabed level. The pipeline is expected to have a diameter of up to 8 inches comprised of material similar to API 5L Grade X65 PSL2 and a preliminary thickness of 8.2 mm. The final wall thickness will be determined based on pressure requirement, buoyancy, and seismic analysis, type of cathodic protection, and other factors.

3.4.5 Regulating and Metering Stations

3.4.5.1 NG Onshore Regulating and Metering Station for Old Harbour Power Plant

Inlet pressure (bar) 37.2 barg, Outlet pressure (bar) 27.5 barg, Number of regulating lines 1 full flow, 1 low flow, Capacity per line (m3/h) full flow – 44,850 scmh, low flow – 3,532 scmh.

3.4.5.2 ADO Onshore Regulating and Metering Station for Old Harbour Power Plant

Inlet pressure (bar) 4.1 barg, Outlet pressure (bar) 4.1 barg, Number of regulating lines 1, Capacity per line (m3/h) 36.3 m3/h.

3.4.6 Vehicle for Distribution

Vehicles will not be used to distribute natural gas. Natural gas will be distributed by pipeline.

3.4.7 Final Consumer

The natural gas will primarily be consumed by a combined cycle gas turbine (CCGT) operated by JPS. The terminal would supply gas at a minimum pressure of ~24.5 barg.

3.5 PROJECT PHASES

3.5.1 Construction

3.5.1.1 Schedule

Figure 3-12 shows the schedule for project construction and Figure 3-13 details the pipeline construction schedule. It is anticipated that NG will be ready to be delivered to the JPS 190 MW Power Plant by the second quarter of 2018.

Figure 3-12 Old Harbour fixed infrastructure development schedule (19 months to COD)

NEW FORTRESS ENERGY

NEW FORTRESS ENERGY
OLD HARBOUR PROJECT
PRELIMINARY PIPELINE CONSTRUCTION SCHEDULE

UniversalPegasus INTERNATIONAL
A Subsidiary of Huntington Ingalls Industries

ID	Task Name	Duration	Start	Finish
1	**PROJECT SANCTION**	**0 days**	**Mon 6/27/16**	**Mon 6/27/16**
2	ENGINEERING	141 days	Mon 6/27/16	Tue 11/15/16
3	VENDOR SELECTION AND AWARD	155 days	Mon 7/11/16	Tue 12/13/16
4	KEY MATERIAL SUPPLY	234 days	Mon 10/3/16	Thu 5/25/17
5	OFFSHORE GEOPHYSICAL & GEOTECHNICAL SURVEYS	60 days	Mon 7/25/16	Fri 9/23/16
6	LANDFALL (HDD) EXECUTION FOR NATURAL GAS (NG) PIPELINE	90 days	Sat 4/15/17	Fri 7/14/17
7	LANDFALL (HDD) EXECUTION FOR ADO PIPELINE	20 days	Fri 7/21/17	Thu 8/10/17
8	OFFSHORE PIPELAY BARGE - USE FOR BOTH NG & ADO PIPELINES	41 days	Wed 7/5/17	Tue 8/15/17
9	PIPELINE FLOOD, CLEAN, GAUGE - NATURAL GAS PIPELINE	14 days	Mon 8/7/17	Mon 8/21/17
10	PIPELINE FLOOD, CLEAN, GAUGE - ADO PIPELINE	12 days	Tue 8/22/17	Sun 9/3/17
11	OFFSHORE TRENCHING OF NATURAL GAS PIPELINE	22 days	Fri 8/25/17	Sat 9/16/17
12	HYDROTEST PIPELINE, INSTALLATION OF TIE-IN SPOOL & HFL AT OFFSHORE LNG PLATFORM LOCATION - NG PIPELINE	15 days	Sat 9/9/17	Sun 9/24/17
13	HYDROTEST PIPELINE & CONNECT PLET TO BUOY USING FLEXIBLE HOSES - ADO PIPELINE	23 days	Sun 9/24/17	Tue 10/17/17
14	PRECOMMISSIONING FROM LANDFALL TO OFFSHORE LNG PLATFORM - NG PIPELINE	25 days	Thu 9/21/17	Mon 10/16/17
15	**PROJECT COMPLETE - PIPE LAID, TRENCHED, CLEANED, PRECOMMISSIONED**	**0 days**	**Mon 10/16/17**	**Mon 10/16/17**
16	**TARGET MILESTONE FOR GAS SUPPLY TO POWER PLANT AT OLD HARBOR (ASSUMED)**	**0 days**	**Mon 1/1/18**	**Mon 1/1/18**

Timeline: 2016 (2nd Quarter: May, Sep) – 2017 (1st Quarter: Jan, May; 4th Quarter: Sep, Jan). Milestones:
- June 27, 2016
- October 16, 2017
- January 1, 2018

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Figure 3-13 Pipeline construction schedule

3.5.1.2 Construction Activities to be Carried Out

Marine Structures Construction

The proposed marine structures will be constructed utilizing jack-up and floating equipment. The primary in-water construction activity is installing the steel pipe piles for the marine structures. Following pile installation, pre-fabricated steel frames will be lowered onto the piles and welded in place to form the substructure of the platform. Modular precast deck slabs will be installed on the frame to form the platform deck. The platform deck modules will then be inter-connected using closure pours. The platforms will be finished with a reinforced topping slab and containment curb.

The four breasting dolphins and the six mooring dolphins consist of steel pipe piles with a steel frame and steel superstructure. The access walkways between the dolphins consist of truss bent structures and the catwalk bent structures supported by steel pipe piles. Marine fenders and quick release hooks will be installed on the dolphins. The steel trusses connecting the dolphins contain pipe supports and cable trays for piping and electrical power and controls.

Process Equipment/Skids

Construction activities for the process equipment and skids will consist of first off-loading equipment/skids/materials/components from barges or vessels followed by setting up of equipment/skids on the platform table-top. Installation and weld-out of pipe supports/sleepers/racks will be the next step followed by installation of interconnecting pipe spools and complete all closure welds. Installation of electrical and control raceways between skids/equipment will be the next step followed by installation of the PDC building. The next steps of the construction will involve power terminations and installation and calibration of shipped loose instruments. The final steps of the construction for process equipment and skids will be pressure testing, touch-up painting, completion of the insulation (cold) followed by installation of the Control Room and the Control System.

Horizontal Directional Drilling (HDD) Construction

The HDD process is described below. It is initiated onshore and exits at a point beyond the coral reef along the predetermined pipeline route. The straight line path for the natural gas line is approximately 5.410 km (3.36 miles) (see figure 3-1). The HDD depth is estimated to be approximately 12 m (40 feet) below the coral. The remaining pipeline length will be trenched to the platform.

The exit point will require some excavation (suction dredging) to provide a smooth transition for the pipeline onto the seabed. An initial estimate of the excavation size is 465 to 557 sq. meters (5,000 to 6,000 sq.ft). Both pipelines (ADO and NG) will be mostly directionally drilled and be at least 25 feet (7.62 m) beneath the ground at the onshore location. Therefore, there will be no need for a cleared maintenance corridor for either pipeline on shore. The drilling process in HDD can be described as follows:

SITE PREPARATION

The construction site is prepared before the main drilling operation. A drilling rig is set up at the proper location. A transmitter is inserted into the housing provided on the pilot drilling string near the drill bit.

Other equipment and facilities such as generators, pumps, storages, and offices are prepared at this stage.

PILOT HOLE DRILLING

A small diameter drilling string will penetrate the ground at the prescribed entry point onshore at a predetermined angle typically between 8 to 18 degrees. The drilling will then continue under the seabed along a design profile.

PRE-REAMING

The final size of the bore will be slightly larger than the outside diameter of the product pipe.

PULLBACK

The pipe is prefabricated on the anchored barge located at the HDD exit offshore. Once the pre-reaming operation is completed, the pipe can be pulled back into the reamed hole.

The drill pipe is connected to the product pipe using a pull head or pulling eye and a swivel. The swivel is a device used to prevent the rotation of the pipeline during pullback. A reamer is also located between the pull head and the drill string to ensure that the hole remains. The pullback operation continues until the pipe or conduit surface at the drill rig, i.e. at the HDD exit point onshore.

Subsea Pipelay Operation

SUBSEA PIPELAY

Subsea pipe lay operation will take place between the HDD exit point offshore and the offshore LNG Terminal location. An anchored barge and support vessels will be used for this purpose. Note that the anchored barge will be used for welding and feeding HDD pipe even before the subsea pipeline is laid. The following is a brief description of the subsea pipe lay operation.

An anchored barge will be mobilized along with support vessels. The anchored barge will set itself up (moor) close to the HDD exit offshore. As mentioned above, the first job of the anchored barge will be to feed pipe strings during the HDD operation. After the HDD pipe operation is completed, the same anchored barge will be used for laying the up to 16 inch diameter subsea pipeline. The anchored barge will recover the HDD tail section at the HDD exit point offshore and remove the blind flange. Next pipe joints will be welded to the HDD pipe end and subsea pipe will be laid through the stinger on the anchored barge. The stinger will be adjusted at an appropriate angle for this purpose. Depending on the specifications of the anchored barge, a support vessel may be required to supply pipe joints to the barge. Other support vessels will include two anchor handlers, a supply boat (to take personnel on and off the offshore LNG platform and for other sundry tasks) and two small barges and tugs.

The pipe lay operation will continue until it reaches close to the offshore LNG terminal. At this point a temporary pig launcher will be attached to the pipeline and the pipeline will be laid on the seabed. The anchored barge will be demobilized at this time as it is generally a large and expensive vessel.

SUBSEA PIPELINE FLOOD, CLEAN AND GAUGE

A small dynamic positioning (DP) Diving support vessel (DSV) complete with pipe flood spread will be mobilized. Personnel and equipment will be located at the landfall site i.e. at the onshore end of the pipeline. The pull head at landfall will be removed and a temporary pig catcher will be installed.

Divers on DP DSV will install flood hoses to a pig launcher at the other end of the pipeline near the offshore LNG terminal. At this point, confirmation of readiness at the landfall and offshore will be established. Next, the subsea pipeline along with the HDD portion will be flooded, cleaned and gauged from offshore to onshore. Onshore personnel will coordinate with the offshore personnel to confirm that pigs arrive in the pig catcher located onshore. The DP DSV will then remove the hoses and pig launcher and install a blind flange at the offshore end of the pipeline.

SUBSEA PIPELINE TRENCHING

The subsea pipeline will need to be buried so that the top of the pipeline is at least 1 m (≈3 ft.) below the seabed to prevent any damage to the pipeline and maintain its integrity as described above.

Pipe trenching personnel and equipment will be mobilized to the site. The DP DSV could be used to carry out trenching operations depending on its capabilities. The DP DSV will be set up at the HDD exit offshore. The first pass of the trenching operation will be carried out from the HDD exit offshore to the pipeline end near the offshore LNG terminal. The second pass will then be performed at the pipeline end near the offshore LNG terminal to the HDD exit offshore. The number of passes required will depend on the subsea soil type, and will be known when results from the geotechnical field survey is completed. Once the trenching operation is complete, the trench will be filled with local overburden (i.e. soil).

HYDROTEST PIPELINE

The hydrotest/pneumatic test will be mobilized from the pipeline end near the offshore LNG terminal and required pumps to pressurize the pipeline will be set up. The pipeline will be per ASME B31.8. At the successful conclusion of Hydrotest (or pneumatic test, as appropriate the pipeline will be depressurized.

INSTALLATION OF RISER AND TIE-IN SPOOL AT OFFSHORE LNG TERMINAL

The riser will be preinstalled on the facility. Metrology will be performed to determine the exact dimensions of the required tie-in spool . This tie-in spool will connect the subsea pipeline to the bottom end of the riser near the seabed. A tie-in spool will be prefabricated and kept on the DP DSV deck. Next, this tie-in spool will be cut to size per metrology results. Non-destructive evaluation (NDE) and Field-joint coating will be carried out on pipe spool. At this juncture, divers and equipment will be mobilized to the DP DSV. The blind flange on the pipeline end near the offshore terminal will be removed and the tie-in spool installed.

PRE-COMMISSIONING OF ENTIRE SUBSEA PIPELINE SYSTEM

Once the tie-in spool is installed a continuous connection is established between the onshore facilities and the offshore LNG platform.

For pre-commissioning of the entire subsea pipeline system, personnel and nitrogen packing equipment will be mobilized and set up at the offshore LNG terminal. Similarly, personnel and pressure testing equipment will be mobilized and set up at the onshore facilities. A leak test of the pipeline will be performed from shore to the platform.

At the successful conclusion of the leak test, the pipeline will be depressurized and a temporary pig catcher will be installed at the offshore LNG terminal. At the same time, a temporary pig launcher will be installed at the pipeline end at the onshore facility. The pipeline will be dewatered with pigs using air from onshore to offshore. Hydrostatic testing will be used but before discharge any water will be tested and treated as needed to meet water quality standards. Alternatively pneumatic testing may be used if allowable by code.

Finally, the pig catcher will be reconfigured as pig launcher and vice-versa. Pigs will be pushed from offshore to onshore with nitrogen. At the conclusion of this operation, valves will be closed at both ends of the pipeline and the entire pipeline system will be ready for commissioning.

3.5.1.3 Sources of Raw Material

Off shore platform

The off shore platforms will be constructed of steel with a concrete deck structure. The concrete will be obtained locally within Jamaica if possible or other alternative locations. Raw materials will consist of structural steel in many forms and shapes, weld rod, flux, welding gases, nuts, bolts, washers, rods, etc. Raw materials will be sourced mainly from U.S. or locally if they meet project requirements.

Seawater intake and auxiliary heat exchanger

Raw materials are limited since the intent is to modularize the equipment/systems to the maximum extent possible. Raw materials may consist of weld rod, flux, welding gases, pipe/fittings, cable/tray, gaskets, nuts, bolts, washers, rods, structural steel in many forms and shapes, etc. Raw materials will be sourced mainly from U.S. or locally if they meet project requirements.

Subsea pipeline

Construction of the subsea pipeline will not require any quarry material except for the following eventualities:

- HDD Drill site preparation: The HDD drill site onshore will require site preparation. Depending on soil conditions of the selected drill site, gravel may be required for surficial soil stabilization so that heavy equipment and vehicles can be brought to site and operated during HDD operation.
- Line pipe storage onshore: As mentioned elsewhere in the EIA, most of the vessels used for pipe lay operation have a certain capacity to store line pipes. The total length of the pipeline in this project is approximately 5,410 m (17,749.30 ft.) which means that it will constitute of 444 pipe joints. Therefore depending on the vessel selected for pipe lay, the entire pipe length could be stored in the vessel itself. The vessel would pick up the pipes at a port on the Gulf of Mexico after concrete coating is completed.

- In the case that pipes cannot be stored in the pipe lay vessel, a secured line pipe storage site will need to be prepared. It can be near the power plant or at the nearest port site where storage site should be readily available. The pipe haul vessel can pick up line pipes from the pipe storage area and supply it to the pipe lay vessel as the pipe lay progresses. In case such storage facility is not available, a secured storage area will need to be prepared elsewhere which may require site preparation, quarry material as well as fencing to prevent pilferage. Alternatively, a logistics plan may be prepared to supply pipe using pipe supply barges from a pipe coating yard in the Gulf of Mexico right when the subsea pipe is being installed.

3.5.1.4 Transportation of Heavy Equipment - Route from Port Esquivel to Proposed Project Site

HDD Equipment transport to Old Harbour Power Plant site: Fifteen trailer loads of equipment will need to be transported to the Old Harbour Power Plant site to carry out the HDD operation. Each of these trailer loads will weigh approximately 36.3 tonnes (40 tons). Equipment in these trailer loads will include the drill rig, power unit, control cab, two mud pumps, two mud tanks as well as general and spare parts. It is expected that these trailers will be offloaded at Port Esquivel and taken to the site via the route suggested in Section 4.4.4 in the Environmental Impact Assessment for the proposed Old Harbour Plant Re-Powering Project (190 MW) submitted to JPS in October 2015 (CL Environmental, 2015). The load restrictions of this route need to be investigated. Marine structural materials and equipment will be shipped to Port Esquivel for customs and inspection and then transported by sea to the offshore site location.

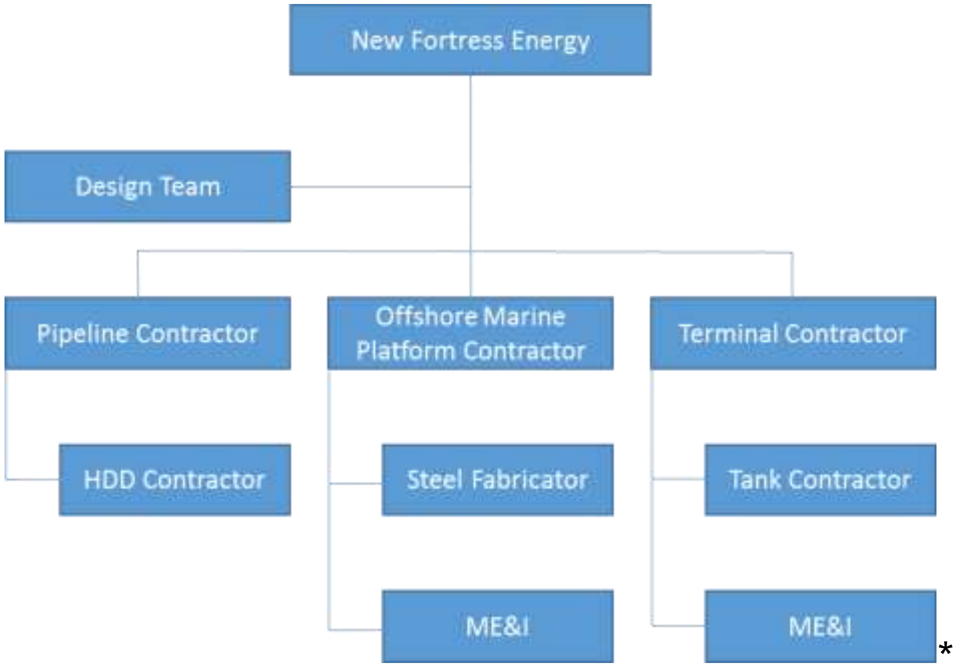
3.5.1.5 Employment and Organization Chart

It is estimated that during site clearance and preparation, approximately 20 persons will be employed. During the construction phases during average and peak periods, the following employment requirements are estimated:

- Construction of off shore platform: ~75-80 persons
- Off shore platform equipment installation and testing: ~40 persons
- Pipeline construction: ~20-30 persons
- Landside operation (including tank construction): ~90 - 100 persons

The actual number of persons employed may vary depending on the timing and exact design of the construction, however it estimated that a total of between 225 persons (average) and 250 persons (peak)will be employed during the project construction.

The organization chart for the construction phase may be seen in Figure 3-14.



** ME&I: Mechanical, Electrical and Instrumentation contractor*

Figure 3-14 Organizational chart during project construction phase

3.5.2 Project Operations and Maintenance

3.5.2.1 Heated Water Discharge

Sea water will be pumped from the ocean using submersible column mounted pumps. The pump columns will extend from the platform operating deck to below the minimum sea level. Column intakes will be provided with screens to prevent suction of marine life/vegetation and/or debris. Pump discharge will be at the top of the column which will be manifolded with other pump columns into a single distribution header. The distribution header will provide sea water for LNG regasification. Cooled sea water will be returned to the ocean (below sea level) at a temperature no more than 5 degree C below the intake temperature via a sea water return pipe. In order to optimize the size of the re-gasification exchangers some of the sea water flow will by-pass the exchangers. This by-pass stream will be re-mixed with the cooled sea water exiting the exchangers prior to returning to the sea.

3.5.2.2 Maintenance

Offshore Platform

Maintenance will be minor at the off shore platform and will consist of routine inspections and special inspections following severe weather in order to ensure the structural integrity of the platform. Routine maintenance may include steel coating repair, or concrete defect repair. Longer term maintenance may include items identified in routine inspections, but may consist of concrete repairs, fender system repairs or replacement, or steel member repairs.

Equipment maintenance can be categorized as routine (short duration) and long duration. Routine maintenance includes activities than can be performed regularly such as: filter replacement, screen cleaning, instrument calibration, instrument replacement, leak assessment and correction, oil changes for equipment, and fan belt tightening. Longer duration maintenance would be recommended by equipment suppliers but could include: pump replacement, compressor re-build (seals, bearings, gaskets, rings, etc.), and pump re-build (seals, bearings, gaskets, etc.).

Floating Storage Unit

The FSU fleet shall follow a risk-based approach to maintenance management, whereby equipment shall be maintained (inspected, monitored, overhauled, and renewed) to achieve the level of reliable operation required to reduce and manage the risk to personnel, equipment, and the environment.

Sub-sea Pipeline

Pipeline pigging should not be required for the gas pipeline since this is a higher quality gas than a typical export quality gas pipeline. Rather, LNG is being regasified into natural gas. Prior to LNG liquefaction, a pre-treatment process is undertaken. As part of the pre-treatment process, the export quality natural gas is dehydrated using molecular sieves which effectively removes all water content from the gas. A periodic pig run with an interval of 6 months to 1 year should be evaluated for confirmation of cleanliness.

Fouling of FSU

The FSU is designed to be moored for extended periods without dry-docking. The vessel's hull is coated with an anti-fouling coating to prevent any fouling.

3.5.2.3 Employment and Organization Chart

During operations, it is estimated that approximately up to 40 persons will be hired primarily to work on the FSU, as well as the platform and land. Figure 3-15 shows the organization chart for this project phase.

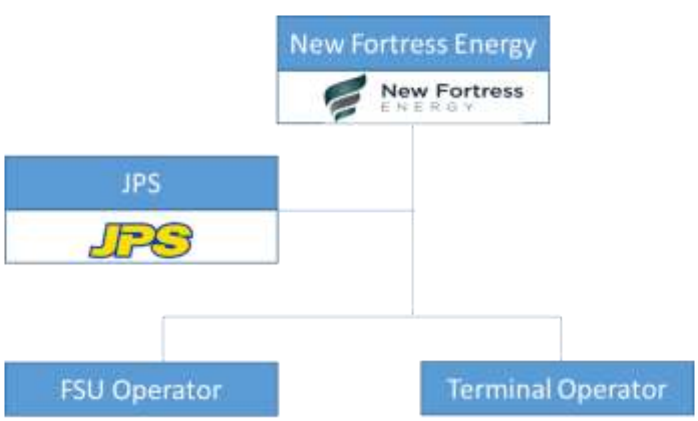


Figure 3-15 Organizational chart during project operation phases

4.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

4.1 ENVIRONMENTAL IMPACT ASSESSMENT FRAMEWORK

4.1.1 Rationale and Basis

An Environmental Impact Assessment (EIA) is "a structured approach for obtaining and evaluating environmental information prior to its use in decision-making in the development process. This information consists, basically, of predictions of how the environment is expected to change if certain alternative actions are implemented and advice on how best to manage environmental changes if one alternative is selected and implemented" (Bisset, 1996). The basis and rationale of an EIA has been summarised as follows (Wood, n.d.):

- Beyond preparation of technical reports, EIA is a means to a larger end - the protection and improvement of the environmental quality of life.
- It is a procedure to discover and evaluate the effects of activities on the environment - natural and social. It is not a single specific analytical method or technique, but uses many approaches as appropriate to the problem.
- It is not a science but uses many sciences in an integrated inter-disciplinary manner, evaluating relationships as they occur in the real world.
- It should not be treated as an appendage, or add-on, to a project, but regarded as an integral part of project planning. Its costs should be calculated as a part of adequate planning and not regarded as something extra.
- EIA does not 'make' decisions, but its findings should be considered in policy - and decision-making and should be reflected in final choices. Thus, it should be part of decision-making processes.
- The findings of EIA should focus on the important or critical issues, explaining why they are important and estimating probabilities in language that affords a basis for policy decisions.

4.1.2 Development Application and the EIA Process

4.1.2.1 General Procedures

The National Environment and Planning Agency (NEPA) [2] has been given responsibility for environmental management in Jamaica under the Natural Resources Conservation Authority Act (NRCA) Act of 1991. Since the promulgation of the NRCA Act, it has been strengthened by various

[2] NEPA represents a merger of the Natural Resources Conservation Authority (NRCA), the Town Planning Department (TPD) and the Land Development and Utilization Commission (LDUC). Among the reasons for this merger was the streamlining of the planning application process in Jamaica.

supporting regulations that became effective in January 1997. The Environmental Permit and License System (P&L) is administered by NEPA through the Applications Section. It was introduced in 1997 to ensure that all developments meet required standards and negative environmental impacts are minimized. Under the NRCA Act of 1991, the NRCA has the authority to issue, suspend and revoke environmental permits and licenses.

The NRCA permit procedure is initiated by the submission of the Project Information Form (PIF) to the Authority. The PIF screening form is reviewed to determine whether an EIA is required and to begin determining areas of environmental significance, especially in waste discharge. Based on the review of the PIF, the NRCA advises if an EIA would be required for the proposed project and determines the scope of the EIA through proposed Terms of Reference (TORs). The TORs are proposed using NRCA guidelines and are ultimately approved by the NRCA. NRCA gives the approved final TORs for the proposed project; Appendix 1 shows those specific to this project.

The NRCA requires that the EIA include the following:

- A description of the present environment, i.e. physical, biological and social environment. This includes, for example, consideration of economic situations, cultural heritage and ecological preservation;
- A description of the significant impacts the environmental professionals expect the development to have on the environment, compared to the environment that would remain if there were no development. This will include indirect and cumulative impacts;
- An analysis of alternatives that were considered in order to consider means of minimising or eliminating the impacts identified above; and
- An Environmental Management Plan, which includes a Monitoring & Hazard Management Plan and an Auditing schedule.

The NRCA guidance on EIAs states that this process "should involve some level of stakeholder consultation in either focus groups or using structured questionnaires." A draft EIA is submitted to the developer to solicit the proponents' input into the description of the project (to check for accuracy of statements, and to enter into realistic discussions on the analysis of alternatives, as well as to inform the proponents of any other relevant legislation with which they must comply). Fourteen copies of the finalised draft are then submitted to NRCA, two to the client, and the consultant keeps one (17 in all are produced). The NRCA distributes these to various other public sector institutions who sit on the Technical Committee (e.g. Water Resources Authority (WRA), Environmental Control Division in the Ministry of Health (ECD), Jamaica National Heritage Trust (JNHT)) for their comments. Typically, this depends on the nature of the project.

As deemed necessary by the NRCA, Public Meeting(s) are then held, following the deposition of the Draft EIA at Parish Libraries (by the NRCA). A verbatim report of the public meetings is required, as well as a summary report of the main stakeholder responses which emerged. The comments of the NRCA, the other GOJ interests and the public are compiled and submitted in writing to the consultant not only for finalisation of the report, but for incorporation into the development's design. The NRCA then reviews this report again, and if further clarifications are needed, these are again requested. Once the NRCA is satisfied, the EIA is submitted to the Technical Committee of the NRCA Board for final approval. If the EIA is not approved, the proponents may appeal to the Office of the Prime Minister.

Please see Appendix 3 for the full guidelines on public participation in EIAs.

4.1.2.2 Project-specific Progress

Under Section 9 of the NRCA Act, all activities associated with Chemical: Construction and Operations for Hydro-Carbon Production, Chemical: Construction and Operations Of Petroleum Storage and Dispensing Facility, Construction Development: Pipelines & Conveyors - Construction or Installation and Operation of Pipelines 20m or More in Length for the Transmission of Noxious, Explosive, Flammable and/or Toxic Material Refining, Storage and Stockpiling, Pipelines and Conveyors, such as the proposed project, require a Permit for construction and may, under Section 10 of the Act, require an EIA.

The Permit Application was submitted on May 13, 2016. It was decided that an EIA was required and this documents fulfils this requirement. The final TORs (Appendix 1) were used to guide the EIA approach and assemble the report.

4.2 NATIONAL LEGISLATION

The following sections include a discussion of relevant national legislation, regulations/standards, policies and other material thought to be relevant to the proposed project. The following main areas are covered:

- *Development Control*: construction (including building codes and site management controls) and subsidiary inputs (quarry material, etc.), public safety and vulnerability to disasters.
- *Environmental Conservation*: forestry, wildlife and biodiversity, protected areas and species, water resources, heritage and cultural resources.
- *Public Health & Waste Management*: air quality, noise levels, public health, solid waste, storm water, etc.

4.2.1 Development Control

This section deals with planning and development issues that can affect the establishment of a FSU and associated pipelines as well as a small onshore LNG distribution facility at old Harbour. Several development and planning related laws and regulations may affect the project. The applicability of these laws is dependent on the location of the development chosen, social and socio-economic issues as well as the availability of land for acquisition. The following agencies are those that may be encountered for planning and development approvals:

- St. Catherine Parish Council (Local Planning Authority - LPA) – All development applications are made through the LPA which include enquiries, planning, building and subdivision approvals.
- National Environment and Planning Agency (NEPA) - Applications reviewed by NEPA include enquiries, planning applications, and building and subdivision applications.
- Factories Cooperation of Jamaica- Guidelines for safety, health and welfare of factory employees.

4.2.1.1 Town and Country Planning Act (TCP Act), 1957 (Amended 1987)

The Town and Country Planning Act (TCP Act) 1957 (Amended 1987) provides the statutory requirements for the orderly development of land through planning, as well as guidelines for the preparation of Development Orders. A Development Order is a legal document which is used to guide development in the area to which it applies and the TCP Act is only applicable in an area where a Development Order exists. It constitutes land use zoning map/s, policy statements and standards relating to land use activities. Tree Preservation Areas and Conservation Areas (as specified areas the gazetted Development Orders) are two types of protected areas associated this Act.

As seen in Figure 4-1, the Development Order relevant to this proposed is the St Catherine Coastal Development Order. The proposed development falls within the boundaries of the St. Catherine Coast Development Order 1964. Further, the proposed site falls within the boundaries of the Old Harbour/ Old Harbour Bay Local Planning Area of the emerging St. Catherine Area Development Order in an area zoned for heavy industrial use. Hence, the proposed development is in conformity with the proposed zoning.

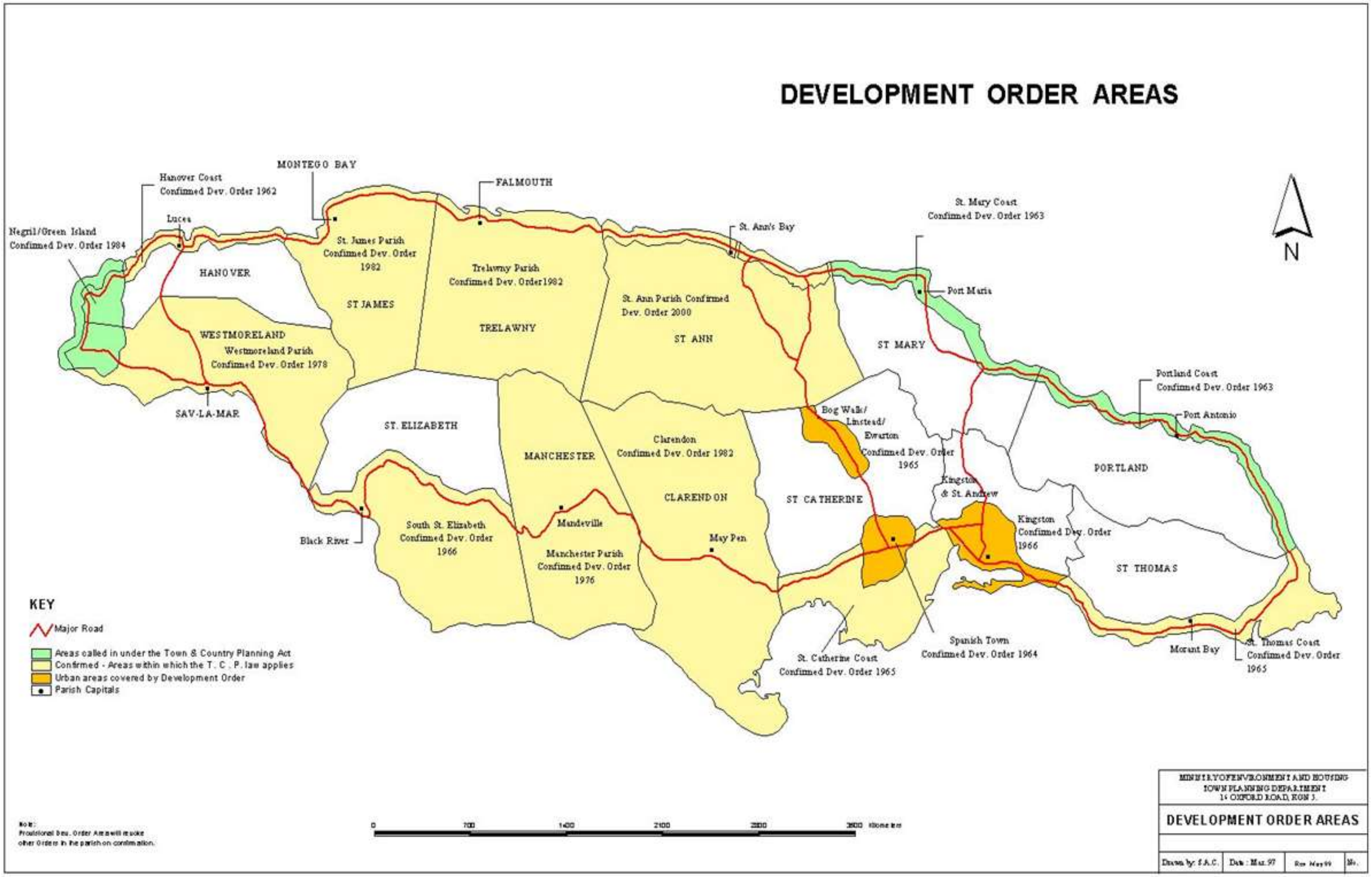
The Town and Country Planning Act Act also establishes the Town and Country Planning Authority, which in conjunction with the Local Planning Authorities (LPAs), also referred to as Parish Councils, and are responsible for land use zoning and planning regulations as described in their local Development Orders. The St. Catherine Parish Council is the LPA for this project. The TCP Act is also administered by the National Environment and Planning Agency.

4.2.1.2 Parish Councils Act 1901 (Amended 2007)

Under the Parish Council Act, each LPA may revoke or alter regulations concerning the construction and restrictions as to the elevation, size and design of buildings built with the approval of the relevant Minister. It may also make regulations concerning the installation of sewers on premises. As mentioned previously, the St. Catherine Parish Council is the local planning authority with responsibility for development within the study area for the proposed project.

4.2.1.3 Local Improvement Act 1944

The Local Improvements Act is the primary statute that controls the subdivision of land.



Source: National Environment and Planning Agency[3]

Figure 4-1 Development Order Areas in Jamaica

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[3] http://www.nepa.gov.jm/symposia_03/Laws/Maps/Map_of_Development_Orders.htm

4.2.1.4 Office of Utilities Regulation (OUR) Act 1995 (Amended 2000)

This Act was promulgated in 1995. Under this legislation, the OUR receives and processes applications for a licence to provide a prescribed utility service and make such recommendations to the Minister in relation to the application as the Office considers necessary or desirable. In relation to environmental management and protection, the OUR may, where it considers necessary, give directions to any licensee or specified organization with a view to ensuring that the prescribed utility service operates efficiently and in a manner designed to:

1. Protect the health and well-being of users of the service and such elements of the public as would normally be expected to be affected by its operation;
2. Protect and preserve the environment; and
3. Afford to its consumers economical and reliable service.

4.2.1.5 The Beach Control Act 1956 and the Beach Control (Amendment) Act 2004

This Act was passed in 1956 to ensure the proper management of Jamaica's coastal and marine resources by means of a licensing system. This system regulates the use of the foreshore and the floor of the sea. In addition, the Act speaks to other issues including access to the shoreline, rights related to fishing and public recreation and establishment of marine protected areas. Under section 5 of this act, it is an offence to encroach on the foreshore or floor of the sea for a public or commercial purpose without a licence.

The *Beach Control (Licensing) Regulations 1956* require a permit for any works on a beach, coastline or foreshore. Application for this permit must be made to NEPA. The requirements of the permit include a Notice of Application to be posted on the landward and seaward sides of the property and said Notice should be served on adjoining neighbours. Member of the Natural Resources Conservation Authority or any officer authorised by the Authority may conduct investigations to ensure compliance with licence and require information to be furnished.

In addition, the following regulations also fall under the Beach Control Act 1956:

- *The Beach Control (Hotel, Commercial and Public Recreational Beaches) Regulations 1978*
- *The Beach Control (Safety Measures) Regulations 1957*

4.2.1.6 The Maritime Areas Act 1996

Under this Act, Jamaica is declared an archipelagic State and defines the internal waters as areas of the sea which are on the landward side of the closing lines within the archipelagic waters. It states that the archipelagic baselines shall consist of straight baselines joining the outermost points of the outermost islands and drying reefs of Jamaica and the breadth of the territorial sea, the contiguous zone and the continental shelf shall be measured from the archipelagic baselines. As an archipelagic State, the sovereignty of Jamaica extends to the waters enclosed by the archipelagic baselines, as well as the air space over the archipelagic waters, their bed and subsoil and the resources, living and non-living, with the boundaries. Stipulations regarding infrastructure within and passage through the archipelagic waters are made as well as limits and jurisdictions regarding the contiguous zone and continental shelf

Offenses under this Act must be borne in mind during construction activities. Offenses include the refusal, neglect or failure to comply with directive of Marine Officer or to produce licence to Marine Officer and participation while on the vessel in acts contrary to Jamaica's peace, order or security.

4.2.1.7 The Harbours Act (The Harbour Rules) 1971

These set of rules apply to any boat or vessel using any harbour in the Island, or the channels or approaches to such harbour; as such, this piece of legislation is an important consideration to the proposed project. Rules pertaining to safety and general conduct, licensing and competence are outlined, as well as special rules for Kingston Harbour and other harbours explicitly stated. Of particular interest to this project, is Section 10, 2 (a), which currently allows a mandatory one hundred (100) metres from any wharf or vessel. The proposed safety buffer for the proposed project is 500m in accordance with international guidelines and therefore complies with this rule.

4.2.1.8 Guidelines and Planning Standards (Natural Gas and LNG Infrastructure)

Guidelines pertaining to NG and LNG were prepared by NEPA in May 2015 and these are outlined below. These documents were developed according to the structure of different chapters of Volume 1 Section 1 of the Development and Investment Manual of the Government of Jamaica. Each of the below set of guidelines will be part of a final set of technical documents.

- **Guidelines and Planning Standards – Gas Pipelines and Regulating & Metering Stations 2015**
  The aim of these guidelines and standards is to present the environment and planning standards, guidelines and/or codes of practice related to natural gas pipelines and regulating and metering stations, required during the application phase to obtain the necessary permits and licenses.
- **Guidelines and Planning Standards – LNG Satellite Plants 2015**
  The aim of these guidelines and standards is to present the environment and planning standards, guidelines and or codes of practice related to Design, Construction and Operation LNG Satellite Plant, required during the application phase to obtain the necessary permits and licenses.
- **Guidelines and Planning Standards – Regasification Terminals 2015**
  The aim of these guidelines and standards is present the environment and planning standards, guidelines and or codes of practice related to a Regasification Terminal, required during the application phase to obtain the necessary permits and licenses.
- **Guidelines for Developing a Natural Gas Sector Regulatory Framework 2015**
  The aim of these guidelines these guidelines is to define the regulatory framework for the natural gas sector in Jamaica.

4.2.1.9 Vision 2030 and National Energy Policy

Overview

Vision 2030 is a National Development Plan for Jamaica, promoting four National Goals as well as associated National Outcomes for each goal, to be achieved by 2030, with the objective of developing Jamaica into a country with a vibrant and sustainable economy, society and environment; a high level of human capital development; greater opportunities and access to these opportunities for the population; and a high level of human security. Of the aforementioned outcomes, two apply directly to the proposed project:

- National Outcome 10: Energy Security and Efficiency (under Goal 3: “Jamaica’s Economy is prosperous.”) and;
- National Outcome 13: Sustainable Management and Use of Environmental and Natural Resources (under Goal 4: “Jamaica has a healthy natural environment.”)

The outcomes outlined above are incorporated in the proposed project by directly increasing the country’s energy efficiency, as well as considering environmental repercussions and outlining mitigation activities throughout the development of this plant. In further accordance with Vision 2030, the proposed development also aligns with the Ministry of Energy and Mining’s National Energy Policy, created under the umbrella of Vision 2030. A synopsis of the goals and elements of the National Energy Policy (Vision of Jamaica’s Energy Sector 2009 – 2030) is as follows:

- Goal 1: Jamaicans use energy wisely and aggressively pursue opportunities for conservation and efficiency.
- Goal 2: Jamaica has a modernized and expanded energy infrastructure that enhances energy generation capacity and ensures that energy supplies are safely, reliably, and affordably transported to homes, communities and the productive sectors on a sustainable basis.
- Goal 3: Jamaica realizes its energy resource potential through the development of renewable energy sources and enhances its international competitiveness, energy security whilst reducing its carbon footprint.
- Goal 4: Jamaica’s energy supply is secure and sufficient to support long-term economic and social development and environmental sustainability.
- Goal 5: Jamaica has a well-defined and established governance, institutional, legal and regulatory framework for the energy sector that facilitates stakeholder involvement and engagement.
- Goal 6: Government ministries and agencies are a model/leader in energy conservation and environmental stewardship in Jamaica.
- Goal 7: Jamaica’s industry structures embrace eco-efficiency for advancing international competitiveness and moves towards building a green economy.

The National Energy Policy seeks to develop a modern, efficient, diversified and environmentally sustainable energy sector providing affordable and accessible energy supplies, with long-term energy security and supported by informed public behaviour on energy issues and an appropriate policy, regulatory and institutional framework. This project being undertaken fulfils the goal of modernizing the energy sector as well as making it more efficient through the primary use of LNG and allowing energy to be more accessible through the replacement of an older, less efficient, diesel-fuelled power plant with a newer, higher capacity, dual fuel capable plant using a cleaner and more cost effective fuel in furtherance of the goals of the National Energy Policy.

Goal 3

Opportunities for further development of indigenous renewable energy resources such as solar, hydro, wind and biofuels will be explored under this goal. The strategies and actions undertaken will be designed to Increase the percentage of renewables in the energy mix with proposed targets of 11% by 2012, 12.5% by 2015 and 20% by 2030. Increased percentage of renewable in the country's energy mix will reduce the dependence on imported oil. Increased use of renewables also will result in lowering the level of air pollution, a smaller carbon footprint for Jamaica and better compliance with international conventions on climate change.

Key points in relation to this Goal include:

- Develop diversification priorities based on cost, efficiency, environmental considerations and appropriate technologies and competitiveness.
- Introduce incentives, where feasible, and a plan of action for implementation to foster the development of wind, solar and renewable technologies. This will require the review by the relevant regulatory authority of existing renewable power generators to afford them such incentives that may be available, to encourage the sustainable development of the sector. The creation of an enabling legislative and regulatory framework will be a priority.
- Develop an inventory of all potential sources of wind, solar and renewable technologies and ranked according to their economics with full economic impact analysis

4.2.2 Environmental Conservation

4.2.2.1 Policy for the National System of Protected Areas 1997

The system of protected areas should be an essential tool for environmental protection, conserving essential resources for sustainable use, helping to expand and diversify economic development, and contributing to public recreation and education. Six types of protected areas are proposed in order to encompass the diverse natural resources and landscape, and are comparable to those of the IUCN (International Union for Conservation of Nature) 4:

1) National Nature Reserve/Wilderness Area (Equivalent to IUCN Category I)
2) National Park, Marine Park (Equivalent to IUCN Category II).

[4] It should be noted that since the publication of the Policy for Jamaica's System of Protected Areas 1997, the IUCN has revised the categories system and guidelines (http://cmsdata.iucn.org/downloads/guidelines_for_applying_protected_area_management_categories.pdf)

3) Natural Landmark/National Monument (Equivalent to IUCN Category III)
4) Habitat/Species Management Area (Equivalent to IUCN Category IV)
5) National Protected Landscape, or Seascape (Equivalent to IUCN Category V)
6) Managed Resource Protected Area (Equivalent to IUCN Category VI)

This legislative instrument is a White Paper and essentially proposes a comprehensive protected areas system for Jamaica (Table 4-1). The NRCA/NEPA is the lead agency with responsibility for the protected area system; however, a number of other government, local management entities, non-governmental entities, private sector and individuals are outlined as important role players as well.

Table 4-1 Existing categories of protected areas in Jamaica (as at 1 January 2012) - protected area system categories

Source: (Protected Areas Committee, 2012)

CATEGORY	RESPONSIBLE AGENCY	LAW
Protected Area	Forestry Department: Water, Land, Environment and Climate Change (MWLECC)	Forest Act, 1996 and Forest Regulations
	NEPA: MWLECC	NRCA Act, 1991
	NEPA: MWLECC	Beach Control Act, 1956
National Park	NEPA: MWLECC	NRCA Act, 1991
Marine Park	NEPA: MWLECC	NRCA Act, 1991
Environmental Protection Area	NEPA: MWLECC	NRCA Act, 1996
Forest Reserve	Forestry Department: MWLECC	Forest Act, 1996 and Forest Regulations
Fish Sanctuary	Fisheries Division: Ministry of Agriculture and Fisheries	Fishing Industry Act, 1976
National Monument	Jamaica National Heritage Trust(JNHT) Ministry of Youth and Culture (MYC)	JNHT Act, 1985
Protected National Heritage	JNHT: MYC	JNHT Act, 1985
Game Sanctuary	NEPA (NRCA): MWLECC	Wild Life Protection Act, 1945
Game Reserve	NEPA (NRCA): MWLECC	Wild Life Protection Act, 1945

Table 4-2 Existing categories of protected areas in Jamaica (as at 1 January 2012) - other designations not considered part of the system

Source: (Protected Areas Committee, 2012)

CATEGORY	RESPONSIBLE AGENCY	LAW
Tree Order Preservation	Local Authority (Town and Country Planning Authority): MWLECC and Local Government Department, through Parish Councils	Town and Country Planning Act, 1958
Conservation Area	NEPA (Town and Country Planning Authority, parish councils): MWLECC	Town and Country Planning Act, 1958
Protected Watershed	NEPA (NRCA): MWLECC	Watershed Act, 1963 Protection

Table 4-3 Existing categories of protected areas in Jamaica (as at 1 January 2012) - international designations

Source: (Protected Areas Committee, 2012)

CATEGORY	RESPONSIBLE AGENCY	CONVENTION
Ramsar Site	NEPA (NRCA): MWLECC	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
World Heritage Site (no existing sites, however submissions have been made)	Jamaica National Heritage Trust: MYC	World Heritage Convention

As seen in Figure 4-2, the proposed study falls within an area protected under various legal instruments and agreements - Portland Bight Protected Area (declared April 22, 1999 under Natural Resources Conservation Authority (NRCA) Act) and the Portland Bight Wetlands and Cays Ramsar Site. Two game reserves are located to the southwest and southeast, namely Long Island Game Reserve (declared August 21, 1998 under Wild Life Protection Act (WLPA)) and Amity Hall Game Reserve (declared August 22, 1997, amended July 28, 2004) respectively. In addition, the Galleon Harbour SFCA and the Salt Harbour SFCA are also located to the southwest and southeast of the project area. Also protected by law is the Great Goat Island forest reserve, 4km southeast of the project area.

4.2.2.2 Natural Resources Conservation Authority Act 1991

The Natural Resources Conservation Authority Act (NRCA) may be considered Jamaica's umbrella environmental law. The purpose of the Act is to provide for the management, conservation and protection of the natural resources of Jamaica. This Act was passed in the Jamaican Parliament in 1991 and subsequent to this, the Natural Resources Conservation Authority (NRCA) was established. The NRCA Act, under Sections 9 and 10 specifies that an Environmental Impact Assessment (EIA) is required from an applicant for a permit for undertaking any new construction, enterprise or development. It also speaks to the designation of national parks, protected areas etc.

The Act also gave power of enforcement of a number of environmental laws to the NRCA, namely the *Beach Control Act*, *Watershed Act* and the *Wild Life Protection Act*, as well as a number of regulations and orders including *The Natural Resources (Permit and Licences) Regulations (1996), The Natural Resources (Marine Park) Regulations 1992, The Natural Resources (Marine Park) (Amendment) Regulations 2003* and *The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order 1996.*

The Natural Resources Conservation (Permit and Licences) Regulations 1996 (Amended 2015)

A permit and licencing system was established under these regulations in order to control the undertaking of any new construction or development of a prescribed nature in Jamaica and the handling of sewage or trade effluent and poisonous or harmful substances discharged into the environment.

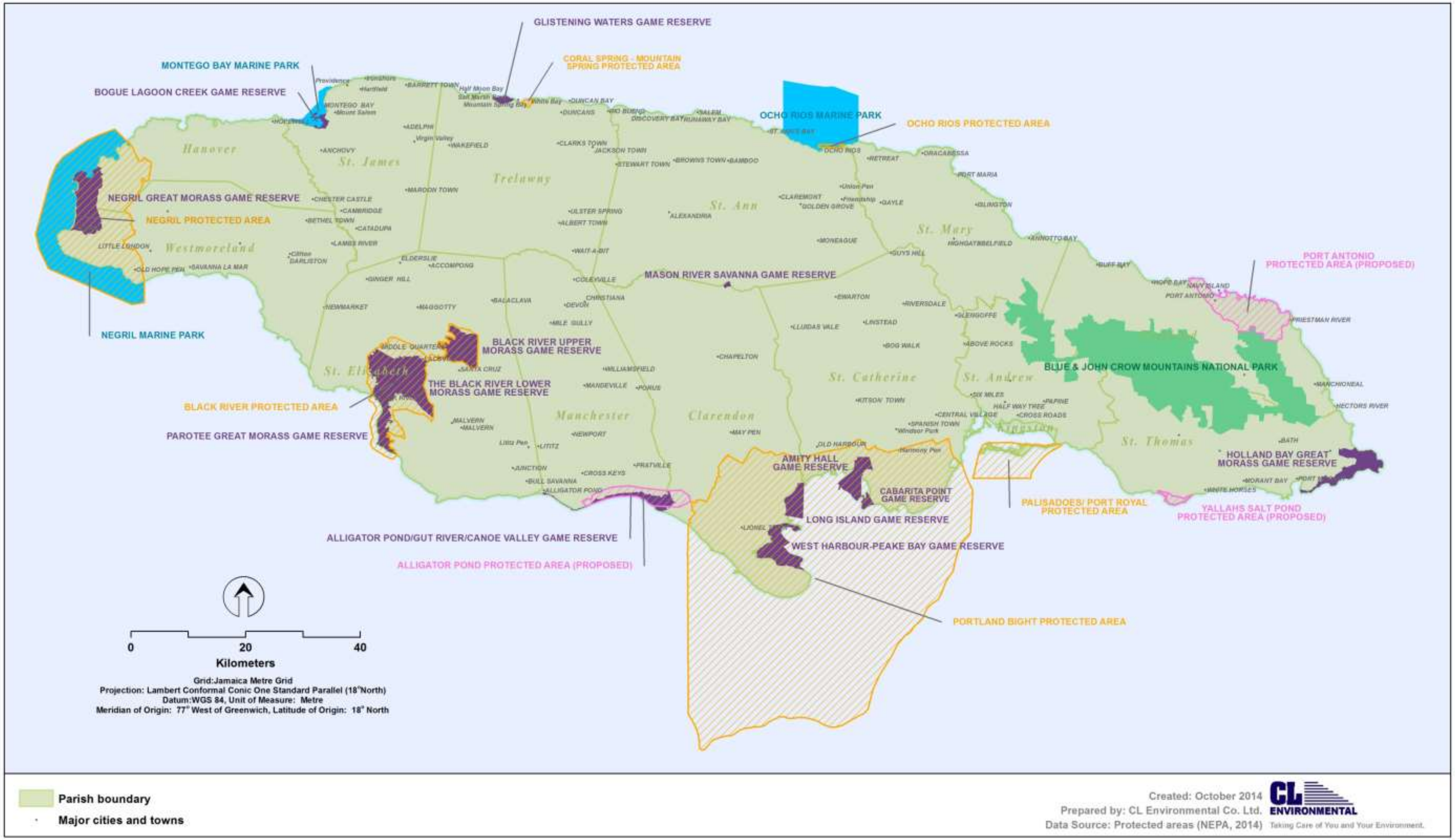


Figure 4-2 Protected areas system in Jamaica

The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order 1996 (Amended 2015)

The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order (1996) and the Permits & Licensing Regulations was passed as a result of section 9 of the NRCA Act. Section 9 of the NRCA Act declare the entire island and the territorial sea as a 'prescribed area', in which specified activities require a permit, and for which activities an environmental impact assessment may be required. The major amendment made in 2015 was the substitution of the Categories of Enterprises, Construction and Development (Column A), which lists the various activities, by category, for which a permit is required. As discussed previously, an EIA was required for the proposed project and this report fulfils one component of the EIA process.

4.2.2.3 The Fishing Industry Act 1975

The Fishing Industry Act 1975 is the overarching instrument relating to fishing activities within Jamaica. The Act speaks to registration and licensing, fisheries protection, prohibited activities and the declaration of an area as a fish sanctuary. Under the most recent Fishing Industry (Special Fishery Conservation Area) Regulations 2012, Special Fishery Conservation Areas (SFCAs), more commonly known as fish sanctuaries, are declared. There are currently 12 SFCAs declared as seen in Figure 4-2. As mentioned previously, the Galleon Harbour SFCA and the Salt Harbour SFCA are located to the southwest and southeast of the project area. Further, although fishing is not an activity to be carried out intentionally during the proposed project, it must be kept in mind during construction activities that it is an offence, during closed seasons, to take, disturb or injure fish, as well as to destroy or land berried lobster and spiny lobster smaller than 3 inches (7.5 cm).

4.2.2.4 Wild Life Protection Act 1945 and Wild Life Protection (Amendment of Second and Third Schedules) Regulations 2016

The Wild Life Protection Act of 1945 is mainly concerned with the protection of specified faunal species and is the only statute in Jamaica specifically designated to this. This Act protects several rare and endangered faunal species and the Wild Life Protection (Amendment of Second and Third Schedules) Regulations 2016 provides substitutions for the Second and Third Schedules of the principal Act which lists these species. The establishment of two types of protected areas, namely Game Sanctuaries and Game Reserves is authorized under this Act. As mentioned previously, two game reserves are located to the southwest and southeast, namely Long Island Game Reserve (declared August 21, 1998) and Amity Hall Game Reserve (declared August 22, 1997, amended July 28, 2004) respectively.

4.2.2.5 The Endangered Species (Protection, Conservation and Regulation of Trade) Act 2000 (Amended 2015)

The Endangered Species (Protection, Conservation and Regulation of Trade) Act was created in 2000 in order to ensure the codification of Jamaica's obligations under the Convention for the International Trade in Endangered Species of Wild Fauna and Flora. This Act governs international and domestic trade in endangered species in and from Jamaica. The regulations associated with this Act were amended in 2015, and include updated fees for the various permits and certificates granted through this legislation.

4.2.2.6 Water Resources Act 1995

The Water Resources Act (1995) established the Water Resources Authority (WRA), which is authorized to regulate, allocate, conserve and manage the water resources of the island. Section 25 advises that a proposed user will have to obtain planning permission, if this is a requirement, under the Town and Country Planning Act. In addition, under Section 21 it states that if the water to be used will result in the discharge of effluents, an application for a license to discharge effluents will have to be made to the Natural Resources Conservation Authority or any other relevant body as indicated by the Minister.

4.2.2.7 Towards an Ocean and Coastal Zone Management Policy in Jamaica 2000

The Council on Ocean and Coastal Zone Management was established in 1998, with responsibility of defining a national policy for Ocean and Coastal Zone Management. The aim of this policy document is to develop a policy that will "enhance the contribution of economic sectors to the integrated management of coastal areas by developing awareness in sector line agencies and resource users." The document recognises the extensive use and resulting degradation of coastal and ocean resources in Jamaica, including coral reefs, mangroves and seagrass beds, as well as non-living resources such as sand.

4.2.2.8 Towards a Beach Policy for Jamaica (A Policy on the Foreshore and the Floor of the Sea) 2000 (DRAFT)

This green paper recognizes the value of beaches in Jamaica and importance of proper management and protection. It was developed in order to review and update existing policies, as well as prepare a comprehensive policy that considered new areas of concern at the time, including erosion and pollution. The policy seeks to balance, the different interests of the main users of the beach - the public, the private sector and fishermen.

4.2.2.9 National Policy for the Conservation of Seagrasses 1996 (DRAFT)

This policy is in its drafting stage and was created in recognition of the values that seagrass possess. The issuing of licenses or permits for development activities including dredging and the disposal of dredged material which have the potential to affect seagrass beds are covered by this draft policy. Though a draft policy at present, the value of seagrass ecosystems should be kept in mind and efforts must be made to conserve these habitats as best as possible. For these reasons, marine assessments were included as part of the biological surveys.

4.2.2.10 Coral Reef Protection and Preservation Policy and Regulation 1997 (DRAFT)

This draft policy and regulation document aims to regulate coastal zone development as it relates to coral reef destruction and or degradation. It discusses the functions and uses of coral reefs, as well as the various issues affecting coral reef ecosystems. The aim of the policy is to ensure the conservation of coral reefs in order to sustain their ecological and socio-economic functions. Though in its drafting stage, the value of coral reef ecosystems should be kept in mind and efforts must be made to avoid destruction and degradation of these habitats as best as possible. For these reasons, marine assessments were included as part of the biological surveys.

4.2.2.11 Draft Policy and Regulation for Mangrove & Coastal Wetlands Protection

As outline in this draft policy, the Government of Jamaica has adopted the policy and regulation in order to promote the management of coastal wetlands. The policy seeks to:

- Provide protection against dredging, filling, and other development;
- Designate wetlands as protected areas;
- Protect wetlands from pollution particularly industrial effluent sewage, and sediment;
- Ensure that all developments planned for wetlands are subject to an Environmental Impact Assessment (EIA);
- Ensure that traditional uses of wetlands are maintained;

4.2.2.12 The Jamaica National Heritage Trust Act 1985

The Jamaica National Heritage Trust Act established the Jamaica National Heritage Trust (JNHT) and has been in operation since 1985. The main goal is the preservation and protection of the country's national heritage. The Act states the following offences are liable to a fine and/or imprisonment:

- Wilfully defacing, damaging or destroying any national monument or protected national heritage;
- Wilfully defacing, destroying, concealing or removing any mark affixed or connected to a national monument or protected national heritage;
- Altering any national monument or marking without the written permission of the Trust;
- Removing any national monument or protected national heritage to a place outside of Jamaica.

4.2.3 Public Health & Waste Management

4.2.3.1 The Natural Resources Conservation Authority (Air Quality) Regulations, 2002

Under section 38 of the NRCA Act, regulations pertaining to air quality in Jamaica are stipulated. The National standards, known as the National Ambient Air Quality Standards (NAAQS) are categorized into two groups. Part I of the NRCA Air Quality Regulations (2002) instructs on license requirements and indicates that every owner of a major or significant facility shall apply for an air pollutant discharge license. Part II makes reference to the stack emission targets, standards and guidelines.

4.2.3.2 The Clean Air Act 1964

The Clean Air Act (1964) refers to premises on which there are industrial works, the operation of which is, in the opinion of an inspector, likely to result in the discharge of smoke, fumes, gases or dust in the air. An inspector may enter any affected premises to examine, make enquiries, conduct tests and take samples of any substance, smoke, fumes, gas or dust that may be considered necessary or proper for the performance of his/her duties.

4.2.3.3 Water Quality Standards

The NRCA has primary responsibility for control of water pollution in Jamaica. National Standards for industrial and sewage discharge into rivers and streams, in addition to standards for ambient freshwater exist. For drinking water, World Health Organization (WHO) Standards are utilized and these are regulated by the National Water Commission (NWC). Since 1996, Jamaica has had draft regulations governing the quality of the effluent discharged from facilities to public sewers and surface water systems. These draft guidelines require the facility to meet certain basic water quality standards for trade effluent including sewage.

Table 4-4 Draft national ambient marine water quality standards for Jamaica, 2009

Source: National Environment and Planning Agency (NEPA)

Parameter	Measured as	Standard Range	Unit
Phosphate,	P*	0.001-0.003	mg/L
Nitrate,	N**	0.007-0.014	mg/L
BOD_5	O	0.0-1.16	mg/L
pH		8.00-8.40	
Total Coliform		2-256	MPN/100mL
Faecal Coliform		<2-13	MPN/100mL

*Reactive phosphorus as P
**Nitrates as Nitrogen

4.2.3.4 The National Solid Waste Management Authority Act 2001

The National Solid Waste Management Authority Act of 2001 is “an act to provide for the regulation and management of solid waste; to establish a body to be called the National Solid Waste Management Authority and for matters connected therewith or incidental thereto”. The National Solid Waste Management Authority (NSWMA) was established in April 2002 as a result of this Act to effectively manage and regulate the collection and disposal of solid waste in Jamaica.

4.2.3.5 Public Health Act 1985

The Public Health Act is administered by the Ministry of Health through Local Boards, namely the parish councils. *The Public Health (Nuisance) Regulations 1995* aims to, control reduce or prevent air, soil and water pollution in all forms. Under the regulations:

- No individual or organization is allowed to emit, deposit, issue or discharge into the environment from any source;
- Whoever is responsible for the accidental presence in the environment of any contaminant must advise the Environmental Control Division of the Ministry of Health and Environmental Control, without delay;

- Any person or organization that conducts activities which release air contaminants such as dust and other particulates is required to institute measures to reduce or eliminate the presence of such contaminants; and
- No industrial waste should be discharged into any water body, which will result in the deterioration of the quality of the water.

4.2.3.6 The Natural Resources (Hazardous Waste) (Control of Transboundary Movement) Regulations 2003

These regulations seek to implement the *Basel Convention on the Transboundary Movement of Hazardous Waste* and control transboundary movement and prevent the illegal trafficking of certain hazardous wastes. It is an offence to unlawfully dump or otherwise dispose of hazardous waste in areas under the jurisdiction of Jamaica. Waste resulting from the proposed project should be properly disposed of, and special attention should be paid to those considered hazardous under these regulations and as listed above.

4.2.3.7 Noise Abatement Act 1997

The Noise Abatement Act of 1997 was created in order to regulate noise caused by amplified sound and other specified equipment. This act has been said to address “some concerns but is too narrow in scope and relies on a subjective criterion” (McTavish). Given this, McTavish conducted a study to recommend wider and more objective criteria in accordance with international trends and standards, but tailored to Jamaica’s conditions and culture. To date, apart from the Noise Abatement Act (1997), Jamaica has no other national legislation for noise.

4.2.3.8 Factories Act 1961

The Factories Act guides employers operating factories in safety, health and welfare provisions. Any plans for new factories need to be provided to the Chief Factory Inspector. Some of the issues outlined under safety include having proper fire escapes and that all electrical apparatus must be properly installed. Under health and welfare, issues such as suitable sanitary conveniences, effective lighting, reasonable temperatures shall be maintained and personal protective equipment (PPE) shall be provided where applicable.

4.2.4 Additional Guidelines

In addition to the legislative instruments outlined in previous sections, there are a number of guidelines prepared by NEPA that are important to the execution of this project:

- NRCA Guidelines for the Environment Impact Assessment 1998
- NRCA Guidelines for Development in the Coastal Zone in Jamaica 1998
- NRCA Guidelines for the Planning, Construction and Maintenance of Facilities for Enhancement and Protection of Shorelines
- NRCA Handbook for Development in the Coastal Zone of Jamaica

4.3 REGIONAL AND INTERNATIONAL LEGISLATIVE AND REGULATORY CONSIDERATIONS

4.3.1 Cartagena Convention (Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region), 1983

Adopted in March 1983 in Cartagena, Colombia, the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, more commonly referred to as the Cartagena Convention, is the sole legally binding environmental treaty for the Wider Caribbean. The Convention came into force in October 1996 as a legal instrument for the implementation of the Caribbean Action Plan and represents a commitment by the participating countries to protect, develop and manage their common waters individually and jointly. The Convention is currently supported by three Protocols as follows:

- *The Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region* (The Oil Spills Protocol), which was adopted and entered into force at the same time as the Cartagena Convention;
- *The Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region* (The SPAW Protocol), which was adopted in two stages, the text in January 1990 and its Annexes in June 1991. The Protocol entered into force in 2000;
- *The Protocol Concerning Pollution from Land-based Sources and Activities in the Wider Caribbean Region* (LBS Protocol), which was adopted in October, 1999.

4.3.2 United Nations Convention on Biological Diversity

Signed by 150 government leaders at the 1992 Rio Earth Summit, the Convention on Biological Diversity (CBD) is committed to promoting sustainable development. The CBD is regarded as a means of translating the principles of Agenda 21 into reality and recognizes that "biological diversity is about more than plants, animals and microorganisms and their ecosystems – it is about people and our need for food security, medicines, fresh air and water, shelter, and a clean and healthy environment in which to live". Jamaica's Green Paper Number 3/01, 'Towards a National Strategy and Action Plan on Biological Diversity in Jamaica', is evidence of Jamaica's continuing commitment to its obligations as a signatory to the Convention.

4.3.3 Convention on Wetlands of International Importance especially as Waterfowl Habitat, "Ramsar Convention" 1971

The Ramsar Convention is an intergovernmental treaty that focuses on maintaining ecological wetland systems and planning for sustainable use of their resources. It was adopted on 2 February 1971 in Ramsar, Iran. The mission of the Convention was adopted by the Parties in 1999 and revised in 2005 - "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world". Under Article 2.2 it is stated:

> Wetlands should be selected for the List on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology" and indicates that "in the first instance, wetlands of international importance to waterfowl at any season should be included.

Jamaica became a contracting party on 7 February 1998 and has 4 sites covering a combined total of 37,847 hectares (378.47 km^2).

4.3.4 United Nations Convention on the Law of the Sea (UNCLOS III) 1982

The United Nations Convention on the Law of the Sea (UNCLOS), also referred to as the Law of the Sea Convention and the Law of the Sea treaty, defines the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources. UNCLOS III supersedes the Convention on the Territorial Sea and the Contiguous Zone (entered into force on 10 September 1964), as well as the Convention on the Continental Shelf (entered into force 10 June 1964), and both agreed upon at the first United Nations Convention on the Law of the Sea (UNCLOS I). Jamaica was the fourth country to ratify the UNCLOS III of 10 December 1982 on 21st March 1983. As of August 2013, 166 countries have joined in the Convention.

4.3.5 Convention on Fishing and Conservation of the Living Resources of the High Seas 1958

This convention considers that the development of modern techniques for the exploitation of the living resources of the sea has increased man's ability to meet the need of the world's expanding population for food and has exposed some of these resources to the danger of being over-exploited. It was done at Geneva on 29 April 1958.

4.3.6 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter

This instrument was adopted at the Inter-Governmental Conference on the Convention on the Dumping of Wastes at Sea, in London, United Kingdom in November 1972 and is commonly known as the London Convention. The London Convention, one of the first international conventions for the protection of the marine environment from human activities, came into force on 30 August 1975. Since 1977, it has been administered by the International Maritime Organization (IMO).

The London Convention prohibits the dumping of certain hazardous materials and specifies that a special permit is required prior to dumping of a number of identified materials and a general permit for other wastes or matter. In 1996, Parties adopted a Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (known as the London Protocol) which entered into force in 2006. It is expected that this Protocol will eventually replace the 1972

Convention. It stressed a "precautionary approach" and introduces a different approach to regulate the use of the sea as a depository for waste materials. Article 4 outlines the prohibition of dumping wastes or other matter with the exception of those listed in Annex 1 of the document.

4.3.7 International Convention on Oil Pollution Preparedness, Response and Co-operation 1990

The International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention) is an international maritime convention that sets measures for the preparation for and response to marine oil pollution incidents. The OPRC Convention was drafted within the framework of the International Maritime Organization (IMO) and entered into force in 1995. Jamaica is one of 107 parties to the convention (as of July 2013).

4.3.8 Equator Principle Requirements

The Equator Principles (EPs) is a credit risk management framework for determining, assessing and managing environmental and social risk in Project Finance transactions. Project Finance is often used to fund the development and construction of major infrastructure and industrial projects. The EPs are adopted by financial institutions and are applied where total project capital costs exceed US$10 million. The EPs are primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making[5]. The EPs are based on the International Finance Corporation Performance Standards on Social and Environmental Sustainability and on the World Bank Group Environmental, Health, and Safety Guidelines (EHS Guidelines).

4.3.8.1 IFC Performance Standards on Social and Environmental Sustainability

Of the eight (8) Performance Standards, seven (7) are applicable:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labour and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 8: Cultural Heritage

4.3.8.2 World Bank Group Environmental, Health, and Safety Guidelines

The Jamaican EIA process has been strongly influenced by the original World Bank Guidelines on EIAs. This EIA report has been reviewed for compliance with International Finance Performance (IFC) Standards 2012 and The World Bank Group Environmental, Health and Safety Guidelines (2007 &

[5] http://www.equator-principles.com/index.php/about-ep

2008) and meets all requirements for the Project from design to implementation. The Bank also provides guidelines which promote minimal resource consumption, including energy use, and the elimination or reduction of pollutants at the source. Pollution control systems are required to meet these specified emission limits. All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating. Guidelines are provided for the following pollution factors (See Relevant sections of the Environmental Health and Safety Guidelines – Thermal Power: Guidelines for New Plants):

- Air Emissions
- Energy efficiency and Greenhouse Gas emissions
- Water consumption and aquatic habitat alteration
- Effluents
- Solid wastes
- Hazardous materials and oil
- Noise
- Occupational Health and Safety

4.3.9 National Fire Protection Association (NFPA) 59A

The NFPA 59A Standard was developed to provide minimum fire protection, safety, and related requirements for the location, design, construction, security, operation, and maintenance of LNG plants. It applies to the following:

1. Facilities that liquefy natural gas
2. Facilities that store, vaporize, transfer, and handle liquefied natural gas (LNG)
3. The training of all personnel involved with LNG
4. The design, location, construction, maintenance, and operation of all LNG facilities

It does not apply to the following:

1. Frozen ground containers
2. Portable storage containers stored or used in buildings
3. All LNG vehicular applications, including fuelling of LNG vehicles

The Standard provides general definitions to terms used in the industry and general requirements such as:

General Requirements

- Corrosion Control Overview
- Control Center
- Sources of Power
- Records

Plant Siting and Layout

- Plant Site Provisions
- Site Provisions for Spill and Leak Control
- Buildings and Structures
- Designer and Fabricator Competence
- Soil Protection for Cryogenic Equipment
- Concrete Design and Materials

Process Equipment

- Installation of Process Equipment

- Pumps and Compressors
- Flammable Refrigerant and Flammable Liquid Storage
- Process Equipment

Stationary LNG Storage
- General
- Design Considerations
- Tank Systems

Vaporization Facilities
- Classification of Vaporizers
- Design and Materials of Construction
- Vaporizer Piping, Intermediate Fluid Piping, and Storage Valves
- Relief Devices on Vaporizers
- Combustion Air Supply
- Products of Combustion

Piping Systems and Components
- Materials of Construction
- Installation
- Pipe Supports
- Piping Identification
- Inspection, Examination, and Testing of Piping
- Purging of Piping Systems
- Safety and Relief Valves
- Corrosion Control
- Cryogenic Pipe-in-Pipe Systems

Instrumentation and Electrical Services
- Liquid Level Gauging
- Pressure Gauging
- Vacuum Gauging
- Temperature Indicators
- Emergency Shutdown
- Electrical Equipment
- Electrical Grounding and Bonding

Transfer Systems for LNG, Refrigerants, and Other Flammable Fluids
- General Requirements
- Piping System
- Pump and Compressor Control
- Marine Shipping and Receiving
- Tank Vehicle and Tank Car Loading and Unloading Facilities
- Pipeline Shipping and Receiving
- Hoses and Arms
- Communications and Lighting

Fire Protection, Safety, and Security
- General
- Emergency Shutdown (ESD) Systems
- Fire and Leak Detection
- Fire Protection Water Systems
- Fire Extinguishing and Other Fire Control Equipment
- Maintenance of Fire Protection Equipment
- Personnel Safety
- Security

Requirements for Stationary Applications Using ASME Containers
- General Requirements
- Containers
- Container Filling
- Container Foundations and Supports
- Container Installation
- Automatic Product Retention Valves
- LNG Spill Containment
- Inspection
- Shop Testing of LNG Containers
- Shipment of LNG Containers
- Field Testing of LNG Containers
- Welding on Containers
- Piping
- Container Instrumentation
- Fire Protection and Safety
- Gas Detection
- Operations and Maintenance

Operating, Maintenance, and Personnel Training
- General Requirements
- Manual of Operating Procedures
- Emergency Procedures
- Monitoring Operations
- Transfer of LNG and Flammables
- Maintenance Manual
- Maintenance
- Personnel Training
- Records

Performance (Risk Assessment) Based LNG Plant Siting
- General Requirements
- Definitions
- Risk Calculations and Basis of Assessment
- LNG and Other Hazardous Materials Release Scenarios
- Release Probabilities and Conditional Probabilities
- Environmental Conditions and Occurrence Probabilities
- Hazard and Consequence Assessment
- Risk Result Presentation
- Risk Tolerability Criteria
- Risk Mitigation Approaches

Three important factors in siting of an LNG facility are defined in the Standard including the methodology in determining the factors. These are vapour dispersion, thermal flux or radian heat flux and container spacing. For vapour dispersion, it states; "the spacing of an LNG impoundment to the property line that can be built upon shall be such that, in the event of an LNG spill as specified in Table 4-5, a predicted concentration of methane in air of 50 percent of the lower flammability limit (LFL) does not extend beyond the property line that can be built upon, in accordance with a model that is acceptable for use by the authority having jurisdiction that has been evaluated by an independent body using the Model Evaluation Protocol facilities published by the Fire Protection Research Foundation report "Evaluating Vapour Dispersion Models for Safety Analysis of LNG Facilities.

Table 4-5 Design Spill

Design Spill Source	Design Spill Criteria	Design Spill Rate and Volume
Containers with Penetrations Below the Liquid Level		
Containers with penetrations below the liquid level without internal shutoff valves	A spill through an assumed opening at, and equal in area to, that penetration below the liquid level resulting in the largest flow from an initially full container If more than one container in the impounding area, use the container with the largest flow	Use the following formula: $q = \frac{4}{3} d^2 \sqrt{h}$ until the differential head acting on the opening is 0. For SI units, use the following formula: $q = \frac{1.06}{10{,}000} d^2 \sqrt{h}$ until the differential head acting on the opening is 0.
Containers with penetrations below the liquid level with internal shutoff valves in accordance with 9.4.2.5	The flow through an assumed opening at, and equal in area to, that penetration below the liquid level that could result in the largest flow from an initially full container	Use the following formula: $q = \frac{4}{3} d^2 \sqrt{h}$ For SI units, use the following formula: $q = \frac{1.06}{10{,}000} d^2 \sqrt{h}$ for 10 minutes.
Containers with Over-the-Top Fill, with No Penetrations Below the Liquid Level		
Full or double containment containers with concrete secondary containers	No design spill	None
LNG Process Facilities		
Containers with over-the-top fill, with no penetrations below the liquid level	The largest flow from any single line that could be pumped into the impounding area with the container withdrawal pump(s) considered to be delivering the full-rated capacity	The largest flow from any single line that could be pumped into the impounding area with the container withdrawal pump(s) delivering the full rated capacity as follows: (1) For 10 minutes if surveillance and shutdown is demonstrated and approved by the authority having jurisdiction (2) For the time needed to empty a full container where surveillance and shutdown is not approved
Impounding areas serving only vaporization, process, or LNG transfer areas	The flow from any single accidental leakage source	For 10 minutes or for a shorter time based on demonstrable surveillance and shutdown provisions acceptable to the authority having jurisdiction

Note: q = flow rate [ft^3/min (m^3/min)] of liquid; d = diameter [in. (mm)] of tank penetration below the liquid level; h = height [ft (m)] of liquid above penetration in the container when the container is full.

For radian heat flux the Standard states that: "The maximum radiant heat flux from a fire shall not exceed the limits listed in Table 4-6.

Table 4-6 Radiant Heat Flux Limits to Property Lines and Occupancies

Radiant Heat Flux		
Btu/hr/ft²	W/m²	Exposure
1,600	5,000	A property line at ground level that can be built upon for ignition of a design spill[a]
1,600	5,000	The nearest point located outside the owner's property line at ground level that, at the time of plant siting, is used for outdoor assembly by groups of 50 or more persons for a fire in an impounding area[b]
3,000	9,000	The nearest point on the building or structure outside the owner's property line that is in existence at the time of plant siting and used for assembly, educational, health care, detention and correction, or residential occupancies for a fire in an impounding area[b,c]
10,000	30,000	A property line at ground level that can be built upon for a fire over an impounding area[b]

[a]See 5.3.3.7 for design spill.
[b]The requirements for impounding areas are located in 5.3.2.
[c]See NFPA *101, Life Safety Code*, or *NFPA 5000, Building Construction and Safety Code*, for definitions of occupancies.

In regards to container spacing from property lines that can be built on, it states: "The minimum separation distance between any type of LNG container of 70,000 gal (265m³) water capacity or less, single containment constructed LNG containers of greater than 70,000 gal (265 m³) water capacity, or tanks containing flammable refrigerants and exposures shall be in accordance with Table 4-7 or with the approval of the authority having jurisdiction at a shorter distance from buildings or walls constructed of concrete or masonry but at least 10 ft. (3.0 m) from any building openings."

The Standard also outlines the minimum distances that vaporizers should be from property lines and the minimum distances between vaporizers.

Table 4-7 Distances from Containers and Exposures

Container Water Capacity		Minimum Distance from Edge of Impoundment or Container Drainage System to Property Lines That Can Be Built Upon		Minimum Distance Between Storage Containers	
gal	m^3	ft	m	ft	m
<125*	<0.5	0	0	0	0
125–500	≥0.5–1.9	10	3	3	1
501–2,000	≥1.9–7.6	15	4.6	5	1.5
2,001–18,000	≥7.6–63	25	7.6	5	1.5
18,001–30,000	≥63–114	50	15	5	1.5
30,001–70,000	≥114–265	75	23		
>70,000	>265	0.7 times the container diameter but not less than 100 ft (30 m)		¼ of the sum of the diameters of adjacent containers [5 ft (1.5 m) minimum]	

*If the aggregate water capacity of a multiple container installation is 501 gal (1.9 m^3) or greater, the minimum distance must comply with the appropriate portion of this table, applying the aggregate capacity rather than the capacity per container. If more than one installation is made, each installation must be separated from any other installation by at least 25 ft (7.6 m). Do not apply minimum distances between adjacent containers to such installation.

5.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 PHYSICAL

5.1.1 Physiography, Geology and Structure

The geology of the area consists of unconsolidated sands and sandy clays, and carbonaceous sandy clays and clays of Holocene age. The present beach sediments consist mainly of non-carbonate grains (Wood, 1976). Unconsolidated or semi-consolidated deposits of Holocene age probably extend to a depth exceeding 100 metres (Figure 5-8); data from Porter and Bateson, 1974, Fernandez, 1983; Halcrow, 1998). All these are underlain by lithified rocks of the White Limestone Group.

5.1.2 Topography and Bathymetry

The Floating Storage Unit (FSU) vessel and regasification platform is to be located in approximately 14 m of water and the pipeline route between 0.5 – 5 m of water depth. Onshore (Landside), the proposed site is largely a flat area with the pipeline and metering station located on lands with site elevations varying from approximately 1.5 m to approximately 3 m above mean sea level.

5.1.2.1 Topography

Recently available topographic data in the area is restricted to Old Harbour Bay the fishing beach and the JPS property. These data were collected during the 2012 & 2014 EIA studies conducted for the proposed JPS 360MW plant (see Figure 5-1 for topographic survey). The data showed the area to be relatively flat with varying in elevations from 0.5 to 1.5 meters above Mean Sea Level (msl) along the coast line of the fishing village to approximately 200 meters inland. Within the vicinity of the JPS Power Plant, the elevations range from 0.32 meters to 2.95 meters above MSL, with a mean elevation of 1.5 meters and a general sloping of the land in a South-East direction. These levels compared well with the 1:12,500 charts available from the survey department. Those charts extend beyond the western and northern boundaries of the project area. The overall topography of the area as indicated on the charts have gently sloping plains extending from the foothills of the mountains in the north down to the shoreline in the south. The western section of the project area near to Rocky Point has the Brazilletto Mountains with moderate to steep slopes down to the mangrove which wetlands separate the foothills from the shoreline.

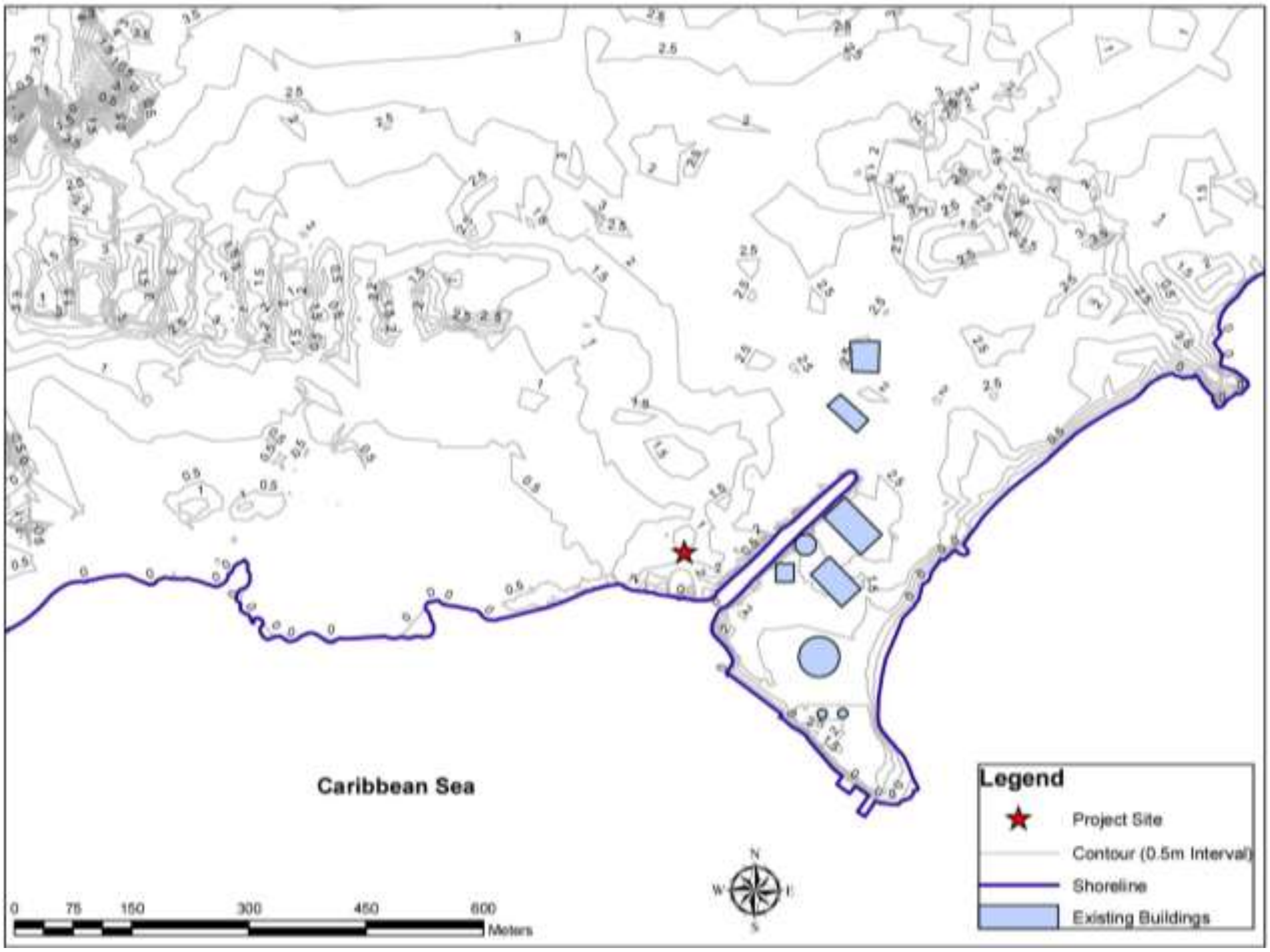


Figure 5-1 Location map showing area within which detailed topographic surveys were conducted (hatched area)

5.1.2.2 Bathymetry

Existing bathymetric data within the Portland Bight area was previously collected during:

- CEAC (2007) study for Jamalco and Rinker Minerals at Rocky Point;
- CEAC study JPS 360 MW power plant (2012); AND
- CEAC Study Jamaica Energy Partners (JEP) Thermal Outfall (2014).

All bathymetric surveys conducted to date, within the Old Harbour Bay area, concur with the water depths identified on the bathymetric admiralty chart.

With respect to the LNG mooring area, bathymetric survey of the project area revealed that the bathymetry is relatively deep (14m) in the immediate area of the pier. As the NG pipeline traverses northerly towards the shore, the bathymetry will become relatively shallow out to the reefs which are approximately 1.7 km from the shoreline. The existing ADO mooring area is located within 9-10 m of water where the associated pipeline travels between two (2) reefs where it continues to traverse until it reaches JPS shores. The seafloor slopes gently at an average of 2 percent from the shoreline out to the reefs (0.3 percent along the pipeline), with depths of 5 to 6 meters between the reefs and the shoreline.

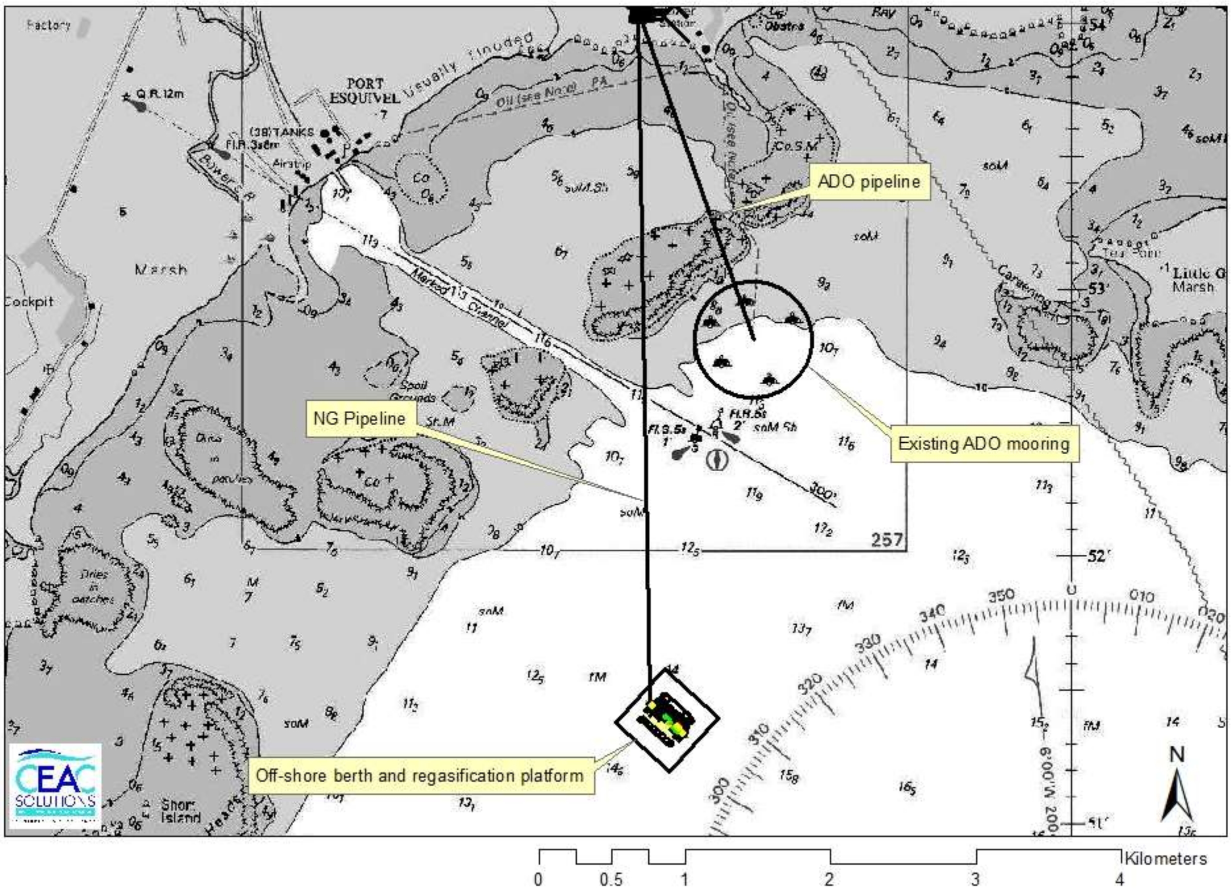


Figure 5-2 Hydrographic chart of the project area showing offshore mooring location and nearshore ADO line.

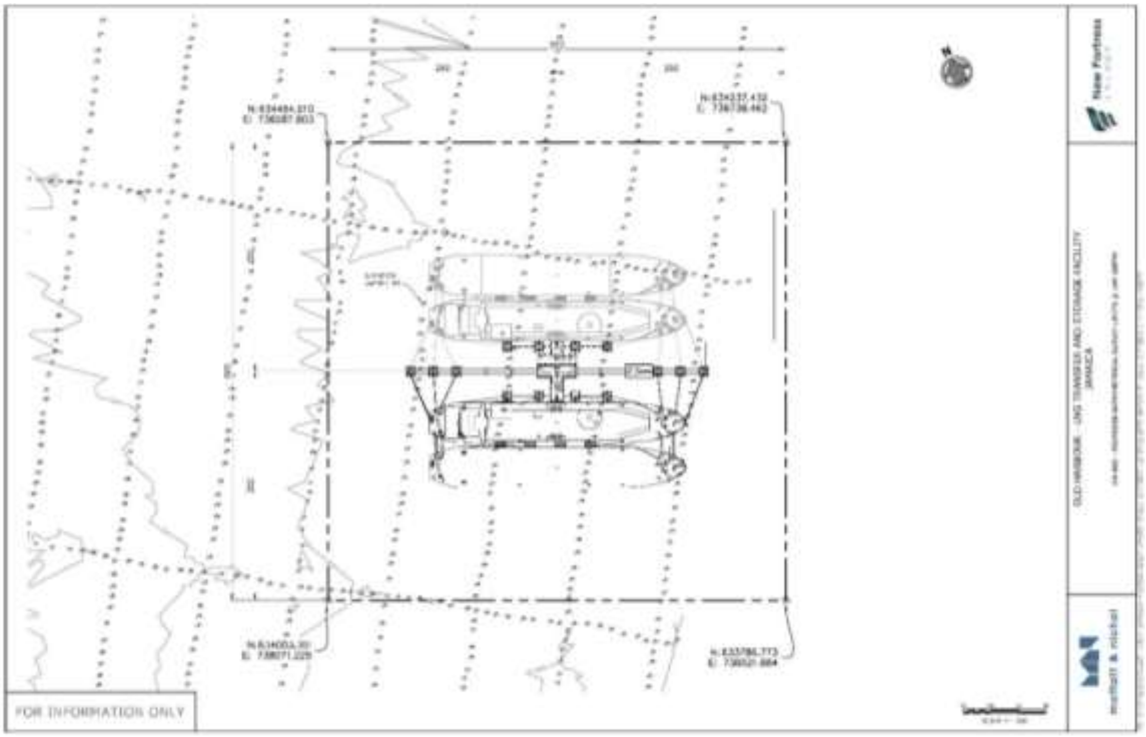


Figure 5-3 Hydrographic survey conducted of the mooring area

5.1.3 Geotechnical Study

A geotechnical investigation of the proposed area was conducted by NHL Engineering Ltd. for the Jamaica Public Service Company Ltd. in November 2010.

The investigation sought to determine the following:

1. The insitu density of the soils on site.
2. Soil stratification and distribution across the site.
3. The design parameters relevant to the design of the anticipated structural and infrastructural elements required on site.
4. Water table level.

The field investigation entailed the drilling and sampling of 14 locations as shown in the test location plan. The borings were to be taken to a depth of 30m (90’).

The borings were made by NHL Drillers using a truck Mounted CME Drill Rig, with a 160 mm hollow stem auger string. Sampling was done with a Split Spoon in accordance with Standard Penetration Test specifications, using a Cathead Hammer (N55 values). In general, S.S samples were taken at 0.76m intervals of depth to the first 3.81m and thereafter at 1.5 metre intervals to the maximum depth. In clayey areas where the blowcounts were determined to be in the soft to firm levels (less than

8 b/ft), Shelby tube (undisturbed) sampling was done. The boreholes were to be used to recover representative samples of the soil for examination by the Soils Engineer and for the carrying out of the laboratory testing programme.

These results were used along with site deductions during the sampling exercise and intuitive knowledge of the deposition history of the area, to arrive at a reasonable presumptive profile and subsequently a design profile across the site.

The results of the field and laboratory tests are found in the Soil Investigation Report - The Proposed Jamaica Public Service Old Harbour Industrial Gas Turbine Expansion Project; St. Catherine, Jamaica (2010). The soils encountered were generally a mixture of very soft/loose Clays/Silts plus some peat overlying very stiff to hard Silty Clays. Ground water was encountered in boreholes at an average of about 1 m below existing ground.

The locations of the boreholes are depicted in Figure 5-4 and Figure 5-5 and an example of the existing site conditions is shown in Plate 5-1.

Figure 5-4 Test Location Plan – JPSCO

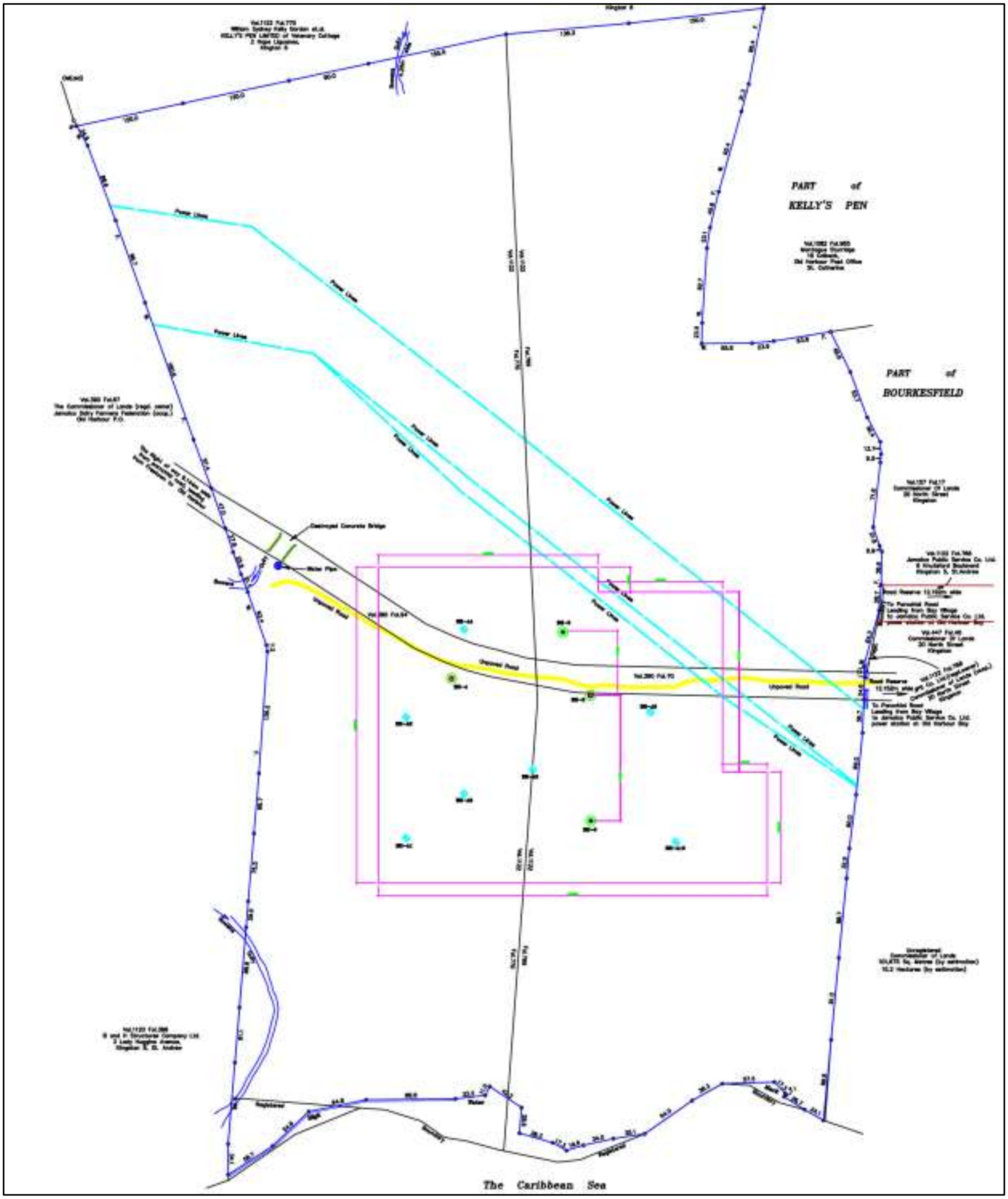


Figure 5-5 Location Plan for Additional Boreholes – JPSCO

Plate 5-1 Picture showing existing site conditions in the vicinity of BH # 1

5.1.3.1 Classification & Index Testing:

Grainsize Distribution:

Figure 5-6 shows the grainsize distribution envelopes of the samples tested. The figure indicates that the samples have gradation that falls essentially into two significant groups. The following is the group description:

1) Group A – the Graded Coarse to Fine Gravels plus Some Sands and Clays/Silts (2)
2) Group B – the Clayey Gap Graded Medium to Fine Sands (5)

Soil Plasticity

The samples tested had significant coarse grained content. They samples classified as inorganic Clays of high plasticity (two exceptions - CM). Their liquid limits ranged from 46.7% to 87.0%; their Plastic Limits ranged from 12.0% to 27.8% and their Moisture Contents ranged from 13.5% to 32.5%.

Based on these results, it is expected that these soils will exhibit high swell shrinkage and compressibility and therefore will bear significantly on the choice and design of the foundations where they were encountered.

Consolidation Tests

Consolidation tests were done on one sample (BH2@1.52 to 2.13m). The Compression Index was 0.24; Coefficient of Consolidation (within the anticipated load range) was 0.027in2/min; initial void ratio was 0.705.

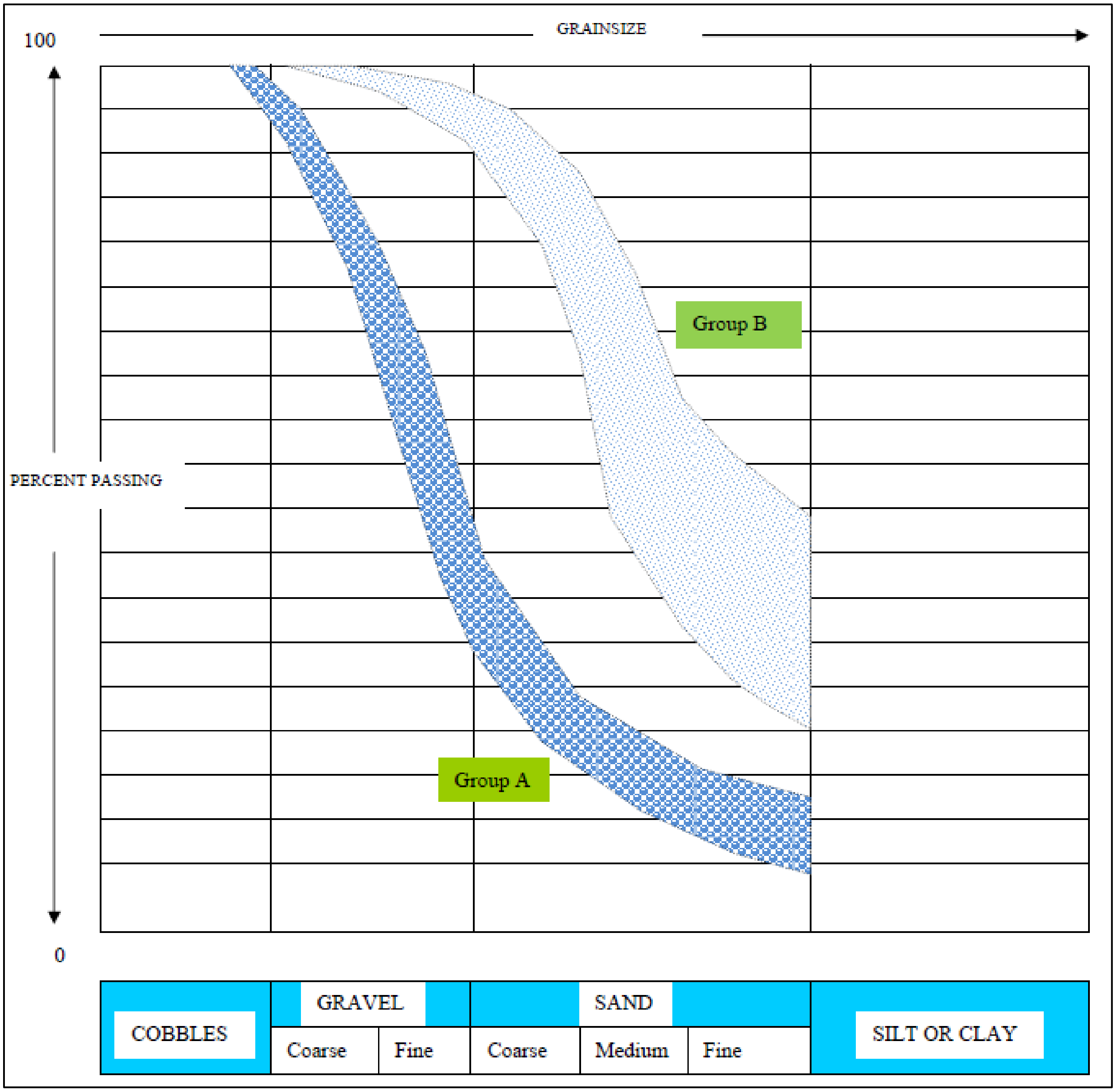


Figure 5-6 Gradation Envelope – JPS Old Harbour Expansion

5.1.3.2 Presumptive Soil Profile

The subsoil layers applicable for evaluating engineering behaviour and construction concerns can be characterized as three (3) distinct types (Figure 5-7). The types are as follows:

A) TOP 1

1) The Very Soft/Loose Silty Clays and Sands+ Trace of Peat
Depth Range 0 – 6 metres
Average N55 = 1

Boreholes #, 1 & 2.

B) MID 1
2) The Firm/Compact Silty Clays & Sands
Depth Range: Variable
Average N55 = 10
Boreholes #, All.

C) BOT 1
3) The Very Stiff to Hard Silty CLAYS + Some Sands
Depth Range 7+ metres
Average N55 = 20
Borehole #s, All

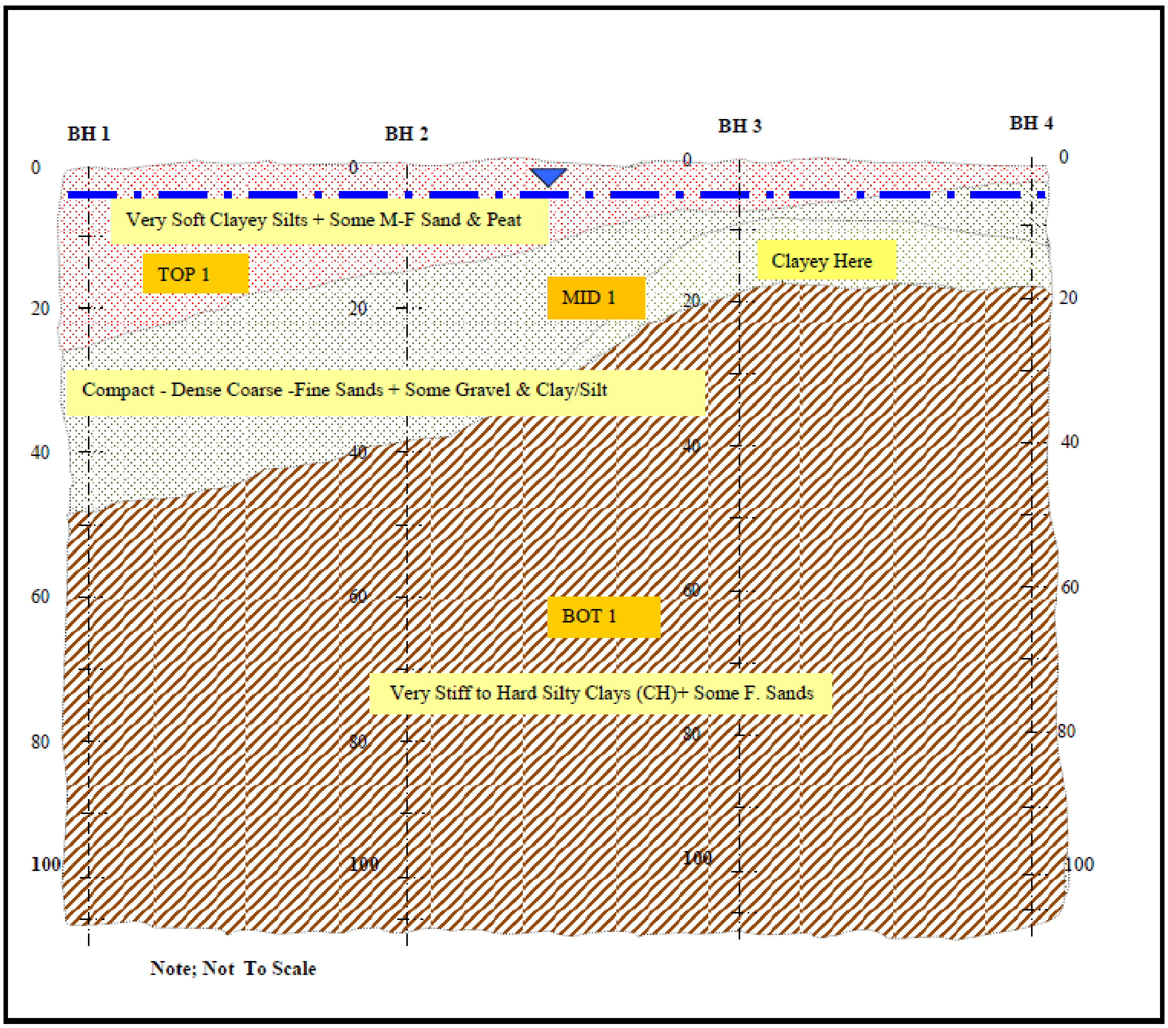


Figure 5-7 Presumptive Profile; Boreholes# 1, 2, 3 & 4

5.1.4 Soils

Soils in the proposed project area consists of Lodge Clay and undifferentiated salina:

- Lodge Clay (POc1) described by (Campbell et al 1986) is equivalent to the Lodge Clay loam (low salinity phase) mapped by Vernon (1958). It is formed from a very mixed gravelly and sandy old alluvium (Campbell et al 1986 and Vernon, 1958) that is from Bowers Gully source. These clays are moderately well drained deep reddish brown cracking clays occurring in primarily topographically flat areas, dominant slope range is 0-2°, but also at slightly elevated sites on the old alluvial clay plain. This soil is typically moist throughout with fair external drainage. Internal drainage is good to 11" (5 cm) and moderate below. Permeability is however low after cracks have been closed. Soils are very hard when dry and very sticky when wet (Campbell et al 1986). The surface layer is dark brown in colour, and ranges in thickness from 40-70 cm (Agricultural Chemistry Division 1964). A saline old alluvial soil, derived partly from mixed gravel is found in the Bowers Gully; depth very deep- more than 60" (1.5 m) (Agricultural Chemistry Division 1964).
- Undifferentiated Salina are saline areas are located between the sea, mangrove swamps and the alluvial coastal plain swamps. They consist of poorly drained, deep, strongly saline and sodic soils of varying textures and colours and are strongly calcareous (Campbell et al 1986). They are mostly devoid of tree/shrub vegetation except for some salt tolerant plants. Soil is classified as typical halaquepts (Campbell et al 1986).

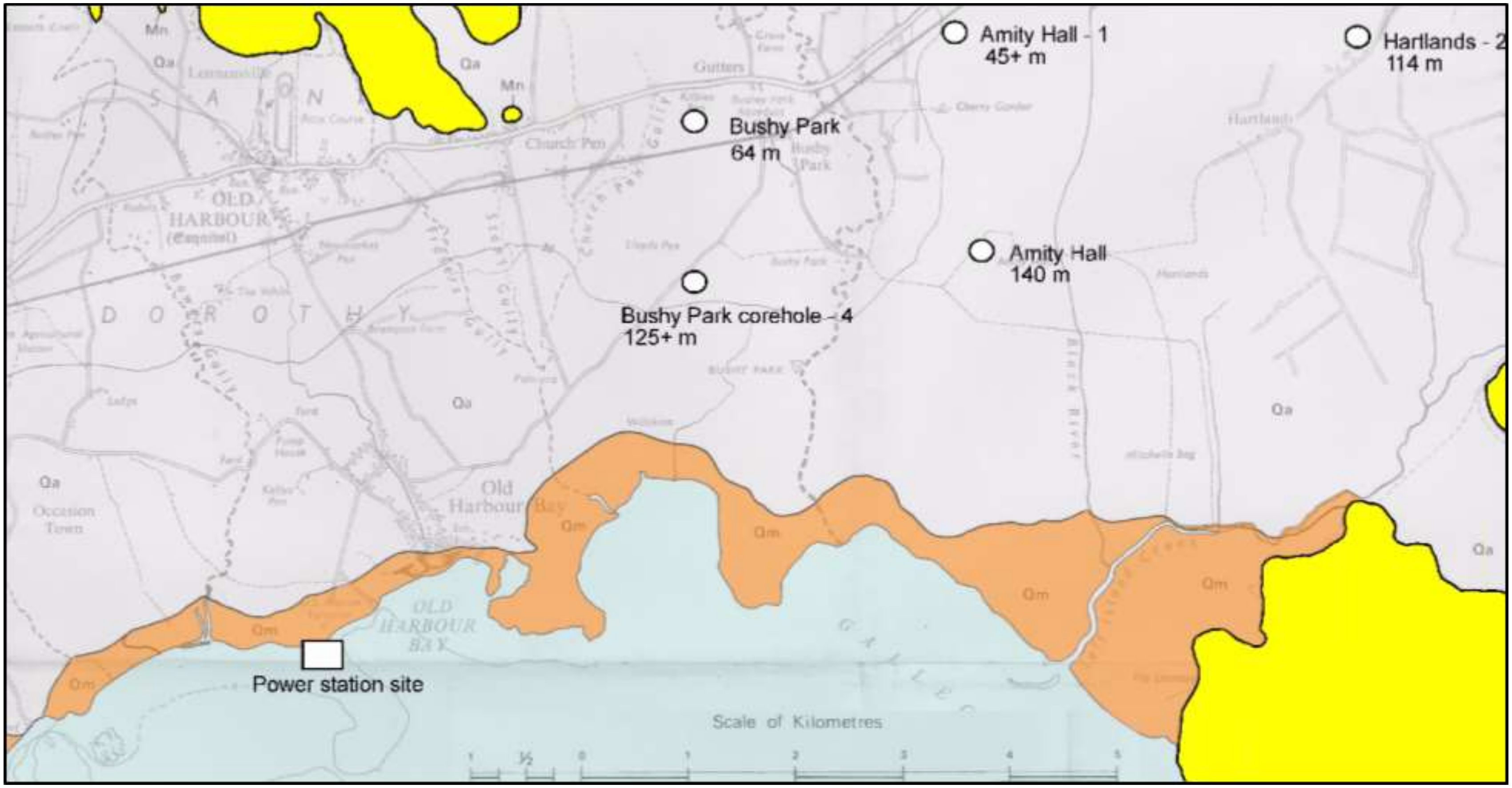


Figure 5-8 Regional geology of the site. Yellow, White Limestone Group; grey, Quaternary sediments of the Rio Cobre alluvial fan; brown, Holocene superficial sediments and soils of the coastline. Large white rectangle is the proposed new site

5.1.5 Sediments

5.1.5.1 Shoreline Sediments

The following shoreline sediment analysis was conducted in 2014 during the EIA for the JPS 190MW plant.

Sediment Size

Surface sediment samples were recovered from the project area at two locations east of the SJPC proposed site. Two samples were collected from each location; one from the Beach front (BF) and the other from the back of the beach (BB) (Figure 5-9). Grain size analysis of these samples was conducted and the results of this analysis are summarized in Figure 5-10 and Table 5-1.

Figure 5-9 Sediment grain size sampling locations

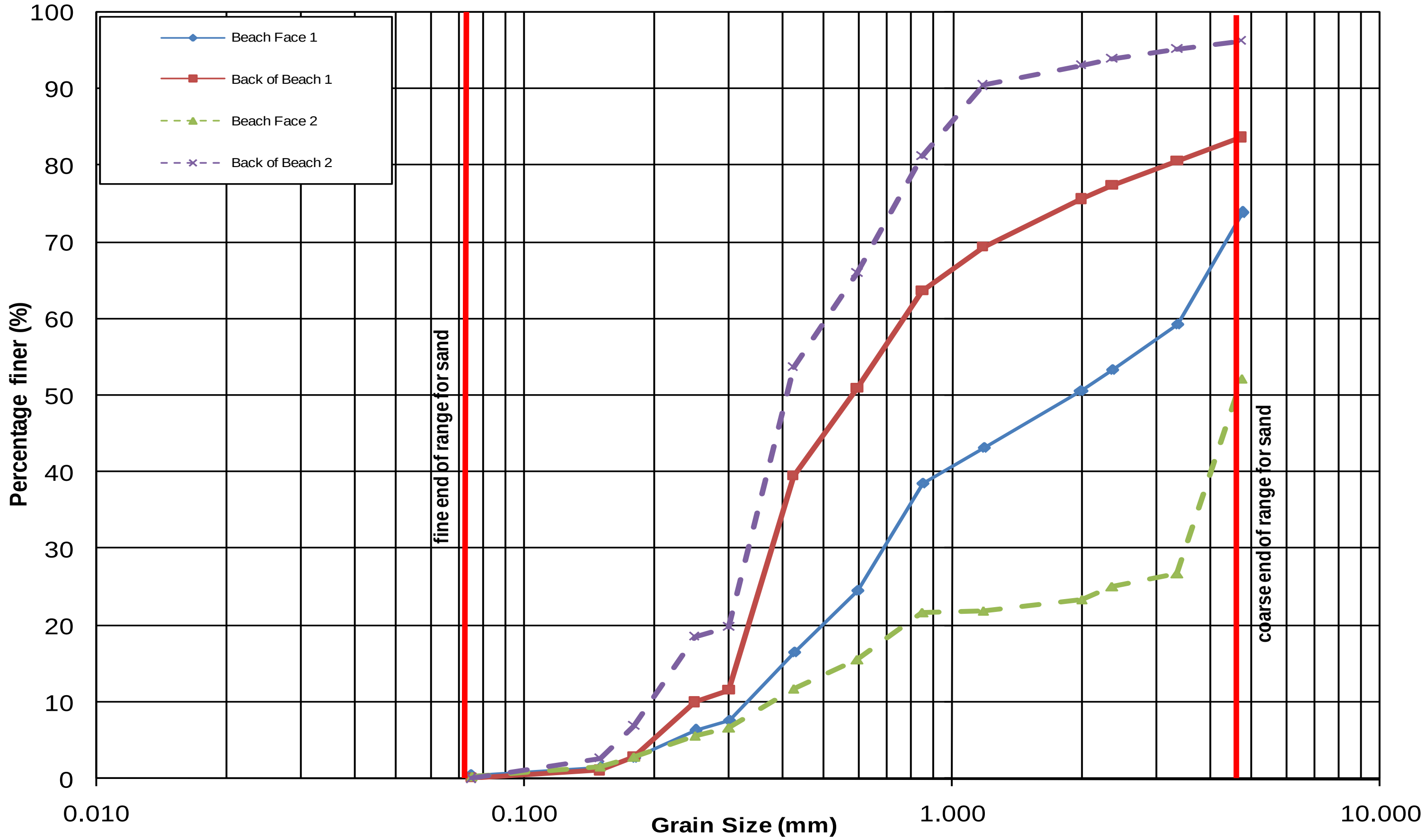


Figure 5-10 Sieve analysis results (graph).

Table 5-1 Sieve analysis results.

Sample ID	Beach Face 1	Back of Beach 1	Beach Face 2	Back of Beach 2
Mean (mm)	1.932	0.586	4.626	0.411
Mean (phi)	-0.950	0.771	-2.210	1.283
Description	very coarse sand	coarse sand	gravel	medium sand
Percentage silt	0.38%	0.13%	0.3%	0.0%
Percentage >0.06mm and <6.0 mm	73%	84%	52%	96%
Uniformity Coefficient	10.257	2.789	17.469	2.589
Standard Deviation	1.441	1.968	1.299	1.143
	poorly sorted	poorly sorted	poorly sorted	poorly sorted
Skewness	0.608	-0.152	2.616	0.986
	strongly positive skewed	negative skewed	V. strongly positive skewed	strongly positive skewed
Kurtosis	0.264	1.095	0.204	1.412
	extremely leptokurtic	mesokurtic	extremely leptokurtic	leptokurtic

The grain size analysis was done using the unified classification system which is widely used for classification of granular material. The sand sizes vary from very coarse to coarse sand moving from the front of the beach to the back of the beach at sample location one with grain sizes of 1.93mm to 0.586mm respectively. Sample location two had grain sizes varying from gravel to medium sand from the front of the beach to the back of the beach with median grain size of 4.626mm and 0.411mm respectively. The levels of silt present in the sands are consistent with what was observed on the beach, with sample location one having the highest concentration/percentage of silt.

Uniformity Coefficient

The uniformity coefficient is a measure of the variation in particle sizes. It is defined as the ratio of the size of particle that has 60 percent of the material finer than itself, to the size of the particle that has 10 percent finer than itself.

The uniformity coefficient is calculated as:

$$Uc = D60/D10$$

Where:

U_c – uniformity coefficient
D60 - The grain size, in mm, for which 60% by weight of a soil sample is finer
D10 - The grain size, in mm, for which 10% by weight of a soil sample is finer

Within the unified classification system, the sand is well graded if U_c is greater than or equal to 6. The samples collected from the front of the beach at both sample locations have well graded sand as the uniformity coefficients were greater than 6. The back of the beach had uniformity coefficient values of 2.8 and 2.6 for sample locations one and two respectively. This sand in this area is considered to be poorly graded.

Standard Deviation

The Standard deviation is a measure of the degree of sorting of the particles in the sample. A standard deviation of one or less defines a sample that is well sorted while values above one are poorly sorted.

The sand samples for the respective beaches are:

- Sample Location 1 (Beach Back- Poorly sorted)
- Sample Location 1 (Beach Front - Poorly sorted)
- Sample Location 2 (Beach Back- Poorly sorted)
- Sample Location 2 (Beach Front - Poorly sorted)

Skewness

Skewness describes the shift in the distribution about the normal. The skewness is described by the equation:

$$S = \frac{\phi 84 + \phi 16 - 2(\phi 50)}{2(\phi 84 - \phi 16)} + \frac{\phi 95 + \phi 5 - 2(\phi 50)}{2(\phi 95 - \phi 5)}$$

This formula simply averages the skewness obtained using the 16 phi and 84 phi points with the skewness obtained by using the 5 phi and 95 phi points, both determined by exactly the same principle. This is the best skewness measure to use because it determines the skewness of the "tails" of the curve, not just the central portion, and the "tails" are just where the most critical differences between samples lie. Furthermore, it is geometrically independent of the sorting of the sample.

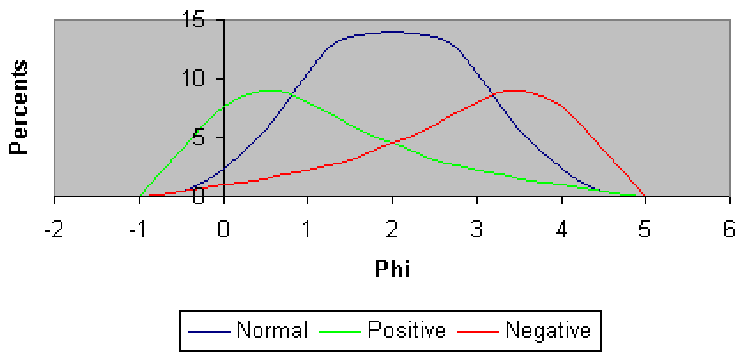


Figure 5-11 Skewness curves.

Symmetrical curves have skewness=0.00; those with excess fine material (a tail to the right) have positive skewness and those with excess coarse material (a tail to the left) have negative skewness. The more the skewness value departs from 0.00, the greater the degree of asymmetry. The limits on skewness are outlined in Table 5-2.

Table 5-2 Descriptive limits of skewness.

Values from:	Values to:	Mathematical Description	Graphical Skew
+1.00	+0.30	Strongly positive skewed	Very Negative phi values, coarse
+0.30	+0.10	Positive skewed	Negative phi values
+0.10	- 0.10	Near symmetrical	Symmetrical
- 0.10	- 0.30	Negative skewed	Positive phi values
- 0.30	- 1.00	Strongly negative skewed	Very Positive phi values, fine

The results for skewness for the stretch of shoreline can be summarized as follows:

- Sample Location one and two at the front of the beach along with sample location two back of the beach have a strong positive skewness ranging from 0.61 to 2.62. This is indicative of excessive fine material and a moderated wave climate that does not wash out the fine sediment particles.

- Sample location one at the back of beach has negative skewness of -0.15. This is indicative of a long coarse tail of particles and an aggressive wave climate that washes out the fines particles.

Kurtosis

Kurtosis describes the degree of peakedness or departure from the "normal" frequency or cumulative curve. In the normal probability curve, defined by the Gaussian formula; the phi diameter interval between the 5 phi and 95 phi points should be exactly 2.44 times the phi diameter interval between the 25 phi and 75 phi points. If the sample curve plots as a straight line on probability paper (i.e., if it follows the normal curve), this ratio will be obeyed and we say it has normal kurtosis (1.00). Departure from a straight line will alter this ratio, and kurtosis is the quantitative measure used to describe this departure from normality. It measures the ratio between the sorting in the "tails" of the curve and the sorting in the central portion. If the central portion is better sorted than the tails, the curve is said to be excessively peaked or leptokurtic; if the tails are better sorted than the central portion, the curve is deficiently or flat-peaked and platykurtic.

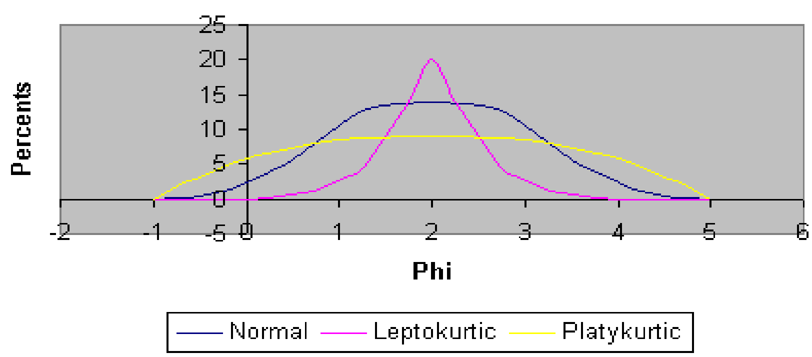


Figure 5-12 Kurtosis curves.

Strongly platykurtic curves are often bimodal with subequal amounts of the two modes; these plot out as a two-peaked frequency curve, with the sag in the middle of the two peaks accounting for its platykurtic character. For normal curves, kurtosis equals 1.00. Leptokurtic curves have a kurtosis over 1.00 (for example a curve with kurtosis=2.00 has exactly twice as large a spread in the tails as it should have, hence it is less well sorted in the tails than in the central portion); and platykurtic have kurtosis under 1.00. Kurtosis involves a ratio of spreads; hence it is a pure number and should not be written with a phi attached.

Table 5-3 Descriptive limits of kurtosis.

Values from	To	Equal
0.41	0.67	very platykurtic
0.67	0.90	platykurtic

Values from	To	Equal
0.90	1.11	mesokurtic
1.10	1.50	leptokurtic
1.50	3.00	very leptokurtic
3.00	∞	extremely leptokurtic

A similar trend was observed in the Kurtosis analysis as was observed in the skewness analysis. The following is a summary:

- Sample location two front and back of beach sediment is leptokurtic to extremely leptokurtic and sample location one of beach is extremely leptokurtic. This is indicative of aggressive coastal processes that sort out the particles into a discrete particle size.
- Sample location one back of beach is mesokurtic. This is indicative of mild to moderate sediment transport processes.

5.1.5.2 Marine Benthic Sediments

The following marine benthic sediment analysis was conducted in 2014 during the EIA for the JPS 190MW plant (2014/2015).

Method

Sediment sampling was conducted on July 22nd, 2014. Five (5) sediment samples were taken using a sediment grab sampler, and analysed for the heavy metals (Pb - lead, As - Arsenic, Cd - Cadmium, Hg-Mercury) and Total Petroleum Hydrocarbons (DRO and GRO). The sediment sampling locations are shown in Table 5-4 and depicted in Figure 5-13. The samples were stored on ice in a cooler and transported to Test America Pensacola Laboratory in Florida for analyses.

Table 5-4 Sediment sampling stations in JAD2001 with corresponding water quality stations

SEDIMENT SAMPLING STATION	NORTHING	EASTING
JP Soil 1	637939.98	736562.72
JP Soil 2	638212.01	736685.40
JP Soil 3	637345.73	737652.15
JP Soil 4	637940.01	737698.80
JP Soil 5	637182.43	739350.31

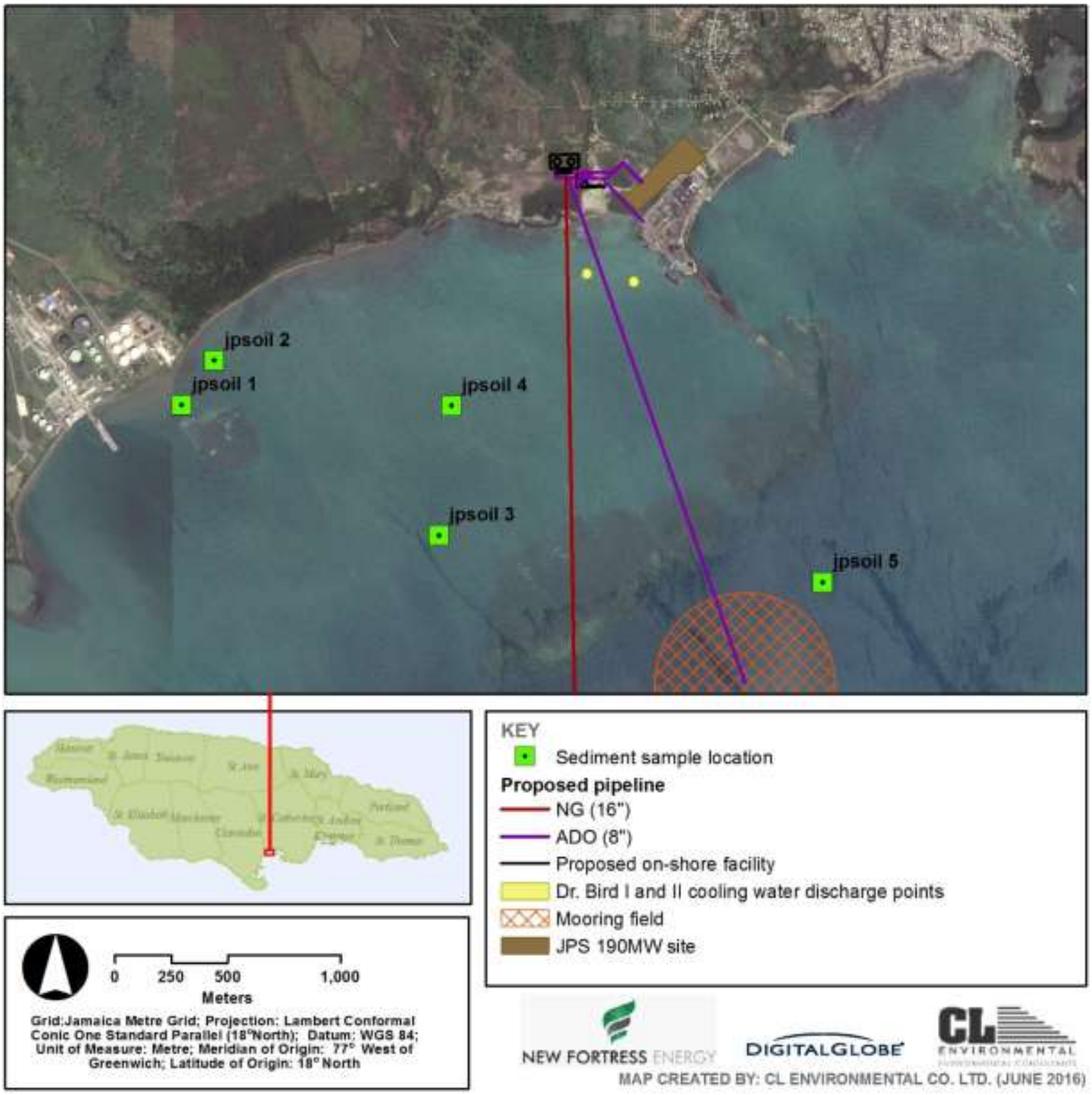


Figure 5-13 Marine sediment sampling locations

Results

Table 5-5 displays the sediment sampling results for various parameters at the various sampling locations. Arsenic values were similar throughout stations, ranging from a low of 5.9 mg/kg at Station 2 to a high of 8.9 mg/kg at Station 3. Lead values were similar throughout the stations with Stations 1, 2 and 3 have concentrations of 11 mg/kg each, with a low of 8.4 mg/kg at Station 5 and a high of 12 mg/kg at Station 4. Mercury values also varied slightly amongst the stations, with Station 2 having a low of 0.088 mg/kg and Station 5 having a high of 0.18 mg/kg. No cadmium, GRO or DRO were detected in any of the samples taken. When compared to the average levels found in Jamaican Soils (Table 5-6), all values were below reported averages.

Table 5-5 Marine Sediment results

Stn	Arsenic (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	GRO (mg/kg)	DRO (mg/kg)
JPSoil 1	7	ND	11	0.1	ND	ND
JPSoil 2	5.9	ND	11	0.088	ND	ND
JPSoil 3	8.9	ND	11	0.14	ND	ND
JPSoil 4	6.7	ND	12	0.11	ND	ND
JPSoil 5	7.4	ND	8.4	0.18	ND	ND

ND – None Detected

Table 5-6 Heavy Metal Concentrations in Jamaican Soils

Metal	Average Conc. (mg/KG)	Range (mg/Kg)	95th Percentile (mg/KG)
Arsenic	25	1.4-203	<64.9
Cadmium	20	0.2-409	<77.6
Lead	46.5	6-897	<90
Mercury	0.2	0.04-0.83	<0.46

Source: A Geochemical Atlas of Jamaica, Centre for Nuclear Sciences, UWI, 1995, Canoe Press.

Comparison with other Sites

The heavy metal concentrations are within the average soil concentrations in Jamaica as listed in the Soil Atlas of Jamaica and had lower concentrations when compared with sediment concentrations at three other marine areas around Jamaica (Table 5-7). Comparison with other international ports and harbours has also shown that the concentrations obtained in Old Harbour 190 MW were below those obtained at the other locations (Table 5-8). Total Petroleum Hydrocarbon (TPH) is not considered a heavy metal, however, the concentrations obtained in Old Harbour 190 MW were in compliance with the NRCA standard of 1000 mg/KG.

Table 5-7 also shows marine sediment metal concentrations obtained during the SJPC 360 MW EIA study from 2012 (highlighted in yellow).

Table 5-7 Heavy metal concentrations at various sites in Jamaica and worldwide

METAL	NEGRIL	OLD HARBOUR SJPC 360 MW EIA	PALISADOES CARIBBEAN SEA SIDE	GEOCHEMICAL ATLAS OF JAMAICA	COMMERCIAL PORTS SAMOA	FISIHING PORTS SAMOA	EAST LONDON HARBOUR	PORT ELIZABETH HARBOUR
Arsenic (As) (mg/KG)	1.1 – 4.5	6.50 – 8.67	9.1 - 14	25				
Cadmium (Cd) (mg/KG)	ND	ND	ND	20			0.3 – 0.7	0.3 – 1.2
Lead (Pb) (mg/KG)	0.93 – 4.0	9.77 – 13.33	0.74 – 5.1	46.5	1,230 – 2,820	790 – 2,030	11.3 – 36.8	15.4 - 44

METAL	NEGRIL	OLD HARBOUR SJPC 360 MW EIA	PALISADOES CARIBBEAN SEA SIDE	GEOCHEMICAL ATLAS OF JAMAICA	COMMERCIAL PORTS SAMOA	FISIHING PORTS SAMOA	EAST LONDON HARBOUR	PORT ELIZABETH HARBOUR
Mercury (Hg) (mg/KG)	ND	0.04 – 0.05	ND	0.2				
TPH (mg/KG)	140 - 1100	11 – 68.67	ND					

Table 5-8 Heavy metal concentration (mg/g) in the sediment from the different regions of the world

Rivers	Cu	Pb	Reference
This study	0.97-3.82	1.23-2.82	
Cochin estuary, India	53.15	71.28	Balachandran *et al.* (2005)[16]
Jurujuba sound, Brazil	51.0	61.0	Baptista Neto *et al.* (2000)[17]
Tolo harbour, Hong Kong	84.0	144.0	Owen and Sandhu, (2000)[18]
Izmit Bay, Turkey	67.6	102.0	Pekey (2006)[19]
Koahsiung Harbour, Taiwan	5-946	9.5-470	Chen *et al.* (2004)[20]
Eastern Harbour, Egypt	14.09	-	Abdallah and Abdallah (2007)[21]
River Ganga, India	0.09	-	Singh *et al.* (2012)[22]
Mudflat of Salinas de San Pedro Lagoon, California, USA	0.085 - 0.47	0.05 - 0.38	Mohammad H.R *et al.* (2013)[23]

Source: Imo T et al. 2014

5.1.6 Climate and Meteorology

5.1.6.1 Climate within Study Area

Methodology

Temperature, relative humidity, wind speed and direction, rainfall and barometric pressure were recorded at one (1) location adjacent to the proposed site (atop the JEP Doctor Bird Barge security post building). This weather station has been recording data from January 6th, 2011 until present. Weather data was recorded by using a Davis Instruments wireless Vantage Pro2 weather system with a data logger and a complete system shelter erected on a tripod. Data were collected every fifteen minutes and stored on the data logger. This information was downloaded using the WeatherLink 5.9.3 software.

Results

Over the course of January 6th, 2011 – May 12th, 2016:

- Average temperature was 27.29 °C and ranged from a low of 18.3 °C to a high of 36.4 °C.
- Average relative humidity was 81.06% and ranged from a low of 40% to a high of 99%.
- Average wind speed was 3.17 m/s and ranged from a low of 0 m/s to a high of 17.0 m/s.
- Dominant wind direction was from the southeast.
- Mean barometric pressure was 1013.4 millibar and ranged from a low of 982.4 millibar to a high of 1020.5 millibar.

The total amount of rainfall over the period was 4960.56 mm. This is divided as is:

- 2169.82 mm from January 6 – December 31, 2011
- 917.28 mm in 2012
- 626.56 mm in 2013
- 368 mm in 2014
- 292.6 mm in 2015
- 586.3 mm from January 1, 2016 - May 12th, 2016.

Figure 5-14 to Figure 5-19 show the rainfall patterns per month for each year. In 2011, rainfall peaked in July, while in 2012 and 2013 rainfall peaked in May and September. In 2014, there was peak rainfall in March and May, while in 2015, rainfall peaked in February and October. In 2016, April had the highest rainfall thus far.

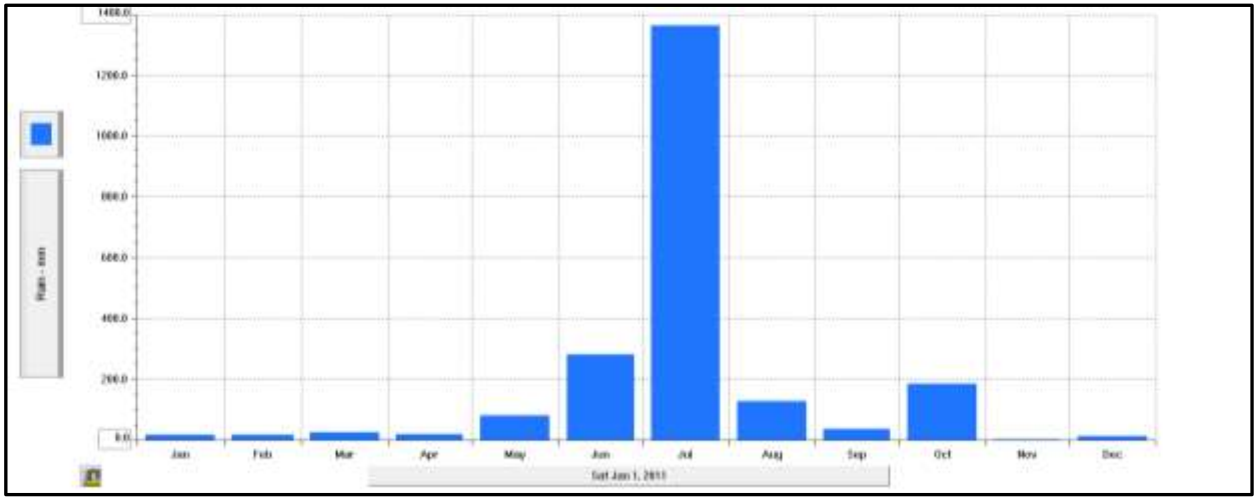


Figure 5-14 Rainfall rates for 2011

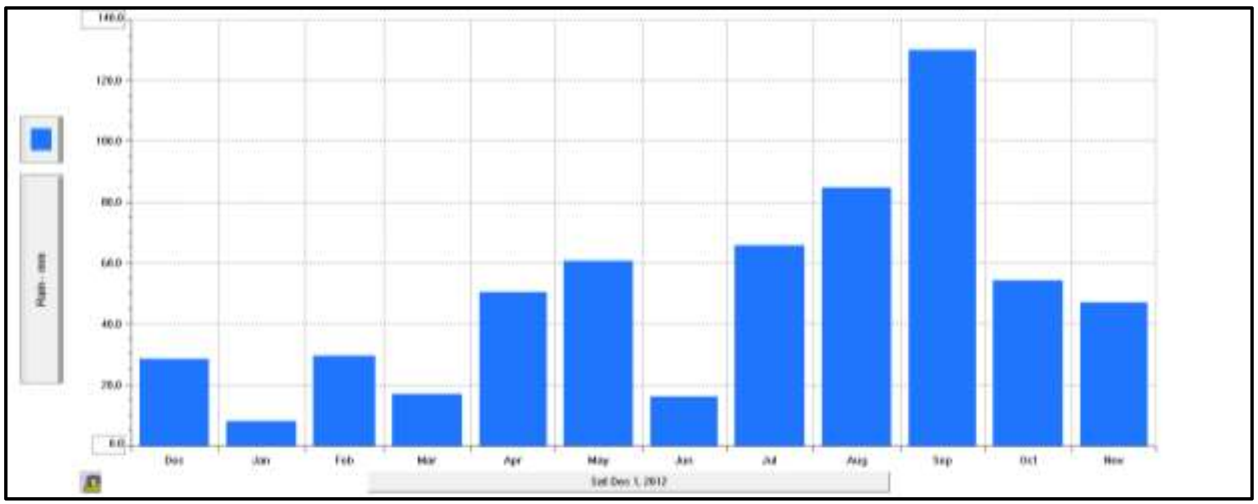


Figure 5-15 Rainfall rates for 2012

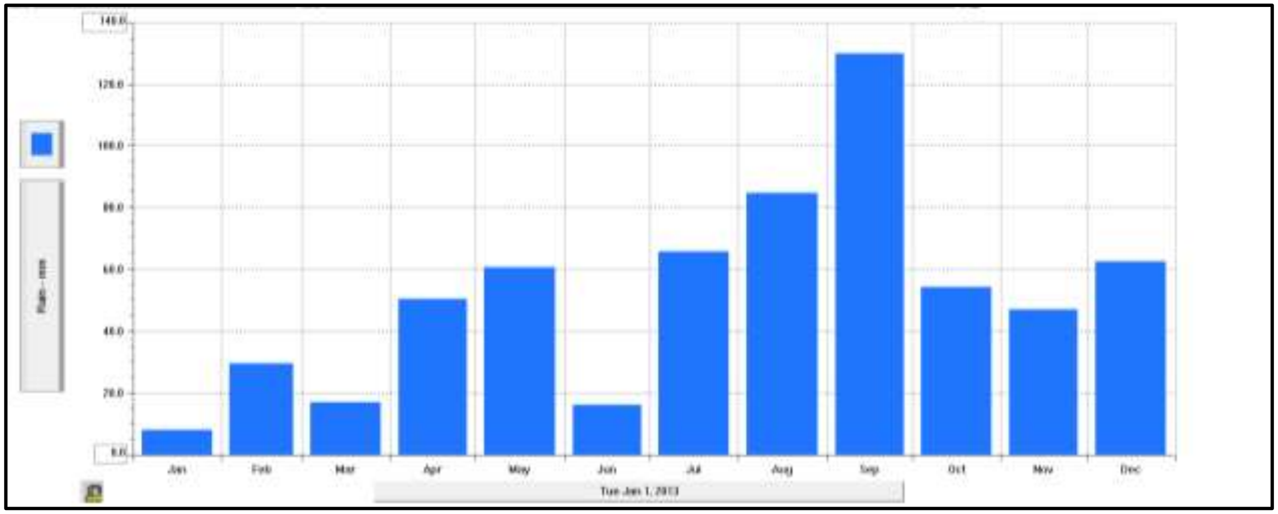


Figure 5-16 Rainfall rates for 2013

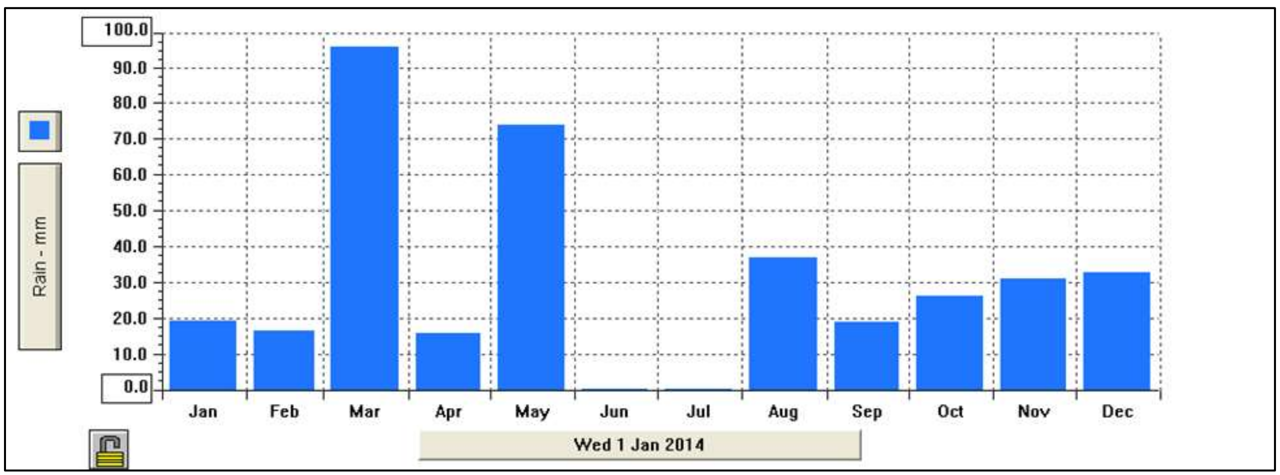


Figure 5-17 Rainfall rates for 2014

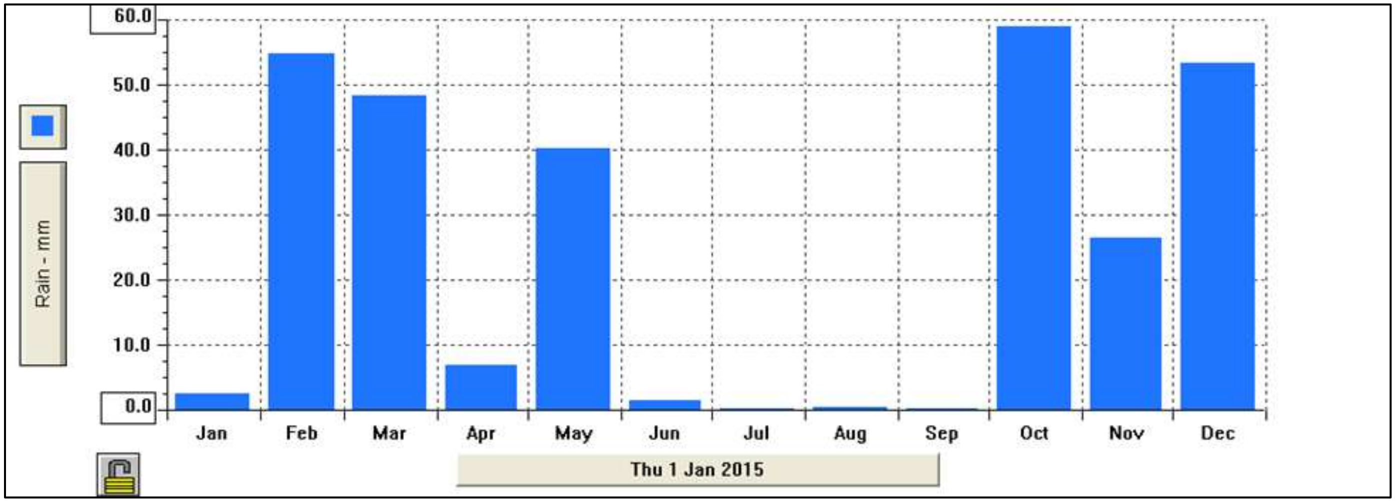


Figure 5-18 Rainfall rates for 2015

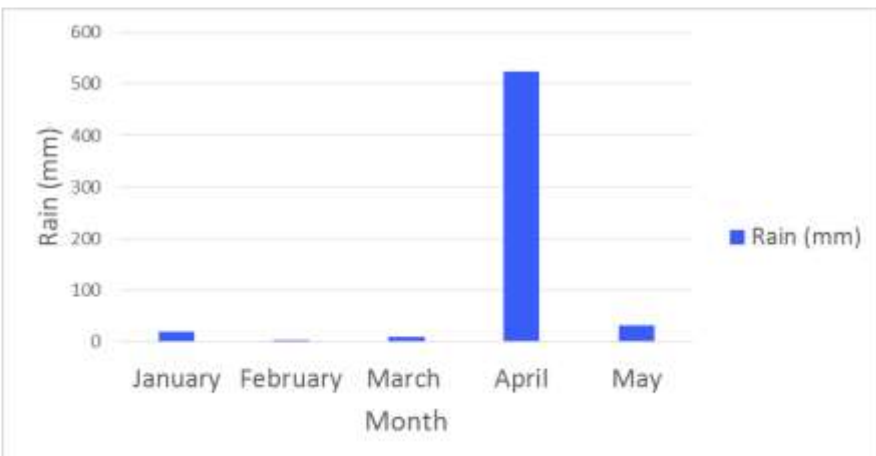


Figure 5-19 Rainfall rates for 2016

5.1.6.2 Historical Climate Data

30 Year Climatological Data (1951-1980)

As seen below in Table 5-9 and Figure 5-20 temperatures are greatest during the months of June through September. Lowest mean minimum temperature of 15.3 ºC is seen to occur in the month of February and the greatest mean maximum temperature of 31.9 occurs in between June and July. Rainfall is seen to have two yearly peaks of greater than 150 mm in September and October. January and February are seen to be the driest months of the year.

Table 5-9 Mean Climatological data for Bodles (1951-1980) – Jamaica Meteorological Service.

1951-80 MEAN CLIMATOLOGICAL DATA FOR SELECTED LOCATIONS													
Station (Altitude)	Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Bodles (Old Harbour) (St.Catherine) (alt. 37 metres)	Max Temp. (C)	29.3	29.2	29.4	30.4	30.4	31.1	31.9	31.9	31.1	30.7	30.4	30.2
	Min Temp. (C)	16.3	15.3	17.0	18.1	19.3	20.1	20.3	20.2	19.7	18.9	19.2	18.1
	Rainfall (mm)	41	42	49	56	123	91	58	97	161	198	83	53
	Rel. Hum.- 7am (%)	94	92	92	88	89	87	86	89	92	94	93	91
	Rel. Hum.- 1pm (%)	64	65	63	62	69	66	63	68	70	70	66	66

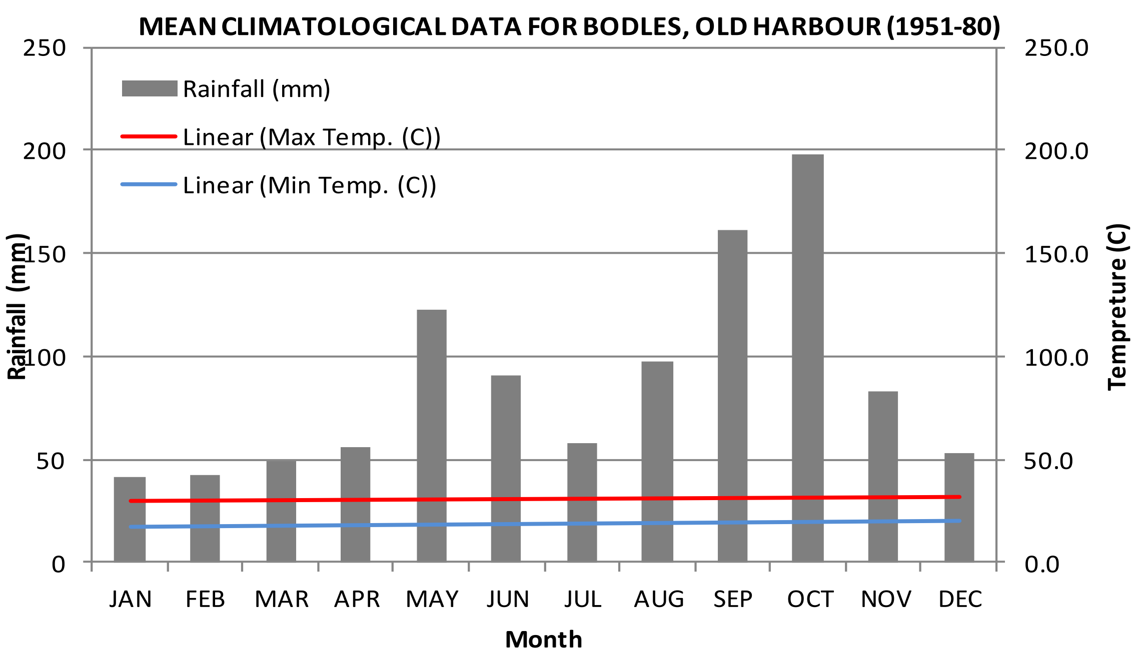


Figure 5-20 Mean Climatological data for Bodles (1951-1980) – Jamaica Meteorological Service.

Extreme Rainfall

The rainfall data for gauges in Jamaica were obtained from the Meteorological Office of Jamaica. Information for the gauges spanned 1930 to 1980 and 1992 to 2008. Both sets of data were subjected to Weibull analysis for the extreme rainfall data ranging for the 2, 5, 10, 25, 50 and 100 year. Historical rainfall extremes for stations across the island for the period 1930 to 1988 were compared with the extremes determined for the period 1992 to 2008. Rainfall depths for corresponding return periods were subjected to comparative analysis in order to determine if there was an overall increase or decrease in extreme rainfall. The analysis has indicated that there has been an overall increase ranging from 11.7% (for the 2 year Return Period Event) to 1.5% (for the 100 year Return Period event) for all stations. This increase has occurred over a time frame of 21 years (1988 to 2009). This equates to 0.7% to 5.6% increase per decade.

Table 5-10 Overall increase in 24-hours rainfall intensity (1988 – 2009).

	Return Period (yr.)					
	2	5	10	25	50	100
Number of stations considered	117	117	117	117	117	116
Average increase (mm)	14.0	10.0	5.6	5.9	6.3	5.3
Average rainfall depth (mm) 1930 to 1988	119.8	175.0	217.7	268.2	307.8	345.7
Overall increase	11.7%	5.7%	2.6%	2.2%	2.1%	1.5%
Increase per decade	5.6%	2.7%	1.2%	1.0%	1.0%	0.7%

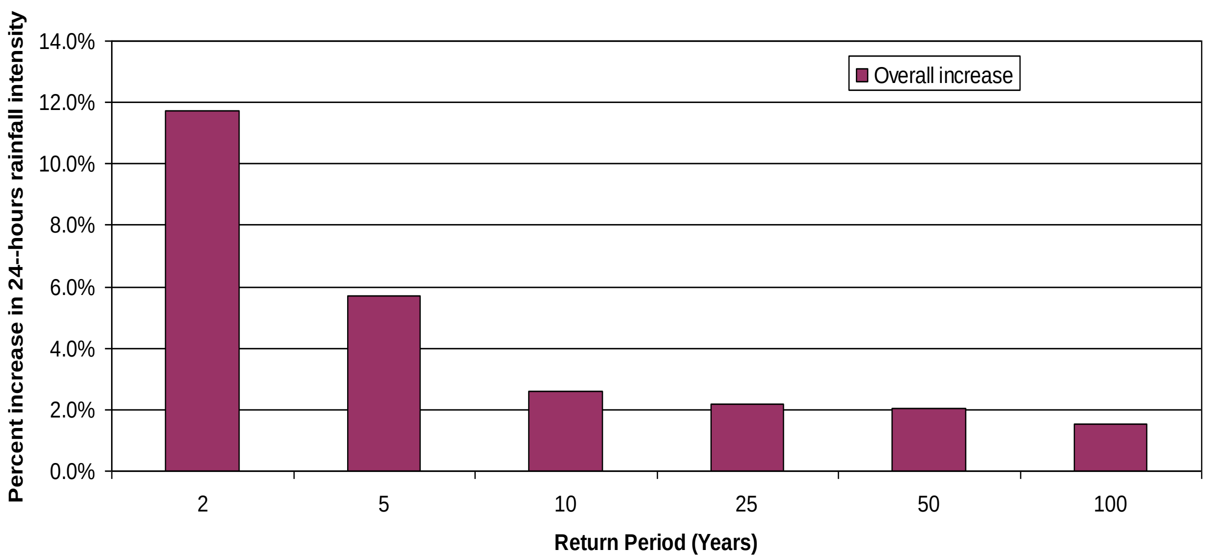


Figure 5-21 Overall increase in 24-hours rainfall intensity for the period between 1988 and 2009.

See Figure 5-22 and Figure 5-23 below for the rainfall changes estimated for the 50year and 100year 24 hour extreme rainfall.

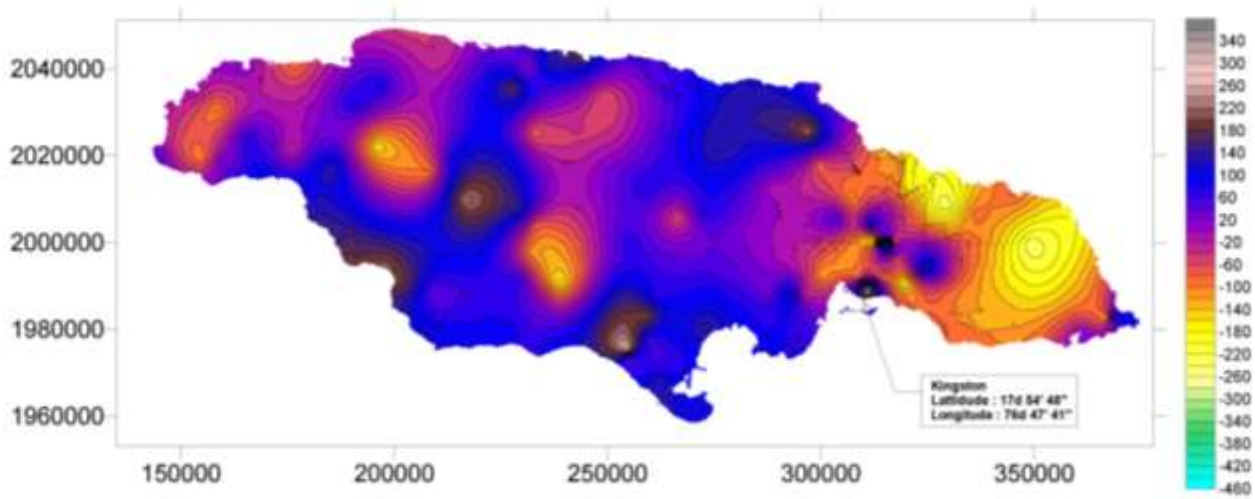


Figure 5-22 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 50 Year Return Period Event.

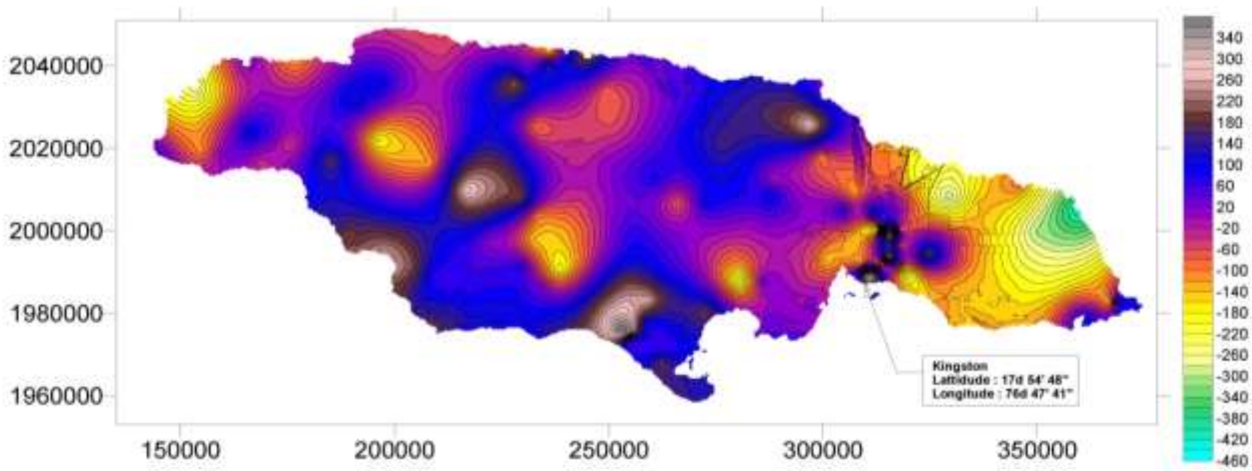


Figure 5-23 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 100 Year Return Period Event.

5.1.7 Hydrology

5.1.7.1 Approach

The methodology used for the analysis is as follows:

1. Data collection to include:
    a. Collection of soils information
    b. Collection of land use maps
    c. The topography of the catchments

   d. Anecdotal data collection
2. Delineating catchments and confirmation of streams/rivers
3. Calculating runoffs using the US Soil Conservation Service (SCS) method considering climate change.

Description of Hydrological Model

Soil Conservation Service (SCS) method is an empirical model for rainfall runoffs which is based on the potential for the soil to absorb a certain amount of moisture. On the basis of field observations, this potential storage S (millimetres or inches) was related to a 'curve number' CN which is a characteristic of the soil type, land use and the initial degree of saturation known as the antecedent moisture condition. Hydrological modelling of the watersheds encompassed three main elements:

- Precipitation
- Rainfall abstraction model (Curve number method)
- Runoff model (Dimensionless unit hydrograph)

The SCS curve number method was used to determine the rainfall excess P_e using the following equation:

$$P_e = \frac{(P^2 - I_a^2)}{P - I_a} + S$$

Where, P = precipitation
I_a = initial abstraction
S = Potential retention which is a measure of the retention capacity of the soil.

The Maximum Potential retention, S, and the watershed characteristics are related through the Curve number CN.

$$S = \frac{25400 - (254 \times CN)}{CN}$$

Curve Numbers have been tabulated by the NRCS on the basis of soils group, soil cover or land use, and antecedent moisture conditions (initial degree of saturation).

The U.S. Army Corps of Engineers' HEC-HMS was utilized to model the precipitation-runoff processes of the Bowers Gully watershed system. A model of the watershed was constructed by separating the hydrologic cycle into manageable segments and delineating a natural watershed of interest. Watershed parameters such as infiltration losses, transforming excess precipitation and hydrologic routing methods were selected based on existing conditions. Historical meteorology data was analysed using the user-specified hyetograph method Hydrographs produced by the program are used directly or in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation.

Hydraulic River Modeling System

The MIKE11 hydrological modelling system, created by the DHI Group, was utilized in simulating surface water flow of the Bowers Gully. MIKE11 can be used to model steady and unsteady, one-dimensional, gradually varied flow in both natural and man-made river channels including hydraulic structures. The hydraulic input parameters used within MIKE11 were created in HEC-HMS. The output created within MIKE11 is used to model flood plain areas using MIKE SHE hydrological (numerical) model.

MIKE SHE includes both a simple, semi-distributed overland flow method for rainfall-runoff modelling and a 2D, diffusive wave, finite difference method for detailed runoff and flood modelling. MIKE SHE can simulate detailed flooding based on fine scale topography in a coarser numerical grid, as well as detailed two-way exchange with surface waters and groundwater. Using the MIKE11 geometry and computed water surface profiles, inundation depth and floodplain boundary datasets are created through MIKE SHE.

Soils Data

MINISTRY OF AGRICULTURE DATABASE

The catchment of Bowers Gully was superimposed on the ministry of Agriculture's soils map of Jamaica to identify the soils distribution within the watershed. Soils are classified into four Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate defined by the Natural Resources Conservation Services (NRCS) TR-55 after prolonged wetting. It was noted that the catchment encompasses ten (10) soils with slight to moderate erosive properties as shown in Table 5-11. It was found that all the sub-catchments had high proportions of Clay loam and Stony loam. The soil types are distributed across the catchment as follows:

1. The upper third catchment basin area of the Bowers Gully has high concentrations of Clay Loam and Clay while its lower reach has a small segment of Sandy Loam.
2. Majority of the middle third of the Bowers Gully basin has over sixty percent (60%) Stony Loam with the remaining segments being Clay Loam and Sandy Loam.
3. The lower third area of the Bowers Gully watershed comprises of over eighty percent (80%) Clay Loam, twenty percent (20%) Sandy Loam and the remaining areas being Stony Clay.
4. The JPS proposed site comprises of more than eighty percent (80%) Clay Loam with the remaining areas being Sandy Loam.

Table 5-11 Outline of soil properties obtained from the Soil and Land Use Surveys.

Soil Type	Erosion Hazard	Drainage through Soil
Bonnygate Stony loam	High if developed	Extremely Rapid
Carron Hall Clay	Slight to Moderate	Moderate

Soil Type	Erosion Hazard	Drainage through Soil
Diamonds Clay Loam	High	Rapid
Whim Sandy loam	Slight	--
Lodge Clay Loam	Slight	--
Union Hill Stony clay	Moderate to high	Fairly Rapid
St. Ann Clay Loam	Moderate to high	Moderate
Bundo Clay	Almost none	Very Slow
Belfied Clay	High	Moderate
Bodles Clay Loam	Slight	Almost none

The relevant sections of the soil textures map over which the Bowers Gully catchment is superimposed is shown in Figure 5-24

SOILS ENGINEERING REPORT

A Soils report prepared by NHL Engineering Ltd in 2011 for JPS was obtained from the client. The report shows where several boreholes were done on the project site and it was found that:

1. The top 0-7m layers of the ground surface consist of silty sands and some clays
2. Ground water was found to be on average 1.75m below the ground surface

These findings were consistent with the ministry of agriculture's soils map within the project site.

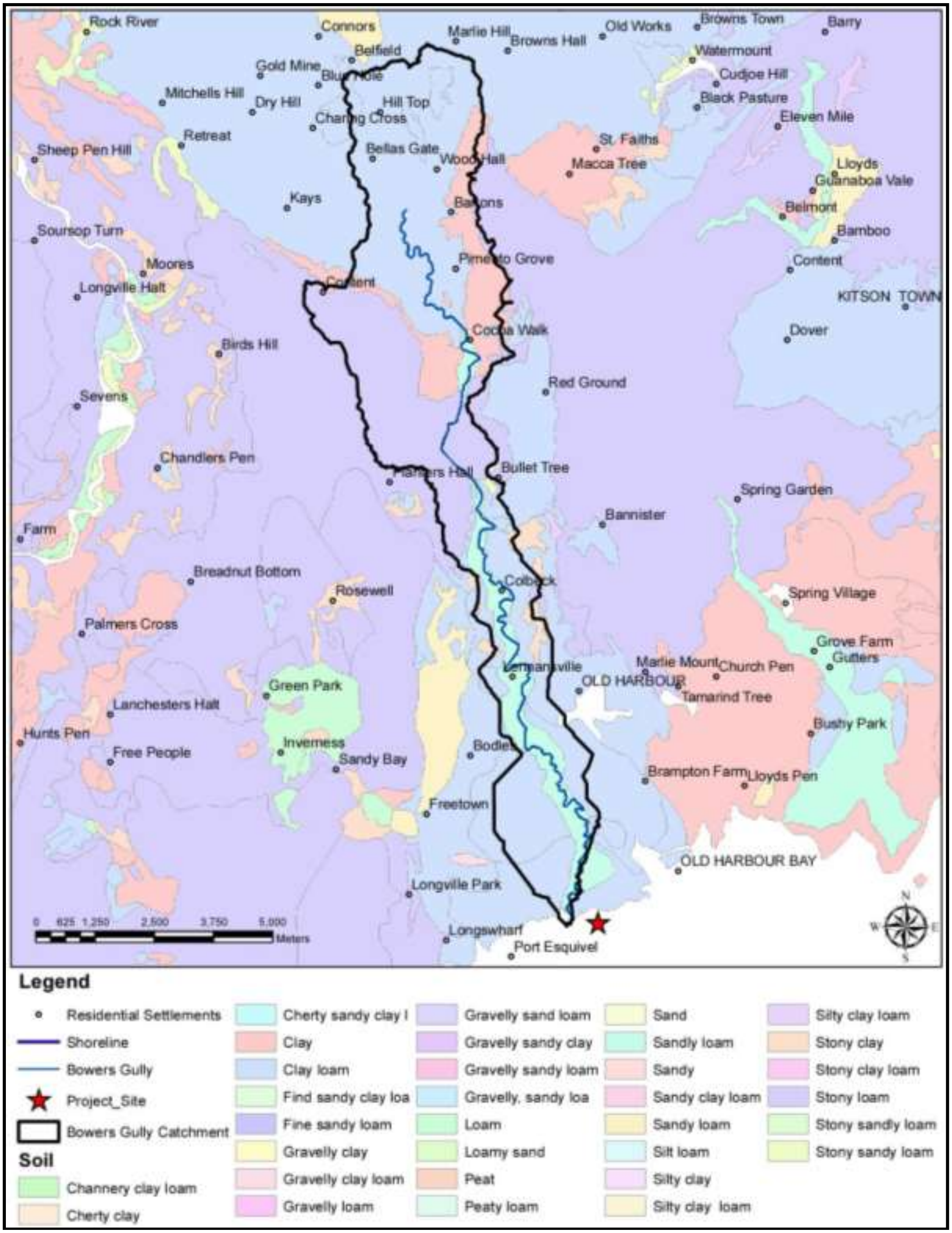


Figure 5-24 Proposed JPS sites and Bowers Gully catchment superimposed on Soils map of Jamaica.

Land Use Data

The Land use for each catchment was determined from inspection of the Forestry Department land use map seen in Figure 5-25, as well as satellite imagery of the catchment. Land use was classified into categories consistent with the schedules published by the Natural Resources Conservation Services (NRCS) TR-55 for cover type and hydrologic condition. The land use of the project area was prepared for the initial evaluation of the pre-development hydrologic condition. This 'benchmark' data is used to evaluate peak flow estimates prior to the application of developed land use changes. The following was noted:

1. The upper regions of the catchment were observed to have mostly forests, fields and crops with sparse residential settlements on lots more than 1/4 acres in area.
2. The lower reaches of the catchment is comprised primarily of fields, forests and plantations; there also exists a small portion of swamp forest.
3. The proposed site of JPS is composed of swamp forest lands.

The land use changes that will be generated by the proposed JPS site development are implemented in the assessment for the post-development hydrologic condition of the catchment area.

5.1.7.2 Runoff Calculations

General

The peak runoffs were calculated using the type III rainfall distribution. The primary inputs into the model are as follows:

- Drainage area size (A) in square miles (square kilometres);
- Time of concentration (Tc) in hours;
- Weighted runoff curve number (RCN);
- Rainfall distribution (see Figure 5-26);
- Total design rainfall (P) in inches (millimetres).

The runoff generated for these events were used in the flood plain model to estimate the flood levels in the bowers gully flood plain. The models were adjusted as necessary to ensure reasonable agreement with the actual observation of the residents.

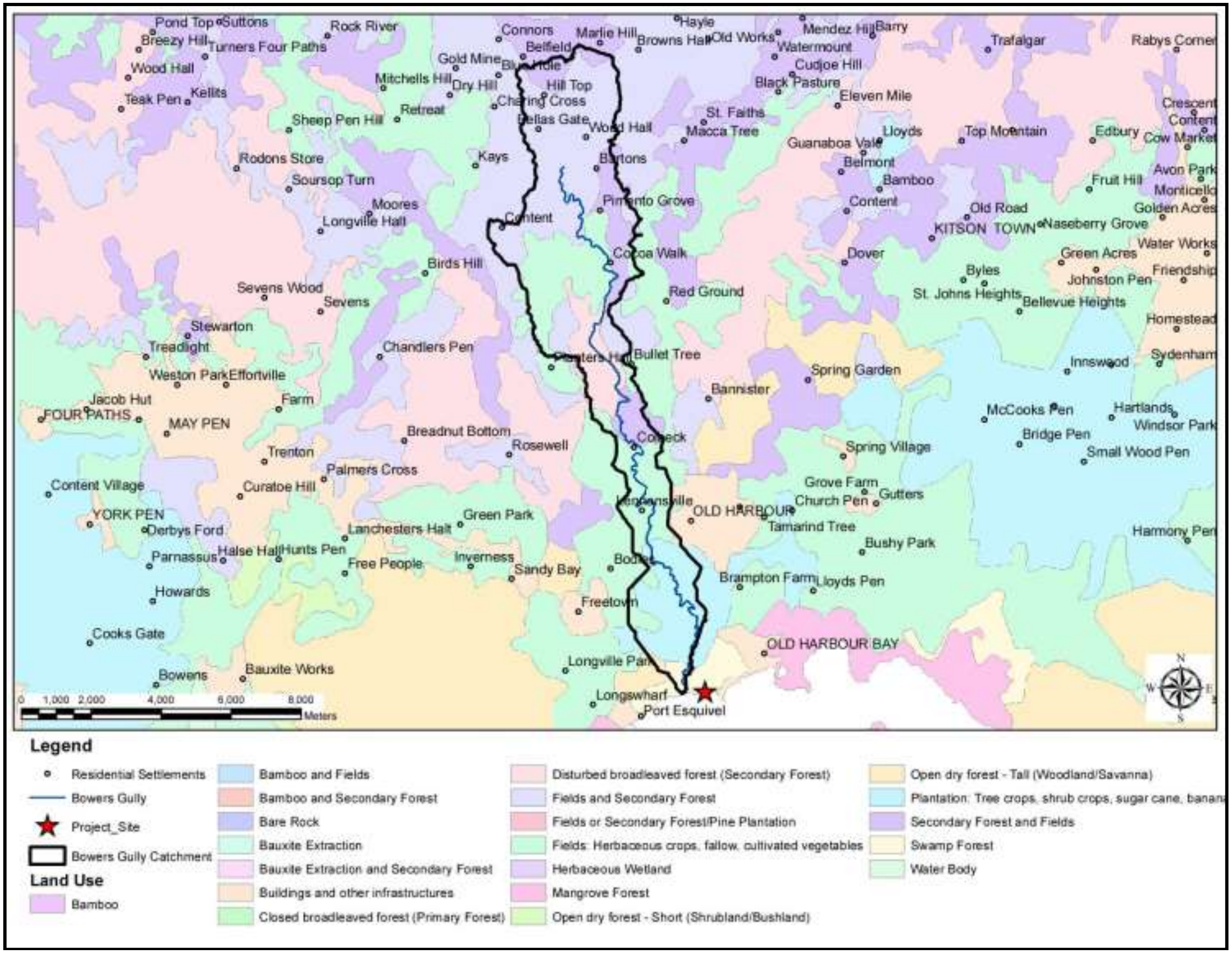


Figure 5-25 Land use map of Jamaica with superimposed catchments and JPS proposed sites.

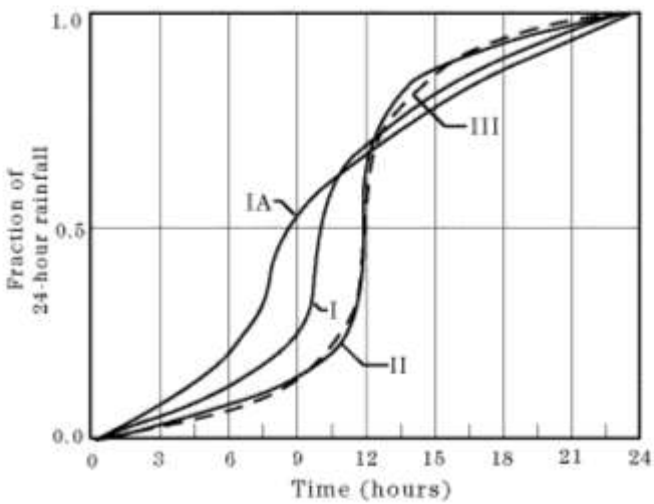


Figure 5-26 SCS 24-hour Rainfall Distributions

Climate Change Resilience

The analysis indicates that there has been an overall increase in the average rainfall ranging from 6.1% (for the 5 year Return Period event) to 42.1% (for the 100 year return period event) and 5% (for the 5 year Return Period event) to 56.6% (for the 100 year return period event) for the Norman Manley International Airport (NMIA) and Sangster's International Airport (SIA) weather stations. This increase will occur over a time frame of 90 years (2010 to 2100). See Table 5-12 and Figure 5-27 below. These were further verified in Burgess et al (2014)

Table 5-12 Summary of 24 hour intensities for 2010 and 2100 period.

Return Period (yrs)	Stationary (2010)	Mean Varying (2100)	Mean + std. dev. Varying (2100)	Mean + std. dev. + skewness Varying (2100)	Mean (2100) Predictions	Average % Increase
5	178 [132.6]	170.9 [132.8]	160.2 [133.1]	166.5 [120.8]	165.9 [128.9]	**−7%** [−3]
10	220.5 [163.6]	216.3 [166.2]	212.4 [172.4]	248 [157.4]	225.6 [165.3]	**2%** [1]
25	271.7 [202.7]	275.1 [209.0]	283.5 [229.2]	378.6 [224.3]	312.4 [220.9]	**15%** [9]
50	308.1 [231.7]	319.8 [241.1]	351.2 [280.0]	562.1 [292.0]	411 [271.0]	**33%** [17]
100	342.9 [260.5]	365.1 [273.3]	426.7 [336.9]	845.1 [381.2]	545.6 [330.5]	**59%** [27]

Table 5-13 Present (1895–2010) climate return period and projected return period (2100) for NMIA and SIA from statistical trend analysis of frequency analysis parameters based on corresponding the present climate intensities for each station.

Present Return Period (1895 - 2010)	NMIA (2100)	SIA (2100)
5	6.1	5
10	9.3	9
25	17.5	19
50	26.3	32.9
100	42.1	56.6

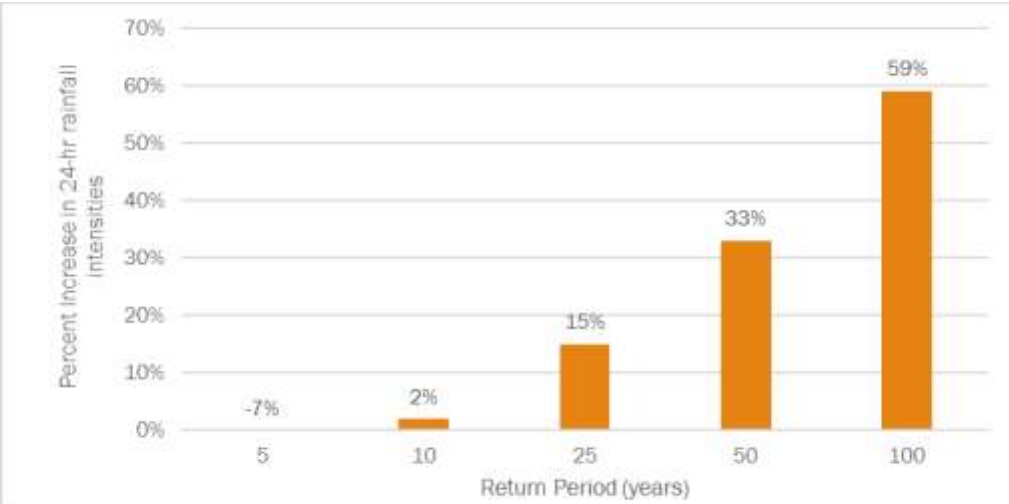


Figure 5-27 Overall increase in 24-hours rainfall intensity for the period between 2010 and 2100.

Meteorological Data

The rainfall data for gauges in Jamaica were obtained from the Meteorological Office of Jamaica. Information for the gauges spanned 1930 to 1980 and 1992 to 2008. Both sets of data were subjected to Weibull analysis for the extreme rainfall data ranging for the 2, 5, 10, 25, 50 and 100 year. Historical rainfall extremes for stations across the island for the period 1930 to 1988 were compared with the extremes determined for the period 1992 to 2008. Rainfall depths for corresponding return periods were subjected to comparative analysis in order to determine if there was an overall increase or decrease in extreme rainfall.

The rain gauge locations were superimposed on the main catchment area to determine rainfall depths that will be used in the hydrology model (Figure 5-28). A total of three (3) gauges were noted inside of and within 3 km of the overall catchment boundary. The revised rainfall intensities for these stations were increased to reflect climate change for all the return periods respectively. The current intensities as well as the recommended design values are listed in Table 5-14.

Table 5-14 Rainfall intensities recorded by associated rain gauges in proximity to Bowers Gully catchment

STATION	PARISH	24 HOURS EXTREME RAINFALL DEPTHS (RECOMMENDED)					
		2	5	10	25	50	100
Longville Park	Clarendon	111.7	193.9	260.7	353.1	425.4	499.5
Bodles	St. Catherine	177.2	228.6	265.3	312.0	346.5	380.3
Bois Content	St. Catherine	164.5	217.0	256.2	307.5	346.0	384.4

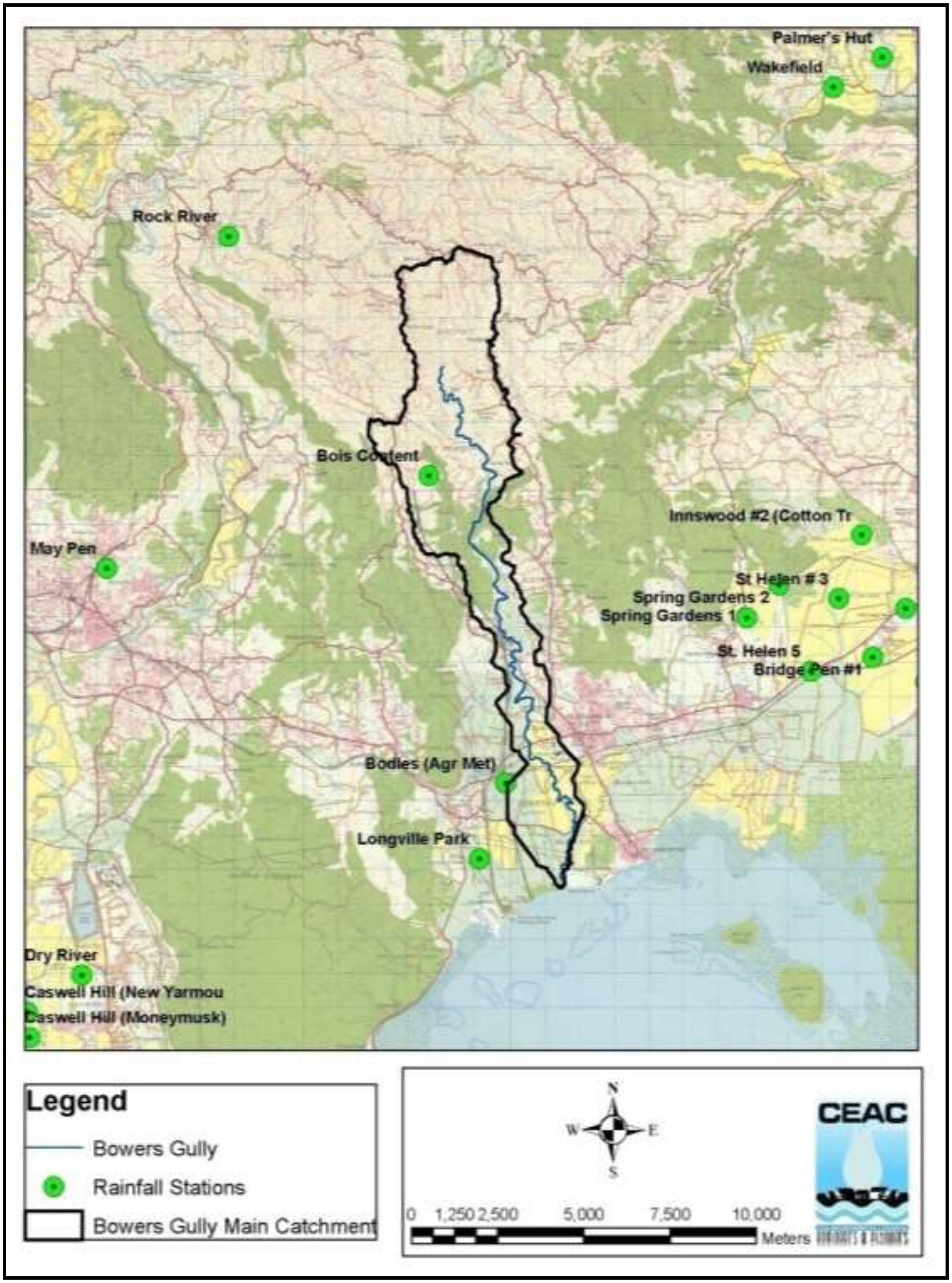


Figure 5-28 Showing the Bowers Gully catchment in relation to the gauges.

Estimated Peak Flows

It was necessary to model the storms that were observed by the residents to calibrate the models before using them to predict the 2, 5, 10, 25, 50, and 100 year return period storm events. Climate change was considered in estimating the peak flows. The peak runoff generated for each event was as follows:

Table 5-15 Summary of peak flows generated for Bowers Gully.

Storm	Peak Flow (m^3/s)
Hurricane Ivan	302.5
1:2 year	62.6
1:5 year	117.4
1:10 year	214.9
1:25 year	328.8
1:50 year	347.6
1:100 year	401.5

The peak runoff was generated for the catchment using the average of the SCS method. Hurricane Ivan flows were noted to be above the 10 year return but below the 25 year storm. For the Bowers Gully, the peak flows ranged from 62.6 to 401.5 m^3/s for the given 2 to 100 year return periods.

5.1.8 Wave Climate

The objective of this exercise is to derive both a nearshore and deepwater wave climate in order to estimate the wave forces on the existing shoreline and the proposed marine outfall. The weakly nonlinear combined refraction and diffraction model described here denoted REFDIF simulated the behaviour of a random sea over an irregular bottom bathymetry incorporating the effects of shoaling, refraction, energy dissipation and diffraction. Although the model is developed to simulate a random sea state, it can also be used to model the behaviour of monochromatic waves.

The output from the storm surge model used for hurricane impact analysis provided the incident wave height and period as well as the water setup for the deepwater extremal analysis, while locally generated waves were predicted using the JONSWAP equations. This equation determines wave height and period from fetch, storm duration and depth of water in the generating area, where fetch is the distance into the wind direction from a point of interest to the nearest shoreline. Portland Bight is significantly large with a maximum fetch of approximately 19 km for a storm moving across the Bay. It is quite possible for local waves with significant wave heights to reach the project area and damage the outfall pipe and so it was necessary for locally generated hurricane waves to also be determined as well. The wind speeds and directions were input into the equations where the corresponding wave heights and periods were determined. These incident wave heights and periods were then used to determine the hurricane climate under future conditions (climate change).

5.1.8.1 Winds

Onshore

Measured wind data are typically available from airports. However, this data may differ from marine winds due to the effects of topography and often these data are unavailable during storm events. For this summary, data from the Norman Manley International Airport (NMIA) was analysed and compared to wind from a 30-year offshore wind model. The database obtained from the NMIA meteorological station consists of data recorded daily for the last 19 years. A "rose plot" and summary table shows the frequency of these winds by direction and intensity.

Percentage of Occurrence

Wind Speed, kt	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
Total	14.97	5.52	2.16	2.84	9.69	14.92	14.78	5.24	3.64	1.90	1.22	0.91	1.88	2.80	5.35	7.88	95.69
>26							0.14										0.25
18–26	0.13			0.23	0.91	2.64	4.59	0.90									9.56
10–18	1.20	0.32	0.22	0.69	4.17	8.23	7.11	1.97	0.24						0.16	0.35	24.89
6–10	5.60	1.82	0.40	0.67	2.74	2.77	1.87	1.35	1.61	0.69	0.33	0.15	0.27	0.47	1.23	2.05	24.03
3–6	6.93	2.85	1.10	0.95	1.50	1.04	0.91	0.87	1.57	1.04	0.71	0.54	1.15	1.88	3.41	4.77	31.19
1–3	1.10	0.51	0.37	0.29	0.34	0.19	0.17	0.15	0.20	0.13	0.14	0.19	0.40	0.36	0.54	0.68	5.77

Figure 5-29 Percentage occurrence of wind speeds associated with all possible directions for onshore node

Offshore Station

Wind data was purchased from Ocean Weather International (OWI) based on regional hindcasts of weather patterns. The model data is extracted at an offshore location 25 miles southeast of Portland Bight. This database of wind records consists hourly wind speed and direction over a 30-year span from 1980 through 2010. This dataset was adjusted to include extreme events (i.e. hurricanes).

Percentage of Occurrence

Wind Speed, kt	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
Total	0.79	2.40	10.04	33.08	38.19	11.37	1.89	0.54	0.29	0.15	0.13	0.14	0.14	0.17	0.23	0.38	99.92
>26			0.12														0.33
18–26		0.33	1.30	3.68	3.58	0.97	0.11										10.13
10–18	0.31	1.01	5.22	21.32	27.09	6.89	0.92	0.18									63.31
6–10	0.19	0.62	2.50	6.47	6.19	2.61	0.47	0.14								0.11	19.61
3–6	0.18	0.34	0.77	1.29	1.12	0.74	0.28	0.12									5.33
1–3			0.13	0.24	0.21	0.14											1.22

Figure 5-30 Percentage occurrence of wind speeds associated with all possible directions for offshore node

Comparison of the two data sets shows similar wind directions but higher speeds for the offshore data corresponding to storm events and open water conditions. Analysis of the offshore wind data for exceedance values are shown in Figure 5-31.

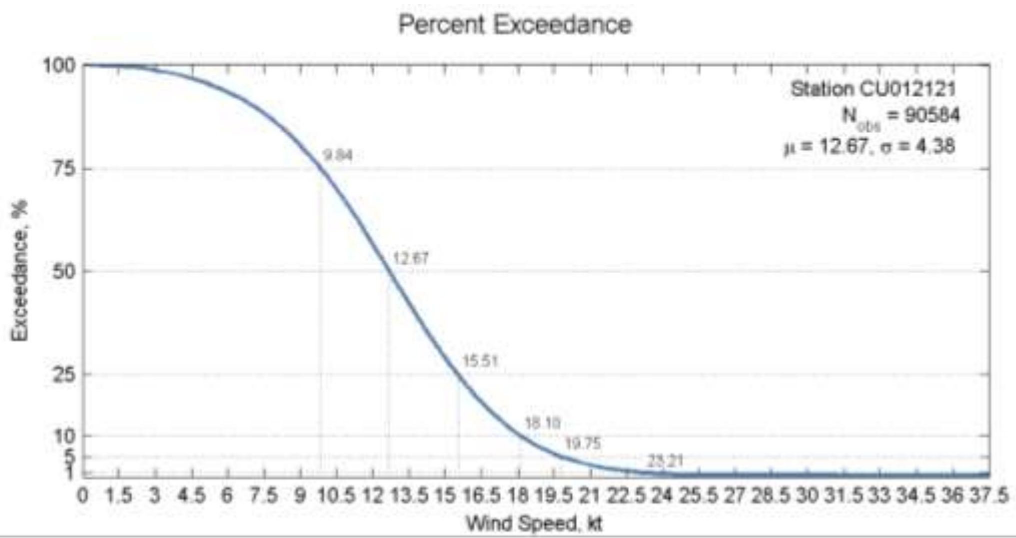


Figure 5-31 Analysis of the offshore wind data for exceedance values

The exceedance chart shows winds exceed 23.2 knots less than 1% of the time. When analysed for return period, the 100-year offshore wind speed is on the order of 60 knots at the indicated location south of Portland Bight. Wind speeds may be higher in other locations around the Country.

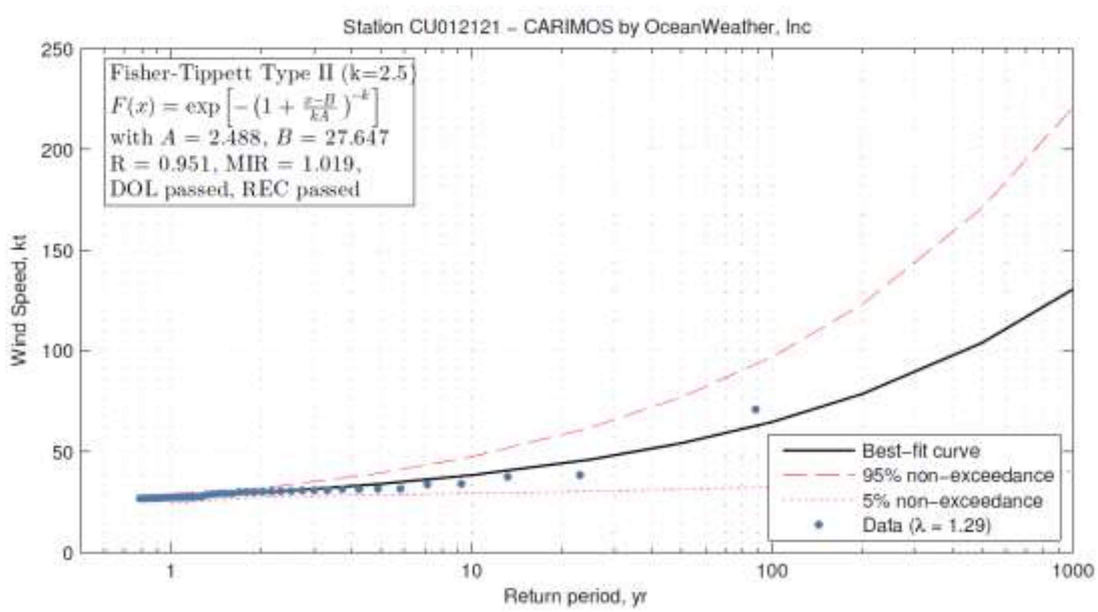


Figure 5-32 Return period analysis of wind speeds

5.1.8.2 Extremal Wave Climate

Wave modelling is an attempt to fill in the gaps where actual measured data is absent. Wave measurements are available for the two ADCP locations. The remainder of the Bay will have different wave conditions which are dependent primarily the bathymetry of the bay.

The Old Harbour Bay coastline is susceptible extreme waves generated within the Bay as a result of passing storms. Direct historical measurements are not available for this area, it was therefore necessary to utilize hindcast modelling to estimate the extreme waves to which the bay and coastline are exposed.

Method

It was necessary to define the deep-water hurricane wave climate at a point offshore Portland Bight:

- Latitude: 17.733 degrees North
- Longitude: 76.975 degrees West

The National Hurricane Center (NOAA) database of hurricane track data in the Caribbean Sea was utilized to carry out a hindcast, wave breaking (along two tracks) followed by a statistical analysis to determine the hurricane: waves, wind and set-up conditions. The database of hurricanes, dating back to 1851 to 2014, was searched for storms that passed within a 300km radius from the site. The following procedure was carried out:

- Extraction of Storms and Storm Parameters from the historical database. A historical database of storms was searched for all storms passing within a search radius of 300km radius of the site.
- Application of the JONSWAP Wind-Wave Model. A wave model was used to determine the wave conditions generated at the site due to the rotating hurricane wind field. This is a widely applied model and has been used for numerous engineering problems. The model computes the wave height from a parametric formulation of the hurricane wind field.
- Application of Extremal Statistics. Here the predicted maximum wave height from each hurricane was arranged in descending order and each assigned an exceedance probability by Weibull's distribution.
- A bathymetric profile from deep-water to the site was then defined and each hurricane wave transformed along the profile. The wave height at the nearshore end of the profile was then extracted from the model and stored in a database. All the returned nearshore values were then subjected to an Extremal Statistical analysis and assigned exceedance probabilities with a three parameter Weibull distribution.

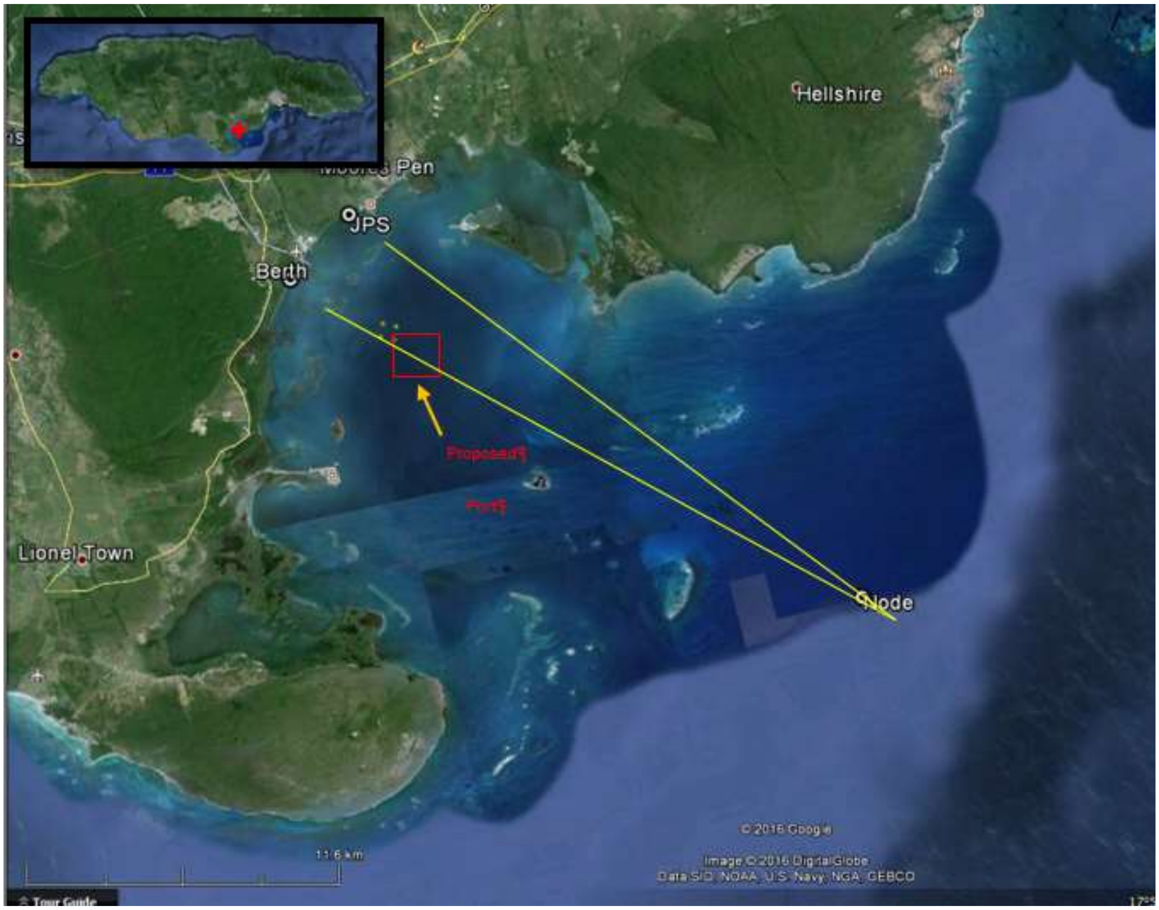


Figure 5-33 Location of offshore point used for Extremal analysis, showing southern and south-eastern track used in the analysis

Historical Hurricanes

Historical hurricane track data was obtained from the NOAA hurricane database. Hurricanes passing 50 nautical miles of Portland Bight are shown in Figure 5-34. Table 5-16 shows names, years, maximum wind speeds, storm category and trajectories for each of the 3 hurricanes that have passed within 10 nautical miles of Portland Bight. Table 5-17 shows names, years, maximum wind speeds, storm category and trajectories for each of the 40 hurricanes and tropical storms that have passed within 65 nautical miles of Portland Bight.

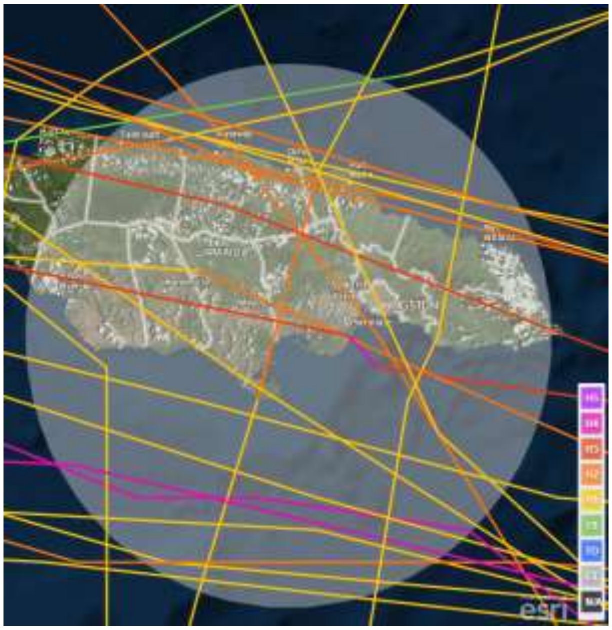


Figure 5-34 Hurricanes passing within 50 nautical miles of Portland Bight

Table 5-16 Characteristics of the hurricanes within 10 nautical miles of Portland Bight

Name	Year	Max. Wind (kts)	Cat.
GILBERT	1988	110	H3
CHARLIE	1951	95	H2
UNNAMED	1874	90	H2

Table 5-17 Characteristics of the hurricanes within 50 nautical miles of Portland Bight

Category	Number of events	Max. Wind (knots)	Year
H5	0	-	-
H4	3	135	1988-2007
H3	2	105	1903-1944
H2	8	90	1852-1951
H1	14	80	1874-2012
TS	13	-	1879-2008

Climate Change Considerations

It was necessary to consider the effect of climate change on the project area. A 2013 study conducted by the Climate Studies Group at the University of the West Indies (UWI) Mona (Climate Studies Group, UWI Mona, 2013) was used to inform the approach; it assessed literature on current and projected trends in sea level rise, wave heights and storm intensities in Jamaica. The findings of the report are summarized in the following subsections.

CURRENT AND PROJECTED TRENDS FOR MEAN AND EXTREME SEA LEVELS

Global sea levels have risen through the 20th century, and it is expected to accelerate through to the 21st century and beyond because of global warming, but their magnitude remains uncertain. Two main factors contribute to this increase: thermal expansion of sea water due to ocean warming and water mass input from land ice melt and land water reservoirs. In Jamaica, and the region near it, the sea level rise is approximately the global average of 3.2 mm/yr (± 0.4) (IPCC 2013). Projected increases in global and Caribbean mean sea level by 2100 relative to the 1980-1999 is 0.37m (± 0.5 m relative to global mean) and this is equivalent to 3.7 mm/yr (IPCC 2007).

CURRENT AND PROJECTED TRENDS IN MEAN AND SIGNIFICANT WAVE HEIGHTS

In 2000 Wang and Swail detected statistical significant changes in the seasonal extremes of significant wave heights in the North Atlantic only for the winter (January – March) season; these changes were found to be linked with the North Atlantic Oscillation. Specifically, significant increases in significant wave heights in the Northeast North Atlantic matched by significant decreases in the subtropical North Atlantic are found to be associated with an intensified Azores High and a deepened Icelandic low.

The IPCC-AR5 predicts that the annual mean significant wave heights will decrease by approximately 1 to 2%. This marginal figure was, not included in the design so as to enable the dunes and mangrove nourishment areas best changes to the climate change projections.

CURRENT AND PROJECTED TRENDS IN STORM INTENSITIES

The AR5 notes that evidence suggests a virtually certain increase in the frequency and intensity of the strongest cyclones in the Atlantic since the 1970s. It is further noted that the average lifetime of North Atlantic tropical cyclones shows an increasing trend 0f 0.07 day/yr for the same period which is statistically significant (Climate Studies Group, UWI Mona, 2013).

The AR4 concluded that a range of modelling studies projects a likely increase in peak wind intensity and near storm precipitation in future tropical cyclones. Simulations consistently find that greenhouse warming causes tropical cyclone intensity to shift towards stronger storms by the end of the 21st century (2 to 11% increase in mean maximum wind globally).

SUMMARY

Based on the assessments and literature reviewed the following climate change factors were incorporated into the design (Table 5-18), specifically the deep water and nearshore wave climate analysis carried out in the following sections.

Table 5-18 Summary of climate change considerations.

	Present Climate		Climate Factor (Cf)	Future Climate	
Water Level (above existing msl)	0		3.75 mm/yr	0.188	
Operational Wave Height (m)	0.6		1 - 2 % decrease	0.6	
Swell Wave Height (m)	1.2			1.2	
	50 YR	*100 YR*		*50 YR*	*100 YR*
Hurricane Wave Height (m)(Harbour)	2.38	2.83	1.054	2.51	2.98
Hurricane Wave Height (m) (Deepwater)	6.70	7.10	1.054	7.06	7.48
Wave Frequency (Increase)			2.2 = 100*log(A1B/CTRL)	5.2%	5.2%

Results

DEEP WATER WAVES

The results of the search clearly indicate the sites overall vulnerability to such systems. In summary:

- 88 hurricane systems came within 300 kilometres of the project area
- 8 of which were classified as catastrophic (Category 5)
- 14 were classified as extreme (Category 4)

The more destructive hurricane events (category 4 and 5) have been occurring more frequently. This speaks to the site's overall vulnerability to such systems and the likelihood of events occurring relatively frequently. The bi-variant table analysis indicates that the waves generated offshore the site have approached from all seaward possible. However, the most frequent hurricane waves have been noted to come from a **south-easterly** direction. In summary, there are:

- 38 (x6 hours) occurrences from the east
- **64 (x6 hours) occurrence from the south-east**
- 61 (x6 hours) occurrence from the south

The south and south-easterly directions are more prevalent for the node considered because of the seaward projection of the eastern part of the bay that buffers the site from remote easterly waves. The site however becomes more exposed as soon as the passing hurricane systems are more south of the island.

Static storm surge was investigated in the analysis for all major components of storm surge. The phenomena considered were:

- Wave breaking and shoaling
- Wind set-up
- Refraction
- Tides

- Global Sea Level Rise (over a 50 year project life)
- Inverse Barometric Pressure Rise

The south eastern profile is the most extreme direction as shown in Table 5-19. The results indicate that the expected 50 and 100 Year storm surge wave setups are 2.14 and 2.34 meters respectively. The maximum and minimum confidence limits showed increased variance from the return values as the return period increases. The confidence limits for the setups showed an average variance of less than 0.36m between return value and the maximum and minimum levels for the 100 year return period. This is reasonable given that the source data covers 125 years.

Table 5-19 Extremal analysis of storm surge wave setup for Portland Bight

Return Period	Total setup (m)								
	All	SW	W	NW	N	NE	E	SE	S
1				0.00	0.00	0.00	0.05	0.05	0.05
2	0.37	0.12	0.07	0.00	0.00	0.00	0.64	0.84	0.40
5	0.85	0.21	0.16	0.00	0.00	0.00	1.01	1.32	0.64
10	1.22	0.27	0.23	0.00	0.00	0.00	1.23	1.60	0.79
20	1.59	0.33	0.31	0.00	0.00	0.00	1.42	1.85	0.92
25	1.71	0.35	0.34	0.00	0.00	0.00	1.48	1.92	0.96
50	2.08	0.40	0.42	0.00	0.00	0.00	1.64	2.14	1.08
75	2.30	0.43	0.47	0.00	0.00	0.00	1.74	2.26	1.15
100	2.45	0.46	0.51	0.00	0.00	0.00	1.80	2.34	1.19
150	2.67	0.49	0.56	0.00	0.00	0.00	1.89	2.45	1.25
200	2.83	0.51	0.60	0.00	0.00	0.00	1.94	2.53	1.30

These are extreme waves with the potential for generating significantly high currents within the bay, and damaging structures on the seafloor. It is more likely, though, that south eastern and southerly waves will have the greatest impact on the project area.

Table 5-20 Extremal analysis of wave heights and wave periods for portland bight

Return Periods	Wave height (m)								
	All	SW	W	NW	N	NE	E	SE	S
1	2.5	1.5	1.5	0.0	0.0	0.0	1.5	1.5	1.5
2	3.7	3.4	3.5	0.0	0.0	0.0	4.5	4.2	3.5
5	4.9	4.0	4.4	0.0	0.0	0.0	5.6	5.2	4.5
10	5.8	4.3	4.8	0.0	0.0	0.0	6.1	5.8	5.0
20	6.6	4.5	5.2	0.0	0.0	0.0	6.6	6.2	5.4
25	6.9	4.6	5.3	0.0	0.0	0.0	6.7	6.4	5.5
50	7.6	4.8	5.7	0.0	0.0	0.0	7.1	6.7	5.9
75	8.1	4.9	5.8	0.0	0.0	0.0	7.2	6.9	6.1
100	8.4	5.0	6.0	0.0	0.0	0.0	7.4	7.1	6.2
150	8.9	5.1	6.1	0.0	0.0	0.0	7.6	7.2	6.4
200	9.2	5.1	6.2	0.0	0.0	0.0	7.7	7.4	6.5

An offshore profile, which considers the proposed mooring area, was compiled and simulated in order to determine the wave heights which the area will experience. During a 1:50yr storm event, the mooring area is expected to experience wave heights of up to 3.16m while during a 100yr event, wave heights up to 3.41 will be observed. The wave heights determined to reach the mooring point are shown in Table 5-21.

Table 5-21 Predicted wave heights in the vicinity of the mooring area

Return Period (yr)	Wave Heights (m)
2	1.34
5	2.07
10	2.47
25	2.89
50	3.16
100	3.42

For the proposed LNG site on land, the vulnerability to storm surge was also investigated. It was determined that the expected storm surge inundation levels for the 50yr and 100yr events is 3.14m and 3.26m respectively. It is recommended that these levels are considered when establishing building floor and foundation pad elevations. The storm surge levels determined to reach the LNG site are shown in Table 5-22.

Table 5-22 Estimated storm surge levels

Return Period (yr)	Storm Surge Level (m)
2	1.34
5	2.07
10	2.47
25	2.89
50	3.16
100	3.42

NEARSHORE WAVES

The nearshore wave climate was simulated with STWAVE, a spectral balance and half plane wave model. It is a finite difference model which considers the propagation, growth and dissipation of spectral energy on a 2-dimensional uniform rectilinear grid. The inputs required were bathymetric and shoreline information as well as the general wave properties. The scenarios examined were for waves coming out of the south and southeast as these were the more likely and extreme directions.

The worst case scenario (100yr storm event) was simulated, including estimated water setup to determine the wave heights anticipated to reach the mooring area and pipelines. The wave heights and periods in Table 5-23 were implemented.

Table 5-23 Wave parameter input

Direction	Wave Height (m)	Wave Period (s)
East	7.380	13.471
South-East	6.183	12.367
South	7.050	13.176

Inspection of the nearshore wave climate conditions revealed that the mooring point will experience wave heights of up to 0.02m, 1.04m and 1.35m for the eastern, southern and south-eastern directions, under hurricane wave climate conditions. The proposed pipeline will be exposed to similar wave heights for the eastern, southern and south-eastern directions.

Additionally, five (5) scenarios were simulated to include sea level rise projections for the year 2050 and 2100. Also, locally generated wave were simulated within the nearshore waters.

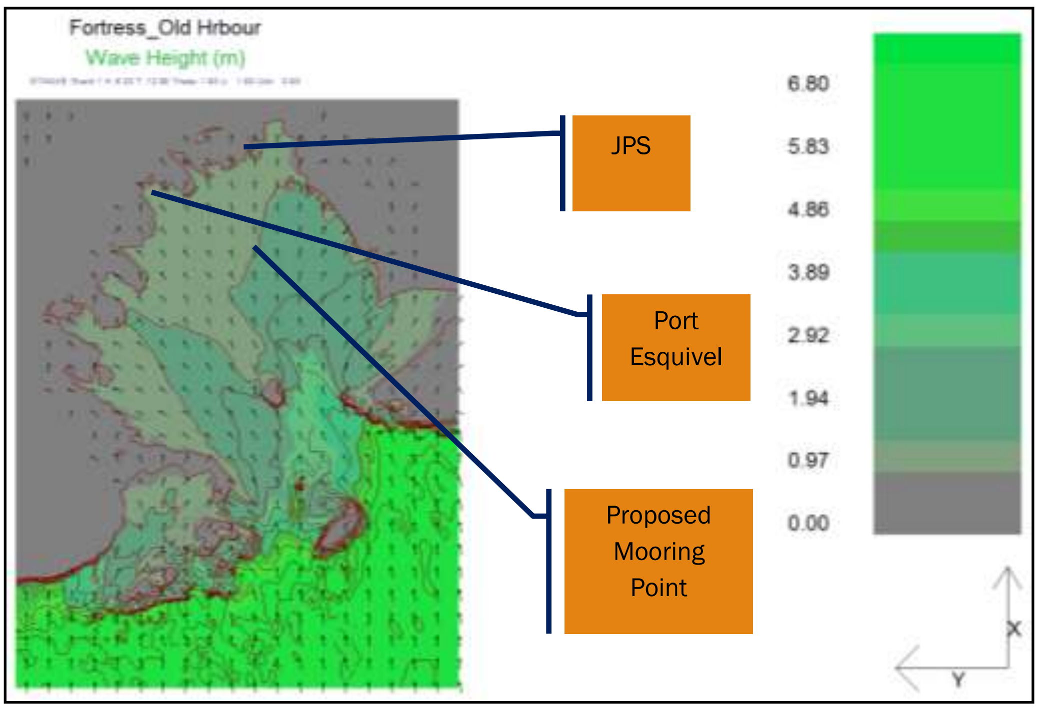


Figure 5-35 Hurricane wave climate for 100 year return period (RP) deepwater waves from the south entering Portland Bight

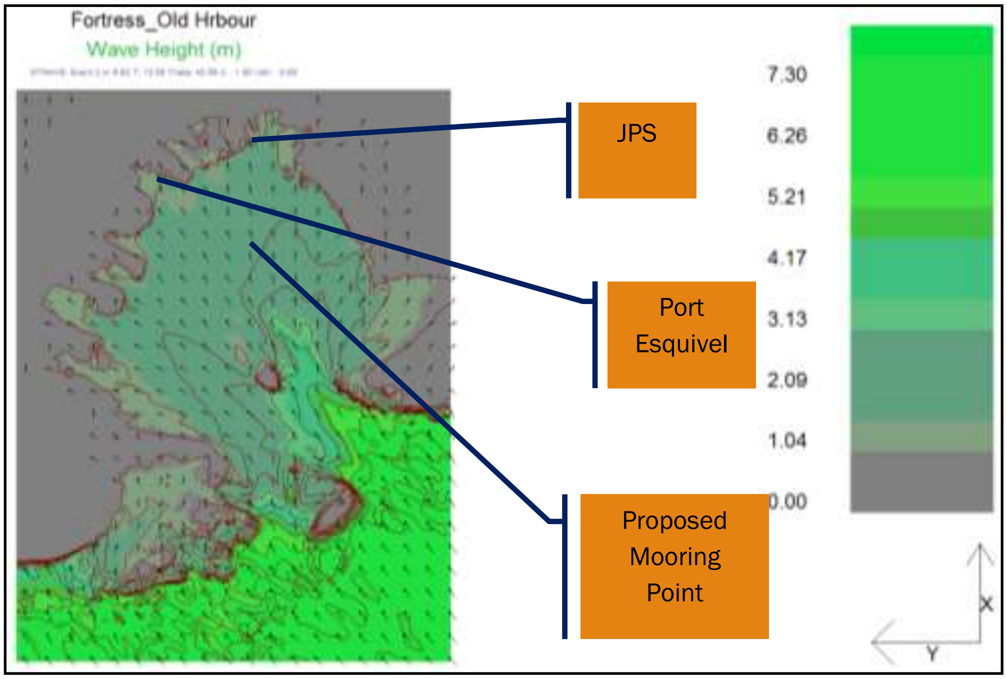


Figure 5-36 Hurricane wave climate for 100 year return period (RP) deepwater waves from the south-east entering Portland Bight

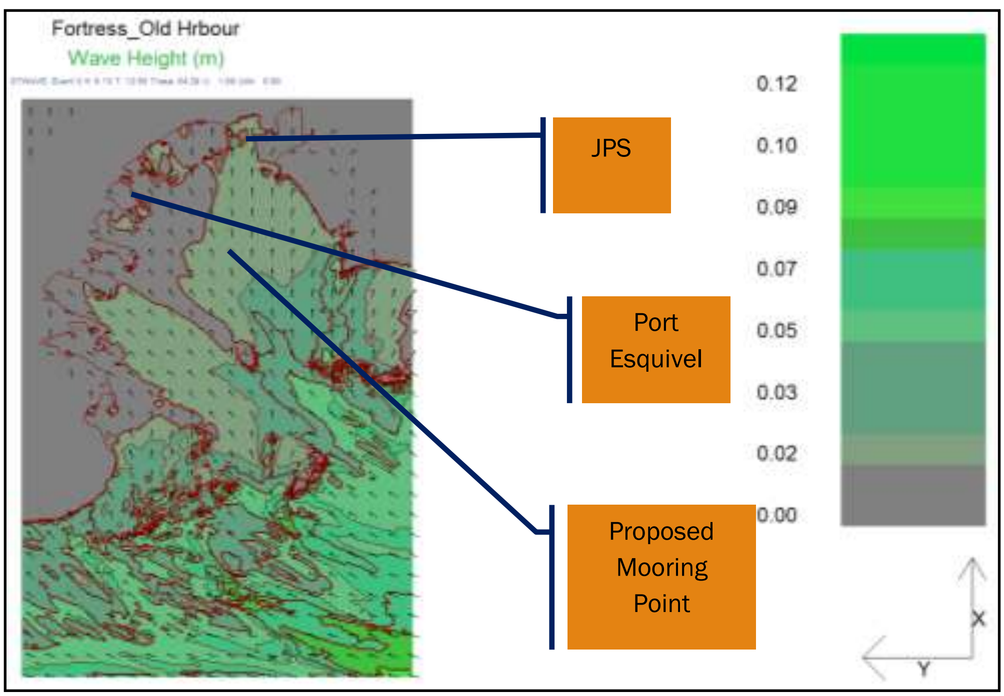


Figure 5-37 Hurricane wave climate for 100 year return period (RP) deepwater waves from the east entering Portland Bright

5.1.9 Hydrodynamics

5.1.9.1 Introduction

The current regime (i.e. patterns and speeds) in the coastal setting determines the ability of an area to flush and maintain sufficiently good water quality. Currents are generated by winds, tides and waves:

- Tides – Rising tides will cause water to enter the harbour and a portion will leave on the falling tide that follows. This will result in some exchange of water between the outside and inside of our project area. This result is dependent on the ratio of the water entering to the water leaving; this ratio is dependent on the tide, range, hydraulic efficiency of the entrance, and the water internal depths.
- Wind – Wind action over the water surface will generate a surface current that will essentially be in the direction of the wind. This wind generated current will be a few degrees to the right of the wind, (in the northern hemisphere), owing to the Coriolis effect, (Bowden, 1983). If the fetch and duration are sufficient, the surface current speeds may approach 2 – 3% of the wind speeds.

Circulation patterns can be predicted by numerical, physical models or field studies. Numerical models are most often used as it simply requires the collection of field data to calibrate and verify the model for use in a predictive mode. The field data includes drogue tracking missions which verify the current speeds and directions recorded by the Acoustic Doppler Current Profiler (ADCP). The models are also robust enough to include prediction of sediments and nutrients dispersion in the Bay.

5.1.9.2 Objectives and Approach

The objectives of this analysis were to:

- Characterize the existing hydrodynamic regime in the area so as to describe the surface current patterns on which the surfaced buoyant plume moves, and
- Determine spatially the most appropriate location of the outfall based on the World Bank guidelines.

The approach was to setup and calibrate a numerical hydrodynamic model (RMA 10) to analyze the effluent temperatures generated at the proposed outfall location. The results were compared to NEPA standards.

5.1.9.3 Drogue Tracking (Currents)

Methodology

In order to facilitate the development of the hydrodynamic model for the area and to fully understand the relationship amongst tides, winds and currents, current speed and direction information was required. In addition to ADCP deployments, drogues have also been used to track currents in the Bay. Tracking sessions were executed within the project area over the last three (3) years. The drogue tracking data spans over the following periods:

i. January 14th, 15th, 28th and 30th of 2014;
ii. January 21st to 23rd of 2015;
iii. September 17th and 18th of 2015;
iv. May 12th and 13th of 2016.

A two-day drogue tracking programme was executed by the CEAC team on May 12th and May 13th, 2016. Eight (8) drogues were placed within the Old Harbour Bay. Four (4) surface and four (4) sub-surface drogues (3m) were placed: (i) near shore (ii) outside the reef (iii) deepwater within the ship channel and (iv) deepwater at the proposed mooring area.

The drogues were tracked during two separate sessions over the two days, one in the morning and the other in the evening, in order to capture the rising and falling tides on each day.

The GPS and drogue log sheet results from the drogue tracking missions were reduced and incorporated in a database. The data was then analyzed in order to determine current speed and directions, and current speed vectors were produced for the rising and falling tides.

Winds During Drogue Tracking Session

Wind data was retrieved from a weather station located at the Norman Manley International Airport. The wind data was retrieved for the days when drogue tracking missions were done. The data was plotted and shown below in Figure 5-38 and Figure 5-39.

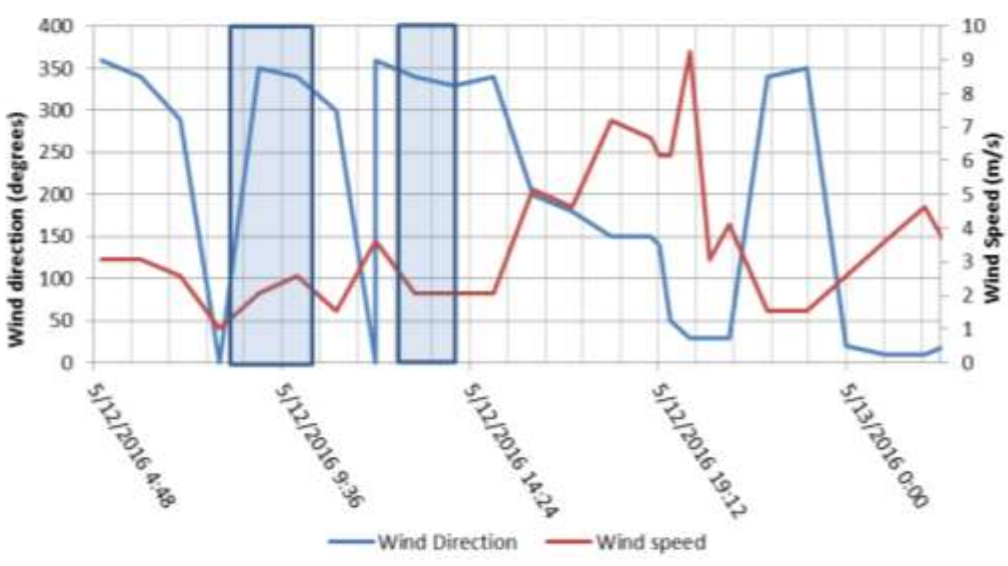


Figure 5-38 Graph showing wind speed and direction on May 12th for falling and rising sessions

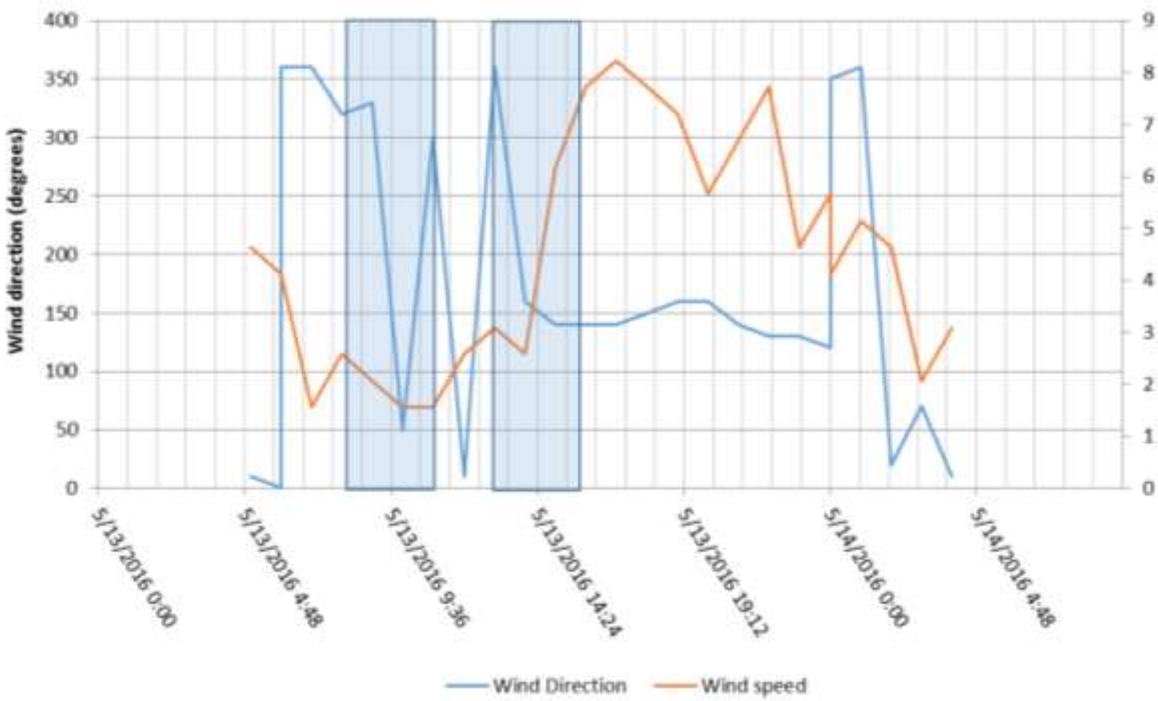


Figure 5-39 Graph showing wind speed and direction on May 13th for falling and rising sessions

The wind speed and direction for each session is shown in Table 5-24 below. From the data we see that generally stronger winds are observed during the rising tide sessions.

Table 5-24 Summary of winds measured during drogue tracking sessions

Session	Tide	Average wind speed (m/s)	Average wind direction
1	Falling	2.83	NNW
2	Rising	6.68	NNW
3	Falling	5.14	SSE
4	Rising	6.95	SSE

Results

FALLING TIDE

Sessions 1 and 3 were conducted during falling tide conditions. The average wind speed recorded for session 1 was 2.83 m/s and that for session 3 was 5.14 m/s. The average wind directions were NNW and SSE for day 1 and 2 respectively.

Near Shore

During sessions 1 and 3, the surface drogues near shore were tracked moving in northerly and westerly directions, at speeds of 2.0 cm/s and 1.9 cm/s respectively. The sub-surface drogues deployed near shore travelled in a north-westerly directions at average speeds of 1.2 cm/s and 1.4 cm/s for sessions

1 and 3 respectively. The directions of the drogues for session 1 correspond to the wind directions measured by the onshore wind station while the results for session 3 did not. This difference indicates the main driver of nearshore currents were not due to winds.

Outside Reef

During sessions 1 and 3, the surface drogues near shore were tracked moving in easterly and north-westerly directions, at speeds of 2.9 cm/s and 5.7 cm/s respectively. The sub-surface drogues travelled in a north-westerly direction with average speeds of 2.9 cm/s during both sessions 1 and 3.

Ship Channel

During sessions 1 and 3, the surface drogues near shore were tracked moving in south-westerly directions, at speeds of 2.2 cm/s and 2.4 cm/s respectively. The sub-surface drogues travelled north-westerly with average speeds of 0.53 cm/s during session 1 while they travelled 1.6 cm/s in a south-westerly direction during session 3.

Mooring Area

During sessions 1 and 3, the surface drogues near shore were tracked moving in south westerly and southerly directions, at speeds of 3.9 cm/s and 2.2 cm/s respectively. The sub-surface drogues travelled south westerly with average speeds of 1.8 cm/s during session 1 while they travelled 2.6 cm/s in a southerly direction during session 3.

Table 5-25 Summarized drogue tracking session #1 – Falling tide conducted on May 12th, 2016

Drogue #	Time (am)	Depth of Sail	Notes	Easting	Northing	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion
8	8:54	Surface	deploy	275648	1975663	19.209	584	3.289	3.919	South Westerly
8	9:04		measurement	275633	1975651	23.409	566	4.136		
8	9:14		measurement	275625	1975629	23.345	561	4.161		
8	9:23		measurement	275608	1975613	22.361	547	4.088		
8	9:32		remove	275588	1975603					
7	8:55	3m	deploy	275647	1975662	13.416	612	2.192	1.791	South Westerly
7	9:05		measurement	275641	1975650	11.314	515	2.197		
7	9:13		measurement	275633	1975642	11.180	535	2.090		
7	9:22		measurement	275628	1975632	3.606	526	0.685		
7	9:31		remove	275626	1975629					
3	8:59	Surface	deploy	276658	1977268	5.831	614	0.950	2.227	South Westerly
3	9:09		measurement	276653	1977271	19.698	527	3.738		
3	9:18		measurement	276645	1977253	9.899	561	1.765		
3	9:27		measurement	276638	1977246	6.708	569	1.179		
3	9:36		remove	276635	1977252					
4	8:59	3m	deploy	276656	1977270	6.708	617	1.087	0.530	North Westerly
4	9:09		measurement	276650	1977273	6.083	505	1.205		
4	9:18		measurement	276649	1977279	2.236	561	0.399		
4	9:27		measurement	276648	1977281	4.123	-34061	-0.012		
4	9:37		remove	276647	1977285					
8	9:45	Surface	deploy	277239	1978739	10.817	605	1.788	2.863	Easterly
8	9:55		measurement	277248	1978745	10.198	361	2.825		
8	10:01		measurement	277258	1978743	13.601	348	3.908		
8	10:07		measurement	277271	1978739	12.042	411	2.930		
8	10:14		remove	277283	1978738					
7	9:52	3m	deploy	276116	1979491	14.422	413	3.492	2.925	North Westerly
7	9:59		measurement	276108	1979503	12.530	335	3.740		
7	10:04		measurement	276102	1979514	8.062	357	2.258		
7	10:10		measurement	276101	1979522	12.530	567	2.210		
7	10:20		remove	276095	1979533					
3	9:52	Surface	deploy	276110	1979496	14.318	362	3.955	2.006	Northerly
3	9:58		measurement	276107	1979510	4.472	359	1.246		
3	10:04		measurement	276111	1979512	9.055	358	2.529		
3	10:10		measurement	276112	1979521	9.220	411	2.243		
3	10:17		remove	276110	1979530					
5	9:46	3m	deploy	277238	1978745	10.770	571	1.886	1.189	North Westerly

Drogue #	Time (am)	Depth of Sail	Notes	Easting	Northing	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion
5	9:55		measurement	277234	1978755	1.414	359	0.394		
5	10:01		measurement	277233	1978754	4.243	344	1.233		
5	10:07		measurement	277230	1978757	7.211	372	1.938		
5	10:13		remove	277236	1978761					

Table 5-26 Summarized drogue tracking session #3 – Falling tide conducted on May 13th, 2016

Drogue #	Time (am)	Depth of Sail	Notes	Easting	Northing	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion
8	8:05	Surface	deploy	275769	1975658	22.561	558	4.043	2.163	Southerly
8	8:14		measurement	275774	1975636	16.031	640	2.505		
8	8:25		measurement	275773	1975620	18.111	-30308	-0.060		
8	8:34		remove	275771	1975602					
7	8:05	3m	deploy	275770	1975653	25.632	610	4.202	2.577	Southerly
7	8:15		measurement	275779	1975629	22.023	612	3.598		
7	8:25		measurement	275778	1975607	21.095	-30354	-0.069		
7	8:34		remove	275776	1975586					
3	8:09	Surface	deploy	276718	1977272	17.029	654	2.604	2.386	South Westerly
3	8:20		measurement	276707	1977259	26.401	543	4.862		
3	8:29		measurement	276691	1977238	27.785	-30591	-0.091		
3	8:41		remove	276667	1977224					
6	8:10	3m	deploy	276708	1977274	11.402	618	1.845	1.583	South Westerly
6	8:21		measurement	276701	1977265	17.464	542	3.222		
6	8:30		measurement	276684	1977261	17.493	-30609	-0.057		
6	8:42		remove	276669	1977252					
8	9:56	Surface	deploy	276178	1979462	33.615	405	8.300	5.693	North Westerly
8	10:02		measurement	276149	1979479	37.537	420	8.937		
8	10:09		measurement	276121	1979504	58.009	-36585	-0.159		
8	10:19		remove	276074	1979538					
7	9:51	3m	deploy	277284	1978783	20.518	486	4.222	2.906	North Westerly
7	9:59		measurement	277270	1978798	17.889	392	4.563		
7	10:06		measurement	277262	1978814	24.083	-36385	-0.066		
7	10:14		remove	277246	1978832					
3	9:51	Surface	deploy	277290	1978778	19.647	484	4.059	1.926	Westerly
3	9:59		measurement	277271	1978773	15.133	386	3.920		
3	10:06		measurement	277256	1978775	25.000	-36360	-0.069		
3	10:13		remove	277236	1978790					

Drogue #	Time (am)	Depth of Sail	Notes	Easting	Northing	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion
6	9:55	3m	deploy	276182	1979461	11.705	448	2.613	1.368	North Westerly
6	10:03		measurement	276178	1979472	12.042	433	2.781		
6	10:10		measurement	276177	1979484	16.553	-36622	-0.045		
6	10:18		remove	276170	1979499					

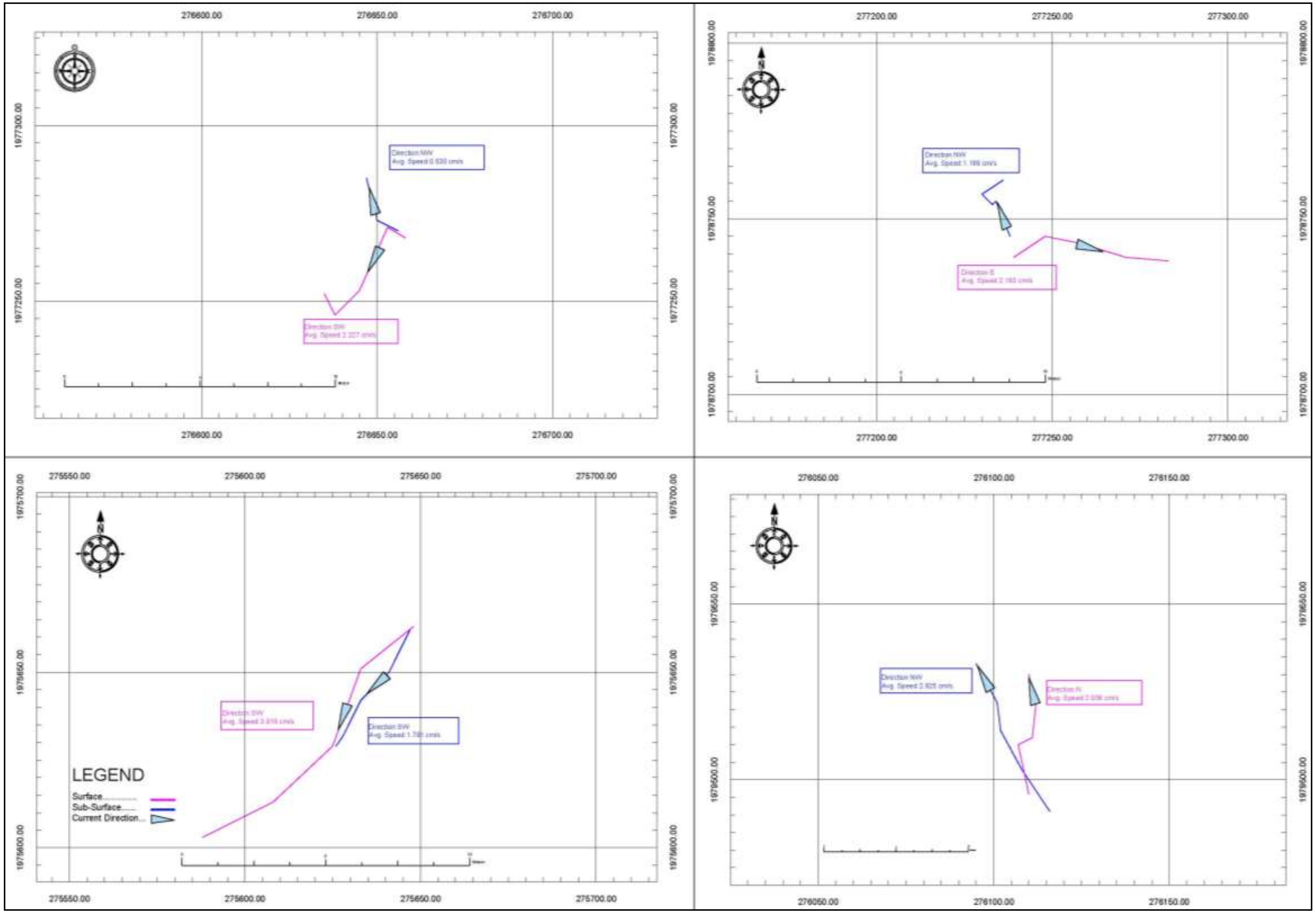


Figure 5-40 Approximate path and direction of the drogues during drogue session #1.

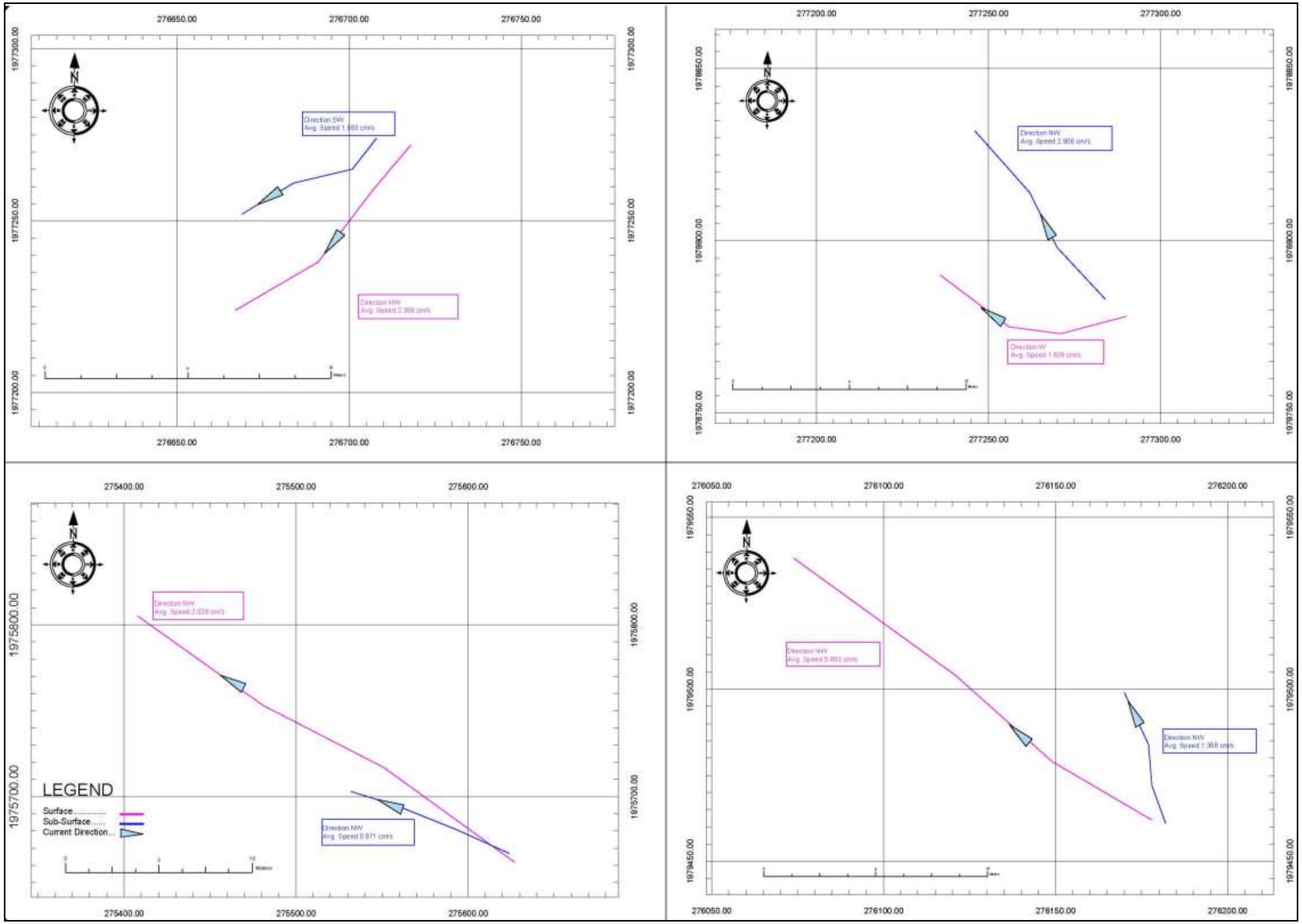


Figure 5-41 Approximate path and direction of the drogues during drogue session #3.

RISING TIDE

Sessions 2 and 4 were conducted during rising tide conditions (Table 5-27 and Table 5-28). The average wind speed recorded for session 2 was 6.68 m/s and that for session 4 was 6.95 m/s (Figure 5-42 and Figure 5-43). The average wind directions were NNW and SSE for day 1 and 2 respectively.

Near Shore

During sessions 2 and 4, the surface drogues near shore were tracked moving in north-westerly directions, at speeds of 3.5 cm/s and 2.2 cm/s respectively. The sub-surface drogues deployed near shore travelled in north-westerly directions at average speeds of 3.8 cm/s and 2.9 cm/s for sessions 2 and 4 respectively. The directions of the drogues for session 2 correspond to the wind directions measured by the onshore wind station while the results for session 3 did not. This difference indicates the main driver of nearshore currents were not due to winds.

Outside Reef

During sessions 2 and 4, the surface drogues near shore were tracked moving in north-westerly directions, at speeds of 4.8 cm/s and 5.8 cm/s respectively. The sub-surface drogues also travelled in a north-westerly direction with average speeds of 4.1 cm/s and 4.5 cm/s during sessions 2 and 4 respectively.

Ship Channel

During sessions 2 and 4, the surface drogues near shore were tracked moving in north-westerly directions, at speeds of 10.5 cm/s and 3.3 cm/s respectively. The sub-surface drogues travelled north-westerly directions with average speeds of 4.3 cm/s during session 2 and 2.9 cm/s during session 4.

Mooring Area

During sessions 2 and 4, the surface drogues near shore were tracked moving in north-westerly directions, at speeds of 6.3 cm/s and 2.0 cm/s respectively. The sub-surface drogues travelled westerly with average speeds of 2.5 cm/s during session 2 while they travelled 0.97 cm/s in a north-westerly direction during session 4.

Table 5-27 Summarized drogue tracking session #2 – Rising tide conducted on May 12th, 2016

Drogue #	Time (am)	Depth of Sail	Notes	Easting	Northing	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion
8	12:45		deploy	275574	1975685	62.801	772	8.135		
8	12:58		measurement	275524	1975723	39.661	-42559	-0.093		
8	1:08	Surface	measurement	275502	1975756	50.931	609	8.363	6.291	North Westerly
8	1:18		measurement	275465	1975791	64.900	741	8.758		
8	1:31		remove	275411	1975827					
7	12:44		deploy	275589	1975663	34.000	872	3.899		
7	12:58		measurement	275559	1975679	17.464	-42628	-0.041		
7	1:08	3m	measurement	275543	1975686	18.358	600	3.060	2.506	Westerly
7	1:18		measurement	275527	1975695	20.100	647	3.107		
7	1:29		remove	275507	1975697					
3	12:51		deploy	276721	1977244	81.271	-42527	-0.191		
3	1:03		measurement	276675	1977311	67.956	645	10.536		
3	1:13	Surface	measurement	276638	1977368	63.781	601	10.612	10.447	North Westerly
3	1:23		measurement	276596	1977416	91.214	895	10.192		
3	1:38		remove	276540	1977488					
4	12:51		deploy	276732	1977234	39.051	-42523	-0.092		
4	1:02		measurement	276702	1977259	42.426	640	6.629		
4	1:13	3m	measurement	276672	1977289	44.385	597	7.435	4.292	North Westerly
4	1:23		measurement	276631	1977306	59.414	-5007	-1.187		
4	1:35		remove	276588	1977347					
8	1:45		deploy	277257	1978838	25.000	503	4.970		
8	1:53		measurement	277237	1978853	15.556	410	3.794		
8	2:00	Surface	measurement	277226	1978864	19.105	366	5.220	4.778	North Westerly
8	2:06		measurement	277224	1978883	27.785	542	5.126		
8	2:15		remove	277210	1978907					
4	1:49		deploy	276097	1979528	23.601	459	5.142		
4	1:57	3m	measurement	276083	1979547	16.553	371	4.462	4.065	North Westerly
4	2:03		measurement	276068	1979554	9.434	364	2.592		
4	2:09		remove	276060	1979559					
3	1:49		deploy	276103	1979526	20.809	468	4.446		
3	1:57	Surface	measurement	276091	1979543	16.971	370	4.587	3.541	North Westerly
3	2:03		measurement	276079	1979555	9.055	363	2.495		
3	2:09		remove	276070	1979556					
5	1:45		deploy	277254	1978849	12.083	493	2.451		
5	1:54	3m	measurement	277249	1978860	14.000	410	3.415	3.800	North Westerly
5	2:00		measurement	277249	1978874	14.142	361	3.917		
5	2:06		measurement	277247	1978888	25.632	630	4.069		

Drogue #	Time (am)	Depth of Sail	Notes	Easting	Northing	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion
5	2:17		remove	277238	1978912					

Table 5-28 Summarized drogue tracking session #4 – Rising tide conducted on May 13th, 2016

Drogue #	Time (am)	Depth of Sail	Notes	Easting	Northing	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion
8	12:48	Surface	deploy	275627	1975662	93.814	-42245	-0.222	2.029	North Westerly
8	1:04		measurement	275551	1975717	78.715	964	8.165		
8	1:20		measurement	275481	1975753	89.627	-4829	-1.856		
8	1:39		remove	275408	1975805					
7	12:48	3m	deploy	275624	1975667	34.015	-42290	-0.080	0.971	North Westerly
7	1:03		measurement	275593	1975681	37.696	1062	3.550		
7	1:21		measurement	275558	1975695	27.203	-4894	-0.556		
7	1:42		remove	275532	1975703					
3	12:56	Surface	deploy	276678	1977261	84.149	-42203	-0.199	3.294	North Westerly
3	1:12		measurement	276618	1977320	95.483	1062	8.991		
3	1:30		measurement	276549	1977386	130.231	-5420	-2.403		
3	1:54		remove	276461	1977482					
6	12:55	3m	deploy	276683	1977253	73.553	-42199	-0.174	2.884	North Westerly
6	1:12		measurement	276632	1977306	81.566	1051	7.761		
6	1:29		measurement	276570	1977359	107.490	-5395	-1.992		
6	1:51		remove	276493	1977434					
8	3:44	Surface	deploy	276234	1979546	42.521	460	9.244	5.843	North Westerly
8	3:51		measurement	276206	1979578	41.773	485	8.613		
8	3:59		measurement	276175	1979606	47.202	-14393	-0.328		
8	4:11		remove	276147	1979644					
7	3:39	3m	deploy	277173	1978832	40.817	575	7.099	4.484	North Westerly
7	3:49		measurement	277138	1978853	26.833	409	6.561		
7	3:55		measurement	277114	1978865	29.411	-14159	-0.208		
7	4:05		remove	277090	1978882					
3	3:39	Surface	deploy	277182	1978819	45.453	584	7.783	2.150	North Westerly
3	3:48		measurement	277147	1978848	20.396	449	4.543		
3	3:56		measurement	277127	1978852	34.438	-14176	-0.243		
3	4:06		remove	277096	1978867					
6	3:43	3m	deploy	276242	1979534	25.000	507	4.931	2.992	North Westerly
6	3:52		measurement	276222	1979549	30.806	495	6.223		
6	4:00		measurement	276197	1979567	34.409	-14427	-0.239		
6	4:09		remove	276169	1979587					

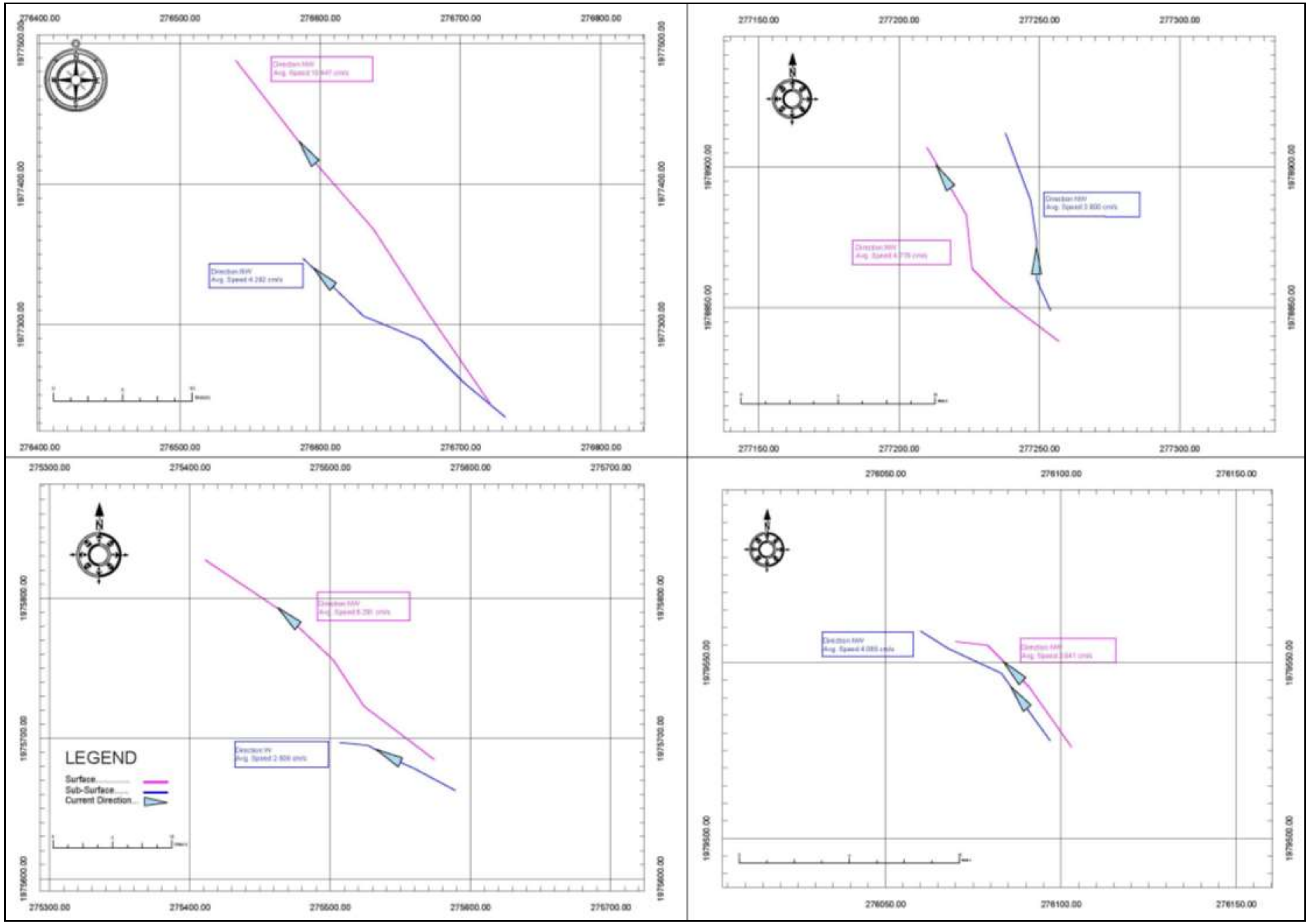


Figure 5-42 Approximate path and direction of the drogues during drogue session #2.

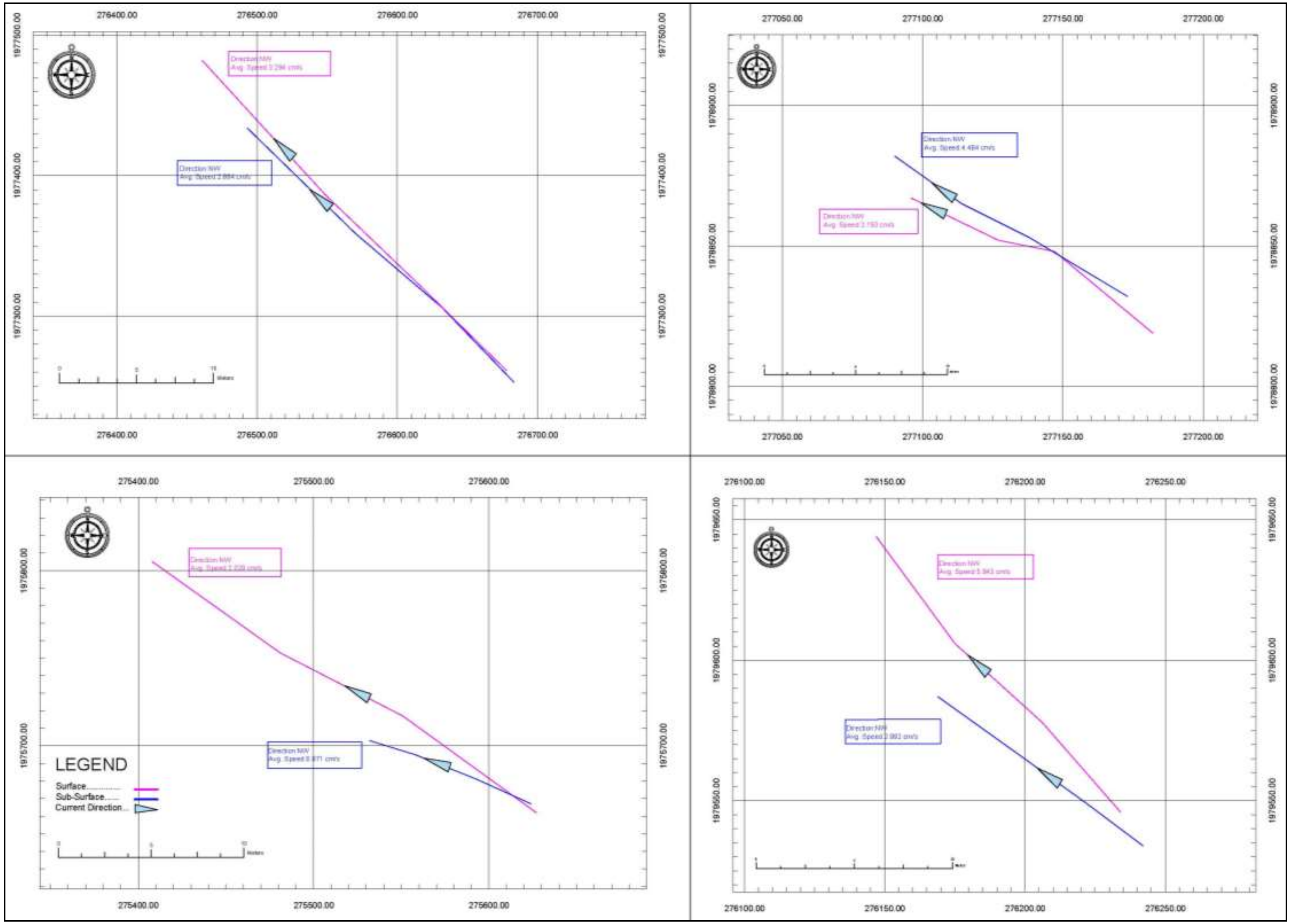


Figure 5-43 Approximate path and direction of the drogues during drogue session #4.

SUMMARY

The two days of drogue tracking involved four (4) sessions total; two (2) falling tides and two (2) rising tide. In regards to the proposed mooring area, the current speeds varied from 2.2 cm/s to 3.9 cm/s and 1.8 cm/s to 2.6 cm/s for the surface and sub-surface drogues respectively for the falling tides. In regards to the ship channel area, the current speeds varied from 2.2 cm/s to 2.4 cm/s and 0.53 cm/s to 1.6 cm/s for the surface and sub-surface drogues respectively for the falling tides. The current speeds varied from 2.9 cm/s to 5.7 cm/s and 2.9 cm/s for the surface and sub-surface currents during the falling tides, just outside the reef. Closer nearshore, the current speeds averaged from 1.9 cm/s to 2.0 cm/s and 1.2 cm/s to 1.4 cm/s for the surface and sub-surface drogues respectively for the falling tides.

In regards to the proposed mooring area, the current speeds varied from 2.0 cm/s to 6.3 cm/s and 0.97 cm/s to 2.5 cm/s for the surface and sub-surface drogues respectively for the rising tides. In regards to the ship channel area, the current speeds varied from 3.3 cm/s to 10.5 cm/s and 2.9 cm/s to 4.3 cm/s for the surface and sub-surface drogues respectively for the rising tides. The current speeds varied from 4.8 cm/s to 5.8 cm/s and 4.0 cm/s to 4.5 cm/s for the surface and sub-surface currents during the falling tides, just outside the reef. Closer nearshore, the current speeds averaged from 2.2 cm/s to 3.5 cm/s and 2.9 cm/s to 3.8 cm/s for the surface and sub-surface drogues respectively for the falling tides.

Knowledge of the prevailing wind conditions allowed for the determination of the effect of wind speed and direction. The current speeds are generally higher for the rising tides than for the falling tide session. It is evident that the deeper waters in the bay area tidally dominated (as expected) and the shallower waters are wind dominated.

5.1.9.4 ADCP Deployment and Measurement

An Acoustic Doppler Current Profilers (ADCP) determines current speed and direction by detecting the Doppler shift of reflected acoustic signals which bounce off particles moving with the water. The ADCP separates depth cells or bins in the water column from which it measured the current speed and direction. Several Studies have been conducted in the Portland Bight Area which have warranted the use of Acoustic Doppler Current Profilers (ADCP) in the past. Historically, however, there has not been any deployment of ADCP within the proposed project area to measure waves, tides or currents.

Two (2) ADCP devices were deployed at off-shore locations over a three (3) week period from May 11th to May 27th, 2016. Unfortunately, due to interference with the recording instrument, current data for May 27th was incomplete. The first location (Location #1) is approximately 4.5km from the JPS shoreline, at the proposed LNG mooring area. The second location (Location #2) is 1.9km from the JPS shoreline, just outside the existing reefs (Figure 5-44). Both ADCPs collected wave, tide and current data which spans May 11th to 27th of 2016.

At Location #1 (JPS), the ADCP was deployed in 12m of deepwater and set to record averaged current and wave readings collected data during 20 minute bursts with a sample interval of 60 minutes (1 hour). Similarly, the ADCP at location #2 was deployed in 7.8m of water collecting data at 1hr intervals.

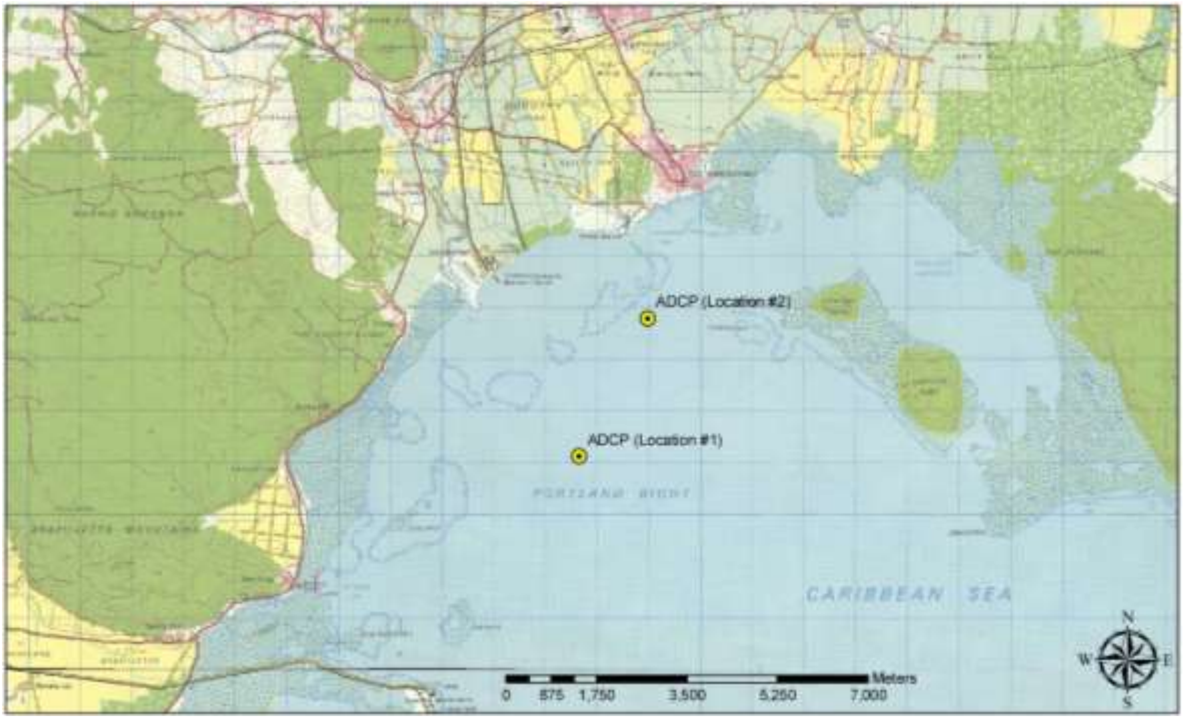


Figure 5-44 Location of the ADCPs within the Portland Bight area

5.1.9.5 Waves

The waves recorded over the period May 11th to 27th of 2016 ranged from 0.2m to 0.84m for location #1 while location #2 experienced wave heights ranging between 0.11 and 0.72m (Figure 5-45 and Figure 5-46). A bivariate analysis of the raw data showed the average wave conditions at locations 1 and 2 were 0.5m and 0.3m respectively. The majority of the recorded waves were out of the southeast to easterly directions.

It can be observed that, based on a comparative analysis, waves of greater heights reach the proposed LNG mooring area than those which arrive at the second location just outside of the reefs. The difference in wave heights vary from 0.03 to 0.36m between both ADCP locations.

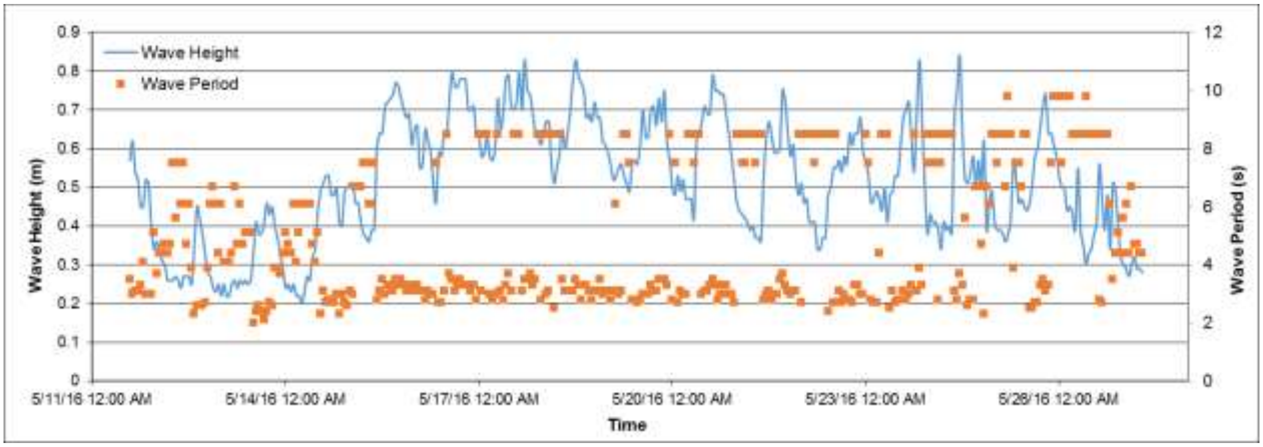


Figure 5-45 Wave heights and periods recorded during the ADCP deployment for the period May 11th to 27th, 2016 for location #1

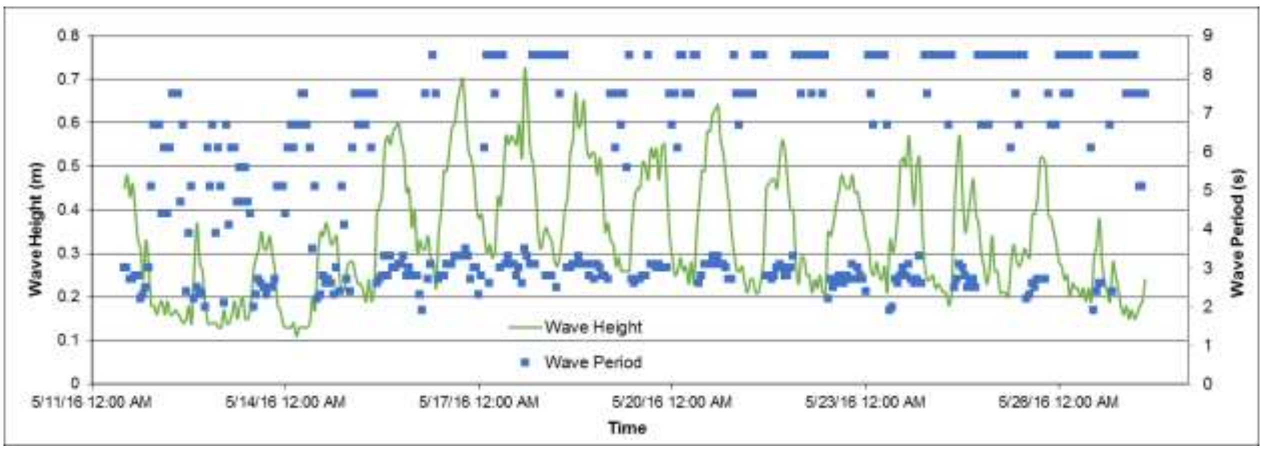


Figure 5-46 Wave heights and periods recorded during the ADCP deployment for the period May 11th to 27th, 2016 for location #2

5.1.9.6 Tides

Tidal information was important in order to build a numerical hydrodynamic model to simulate the currents and water level fluctuations within the Bay. Tides were recorded at two (2) locations – proposed mooring area and just outside the reef.

Location 1 (Proposed Mooring Area)

The tide range measured at Rocky point during the period May 11th, 2016 to May 27th, 2016 deployment period was -0.15 to 0.22m.

Tidal harmonics is essentially the blending of the different cosine curves for each harmonic constituent of the tide until it closely matches that obtained from the recorded tidal signature. This is useful for predicting the tides for future times when there is no data available.

The amplitudes of the seven most significant harmonic constituents were determined from the raw tide data by utilizing the least squares method. In this method, a set of cosine terms are used as a model. The blended curve is made to fit the data recorded by the ADCP by making the sum of the squared differences between observed and model-predicted tides to be as small as possible. The resulting amplitudes and phase lag are outlined below in Table 5-29, and it allowed reasonable tide predictions for future times when running FEM and wave models. It is evident that the K1 constituent, that is, the diurnal tide, is dominant. Both semi-diurnal tidal constituents were detected.

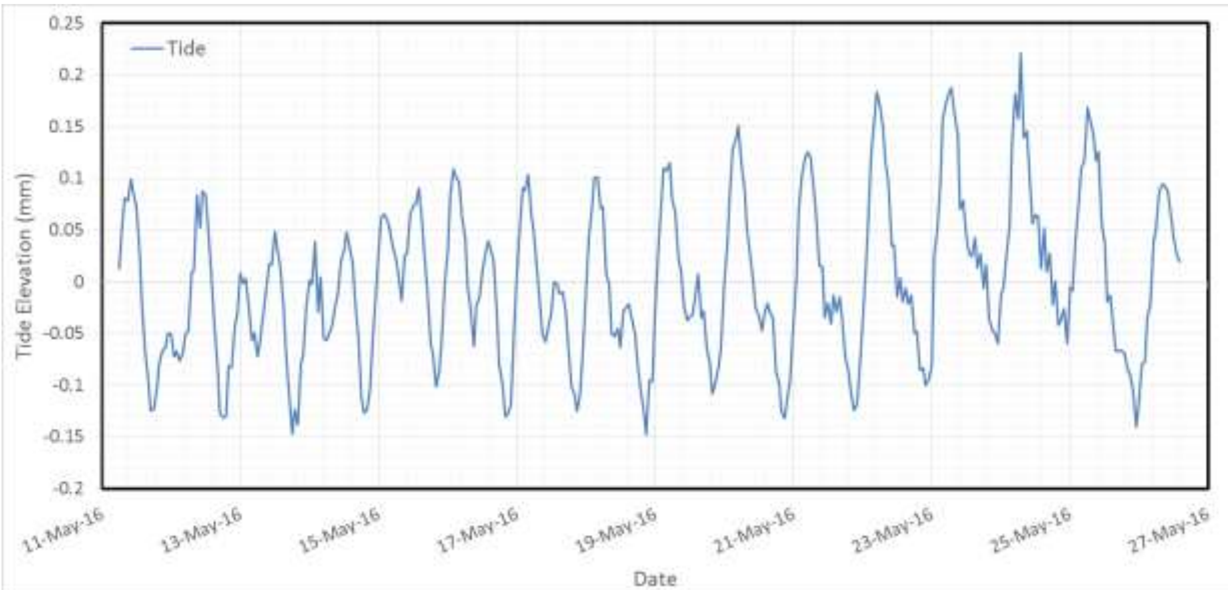


Figure 5-47 Tide signal recorded using the ADCP at location #1 during the period 11th to 27th of May, 2016

Table 5-29 Tidal Constituents obtained from the harmonic analysis of the raw ADCP data collected along the Old Harbour Bay (Location 1)

Tide Constituent	M2	S2	O1	K1	N2	P1	L2
Speed (hours per period)	12.42	12	25.82	23.93	12.66	24.07	12.19
Phase lag (radians)	-4.22	-2.04	1.71	13.11	-0.39	1.33	-3.00
Amplitude (meters)	0.046	0.023	0.050	0.074	0.017	0.042	0.016

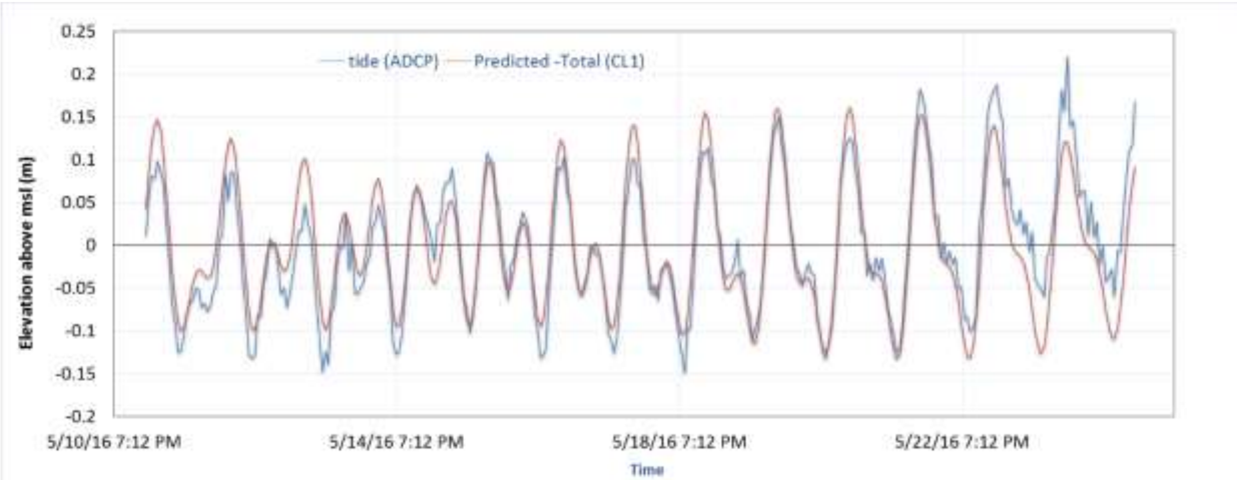


Figure 5-48 Measured and predicted tidal signature for Old Harbour Bay for the period May 11th to May 27th, 2016

Location 2 (Outside Reef)

The tide range measured at Rocky point during the period May 11th to May 27th, 2016 deployment period was -0.147 to 0.221m.

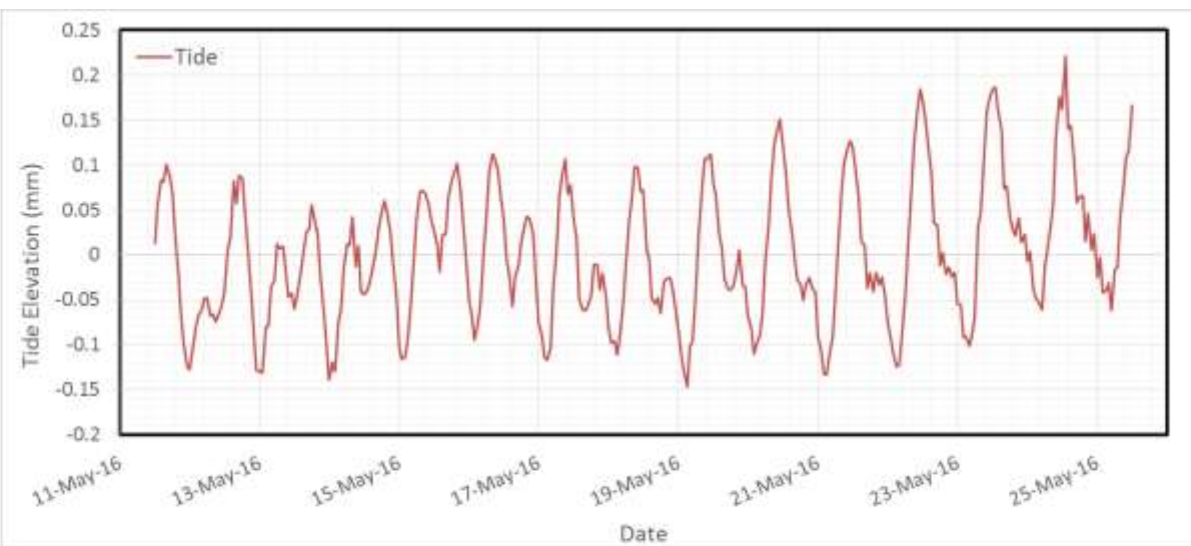


Figure 5-49 Tide signal recorded using the ADCP at location #2 (Proposed mooring area) during the period 11th of May to 27th of May, 2016

Tidal harmonics is essentially the blending of the different cosine curves for each harmonic constituent of the tide until it closely matches that obtained from the recorded tidal signature. This is useful for predicting the tides for future times when there is no data available.

The amplitudes of the seven most significant harmonic constituents were determined from the raw tide data by utilizing the least squares method. In this method, a set of cosine terms is used as a model. The blended curve is made to fit the data recorded by the ADCP by making the sum of the squared differences between observed and model-predicted tides to be as small as possible. The resulting amplitudes and phase lag are outlined below in Table 5-30, and it allowed reasonable tide predictions for future times when running FEM and wave models. It is evident that the K1 consistent, that is, the diurnal tide, is dominant. Both semi-diurnal tidal constituents were detected.

Table 5-30 Tidal Constituents obtained from the harmonic analysis of the raw ADCP data collected along the Old Harbour Bay (Location 2)

Tide constituent	M2	S2	O1	K1	N2	P1	L2
Speed (hours per period)	12.42	12	25.82	23.93	12.66	24.07	12.19
Phase lag (radians)	-1.78	1.15	-1.65	12.77	-2.55	-1.13	-2.53
Amplitude (meters)	0.047	0.023	0.050	0.061	0.017	0.038	0.015

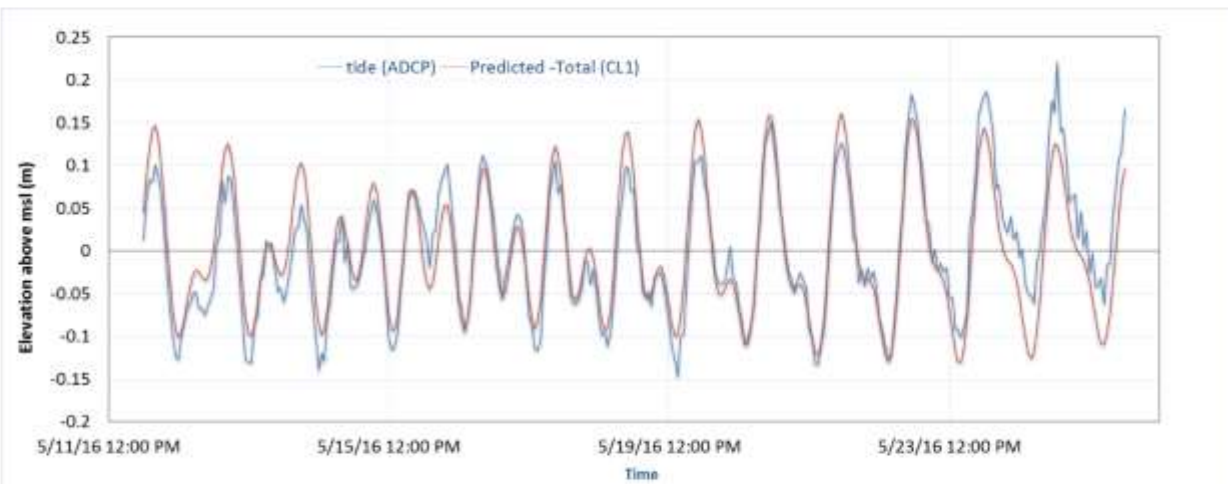


Figure 5-50 Measured and predicted tidal signature for Old Harbour Bay for the period May 11th to May 27th, 2016

Summary

The tide range measured at location #1 during the period May 11th through May 27th, 2016 deployment period was -0.15 to 0.22m. In comparison, the tide range measured at location #2 during the same deployment period was -0.147 to 0.221m.

The amplitudes of the seven most significant harmonic constituents were determined for both locations. It can be evident that for both locations, the K1 constituent (which represents diurnal tide) was dominant and comparable. This confirms the results from the ADCPs are truthful and can be used for the simulation of the model.

5.1.9.7 Currents

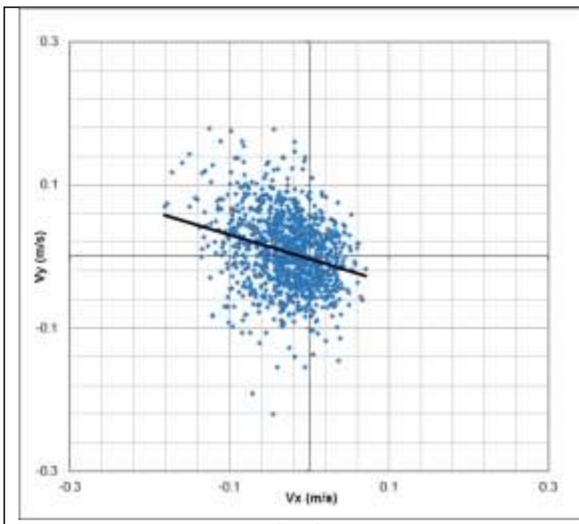
Location 1

The ADCP determines current speed and direction by detecting the Doppler shift of reflected acoustic signals which bounce off particles moving with the water. The ADCP separates depth cells or bins in the water column from which it measured the current speed and direction. The currents in three layers of the water column were examined, the surface, mid depth and just above the sea floor.

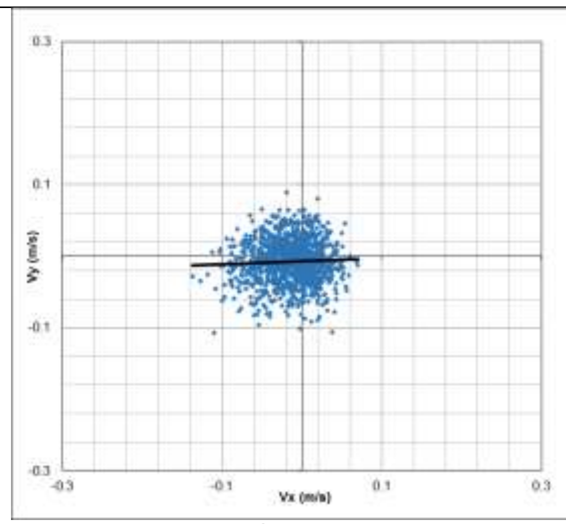
X-Y vectors of the currents were plotted to show the direction and speeds of the currents in the vicinity of the deployment for both locations. At Location #1, the plots indicated that the surface currents in the area moved predominantly towards the northwest and west with speeds up to 0.23 m/s and 0.15 m/s for the surface and sub-surface currents respectively. The subsurface currents are similarly distributed, (Table 5-31).

The determination of current speeds is a manual process whereby the observer measures the time it takes for the currents to physically move the drogue from one point to another. Drogue plots were generated based on the four (4) tracking sessions completed.

Table 5-31 Current velocities recorded in the project area for the ADCP deployment between May 11th to May 27th, 2016 for the surface and sea floor respectively.



Surface



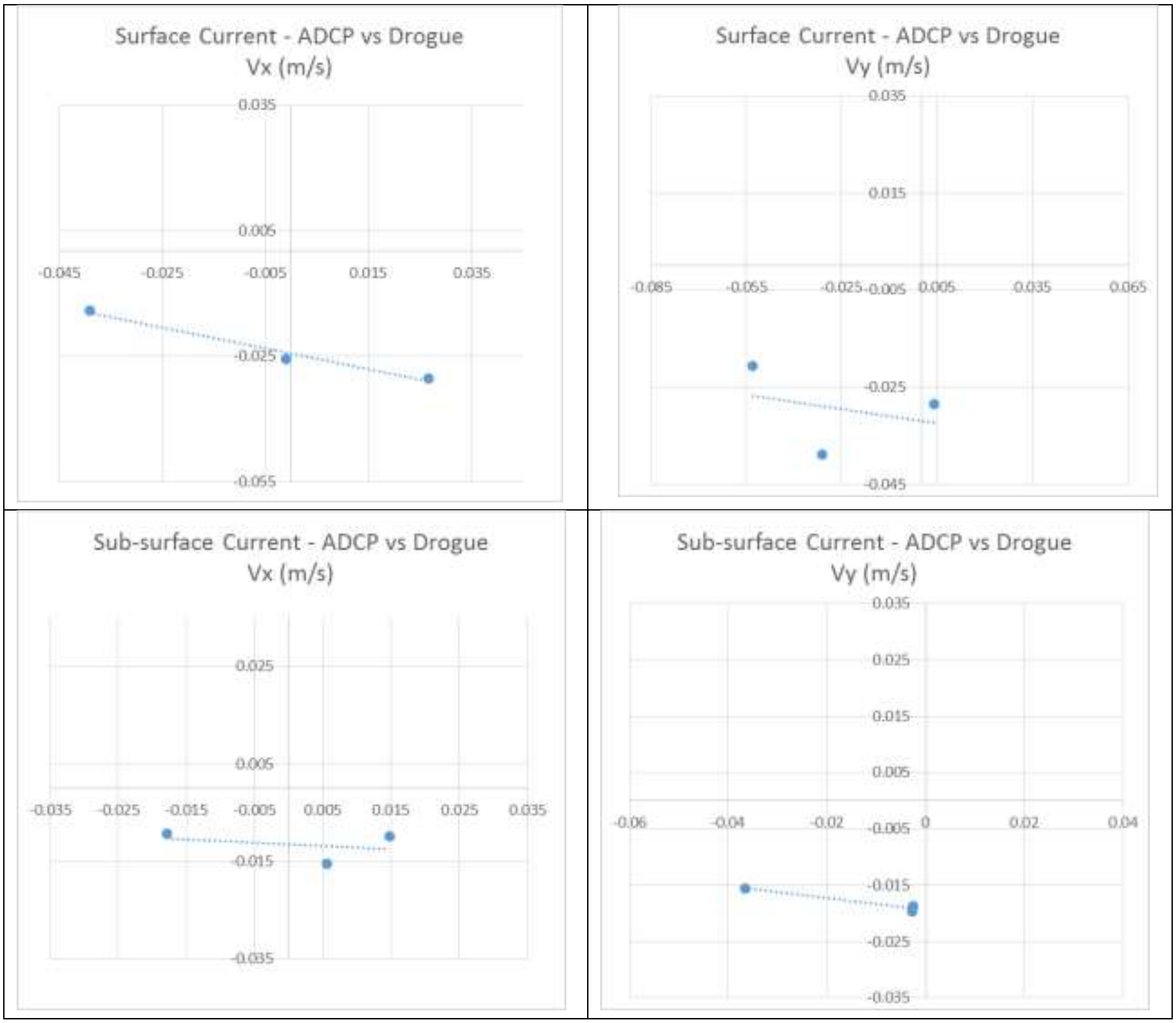
Sea Floor

The currents recorded by the ADCP were checked against the drogues to confirm that the ADCP was recording the correct currents (speeds and direction); the X and Y components of the currents were compared. For the surface drogues, a 98.8% and 31.1% correlation was obtained for the X and Y components respectively, while for the sub-surface drogues the correlation was 30.7% and 97.6% for the same components respectively. Table 5-32 summarizes these findings and Table 5-33 presents graphs that highlight the correlation using scatter plots. These figures indicate that the relationship between the ADCP and the drogues were good in terms of magnitude, but the directions in some cases were different.

Table 5-32 Statistical comparison of the currents measured by the drogues and ADCP deployed in Old Harbour Bay for Location 1

Depth	Correlation	
	Vx (m/s)	Vy (m/s)
Surface	-98.8%	-31.1%
Sub-Surface	-30.7%	-97.6%

Table 5-33 Comparison plots for the X and Y components of velocity for the drogues (surface and sub-surface currents) versus the ADCP measurements in Old Harbour Bay for the May 11th – 27th, 2016 deployment period

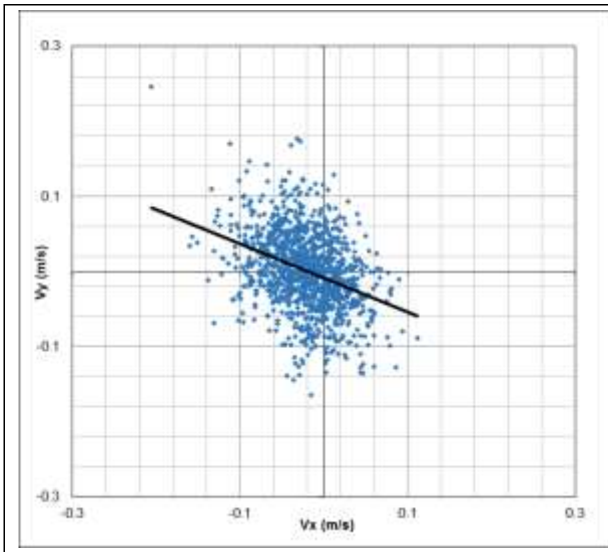


Location 2 (Proposed Mooring Area)

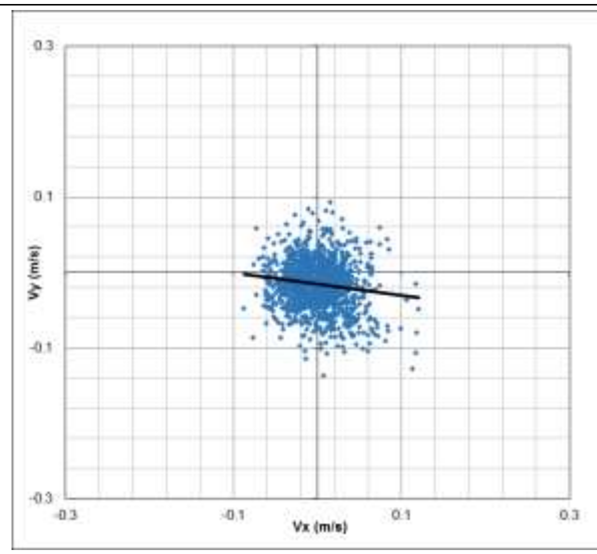
At the proposed mooring area, the surface currents were in the order of 0.11 to 0.25 meters per second and were predominantly north-westerly and south-westerly within the north and south quadrants respectively. The subsurface currents are south-easterly aligned and much slower, i.e. less than 0.15 meters per second.

X-Y vectors of the currents were plotted to show the direction and speeds of the currents in the vicinity of the deployment for both locations. At Location 2, the plots indicated that the surface currents in the area moved predominantly north-westerly and westerly. Analyzing the long term historical wind data (Table 5-38), it can be concluded that the currents in this area move in the north-western to western direction as they are wind driven; the wind and current directions have a strong correlation.

Table 5-34 Current velocities recorded in the project area for the ADCP deployment between May 11th to May 27th, 2016 for the surface and sea floor respectively.



Surface



Sea Floor

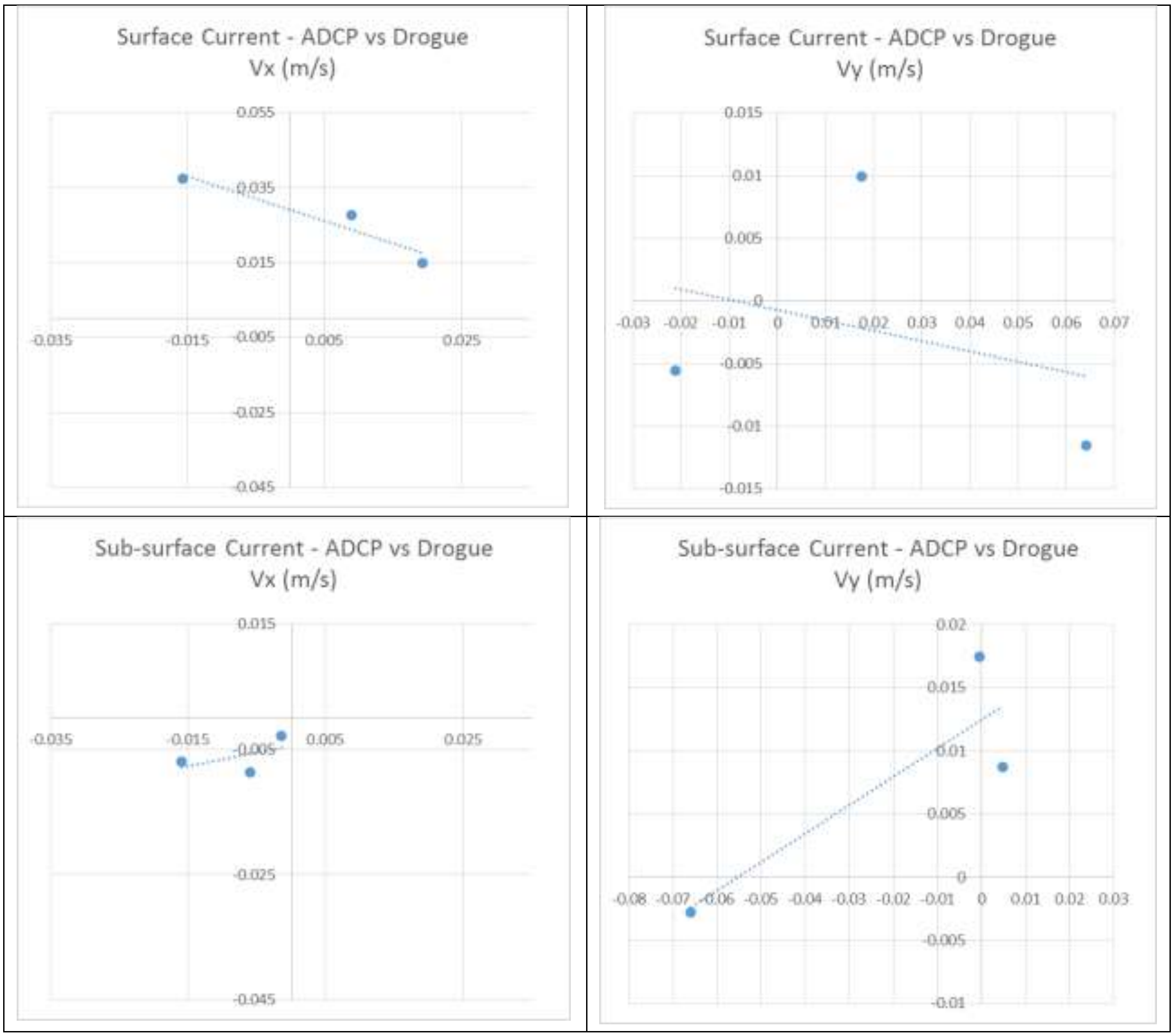
The currents recorded by the ADCP were checked against the drogues to confirm that the ADCP was recording the correct currents (speeds and direction); the X and Y components of the currents were compared. For the surface drogues, a 95.2% and 32% correlation was obtained for the X and Y components respectively, while for the sub-surface drogues the correlation was 52.2% and 97.2% for the same components respectively.

Table 5-26 summarizes these findings and Table 5-27 presents graphs that highlight the correlation using scatter plots. These figures indicate that the relationship between the ADCP and the drogues were good in terms of magnitude, but the directions in some cases were different. Analyzing the drogue plots, it can be concluded that the surface currents were predominantly driven by the wind whereas the subsurface currents were mostly driven by tides.

Table 5-35 Statistical comparison of the currents measured by the drogues and ADCP deployed in Old Harbour Bay for location #2

Depth	Correlation	
	Vx (m/s)	Vy (m/s)
Surface	-95.2%	-32.0%
Sub-Surface	52.2%	97.2%

Table 5-36 Comparison plots for the X and Y components of velocity for the drogues (surface and sub-surface currents) and the ADCP in Old Harbour Bay for the May 11th – 27th, 2016 deployment period



Summary

Analyzing the ADCP and drogue data, it can be concluded that the surface currents were predominantly driven by the wind whereas the subsurface currents were mostly driven by tides. Within location #1 (proposed mooring area), majority of the surface currents were observed to be moving in a westerly to north-westerly direction with speeds up to 0.06m/s. The sub-surface currents travelled southerly to south-westerly directions with speeds up to 0.03m/s.

The data for location #2 indicates that the surface currents were predominantly driven by the wind whereas the subsurface currents were mostly driven by tides. Majority of the surface currents were observed to be moving in a westerly to north-westerly direction with speeds up to 0.05m/s. The sub-surface currents were observed to be moving in a north-westerly direction with speeds up to 0.04m/s. The proposed mooring area (location #1) is exposed to faster moving surface currents than the second location (outside the reefs) while for the sub-surface currents it is the opposite.

5.1.9.8 Wind Regime

Historical and current wind data for the project area was obtained from two main sources:

- Offshore measurements - NOAA climate service floating stations (buoys); and
- Onshore measurements – Weather station on JEP site and Norman Manley International Airport (NMIA) Meteorological Station.

Historical Wind

NOAA CLIMATE SERVICE (THE NCEP/NCAR REANALYSIS MODEL DATA)

A node was chosen in front of the bay and the wind and wave data corresponding to that node obtained. The node used was:

- Zone: 18
- Easting: 286049
- Northing: 1948299

The data spanned the years of 1999 to 2007 recorded on a daily basis at three hour intervals. The data is shown in a wind rose in Figure 5-52. The data was analyzed in terms of percentage occurrence of various wind speed and direction combinations in order to characterize the wind climate for the site. The analysis revealed that the winds have a direction of NE to ESE direction with wind speeds of 20 m/s or less approximately. Southerly and Westerly wind directions were noted to occur but rarely. Overall the average wind speed and direction is between 6 to 8 m/s from the ENE to ESE.

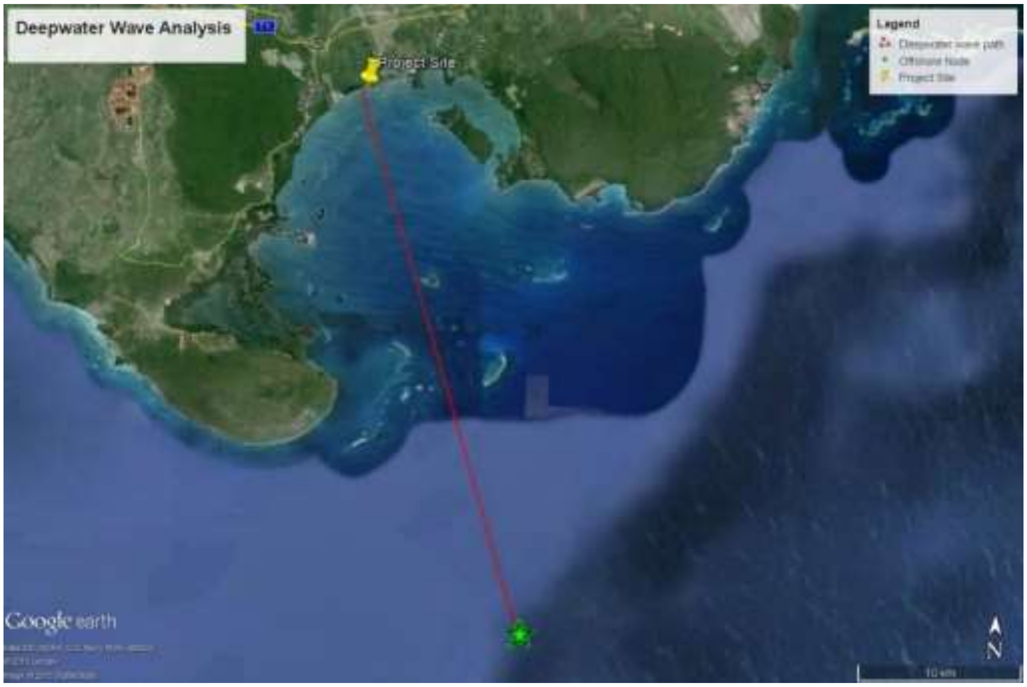


Figure 5-51 Satellite imagery of the area which shows the location of the offshore node used to determine deepwater wave climate

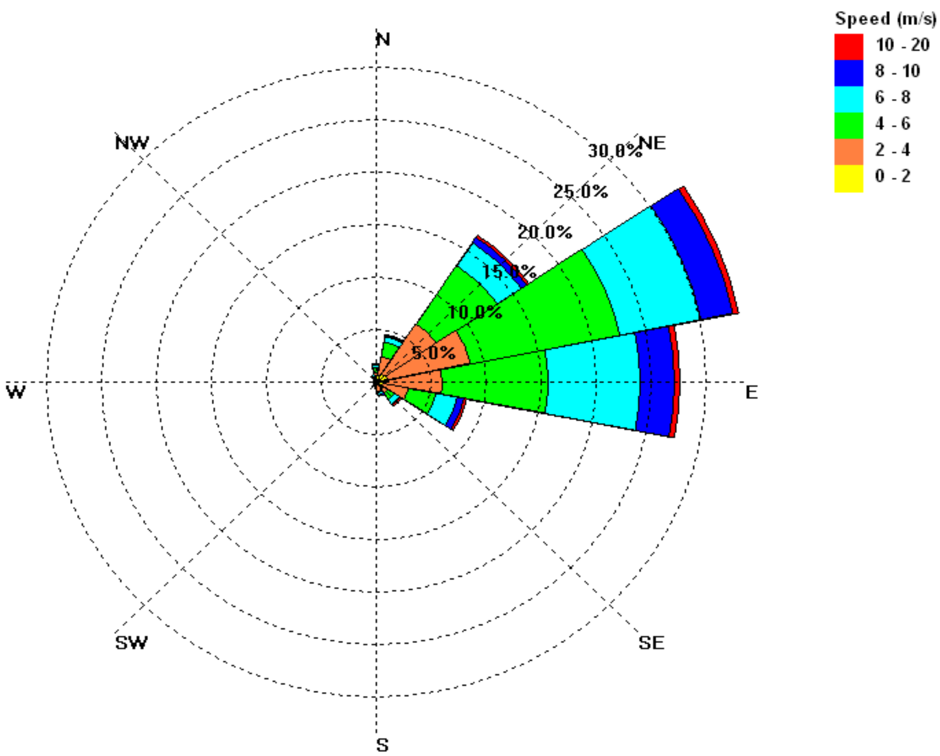


Figure 5-52 Wind Rose of NOAA Wind Data for 1999 – 2007

NMIA METEOROLOGICAL STATION

The data obtained from the NMIA Meteorological station spanned the years 2004 to 2009. Analysis of this data revealed that the winds were predominantly from the ENE to ESE directions approximately with winds of 6-8m/s over 20 percent of the time.

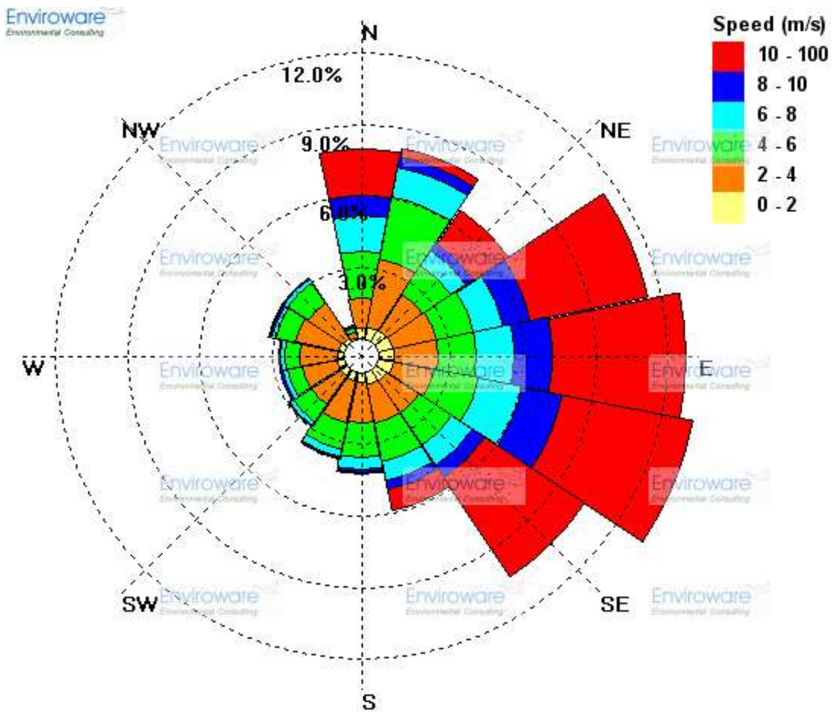


Figure 5-53 Wind Rose of Norman Manley International Airport wind data (2004-2009)

ROCKY POINT - JAMALCO PIER (ONSITE ANEMOMETER)

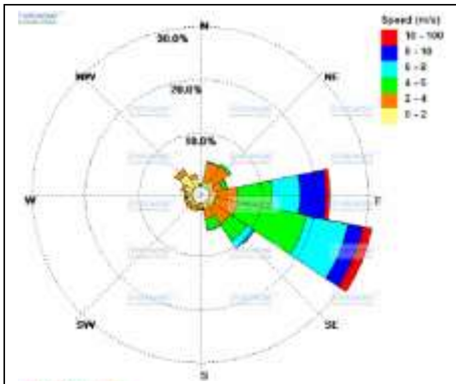
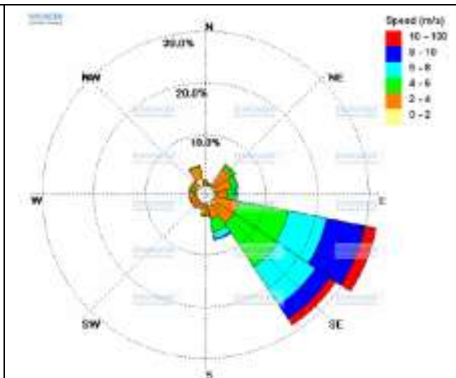
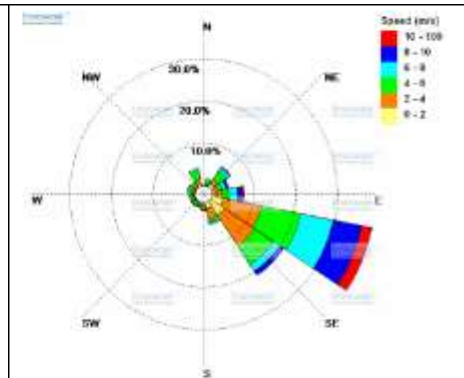
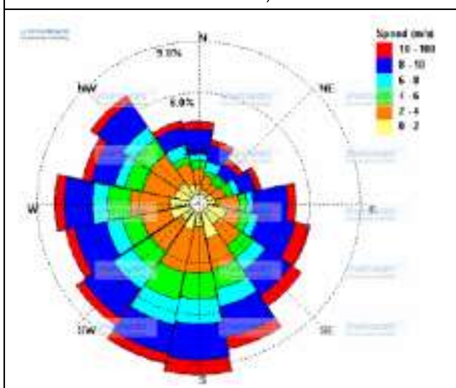
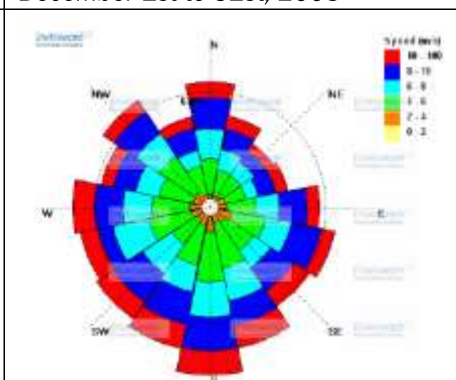
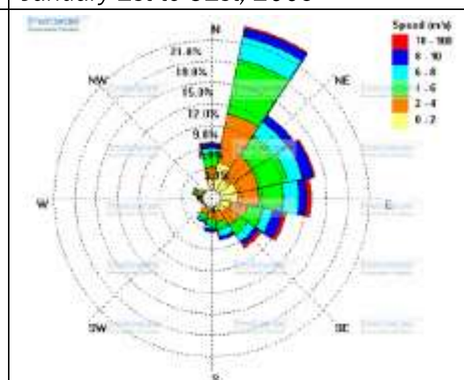
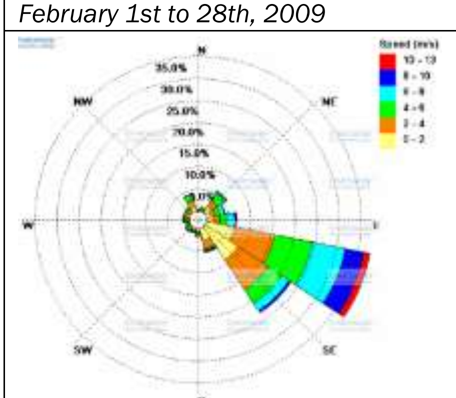
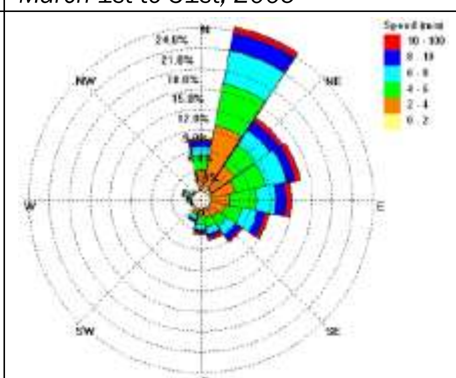
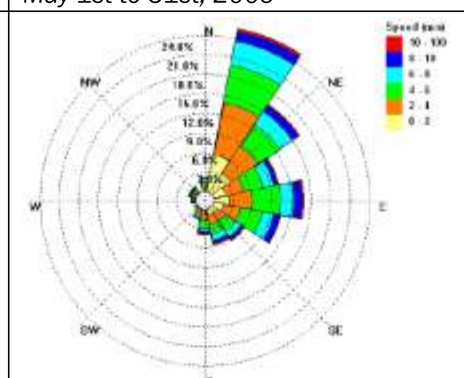
A temporary weather station was established and maintained by environmental consultants, CEAC Solutions Co. Ltd., located on the eastern end of the Jamalco pier (Rocky Point). Wind readings were obtained, the data analyzed and respective graphs plotted. From the Table 5-37 below, it can be determined that, during the eleven (11) months of monitoring, the average and maximum wind speeds experienced was 5.2 m/s and 14.6 m/s respectively. Table 5-38 shows wind rose plots for Rocky Point, Clarendon which illustrates distinctive peaks of wind speed and wind direction with the exception of February and March (see Table 5-38). These high wind speeds tend to blow to a generally easterly direction (blowing from west to east).

Table 5-37 Historical wind data collected from Jamalco met station (October 2008 – August 2009)

Data Collection Period	Average Wind Direction	Wind Speed (m/s)		
		Range	Average	Max
Oct 2nd - 31st, 2008	SE	0.2 - 13.7	4.7	13.7
Nov 3rd - 30th, 2008	ESE	0.2 - 13.8	4.8	13.8
Dec 1st - 31st, 2008	ESE	0.5 - 13.1	5.1	13.1
Jan 1st - 31st, 2009	ESE	0.47 - 13.2	5.1	13.2
Feb 1st - 28th, 2009	SSW	0.4 - 12.1	5.8	12.1

Data Collection Period	Average Wind Direction	Wind Speed (m/s)		
		Range	Average	Max
Mar 1st - 31st, 2009	SSW	3 - 14.3	7.2	14.3
Apr 1st - 31st, 2009	SSW	0.39 - 13.9	5	13.9
May 1st - 31st, 2009	NNE	0.17 - 13.7	4.8	13.7
Jun 1st - 30th, 2009	ESE to SE	0 – 12.0	3.9	12.0
Jul 1st - 31st, 2009	NNE to ENE	1.1 - 14.63	5.9	14.6
Aug 1st - 31st, 2009	NNE to ENE	0 - 13.52	4.7	13.5

Table 5-38 Wind Rose Plots for Rocky Point, Clarendon

 *November 3rd to 31st, 2008*	 *December 1st to 31st, 2008*	 *January 1st to 31st, 2009*
 *February 1st to 28th, 2009*	 *March 1st to 31st, 2009*	 *May 1st to 31st, 2009*
 *June 1st to 30th, 2009*	 *July 1st to 31st, 2009*	 *August 1st to 31st, 2009*

Current Wind

A weather station, maintained and monitored by environmental consultants CL Environmental Ltd is located north of the JEP barges at the JEP Offices. Data were collected from the station to support the drogue studies and to calibrate a numerical hydrodynamic model of the area during the study. Wind readings were obtained, the data analyzed and respective graphs plotted. There are distinctive peaks of wind speed and wind direction (Figure 5-54,). The general trend shows that these peak wind speeds occur after 12 pm each day. The maximum wind speed observed during the three (3) day period was 10.7 m/s which occurred on May 11th around noon. These high wind speeds tend to blow to a generally north-westerly direction. The wind direction graph in Figure 5-55 also shows the majority of recording points in the ranges corresponding to the wind originating from the south-east.

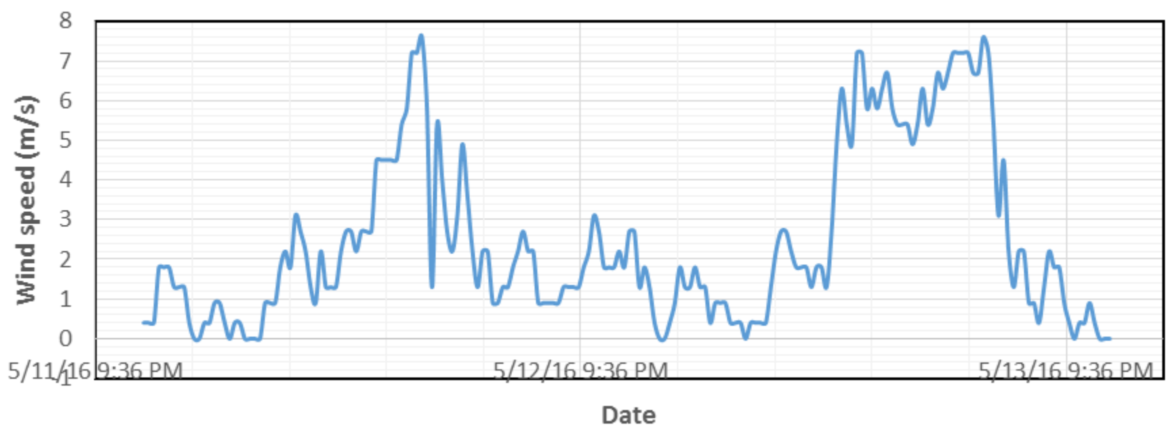


Figure 5-54 Wind speed from JPS weather station from May 11th through May 13th, 2016.

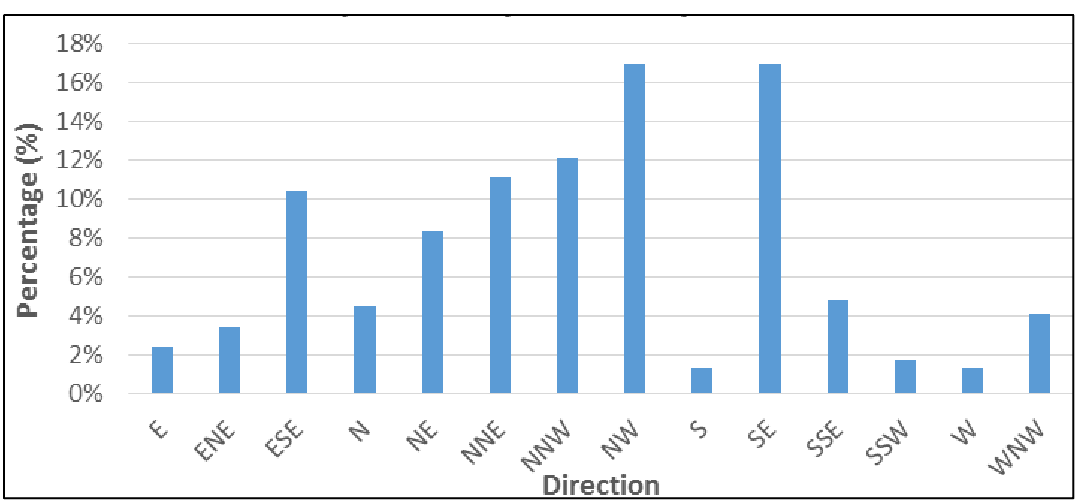


Figure 5-55 Wind direction from JPS weather station from May 11th through May 13th, 2016.

Annually, the historical wind data illustrates that majority of the winds are out of the east. On a micro level, the first quarter of the year have a spread about the northern and southern directions with bias to the west. As the year progresses, the winds tend to move towards the north where they predominantly originate from the east for the latter parts of the year.

5.1.9.9 Hydrodynamic Model Development

Description of Model (RMA 10)

The model used to simulate the currents across the project area is known as the RMA 10 model developed in Australia. RMA-10 is a three-dimensional finite element model for stratified flow by King (1993). The primary features of RMA-10 are:

- The solution of the Navier-Stokes equations in three-dimensions;
- The use of the shallow-water and hydrostatic assumptions;
- Coupling of advection and diffusion of temperature, salinity and sediment to the hydrodynamics;
- The inclusion of turbulence in Reynolds stress form;
- Horizontal components of the non-linear terms are included;
- A capacity to include one-dimensional, depth-averaged, laterally-averaged and three-dimensional elements within a single mesh as appropriate;
- No-, partial- and full-slip conditions can be applied at both lateral boundaries;
- Partial or no-slip conditions can be applied at the bed;
- Depth-averaged elements can be made wet and dry during a simulation; and
- Vertical turbulence quantities are estimated by either a quadratic parameterization of turbulent exchange or a Mellor-Yamada Level 2 turbulence sub-model.

Finite Element Mesh Development

The process of mesh developments entails the following steps:

- Input of bathymetric data for the wider area and in detail for the project area
- Specifying of nodes in the mesh
- Element construction in the mesh
- Interpolation for depth at nodes
- Specifying of open boundaries

The mesh constructed for the calibration and existing configuration extended some 34 kilometers in a southerly direction from the shoreline at the JPS Power Plant. The outer deep water areas were gridded with large mesh which gradually decreases on approach to the project area (Figure 5-56). The eastern and western boundaries were used as the open boundaries on which tides were applied.

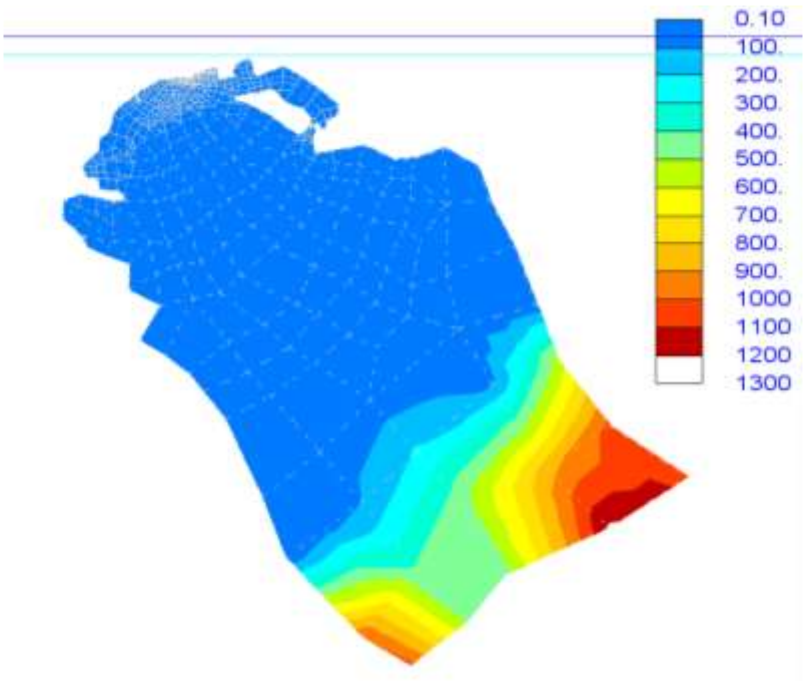


Figure 5-56. Overview of entire Finite Element Mesh used for this project showing depth in metres

Calibration

The model was calibrated, both deepwater and nearshore, by adjusting the tide elevation signal on the model boundaries, turbulence and viscosity parameters, until there was reasonable agreement between the observed currents and model predictions. This was conducted for all historical drogue sessions executed.

Predicted current speeds and directions and drogue tracking sessions' data (May 2016) are summarized in Table 5-39. The model predictions were within the data ranges for the observed occurrences in most instances. Of the four (4) calibration sessions, three (3) showed a positive correlation ranging between 82 to 95%. The remaining session displayed strong but negative correlation. This means that there was no direct positive relationship between the variations of the values at different points during those two sessions even though the predicted currents were generally similar in direction and magnitude to the drogues.

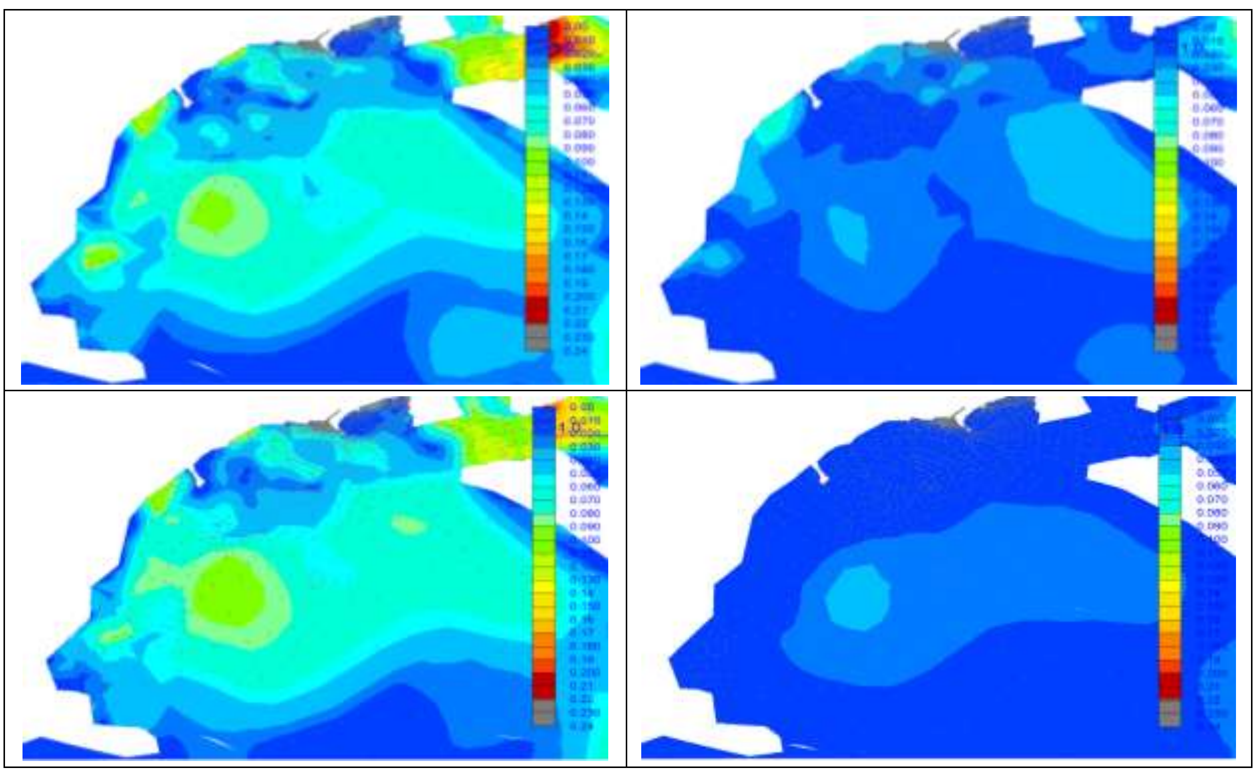
Table 5-39 Calibration data for FEM for the existing bathymetric configuration based on drogue and wind data for the drogue tracking missions carried out in May 2016.

Date	Session (Tide)	Location	Drogue		Model		Correlation
			Speed (cm/s)	Direction	Speed (cm/s)	Direction	
12-May-16	Falling	Mooring Area (Deepwater)	3.9	SW	1	SW	-0.58
		Ship Channel (Deepwater)	2.2	SW	2	SW	
		Outside Reef (Offshore)	2.8	E	5	NW	
		Nearshore	2.0	N	5	NW	

Date	Session (Tide)	Location	Drogue		Model		Correlation
			Speed (cm/s)	Direction	Speed (cm/s)	Direction	
12-May-16	Rising	Mooring Area (Deepwater)	6.2	NW	3	N	0.93
		Ship Channel (Deepwater)	10.4	NW	11	N	
		Outside Reef (Offshore)	4.7	NW	3	NW	
		Nearshore	3.5	NW	3	NW	
13-May-16	Falling	Mooring Area (Deepwater)	2.1	S	1	S	0.82
		Ship Channel (Deepwater)	2.3	SW	1	SE	
		Outside Reef (Offshore)	1.9	W	3	NW	
		Nearshore	5.6	NW	5	NW	
13-May-16	Rising	Mooring Area (Deepwater)	2.0	NW	2	NW	0.95
		Ship Channel (Deepwater)	3.2	NW	2	NW	
		Outside Reef (Offshore)	2.1	NW	2	NW	
		Nearshore	5.8	NW	3	NW	

The calibration data essentially indicates that there is reasonable agreement between the model and the data (observations). The model was considered suitable for analyzing the design conditions that would be experienced within the bay, in regards to the Liquefied Natural Gas (LNG) and Automotive Diesel Oil (ADO) pipelines and mooring areas. The calibration parameters were kept constant and used for prediction under varied wind and tide conditions and their impacts on far-field dispersion of effluent (cooling water in this instance).

Table 5-40 Calibration plot of currents (in m/s) for drogue: Session 1 – Falling (Top Left), Session 2 – Rising (Top Right), Session 3 – Falling (Bottom Left), Session 4 – Rising (Bottom Right).



5.1.9.10 Current Predictions

Approach

The current speeds were investigated for different wind speeds and directions given their impacts on currents within the Bay. The wind directions and speeds investigated were from the more predominant south-eastern direction. The speeds and directions used are summarized in Table 5-41.

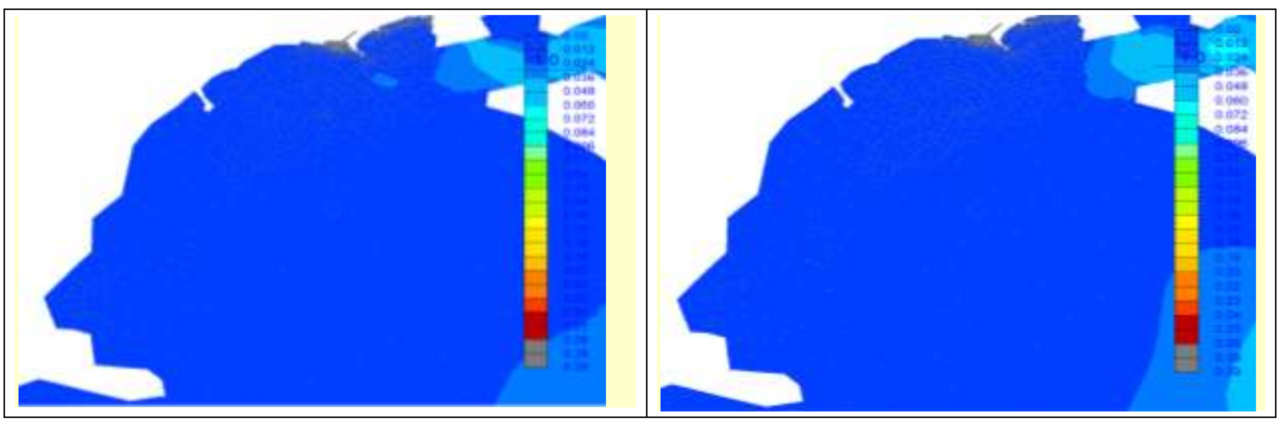
Table 5-41 Summary of wind speeds and directions investigated

Conditions	Speed (m/s)	Direction
Slow	2.0	South-Easterly
Average	5.5	South-Easterly
Fast	15.5	South-Easterly

Slow Wind Conditions

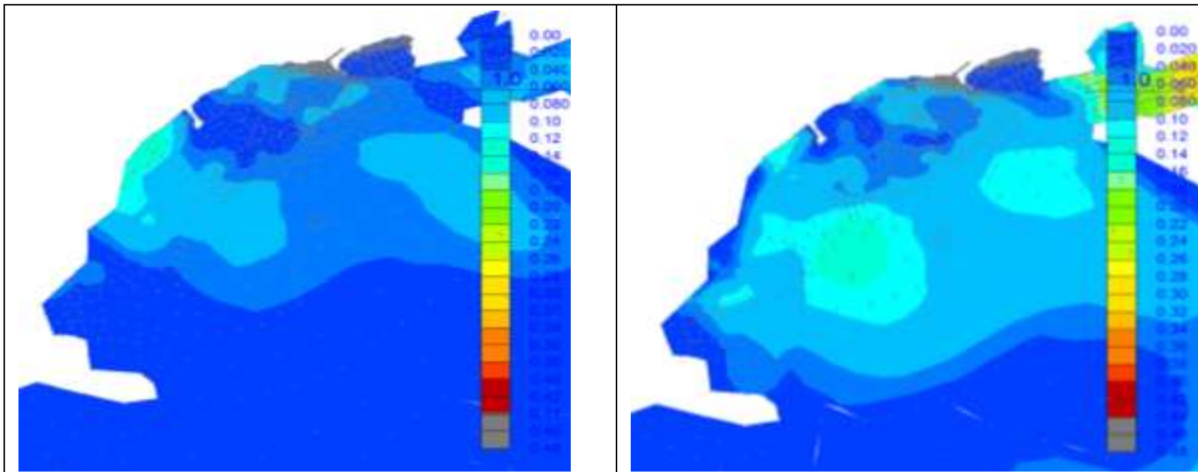
Surface current predictions for the slow wind speed meteorological conditions for the existing shoreline configuration indicated that current velocities below 2 cm/s can be expected within the proposed LNG and existing ADO mooring areas and respective pipelines. The current directions are predominantly north-westerly which indicates the surface currents are wind driven during periods when the tidal currents are not very active. Along the route of the LNG and ADO pipelines, currents speeds of up to 1.2 cm/s can be expected under the slow wind conditions.

Table 5-42 Predictions for current speeds in falling tide (left) and rising tide (right) under slow wind conditions (current speeds less than 2 cm/s)



Average Wind Conditions

Surface current predictions for the average wind speed meteorological conditions for the existing shoreline configuration indicate that current velocities below 12 cm/s for rising and falling tides within the bay. The current directions are predominantly towards the west and north-west indicating that the surface currents are predominantly wind driven. Both along the route for the proposed pipelines and at the mooring area, currents speeds ranging from 1cm/s to 8 cm/s can be expected under the average wind conditions.

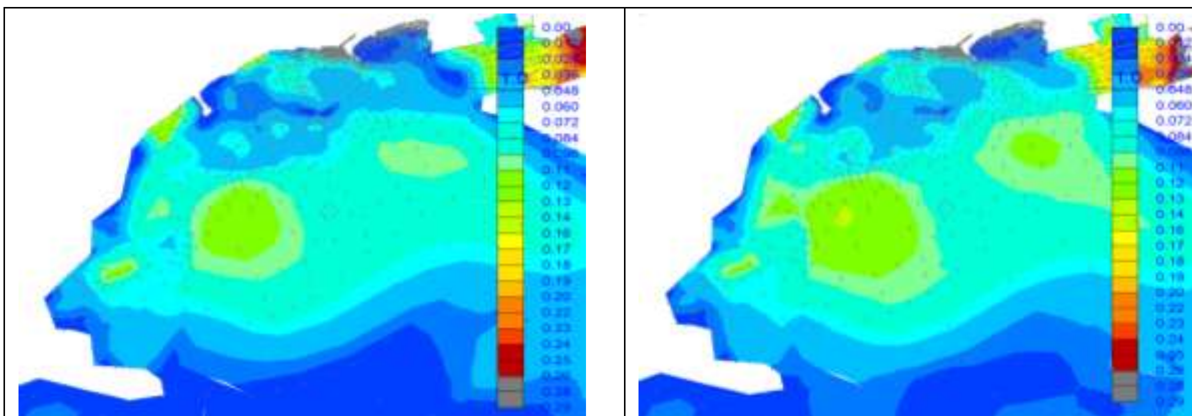


Rising Tide | *Falling Tide*

Figure 5-57 Predictions for current speeds in falling tide (Left) and rising (Right) tide under average wind conditions (current speeds less than 12 cm/ s but greater than 2 cm/s)

Fast Wind Conditions

Surface current speeds in proximity to the proposed mooring area are expected to remain below 20cm/s. The currents during these periods are driven primarily by the fast winds. It should be noted that these conditions are expected to occur less than 5% to 10% percent of the time. Along the route for the proposed LNG and ADO pipelines, currents speeds range from 6 cm/s to 17 cm/s can be expected under the fast wind conditions.



Rising Tide | *Falling Tide*

Figure 5-58 Predictions for current speeds in RISING tide (Left) and FALLING (Right) tide under fast wind conditions (CURRENT speeds greater than 6 cm/s)

Summary

The surface currents in the bay move predominantly in a westerly direction during the falling tides regardless of the wind condition. This can be observed where the current speeds increase with wind speed in the direction to which the wind blows. During slow wind conditions, the tides have no clear direction in the project area, however when the wind speeds increase, the currents adopt the wind direction. The currents in the project area are mostly influenced by the direction of the prevailing winds.

During rising tides, the surface currents are generally below 2 cm/s, moving in a north-westerly direction, for the slow wind speed meteorological conditions. During the falling tides, the currents are generally slower in the near shore than the offshore and tend to move north-westerly along the shoreline. Surface current predictions for the average wind speed meteorological conditions for the existing shoreline configuration indicate that current velocities below 12 cm/s for rising and falling tides within the bay. Surface current predictions for the average wind speed meteorological conditions for the existing shoreline configuration indicate that current velocities up to 20cm/s for falling and rising tides could occur in sections of the bay. The currents during these periods are driven primarily by the fast winds. It should be noted that these conditions are expected to occur less than 5% to 10% percent of the time.

5.1.10 Water Quality

Water quality sampling exercises were conducted in the area in 2012 and 2014 during the South Jamaica Power Company 360 MW EIA and the Jamaica Public Service Co. Ltd. 190 MW EIA respectively. There were eleven (11) water quality stations in common between the two studies. Sampling dates were as follows:

- April 26, 2012
- May 10, 2012
- May 24, 2012
- July 9, 2014
- July 22, 2014
- August 7, 2014

Sampling was also conducted at four (4) locations in 2016 on the following dates:

- April 28, 2016
- May 11, 2016
- May 18, 2016

5.1.10.1 Methodology

Physical data (Temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, and total dissolved solids - TDS) was collected *in situ* at identified marine locations within the project environs and potable water location, using a Hydrolab DataSonde DS-5 meter (Calibration Certificate in Appendix 4).

Measurements were taken at intervals throughout the water column. Chemical and biological data were obtained from whole water samples collected at a depth of approximately 0.5 m. The samples were collected in pre-cleaned 1L plastic bottles. Bacterial samples were collected in sterilised 100 ml bottles at above mentioned depth. Fats Oil and Grease samples were collected in glass bottles. The samples were stored on ice in a cooler and transported to Caribbean Environmental Testing and Monitoring Services, and Test America Pensacola Laboratory for laboratory analyses. Thirteen (13) marine and one (1) potable water quality sampling stations were sampled. The potable water sample was taken from the JPS Old Harbour Bay power station bathroom faucet (Station 12). Their locations in JAD2001 are listed in Table 5-43 and depicted in Figure 5-59, for the 2012 and 2014 studies. Stations 1 – 11 were common between the 2012 and 2014 EIA studies. Water quality sampling locations for 2016 are also depicted in Figure 5-59 and listed in Table 5-44. These were accurately mapped using Trimble® GeoExplorer 6000 GPS units.

Table 5-43 Water quality sampling stations in JAD 2001 (2012 and 2014/2015 Studies)

STATION NUMBER	JAD 2001 (m)	
	NORTHINGS	EASTINGS
1	639438.343	737654.465
2	638597.429	737507.143
3	638357.524	738155.675
4	637987.383	738937.267
5	638813.095	738832.651
6	637216.854	738447.687
7	636661.153	739006.650
8	636051.270	737552.652
9	636842.198	736505.603
10	637635.129	737550.379
11	637982.890	736600.345
13	638772.680	738504.530
14	634110.970	737380.530

Table 5-44 Water quality sampling stations in JAD 2001 (2016)

STATION NUMBER	JAD 2001 (m)	
	NORTHINGS	EASTINGS
1	634248.819	737968.303
2	634041.386	737898.453
3	634551.503	737727.002
4	634331.369	738309.087

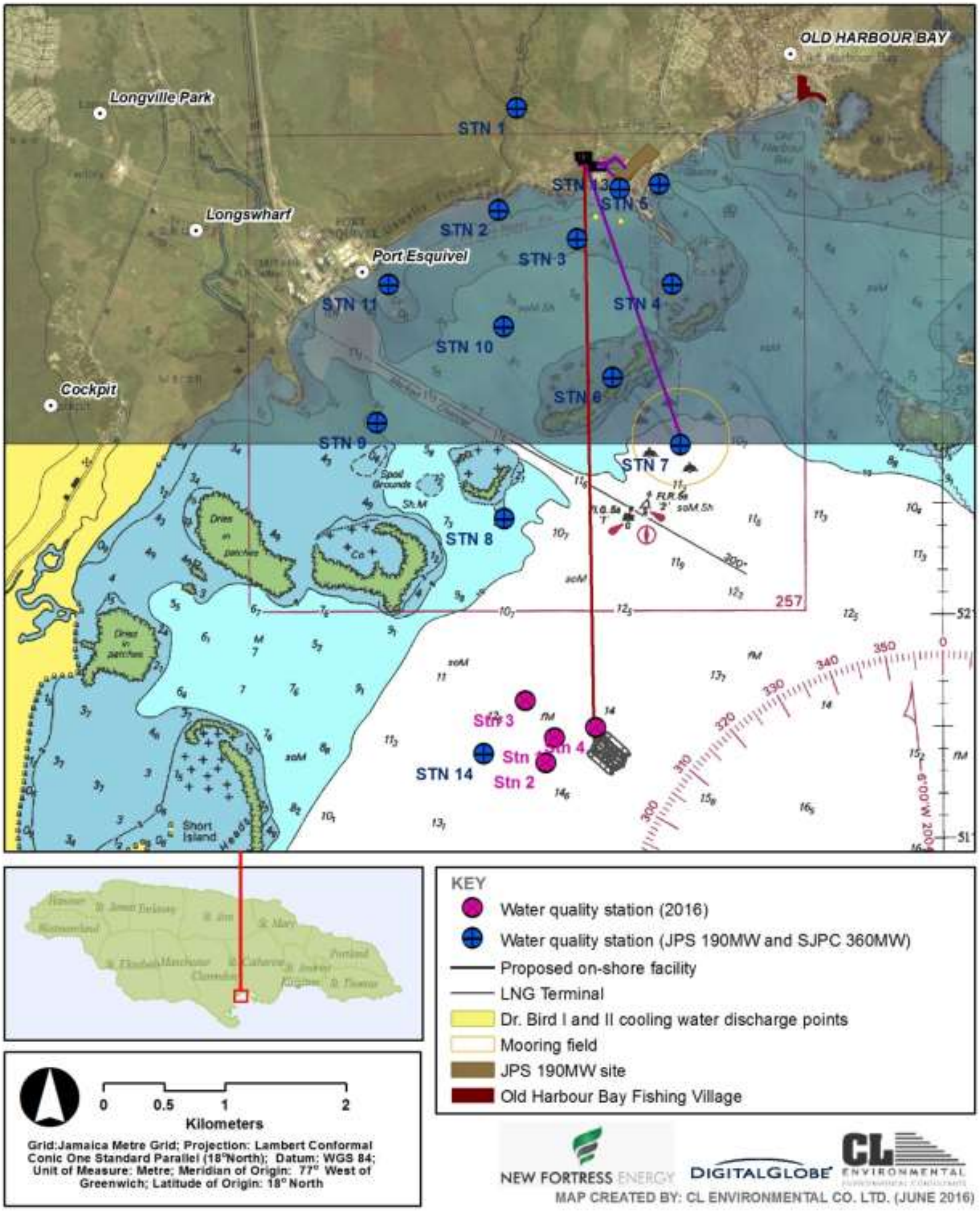


Figure 5-59 Water quality sampling locations in 2012, 2014/2015 (SJPC 360MW and JPS 190MW) and 2016

The parameters analysed for the marine water samples were: BOD, Total Suspended Solids, Nitrates, Phosphates, Oil and Grease, Faecal Coliform and Total Petroleum Hydrocarbons (TPH) – Gasoline Range Organics (GRO) and Diesel Range Organics (DRO). The parameters analysed for the potable water sample were: barium, boron, fluoride, manganese, nitrates, faecal coliform, residual chlorine, arsenic, cadmium, chromium, copper, cyanide, lead, mercury, nickel and selenium.

The results from these sampling runs were compared to National Environment and Planning Agency (NEPA) Standards and World Health Organization (WHO) Guidelines where applicable.

Spatial interpolation of the data (temperature, conductivity and salinity) was undertaken in order to model the spatial patterns within the study area.

5.1.10.2 Results (2012 and 2014/2015)

Table 5-45 shows the average physicochemical water quality data for each station while Table 5-46 shows the average biochemical data.

Table 5-45 Average physicochemical water quality data for 2012 and 2014/2015

Stn	TEMP. °C	COND (mS/cm)	SAL (ppt)	pH	PAR (uE/cm/s)	D.O. (mg/l)	Turb (NTU)	TDS (g/l)
1	30.33	49.78	32.69	7.74	N/A	6.19	30.26	31.87
2	30.03	54.53	36.17	7.98	785	5.53	44.50	34.91
3	29.32	54.52	36.15	8.02	458	5.86	6.27	34.90
4	29.01	54.45	36.11	8.06	385	5.79	3.75	34.89
5	28.84	54.30	36.00	8.04	311	5.77	18.03	34.76
6	28.86	54.31	36.01	8.00	465	5.34	1.50	34.76
7	28.80	54.44	36.10	8.06	321	6.03	4.55	34.84
8	28.94	54.43	36.10	8.04	350	5.76	5.84	34.83
9	29.41	54.39	36.07	8.06	431.46	6.06	75.54	34.81
10	29.23	54.53	36.17	8.05	399.81	5.99	8.83	34.90
11	29.42	54.29	36.01	8.04	597.22	5.71	11.12	34.77
13	36.55	55.03	36.54	8.22	915.00	6.00	12.29	35.13
14	29.23	54.96	36.48	8.33	159.83	6.32	4.92	35.18

Table 5-46 Average biochemical water quality data for 2012 and 2014/2015

Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	F. coliform (MPN/100ml)	DRO (mg/l)	GRO (mg/l)
1	6.83	42.00	0.60	0.64	11.96	150.00	ND	ND
2	6.50	19.34	0.90	0.49	14.62	10.50	ND	ND
3	7.00	5.84	1.35	0.43	6.91	657.50	1.5	ND
4	9.84	7.00	0.97	1.09	6.91	10.50	ND	ND
5	7.17	12.17	1.04	0.33	3.15	83.17	ND	ND
6	7.00	5.50	1.32	1.08	3.53	52.67	ND	ND
7	9.17	8.33	1.40	0.65	7.91	35.50	ND	ND
8	6.17	5.00	1.20	1.07	5.38	10.50	ND	ND
9	6.17	8.50	1.23	0.27	25.79	49.17	ND	ND
10	5.84	6.17	0.92	0.25	4.79	28.84	ND	ND

Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	F. coliform (MPN/100ml)	DRO (mg/l)	GRO (mg/l)
11	7.67	9.34	0.89	0.17	19.34	292.34	ND	ND
13	1.67	7.33	2.07	2.48	2.33	18.67	ND	ND
14	2.67	6.33	1.57	1.34	2.00	10.00	ND	ND

ND – None Detected

Temperature

Average temperature values ranged from 28.80 – 36.55ºC across the stations. The highest temperature value was reported at station WQ13 (by the JPS cooling water outlet) and the lowest temperature was at station WQ7 (Figure 5-60). Figure 5-61 shows the spatial temperature comparison in contour form for depths of 0m, 1m, 2m and 3m. It clearly shows that the source of higher temperature water within the bay is from the JPS cooling water outlet and gradually spreads along the nearshore down past the WINDALCO pier in a southwesterly direction.

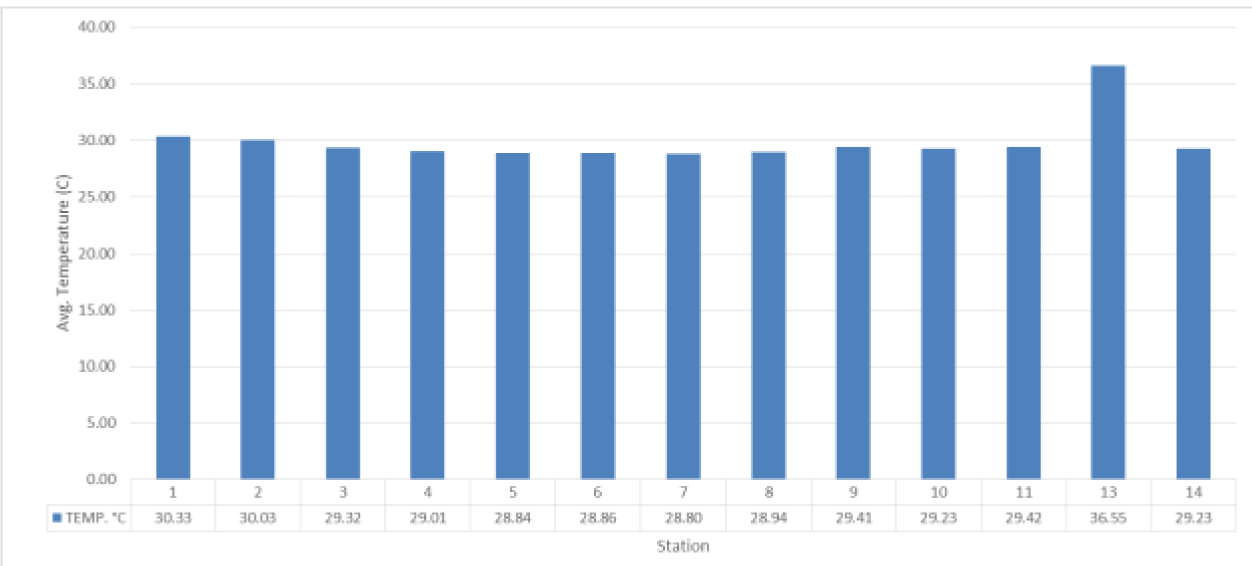


Figure 5-60 Average Temperature values at the various stations

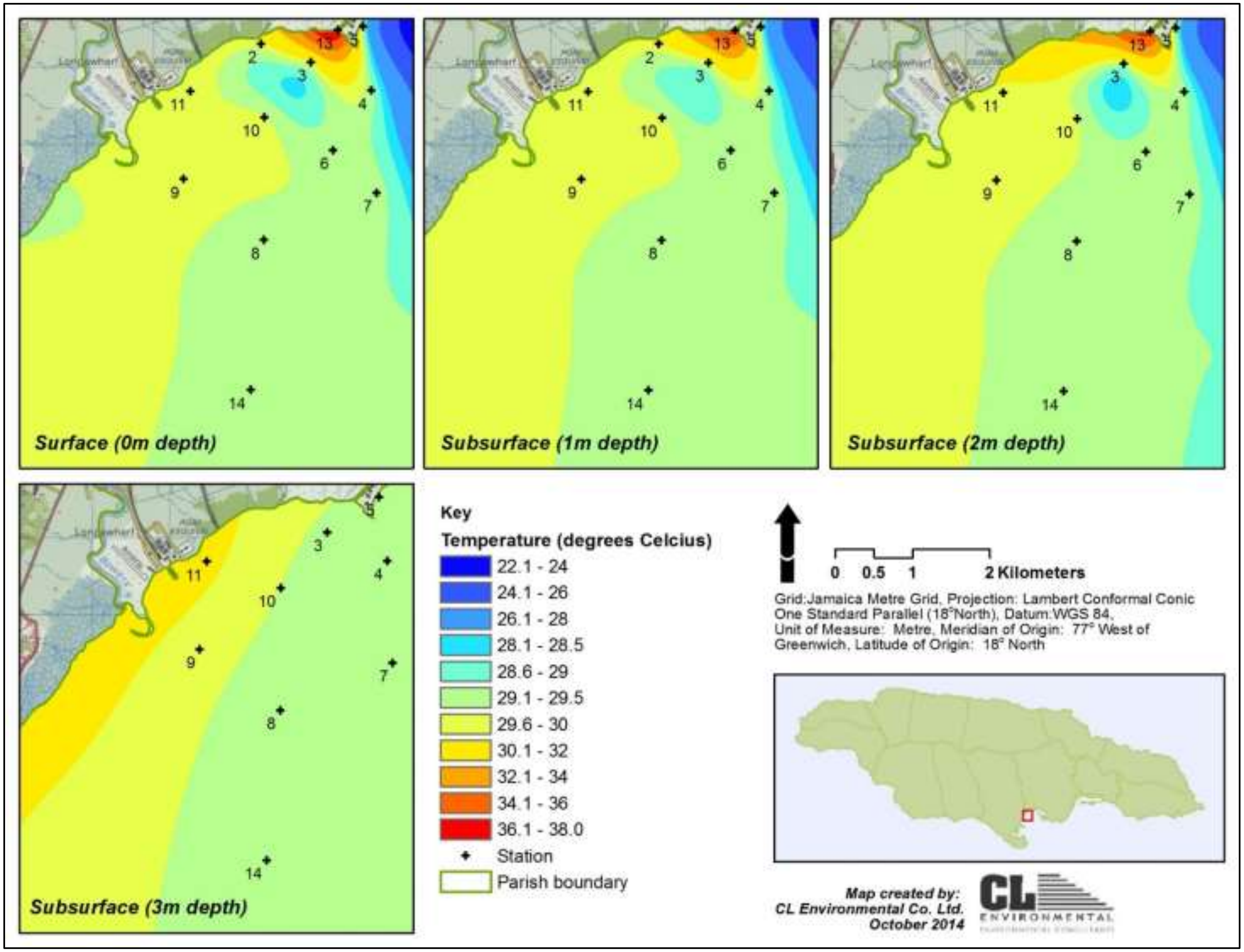


Figure 5-61 Spatial temperature comparison for 0m, 1m, 2m and 3m depths in 2014/2015 study

Specific Conductivity (SpC)

Average specific conductivity values ranged from 49.78 – 55.03mS/cm across the stations. The lowest values were reported at station WQ1 while station WQ13 had the highest value. WQ1 is located within the Bowers Gully, thus freshwater influence would result in lowered conductivity and salinity values (Figure 5-62).

Figure 5-63 shows the spatial conductivity comparison in contour form for depths of 0m, 1m, 2m and 3m, taken during the 2014 study. It clearly shows that the source of higher conductivity/salinity water (at the time of sampling - 2014) is from the Bowers Gully and gradually spreads outwards in a south southeasterly direction into and throughout the bay. This extreme salinity/conductivity within the gully could be a combination of salt water intrusion from the sea and drought conditions throughout the island during the sampling period. Although Station 1 is not seen on the map, Station 2 is located at the mouth of the Bowers Gully and shows the highest conductivity values. Figure 5-63 also shows a source of lower conductivity/salinity water to be the JPS cooling water outlet (Station 13) compared to the conductivity/salinity at Station 2.

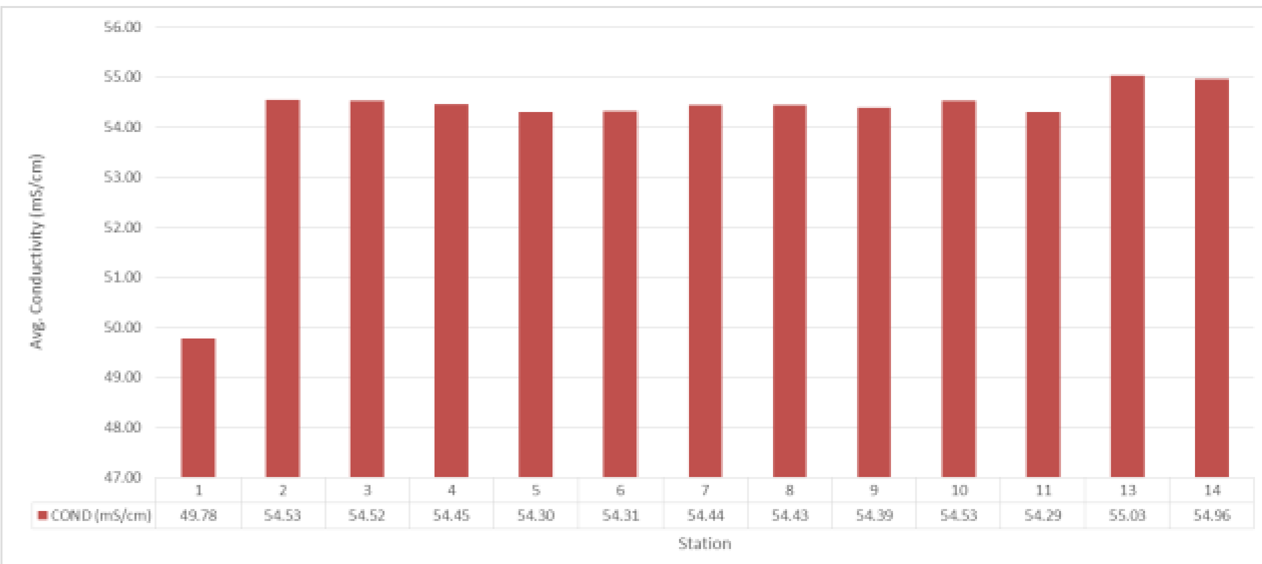


Figure 5-62 Average Conductivity values at the various stations

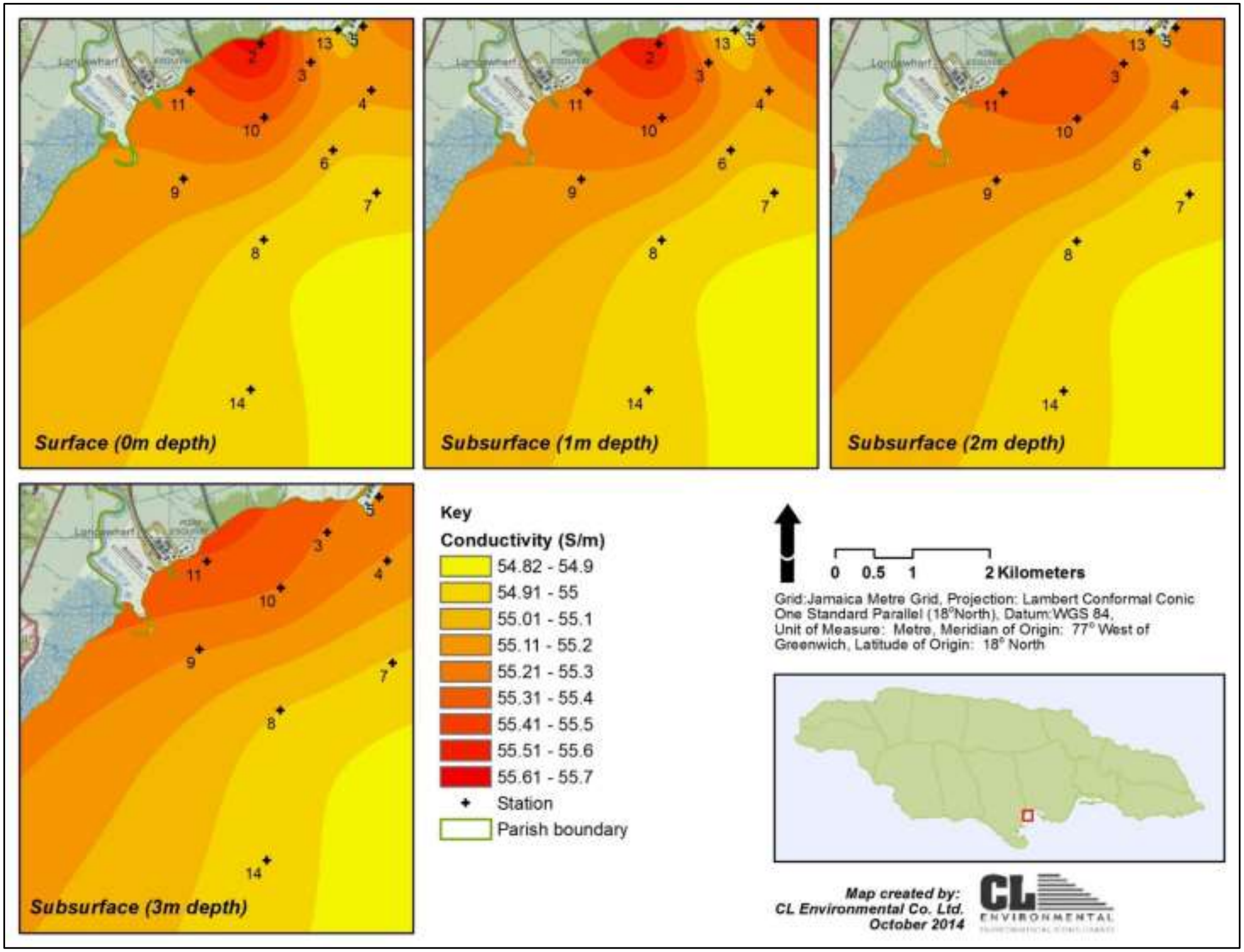


Figure 5-63 Spatial conductivity comparison for 0m, 1m, 2m and 3m depths in 2014 study

Salinity

Average salinity values ranged from 32.69 – 36.54ppt across the stations. The lowest values were reported at station WQ1 while station WQ13 had the highest value. WQ1 is located within the Bowers Gully, thus freshwater influence would result in lowered conductivity and salinity values (Figure 5-64).

Figure 5-65 shows the spatial salinity comparison in contour form for depths of 0m, 1m, 2m and 3m taken during the 2014 study. It clearly shows that the source of more saline water (at the time of sampling - 2014) is from the Bowers Gully and gradually spreads outwards in a south southeasterly direction into and throughout the bay. This extreme salinity/conductivity within the gully could be a combination of salt water intrusion from the sea and drought conditions throughout the island during the sampling period. Although Station 1 is not seen on the map, Station 2 is located at the mouth of the Bowers Gully and shows the highest salinity values. Figure 5-65 also shows a source of lower salinity water to be the JPS cooling water outlet (Station 13) compared to the salinity at Station 2.

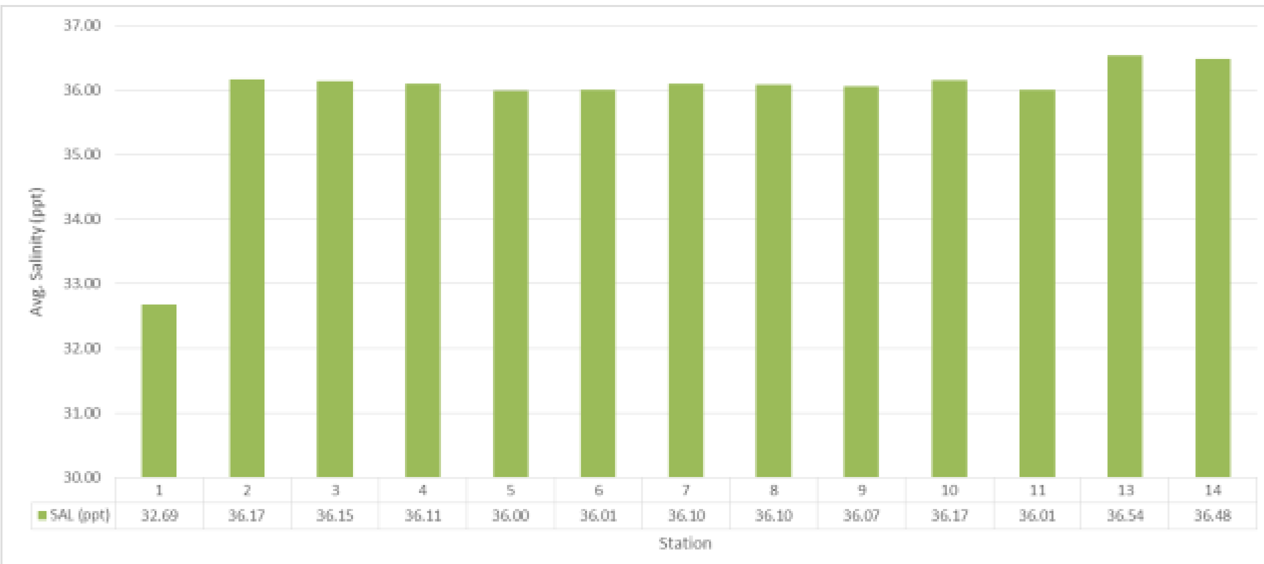


Figure 5-64 Average Salinity values at the various stations

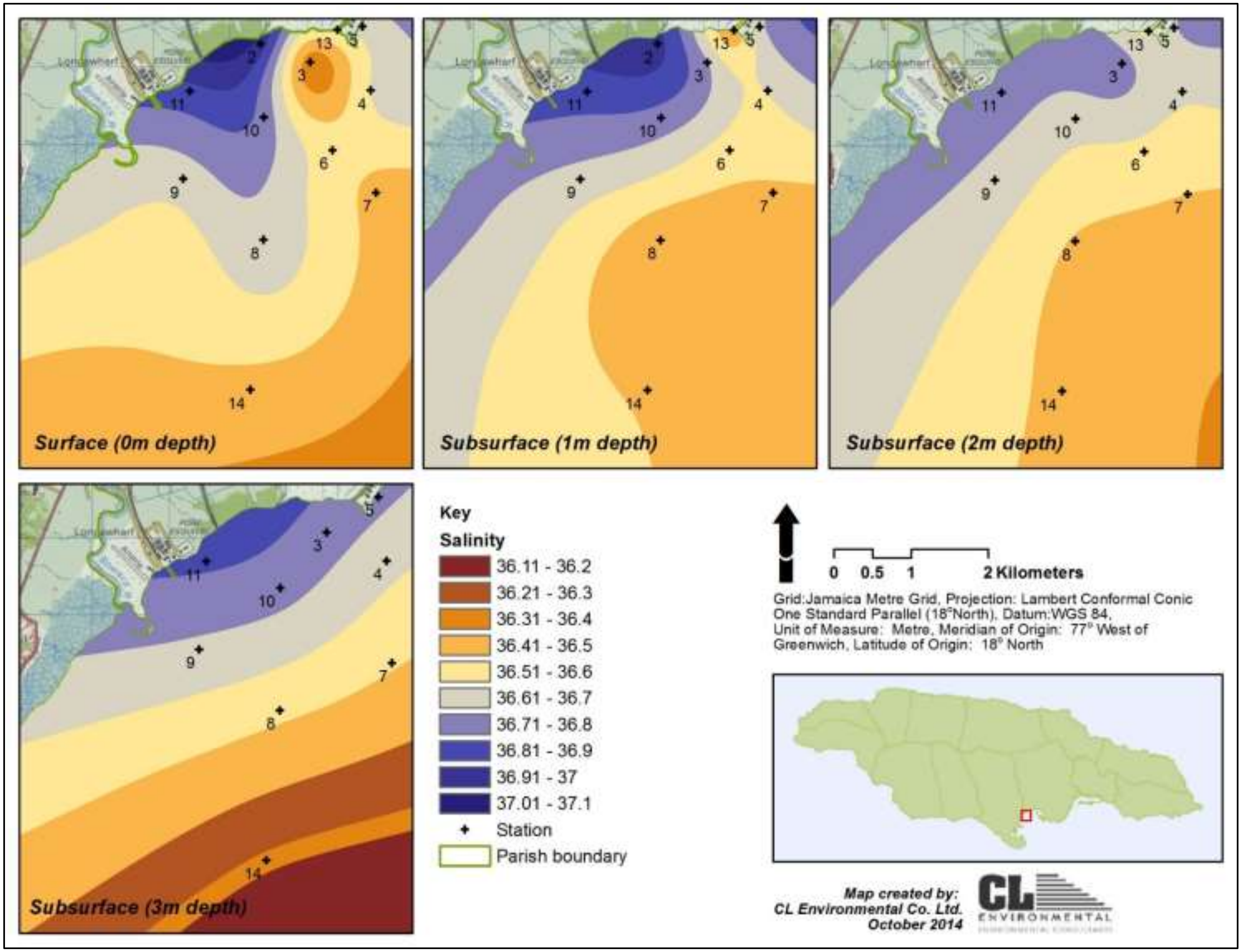


Figure 5-65 Spatial salinity comparison for 0m, 1m, 2m and 3m depths in 2014 study

pH

Average pH values ranged from 7.74 – 8.33 across the stations. The highest pH value was reported at station WQ14 and the lowest pH was reported at station WQ1. All stations were within the NEPA Standard for Seawater of 8.0 – 8.4 for pH, excepting for Station WQ1 located in the Bowers Gully and Station WQ2 located at the mouth of the Bowers Gully (Figure 5-66). In marine waters, pH levels tend to range between 8-9 pH units. Higher pH indicates the possibility of photosynthesis changing the pH within the zone.

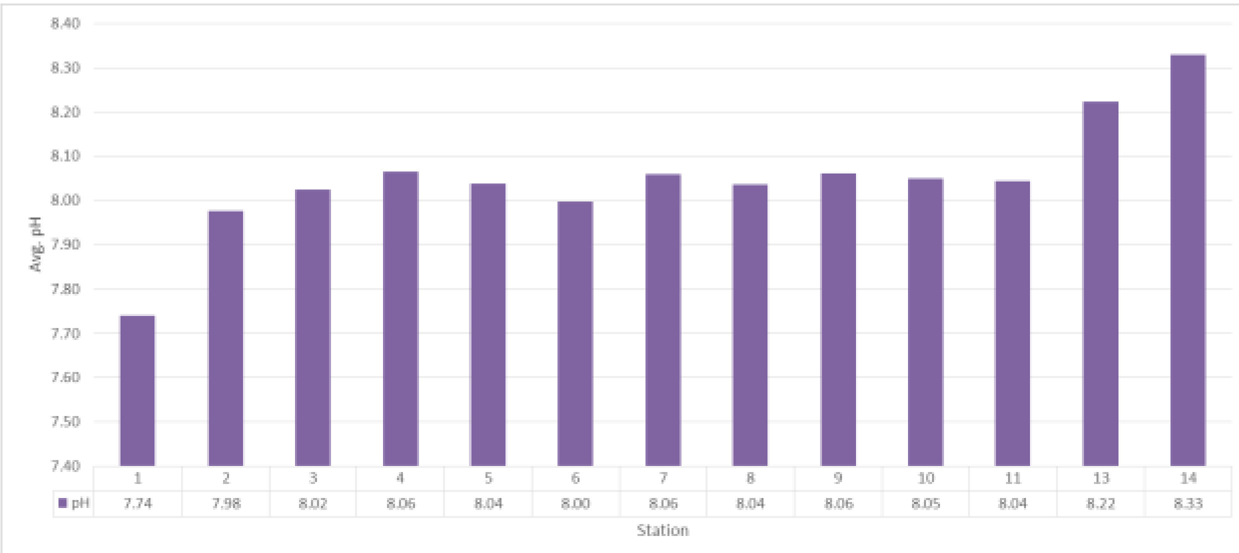


Figure 5-66 Average pH values at the various stations

Dissolved Oxygen (DO)

Average Dissolved oxygen values ranged from 5.34 – 6.32mg/l across the stations. The highest value was observed at station WQ14, as this was the station located furthest from the coastline and prone to having less anthropogenic pollution sources thus higher dissolved oxygen content. The lowest D.O. value was reported at station WQ5. Average D.O. values at all locations were above the NEPA standard of 5 mg/l (Figure 5-67). Dissolved oxygen levels were all within acceptable levels (>4 mg/l) and above the level that would be considered detrimental to aquatic life (≤ 3 mg/l).

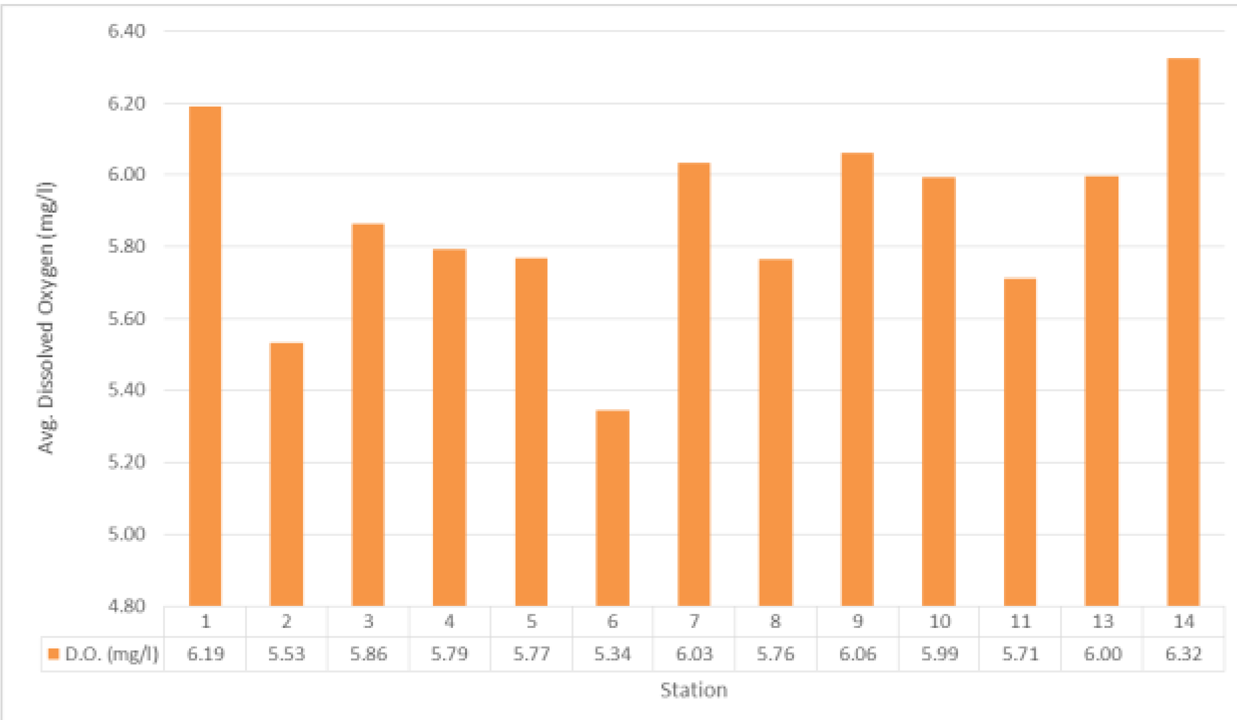


Figure 5-67 Average Dissolved oxygen values at the various stations

Turbidity

Average Turbidity values ranged from 1.5 – 75.4 NTU across the stations. The highest turbidity value was reported at station WQ9 while the lowest value was observed at station WQ6 which is located on a shallow area of reef northeast of the entrance to the shipping channel (Figure 5-68).

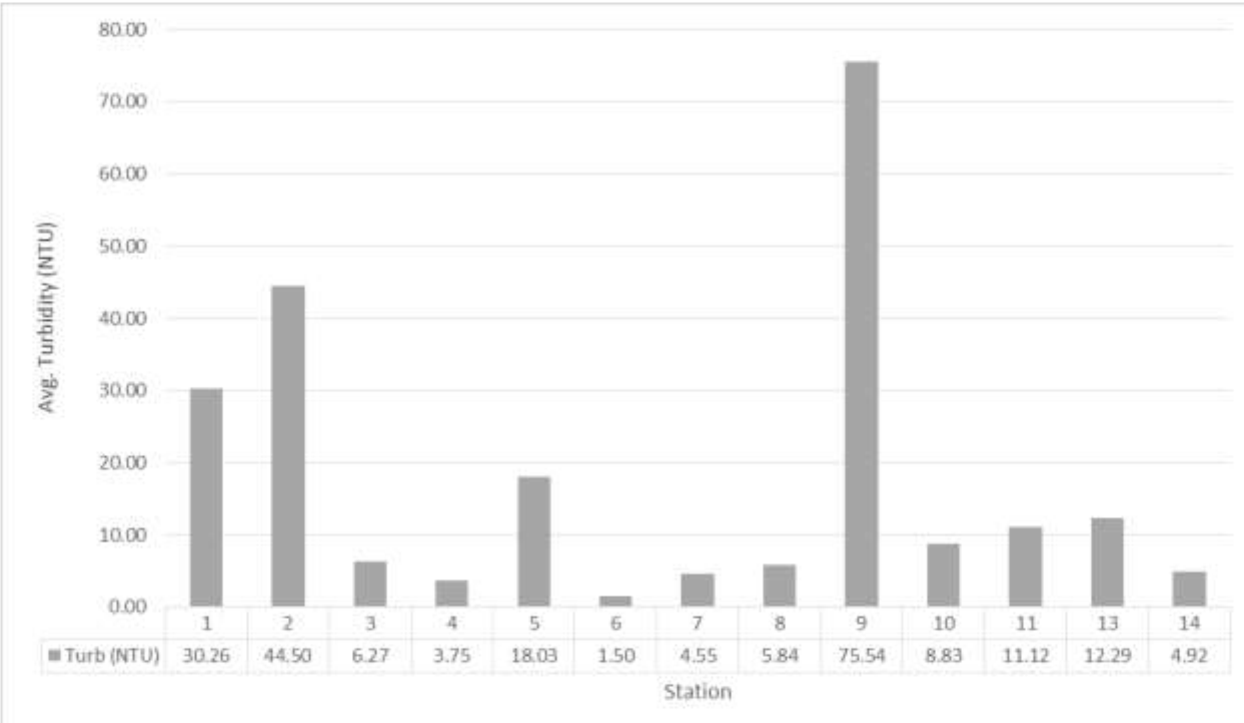


Figure 5-68 Average Turbidity values at the various stations

Total Dissolved Solids (TDS)

Average TDS varied little across the stations ranging from 31.87 – 35.18g/l. The lowest value was reported at WQ1 and the highest TDS value was reported at station WQ14 (Figure 5-69).

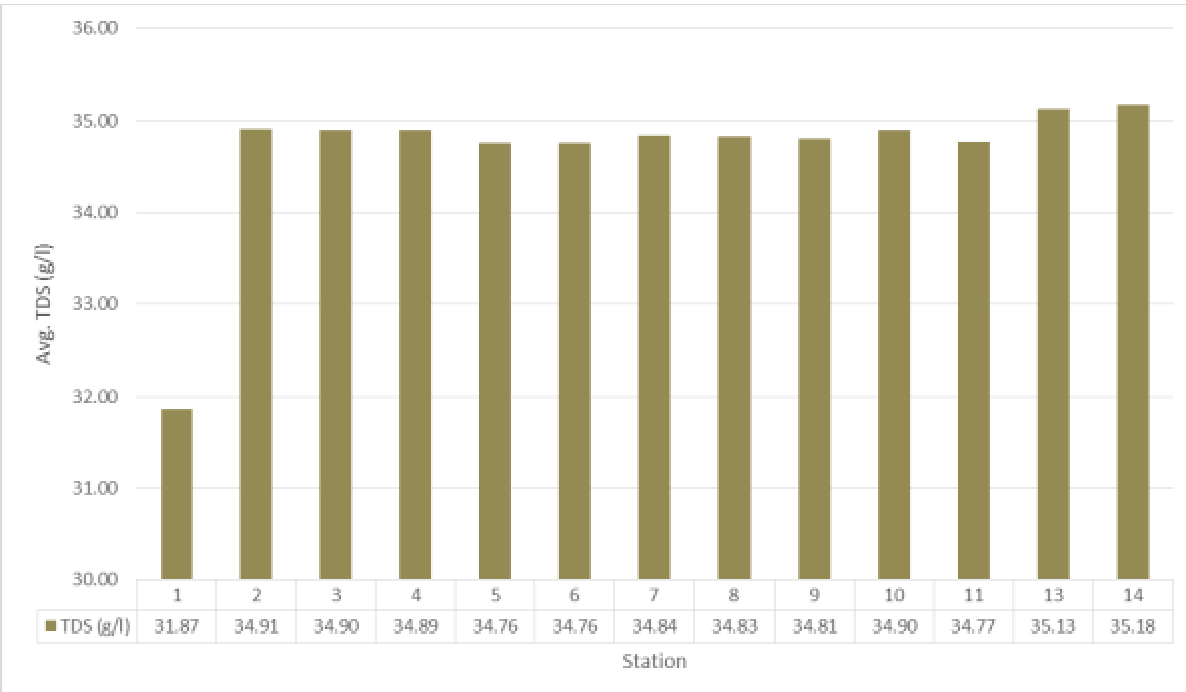


Figure 5-69 Average TDS values at the various stations

Photosynthetically Active Radiation (PAR)

Average PAR values ranged from 159.83 – 915 uE/m^2/s across the stations. The lowest PAR reading was obtained at station WQ14 and the highest value was obtained at station WQ13. When compared with depth, all stations showed a general decrease in PAR levels with increasing depth. This is expected as with increasing depth less active radiation is able to penetrate (Figure 5-70).

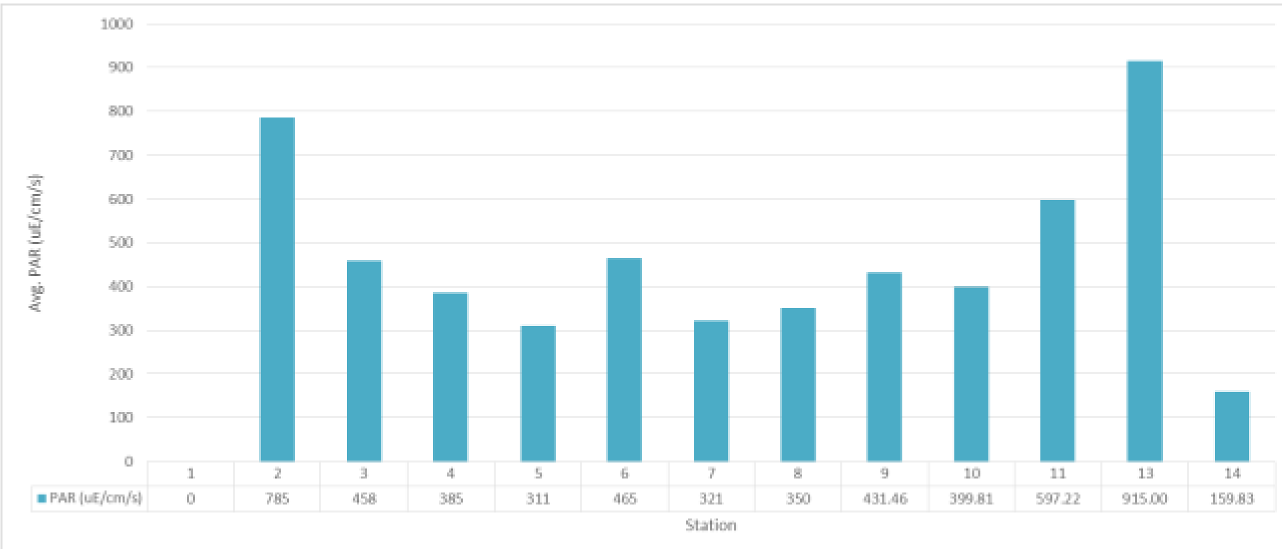
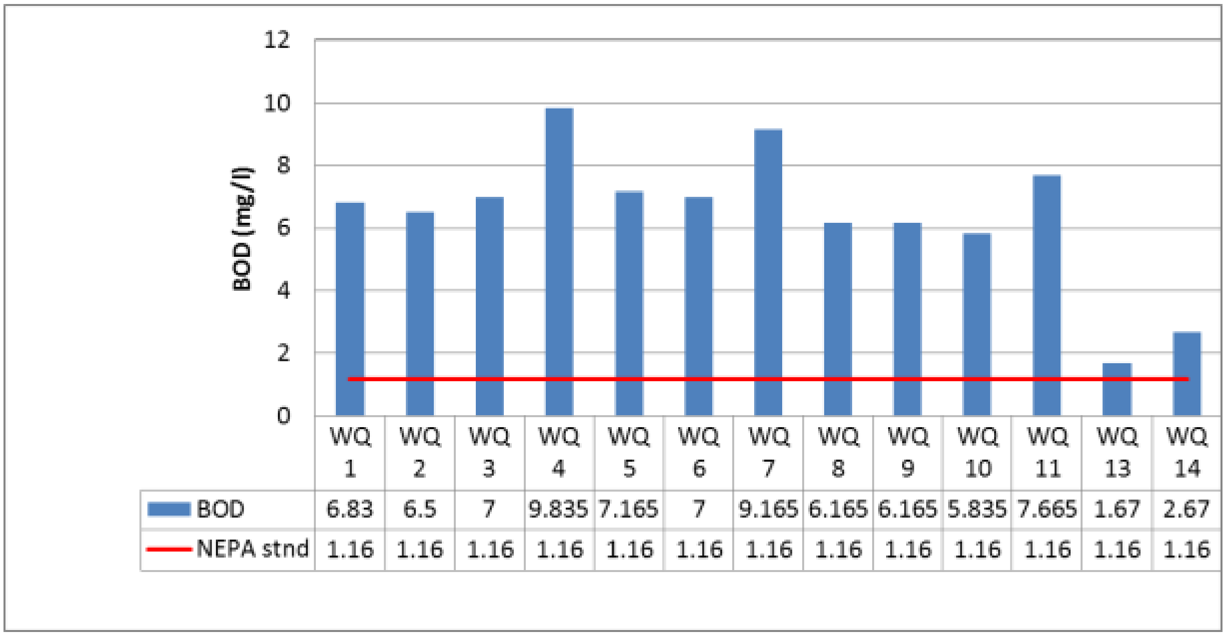


Figure 5-70 Average PAR values at the various stations

Biochemical Oxygen Demand (BOD)

Average BOD values ranged from 1.67 – 9.835 mg/l across the stations. The highest average BOD value was reported at station WQ4 whereas the lowest value was observed at station WQ13. All stations had values that were above the NEPA BOD Standard for Seawater of 1.16mg/l (Figure 5-71).



	WQ 1	WQ 2	WQ 3	WQ 4	WQ 5	WQ 6	WQ 7	WQ 8	WQ 9	WQ 10	WQ 11	WQ 13	WQ 14
BOD	6.83	6.5	7	9.835	7.165	7	9.165	6.165	6.165	5.835	7.665	1.67	2.67
NEPA stnd	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16

Figure 5-71 Average BOD values at the various stations

Total Suspended Solids (TSS)

Average TSS values ranged from 5.0 – 42.0mg/l across the stations. Station WQ1 reported the highest value whereas the lowest value was observed at station WQ8. The Bowers Gully is prone to high suspended solid content from land based sources of pollution and terrigenous sediments. The lowest value was observed at station WQ8 which is located far from the coastline and prone to having low sediment churning and low anthropogenic pollution sources thus low suspended solid content (Figure 5-72).

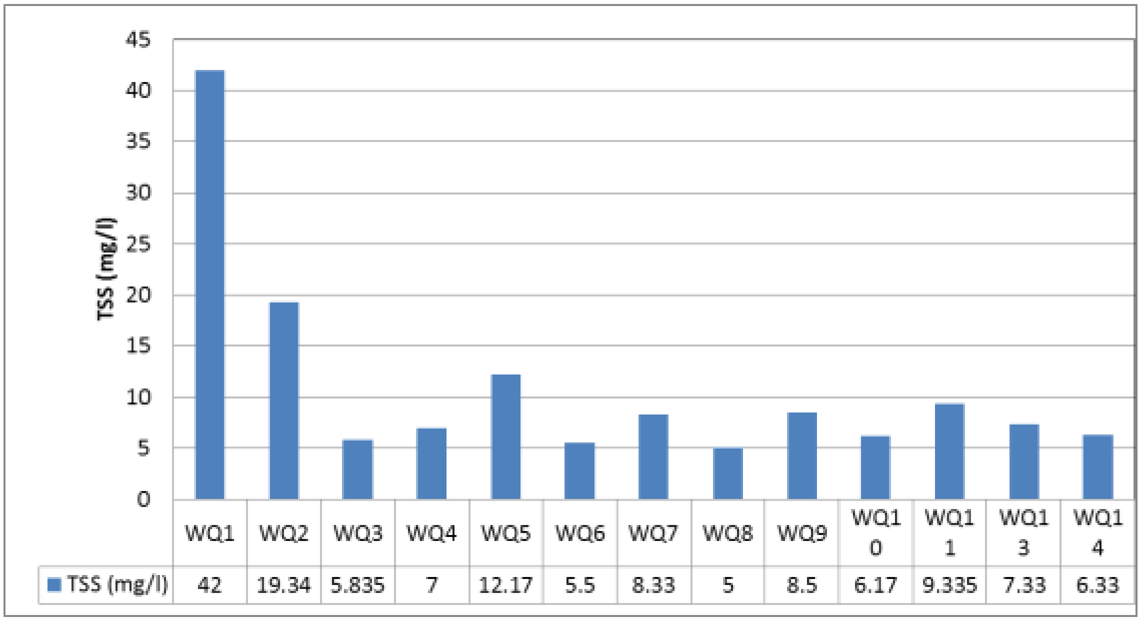


Figure 5-72 Average TSS values at the various stations

Nitrate

Average Nitrate values ranged from 0.6 – 2.07mg/l across the stations. The lowest nitrate value was reported at station WQ1 which is the Bowers Gully. The highest nitrate value was observed at station WQ13 located by the JPS cooling water outlet. All stations were above the NEPA standard for Seawater for nitrates; however, these values are typical for Jamaican coastal waters (Figure 5-73).

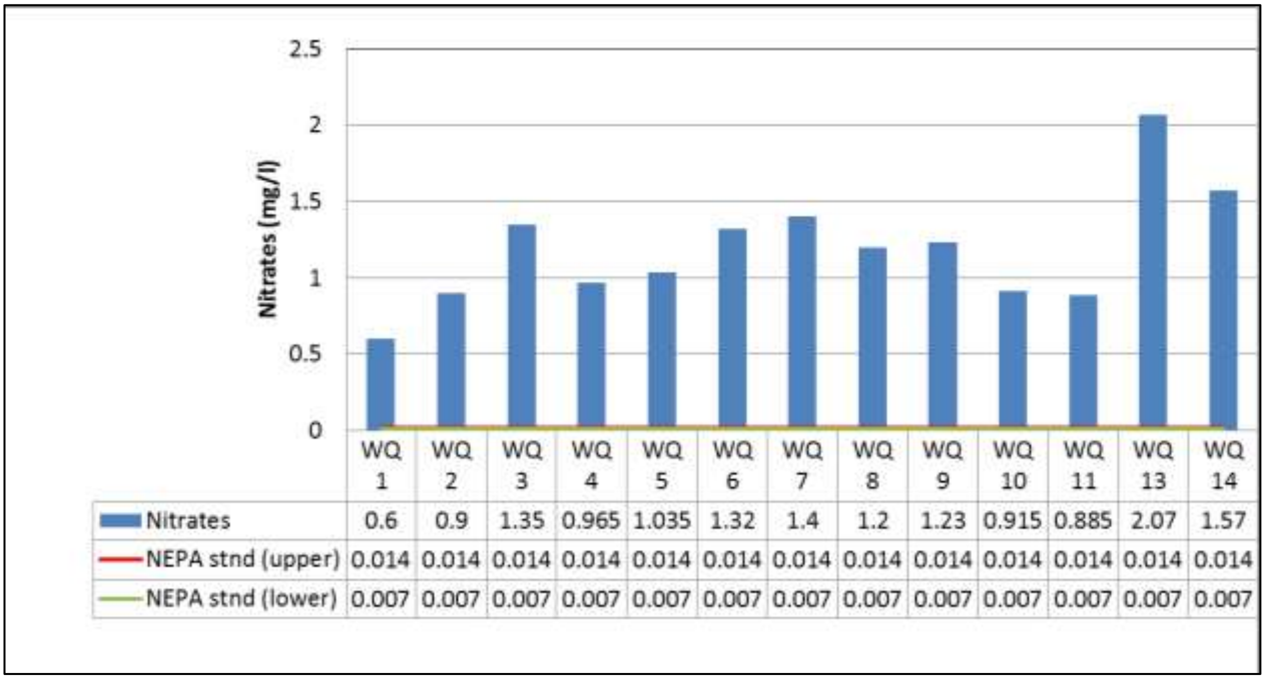
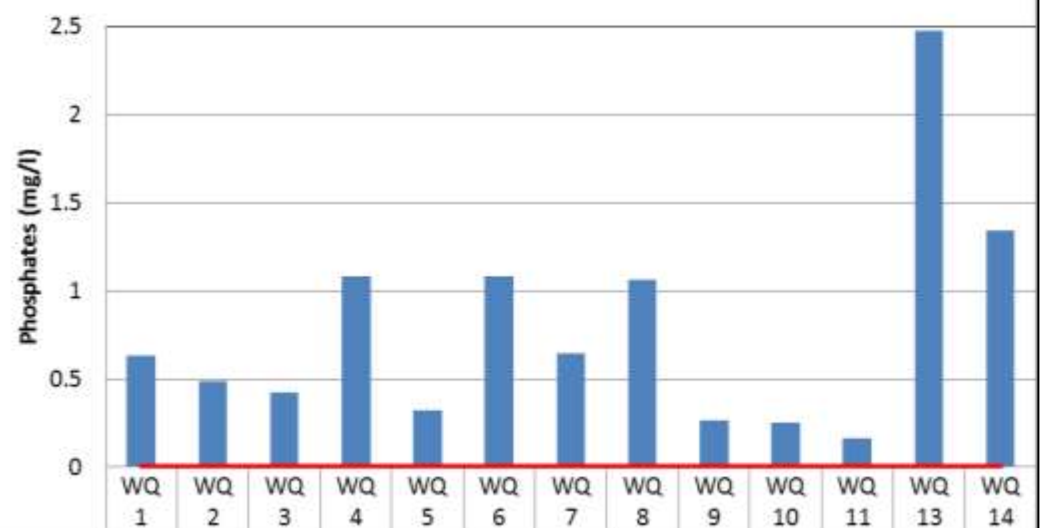


Figure 5-73 Average Nitrate values at the various stations

Phosphate

Average Phosphate values ranged from 0.165 – 2.48 mg/l across the stations. The lowest phosphate value was reported at station WQ11 while the highest phosphate value was observed at station WQ13 located by the JPS cooling water outlet. Similar to the nitrate values, all stations were above the NEPA standard for seawater for phosphates; however, these values are typical for Jamaican coastal waters (Figure 5-74).



	WQ 1	WQ 2	WQ 3	WQ 4	WQ 5	WQ 6	WQ 7	WQ 8	WQ 9	WQ 10	WQ 11	WQ 13	WQ 14
Phosphates	0.635	0.49	0.425	1.085	0.325	1.08	0.645	1.065	0.265	0.25	0.165	2.48	1.34
NEPA stnd (lower)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
NEPA stnd (upper)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

Figure 5-74 Average Phosphate values at the various stations

Fats, Oils and Grease (FOG)

Average FOG values ranged from 2.0 – 25.785 mg/l across the stations. The highest value was reported at station WQ9 while the lowest value was reported at station WQ14 (Figure 5-75).

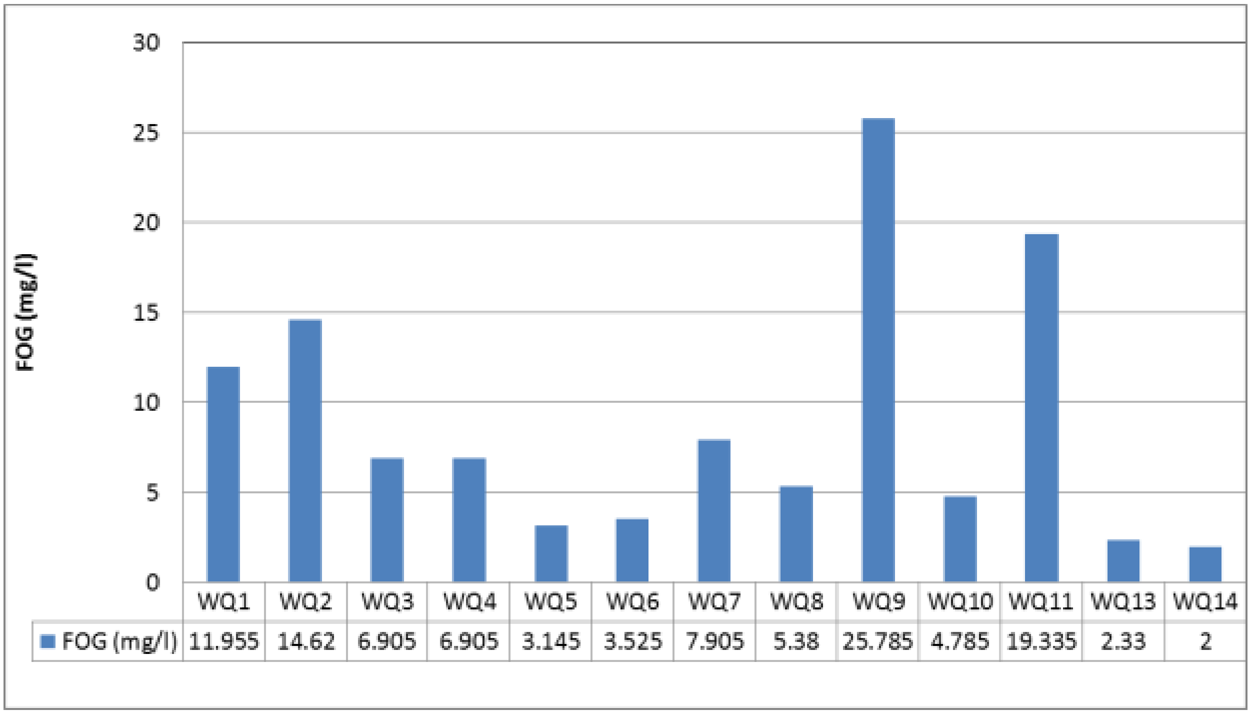


Figure 5-75 Average FOG values at the various stations

Faecal Coliform

Average Faecal coliform values ranged from 10 – 657.5 MPN/100ml across the stations. The highest value was reported at station WQ3 while the lowest value was reported at stations WQ 14 (Figure 5-76). It is important to note that goat and cattle farming are prevalent in the area close to the Bowers Gully and informal settlements are also located in and around this area, which may contribute to elevate coliform levels in the gully and marine areas.

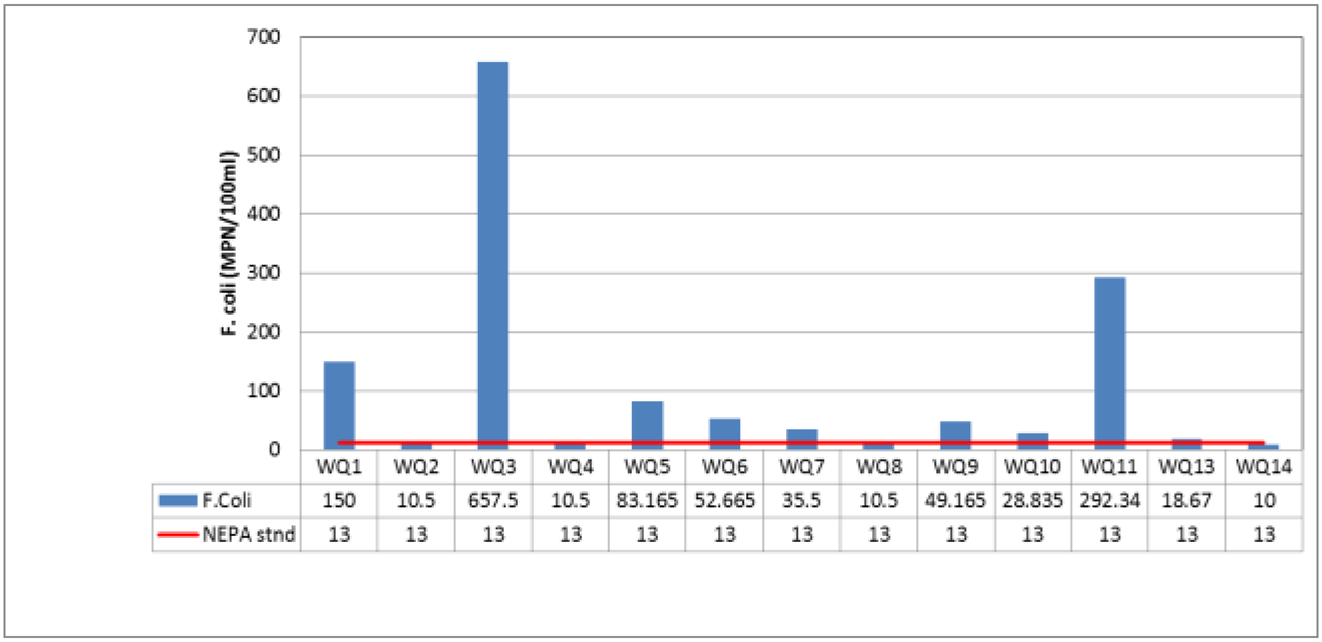


Figure 5-76 Average Faecal coliform values at the various stations

Total Petroleum Hydrocarbons – DRO and GRO

Average Diesel Range Organics (DRO) of 1.5 mg/l was detected at Station 3 during the 2012 study. No other Total Petroleum Hydrocarbons (TPH – DRO and GRO) were detected at any other stations on any of the sampling runs.

Potable Water (Station 12)

Table 5-47 and Table 5-48 below shows the average potable water quality values for Station 12, compared with the NEPA Draft Ambient Freshwater Standards, 2009 and World Health Organization Drinking Water Guidelines. The results indicate that the water is of good quality.

Table 5-47 Average Physicochemical data for potable water station 12.

Station	Temp. (°C)	Cond. (mS/cm)	Sal. (ppt)	pH	D.O. (mg/l)	Turb (NTU)	TDS (g/l)
12	30.13	1.35	0.71	7.56	7.44	0.57	0.81
NEPA Standard	-	*0.15–0.6*	-	*7 – 8.4*	-	-	*0.12-0.3*

Values in red are non-compliant with Standard/Guideline

Table 5-48 Chemical data for potable water station 12.

Station	Residual Chlorine (mg/l)	Nitrate (mg/l)	F.coliform (mpn/100ml)	Arsenic (mg/l)	Barium (mg/l)	Boron (mg/l)	Cadmium (mg/l)	Chromium (mg/l)
12	0.42	2.0	19.8	ND	0.084	0.028	ND	ND
NEPA Standard	-	*0.1-7.5*	-	-	-	-	-	-
WHO Guideline	***0.2***	***50***	-	***0.01***	***0.7***	***0.5***	***0.003***	***0.05***
	Copper (mg/l)	Lead (mg/l)	Manganese (mg/l)	Nickel (mg/l)	Selenium (mg/l)	Mercury (mg/l)	Tot. Cyanide (mg/l)	Fluoride (mg/l)
12	0.016	ND	0.004	ND	ND	ND	ND	0.14
NEPA Standard	-	-	-	-	-	-	-	-
WHO Guideline	***2***	***0.01***	***0.4***	***0.07***	***0.01***	***0.006***	***0.07***	***1.5***

ND – None Detected

5.1.10.3 Results (2016)

Apart from the physical parameters (temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, and total dissolved solids - TDS), the parameters analysed for the marine water samples were: BOD, COD, Total Suspended Solids, Nitrates, Phosphates, Faecal Coliform and Total Petroleum Hydrocarbons (TPH) – Gasoline Range Organics (GRO) and Diesel Range Organics (DRO), at four (4) marine locations by the proposed floating storage regasification terminal.

Table 5-49 shows the average physicochemical water quality data for each station while Table 5-50 shows the average biochemical data.

Table 5-49 Average physicochemical water quality data for 2016

Stn	TEMP. °C	COND (mS/cm)	SAL (ppt)	pH	PAR (uE/cm/s)	D.O. (mg/l)	Turb (NTU)	TDS (g/l)
WQ1	29.52	56.10	37.34	8.10	427	6.25	2.15	35.90
WQ2	29.49	56.06	36.81	8.07	389	6.19	2.32	35.44
WQ3	28.94	56.13	37.35	8.10	439	6.25	0.88	35.91
WQ4	29.51	56.08	37.32	8.11	499	6.25	2.20	35.89

Table 5-50 Average biochemical water quality data for 2016

Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	COD (mg/l)	F. coliform (MPN/100ml)	DRO (mg/l)	GRO (mg/l)
WQ1	0.9	<5	1.45	0.065	243	26	ND	ND
WQ2	0.765	<5	1.6	0.085	132	<2	0.22	ND
WQ3	0.33	<5	1.7	0.12	123	<2	0.52	ND
WQ4	0.9	<5	1.7	0.055	154	<2	0.23	ND

ND – None Detected

Temperature

Average temperature values ranged from 28.94 – 29.52°C across the stations. The highest temperature value was reported at station WQ1 and the lowest temperature was at station WQ3 (Figure 5-77).

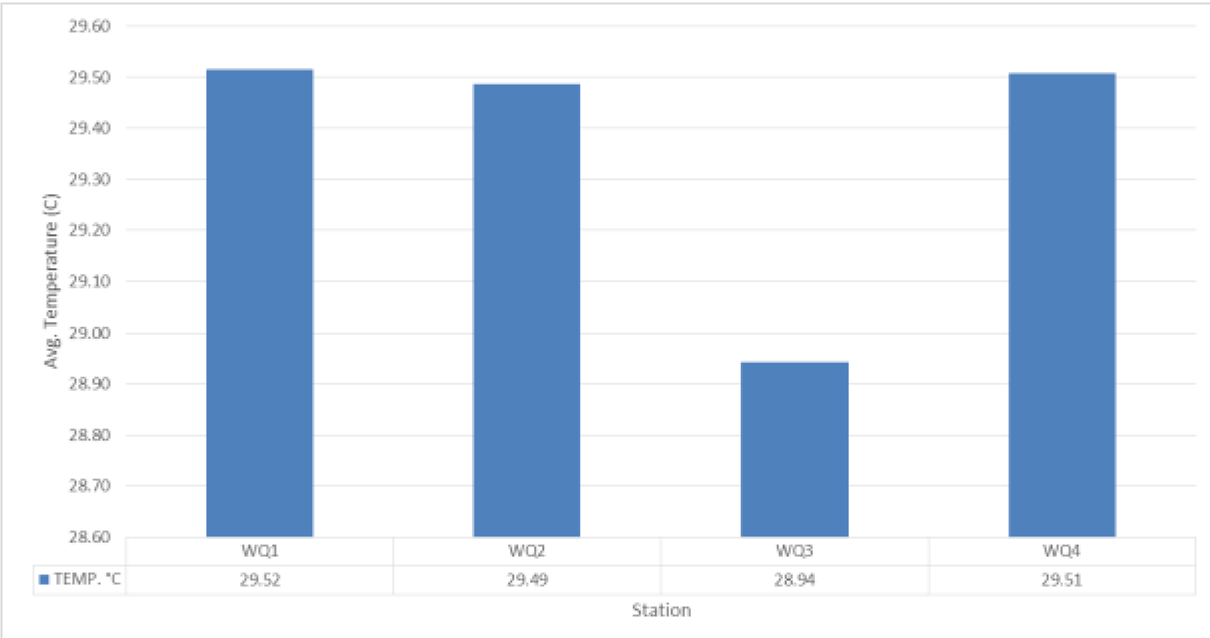


Figure 5-77 Average Temperature values at the various stations

Specific Conductivity (SpC)

Average specific conductivity values ranged from 56.06 – 56.13mS/cm across the stations. The lowest values were reported at station WQ2 while station WQ3 had the highest value (Figure 5-78).

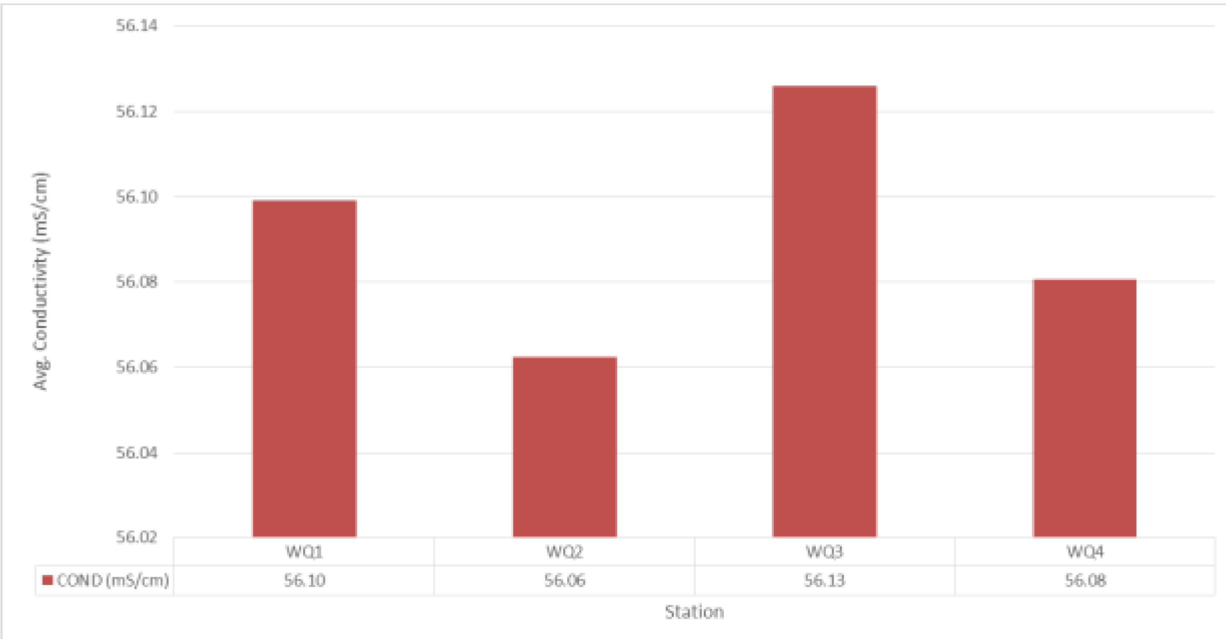


Figure 5-78 Average Conductivity values at the various stations

Salinity

Average salinity values ranged from 36.81 – 37.35ppt across the stations. The lowest values were reported at station WQ2 while station WQ3 had the highest value (Figure 5-79).

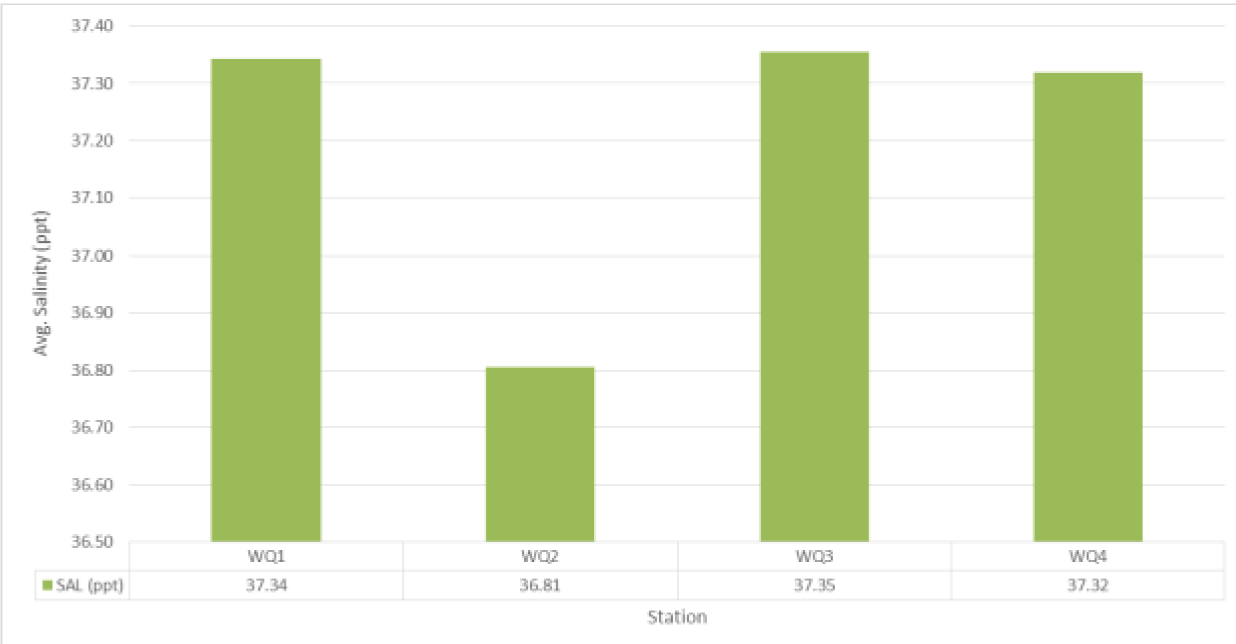


Figure 5-79 Average Salinity values at the various stations

pH

Average pH values ranged from 8.07 – 8.11 across the stations. The highest pH value was reported at station WQ4 and the lowest pH was reported at station WQ2. All stations were within the NEPA Standard for Seawater of 8.0 – 8.4 for pH (Figure 5-80). In marine waters, pH levels tend to range between 8-9 pH units. Higher pH indicates the possibility of photosynthesis changing the pH within the photic zone.

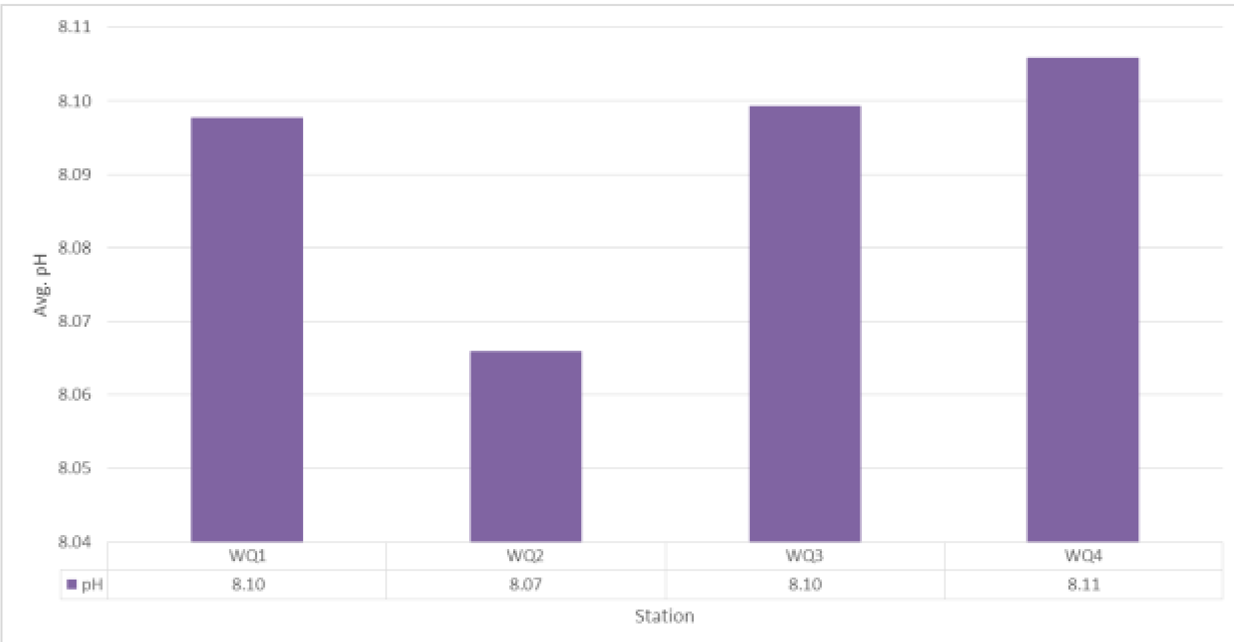


Figure 5-80 Average pH values at the various stations

Dissolved Oxygen (DO)

Average dissolved oxygen values ranged from 6.19 – 6.25mg/l across the stations. The highest value was observed at stations WQ1,3 and 4 (6.25 mg/l) while the lowest D.O. value was reported at station WQ2. Average D.O. values at all locations were above the NEPA standard of 5 mg/l (Figure 5-81). Dissolved oxygen levels were all within acceptable levels (>4 mg/l) and above the level that would be considered detrimental to aquatic life (≤ 3 mg/l).

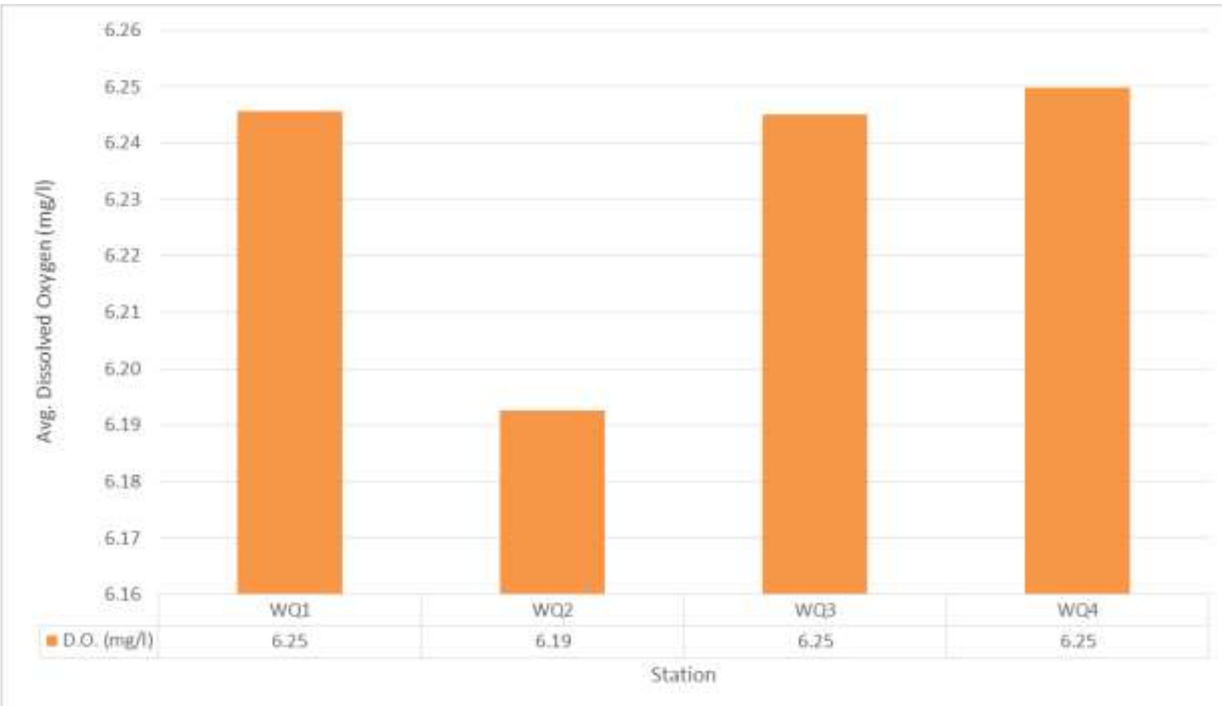


Figure 5-81 Average Dissolved oxygen values at the various stations

Turbidity

Average turbidity values ranged from 0.88 – 2.32 NTU across the stations. The highest turbidity value was reported at station WQ2 while the lowest value was observed at station WQ3 (Figure 5-82).

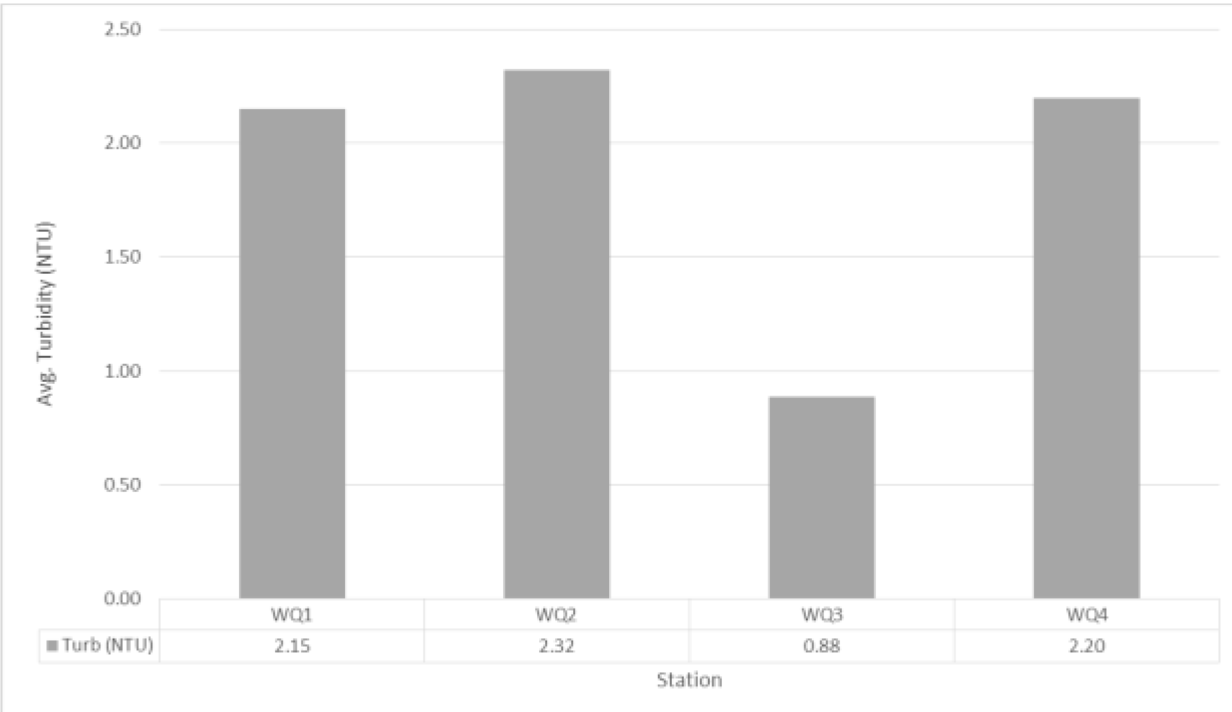


Figure 5-82 Average Turbidity values at the various stations

Total Dissolved Solids (TDS)

Average TDS values ranged from 35.44 – 35.91 g/l. The lowest value was reported at WQ2 and the highest TDS value was reported at station WQ3 (Figure 5-83).

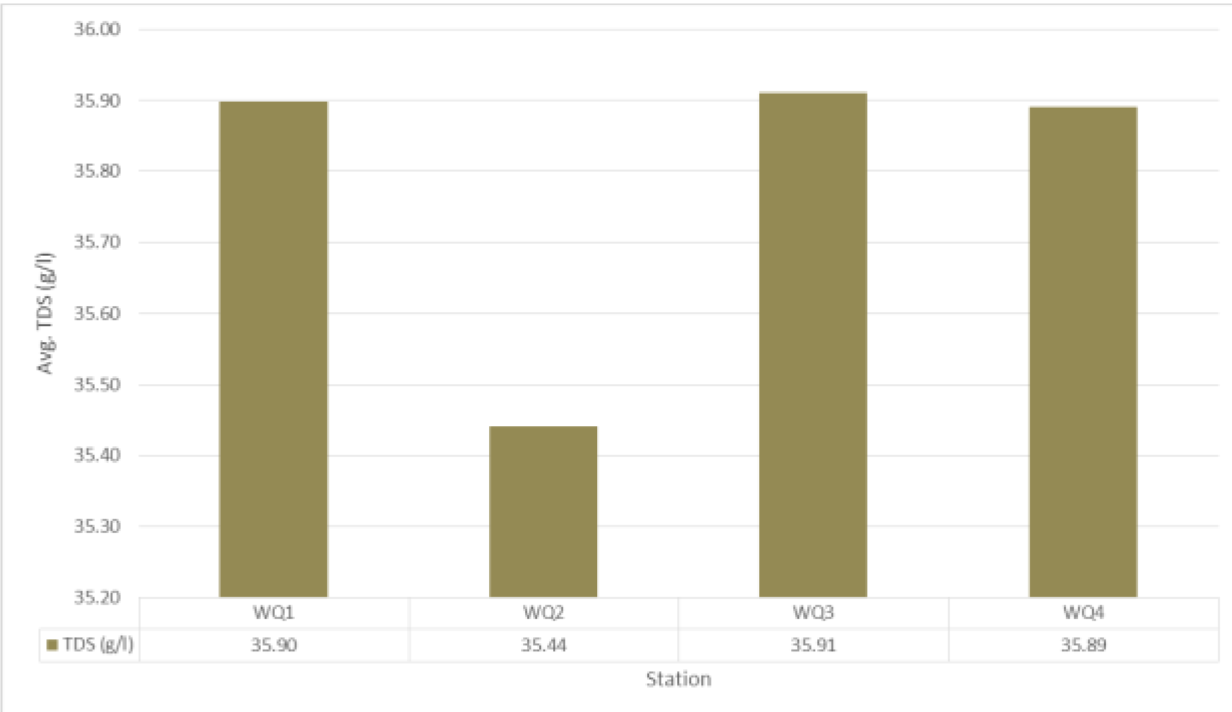


Figure 5-83 Average TDS values at the various stations

Photosynthetically Active Radiation (PAR)

Average PAR values ranged from 389 – 499 uE/m^2/s across the stations. The lowest PAR reading was obtained at station WQ2 and the highest value was obtained at station WQ4. When compared with depth, all stations showed a general decrease in PAR levels with increasing depth. This is expected as with increasing depth less photosynthetically active radiation is able to penetrate the water column (Figure 5-84).

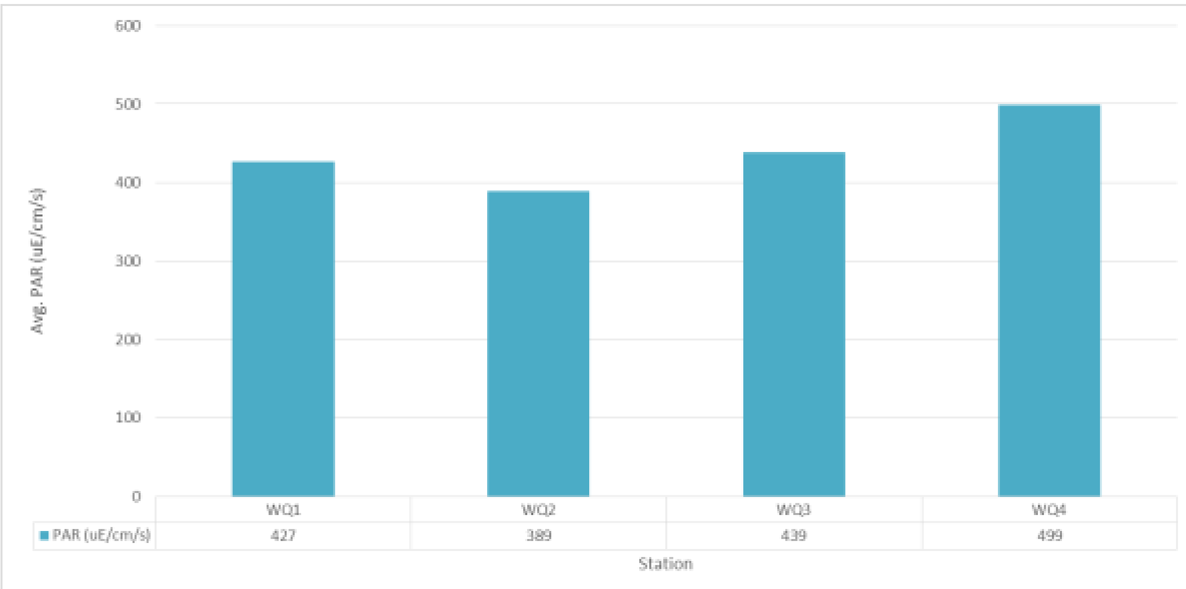


Figure 5-84 Average PAR values at the various stations

Biochemical Oxygen Demand (BOD)

The average BOD values ranged from 0.33 – 0.9 mg/l across the stations. The highest average BOD value was reported at station WQ1 and WQ4 whereas the lowest value was observed at station WQ3. All stations had values that were compliant with the NEPA BOD Standard for Seawater of 1.16mg/l (Figure 5-85).

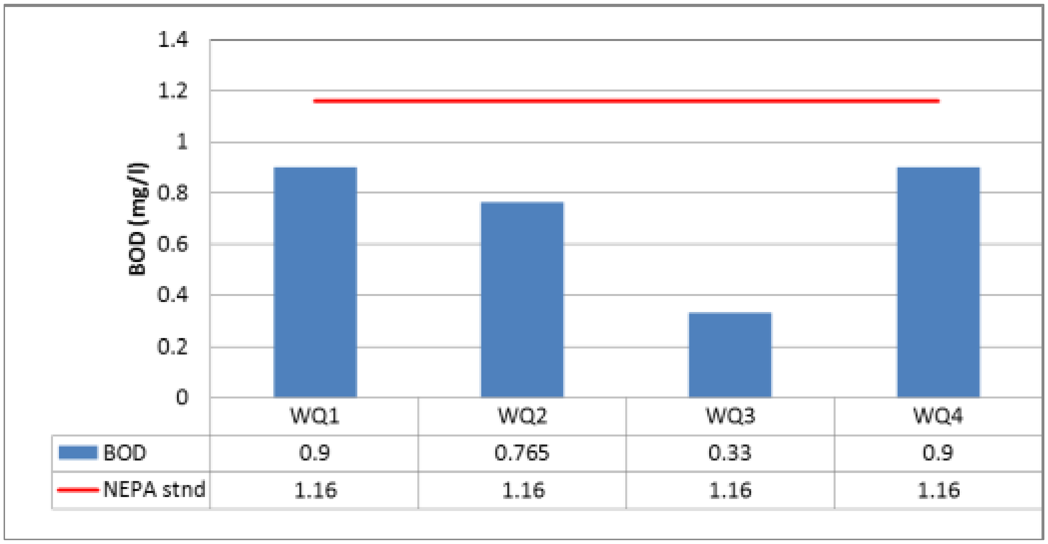


Figure 5-85 Average BOD values at the various stations

Total Suspended Solids (TSS)

Average TSS values were all less than 5 mg/l. These concentrations indicated clear water as they were below 20mg/l. (Figure 5-86).

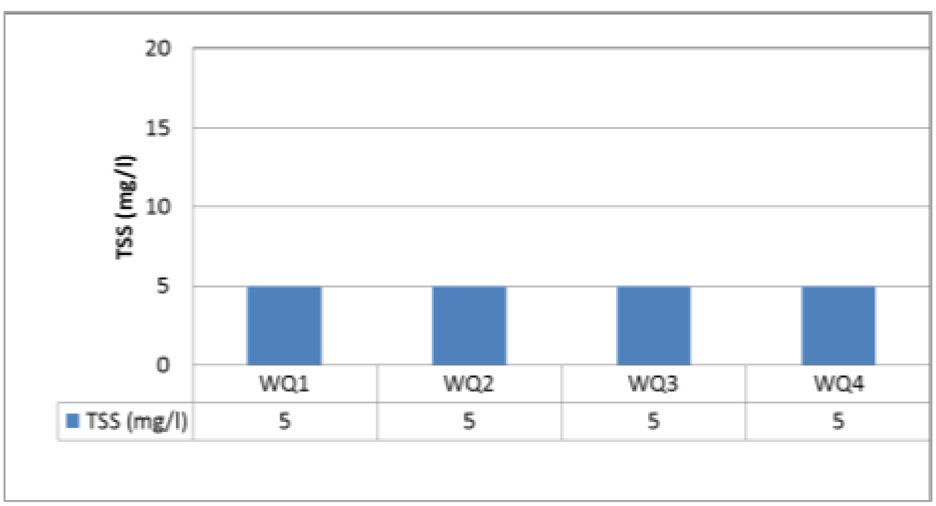


Figure 5-86 Average TSS values at the various stations

Nitrate

Average nitrate values ranged from 1.45 – 1.7mg/l across the stations. The lowest nitrate value was reported at station WQ1 while the highest nitrate values were observed at stations WQ3 and WQ4. All stations were above the NEPA standard for Seawater for nitrates; however, these values are typical for Jamaican coastal waters (Figure 5-87).

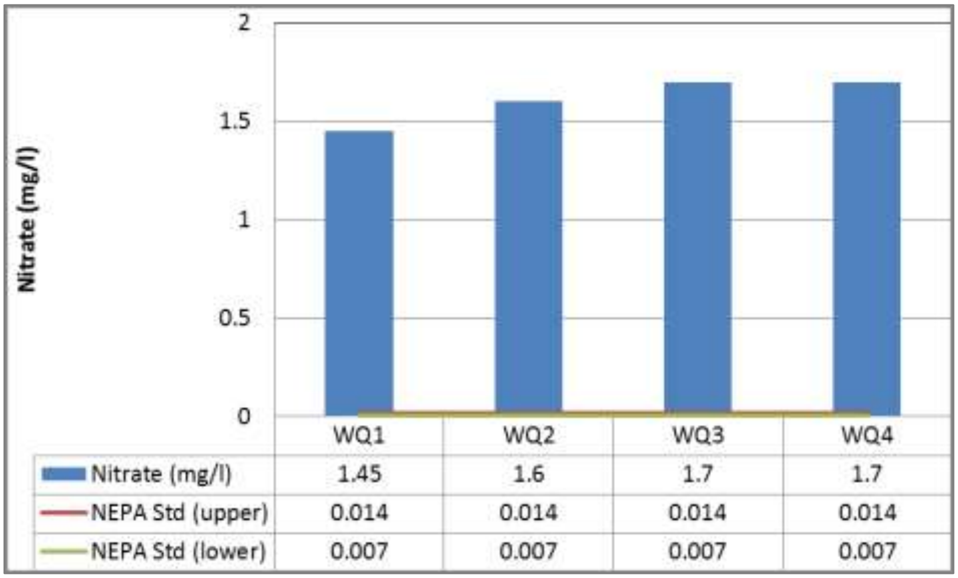


Figure 5-87 Average Nitrate values at the various stations

Phosphate

Average phosphate values ranged from 0.055 – 0.12 mg/l across the stations. The lowest phosphate value was reported at station WQ4 while the highest phosphate value was observed at station WQ3. Similar to the nitrate values, all stations were above the NEPA standard for seawater for phosphates; however, these values are typical for Jamaican coastal waters (Figure 5-88).

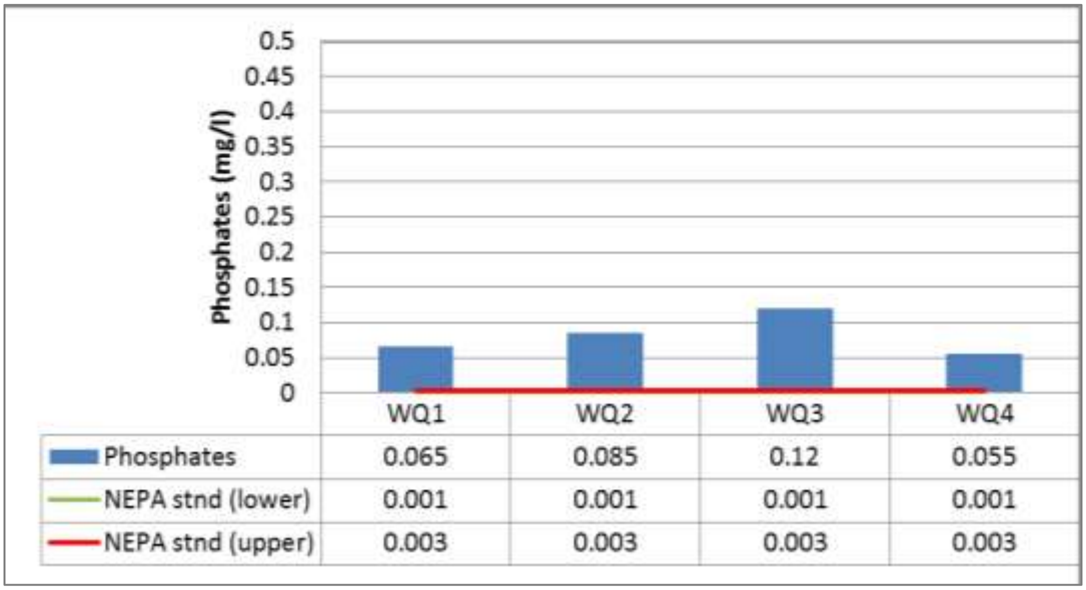


Figure 5-88 Average Phosphate values at the various stations

Chemical Oxygen Demand (COD)

COD values ranged from 123 – 243 mg/l across the stations. The highest value was reported at station WQ1 while the lowest value was reported at station WQ3 (Figure 5-89).

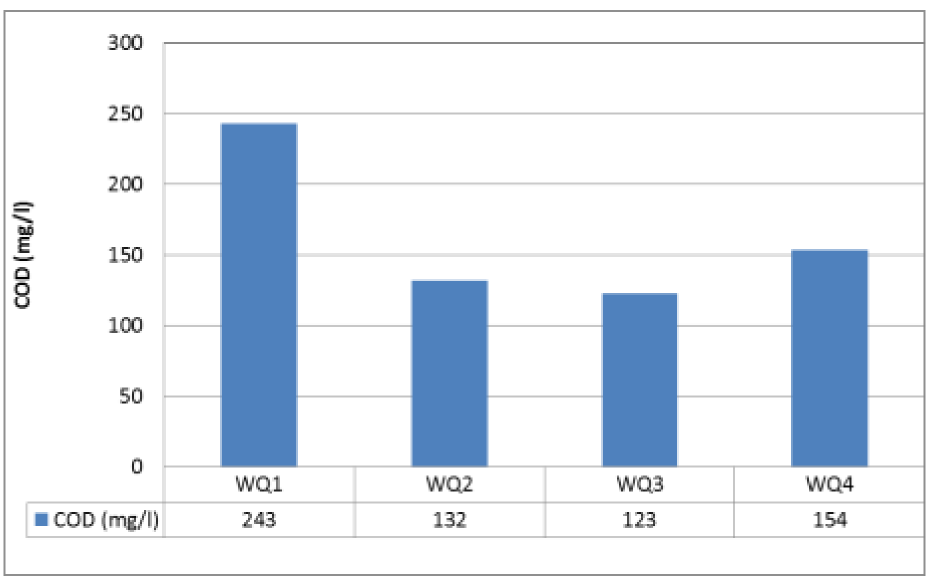


Figure 5-89 Average COD values at the various stations

Faecal Coliform

Average Faecal coliform values ranged from 1.95 – 26 MPN/100ml across the stations. The highest value was reported at station WQ1 while the lowest values were reported at the other three stations (1.95 MPN/100ml) (Figure 5-90). Only WQ1 exceeded the NEPA standard.

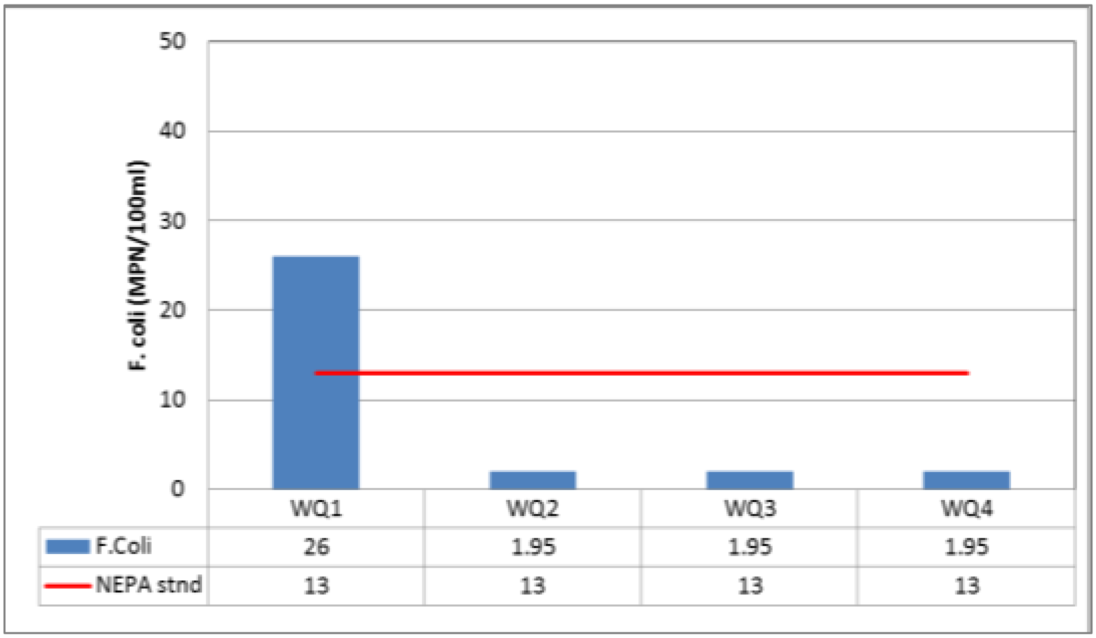


Figure 5-90 Average Faecal coliform values at the various stations

Total Petroleum Hydrocarbons – DRO and GRO

Gasoline Range Organics (GRO) were not detected in any of the samples taken on any sampling runs. However, there were minor traces of Diesel Range Organics (DRO) detected at Stations WQ2, WQ3 and WQ4. No traces of DRO were detected at Station WQ1.

5.1.11 Air Quality

5.1.11.1 Historical Ambient Air Quality Monitoring Data (SO_2, NO_2, O_3)

Data from the Lauderwood Air Quality Monitoring Station operated by JPS are indicated in Table 5-51. The table shows the measured 1-h and 24-h maximum and annual mean SO_2 concentrations, the 1-h maximum and annual mean NO_2 concentrations and the 1-h maximum O_3. All measurements for all five years are below the National Ambient Air Quality Standards for the respective averaging periods.

Table 5-51 Historical ambient air quality monitoring data for Lauderwood Air Quality Monitoring Station

Pollutant	Year	Max 1-h, µg/m³	Max 24-h, µg/m³	Annual Mean, µg/m³
SO_2	2009	235.4	75.6	15.5
SO_2	2010	47.1	17.95	8.9
SO_2	2011	258.2	174.7	3.1

Pollutant	Year	Max 1-h, µg/m³	Max 24-h, µg/m³	Annual Mean, µg/m³
SO_2	2012	146.5	31.5	6.5
SO_2	2013	505.1	38.0	5.7
SO_2	Standard	700	280	60
NO_2	2009	103.4	N/A	11.2
NO_2	2010	105.3	N/A	6.4
NO_2	2011	157.9	N/A	5.5
NO_2	2012	377.9	N/A	11.1
NO_2	2013	45.9	N/A	8.8
NO_2	Standard	400	N/A	100
O_3	2009	134.4	N/A	18.3
O_3	2010	51	N/A	9.9
O_3	2011	82.4	N/A	15.75
O_3	2012	227.5	N/A	11.6
O_3	2013	113.8	N/A	25.9
O_3	Standard	235	N/A	N/A

5.1.11.2 Particulate Sampling (PM2.5 and PM10)

The following particulate data was taken from the 2015 JPS 190 MW EIA and the 2012 SJPC 360MW EIA documents. The particulates assessment was conducted to establish baseline conditions along the proposed boundaries of both the JPS 190 MW and the SJPC 360 MW power plant sites and in the surrounding environs. There were no particulate monitoring locations in common between the two EIA studies.

Methodology

The readings were taken at locations listed in Table 5-52 and Table 5-53 and depicted in Figure 5-91 at the boundaries of the proposed sites and in the surrounding environs.

PM2.5 and PM10 particulate sampling was conducted for 24 hours using Airmetrics Mini-Volume Tactical Air Samplers and Tisch High Volume Samplers. Coarse particles (PM10) are airborne pollutants that fall between 2.5 and 10 micrometres in diameter. Sources of coarse particles include crushing or grinding operations and dust stirred up by vehicles traveling on roads. Fine particle (PM2.5) are airborne pollutants that fall below 2.5 micrometres in diameter. Sources of fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

Total Suspended Particles (TSP) particulate sampling was conducted for the JPS 190 MW EIA. TSP are particles of sizes 100 micrometres or less and include coarse (PM10) and fine (PM2.5) particles.

In 1987, U.S. Environmental Protection Agency replaced TSP with PM10 as the indicator for both the annual and 24-hour health-related standards. The reason for this is because exposure to PM10 particles may cause serious health/respiratory related issues as these particles are retained deep in the lungs.

Table 5-52 JPS 190MW EIA Particulate sampling locations

STATIONS	LOCATIONS	JAD 2001 (m)	
		E	N
P1	North-Western Property Boundary	738508.72	638937.99
P2	South-Western Property Boundary	738486.45	638860.04
P3	South-Eastern Property Boundary	738573.82	638884.88
P4	North-Eastern Property Boundary	738614.94	638979.11
P5	Old Harbour Bay Police Station	739747.33	639705.67

Table 5-53 SJPC 360MW EIA Particulate sampling locations

STATIONS	LOCATIONS	JAD 2001 (m)	
		E	N
P1	Northern Property Boundary	738107.646	639615.054
P2	Eastern Property Boundary	738230.127	639360.186
P3	Southern Property Boundary	738104.944	639109.821
P4	Western Property Boundary	737985.165	639362.888
P5	Esquivel Road	639772.19	737461.54
P6	Sandy Bay	643272.05	733434.60
P7	Blackwood Gardens Housing Scheme	639881.159	739192.250
P8	Bannister	647364.690	737793.276
P9	Colbeck	646766.871	734924.108

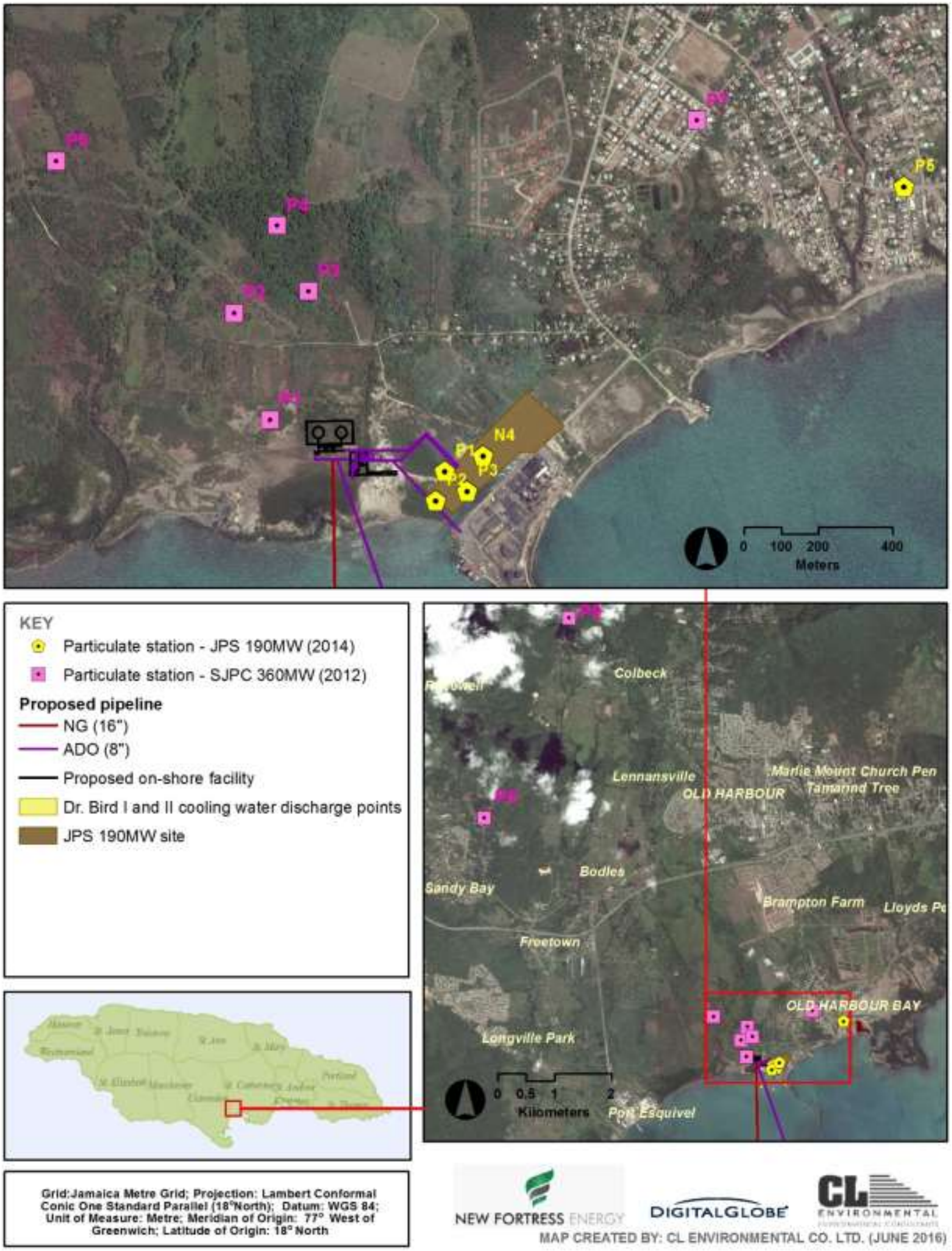


Figure 5-91 JPS 190MW and SJPC 360MW particulate sampling stations

Results

PM10

Table 5-54 and Table 5-55 shows the 2014 and 2012 PM10 results respectively. The PM10 results indicate that all locations during both EIA studies had particulate values compliant with the 24-hour US EPA standard of 150 µg/m³.

Table 5-54 JPS 190MW EIA PM10 Results

Station	Location	Range Result (µg/m³)	Mean Result (µg/m³)	US EPA Std. (µg/m³)
P1	North-Western Property Boundary	17.64 – 26.39	22.02	**150**
P2	South-Western Property Boundary	26.67 – 41.53	34.1	**150**
P3	South-Eastern Property Boundary	18.75 – 36.25	27.5	**150**
P4	North-Eastern Property Boundary	19.17 – 30.14	24.65	**150**
P5	Old Harbour Bay Police Station	42.36 – 44.17	43.26	**150**

Table 5-55 SJPC 360MW EIA PM10 Results

STATION	LOCATION	Range Result (µg/m³)	Mean Result (µg/m³)	US EPA Std. (µg/m³)
P1	Proposed Site- Southern Boundary	31.53 – 60.97	48.65	**150**
P2	Proposed Site- Western Boundary	32.78 – 57.22	45.69	**150**
P3	Proposed Site- Eastern Boundary	32.22 – 57.78	46.71	**150**
P4	Proposed Site- Northern Boundary	34.86 – 55.69	45.97	**150**
P5	Esquivel Road	38.06 – 59.31	49.91	**150**
P6	Sandy Bay	58.06 – 62.5	60.51	**150**
P7	Blackwood Gardens Housing Scheme	47.62 – 64.34	58.28	**150**
P8	Bannister	28.13 – 54	45.37	**150**
P9	Colbeck	27.65 – 54.71	45.06	**150**

PM 2.5

Table 5-56 and Table 5-57 shows the 2014/2015 and 2012 PM2.5 results respectively. The PM2.5 results indicate that all locations during both EIA studies had particulate values compliant with the 24-hour US EPA standard of 35 µg/m³.

Table 5-56 JPS 190MW EIA PM2.5 Results

Station	Location	Range Result (µg/m³)	Mean Result (µg/m³)	US EPA Std. (µg/m³)
P1	North-Western Property Boundary	11.94 – 16.53	14.24	**35**
P2	South-Western Property Boundary	4.17 – 11.39	7.78	**35**
P3	South-Eastern Property Boundary	7.08 – 11.39	9.24	**35**
P4	North-Eastern Property Boundary	13.06 – 16.25	14.66	**35**
P5	Old Harbour Bay Police Station	15.42 – 17.36	16.39	**35**

Table 5-57 SJPC 360MW EIA PM2.5 Results

STATION	LOCATION	Range Result (µg/m³)	Mean Result (µg/m³)	US EPA Std. (µg/m³)
P1	Proposed Site- Southern Boundary	13.06 – 16.53	14.4	**35**
P2	Proposed Site- Western Boundary	7.5 – 16.11	11.34	**35**
P3	Proposed Site- Eastern Boundary	7.92 – 11.53	9.96	**35**
P4	Proposed Site- Northern Boundary	6.11 – 10.69	7.68	**35**
P5	Esquivel Road	8.06 – 14.72	10.28	**35**
P6	Sandy Bay	6.25 – 10.14	7.73	**35**
P7	Blackwood Gardens Housing Scheme	12.03 – 23.73	16.5	**35**
P8	Bannister	5.48 – 36.35	16.16	**35**
P9	Colbeck	6.3 – 16.25	10.82	**35**

TSP

Table 5-58 shows the 2014/2015 JPS 190MW TSP results. The TSP results indicate that all locations had particulate values compliant with the 24-hour NEPA standard of 150 µg/m³.

Table 5-58 JPS 190MW EIA TSP Results

Station	Location	Range Result (µg/m³)	Mean Result (µg/m³)	NEPA TSP Standard (µg/m³)
P1	North-Western Property Boundary	41.94 – 69.44	55.69	**150**
P2	South-Western Property Boundary	53.19 – 74.58	63.89	**150**
P3	South-Eastern Property Boundary	67.5 – 99.58	83.54	**150**
P4	North-Eastern Property Boundary	45.42 – 78.89	62.16	**150**
P5	Old Harbour Bay Police Station	69.72 – 72.78	71.25	**150**

5.1.12 Noise

The following noise data were taken from the 2014/2015 JPS 190 MW EIA and the 2012 SJPC 360MW EIA documents. The data logging noise survey exercises were conducted to establish baseline conditions along the proposed boundaries of both the JPS 190 MW and the SJPC 360 MW power plant sites and in the surrounding environs. Only three (3) noise survey stations were common between the two EIA studies. These were Blackwood Gardens Housing Scheme, Old Harbour Bay Police Station and Longville Park Housing Scheme.

5.1.12.1 Methodology

The readings were taken at locations listed in Table 5-59 and Table 5-60 and depicted in Figure 5-92 and at the boundaries of the proposed sites and in the surrounding environs.

Noise level readings were taken for twenty-four (24) hours by using Quest Technologies SoundPro DL Type 1 hand held sound level meters with real time frequency analyser setup in outdoor monitoring kits. The octave band analysis was conducted concurrently with the noise level measurements. Measurements were taken in the third octave which provided thirty-three (33) octave bands from 12.5 Hz to 20 kHz (low, medium and high frequency bands). The noise meters were calibrated pre and post noise assessment by using a Quest QC - 10 sound calibrator (Appendix 5). The meters were programmed using the Quest suite Professional II (QSP II) software to collect third octave, average sound level (Leq) over the period, Lmin (The lowest level measured during the assessment) and Lmax (The highest level measured during the assessment) every ten (10) seconds.

Average noise levels over the period were calculated within the QSP II software using the formula:

$$\text{Average dBA} = 20 \log 1/N \sum_{j=1}^{N} 10^{(Lj/20)}$$

Where N = number of measurements, Lj = the jth sound level and j = 1, 2, 3 .... N.

A windscreen (sponge) was placed over the microphone to prevent measurement errors due to noise caused by wind blowing across the microphone.

Table 5-59 JPS 190MW EIA Noise Station numbers and locations in JAD2001

STATIONS	LOCATIONS	JAD 2001 (m)	
		E	N
N1	North-Western Property Boundary	738508.72	638937.99
N2	South-Western Property Boundary	738486.45	638860.04
N3	South-Eastern Property Boundary	738573.82	638884.88
N4	North-Eastern Property Boundary	738614.94	638979.11
N5	Informal Settlement Area	738505.24	639265.58
N6	Blackwood Garden Housing Scheme	738916.05	639430.47
N7	Old Harbour Bay Police Station	739747.33	639705.67
N8	New Harbour Village Phase II Housing Scheme	738540.52	640820.15
N9	Longville Park Housing Scheme	733211.19	639734.29

Table 5-60 SJPC 360MW EIA Noise Station numbers and locations in JAD2001

STATIONS	LOCATIONS	JAD 2001 (m)	
		E	N
N1	Northern Property Boundary	738107.646	639615.054
N2	Eastern Property Boundary	738230.127	639360.186
N3	Southern Property Boundary	738104.944	639109.821
N4	Western Property Boundary	737985.165	639362.888
N5	JPS Guard House	738788.007	639001.909
N6	Blackwood Garden Housing Scheme	738916.05	639430.47
N7	Old Harbour Bay Police Station	739747.33	639705.67
N8	New Harbour Village – Phase 1	738671.956	642070.095
N9	Church Pen	740726.535	643518.684
N10	Bodles	735978.556	642313.288
N11	Longville Park Housing Scheme	733211.19	639734.29

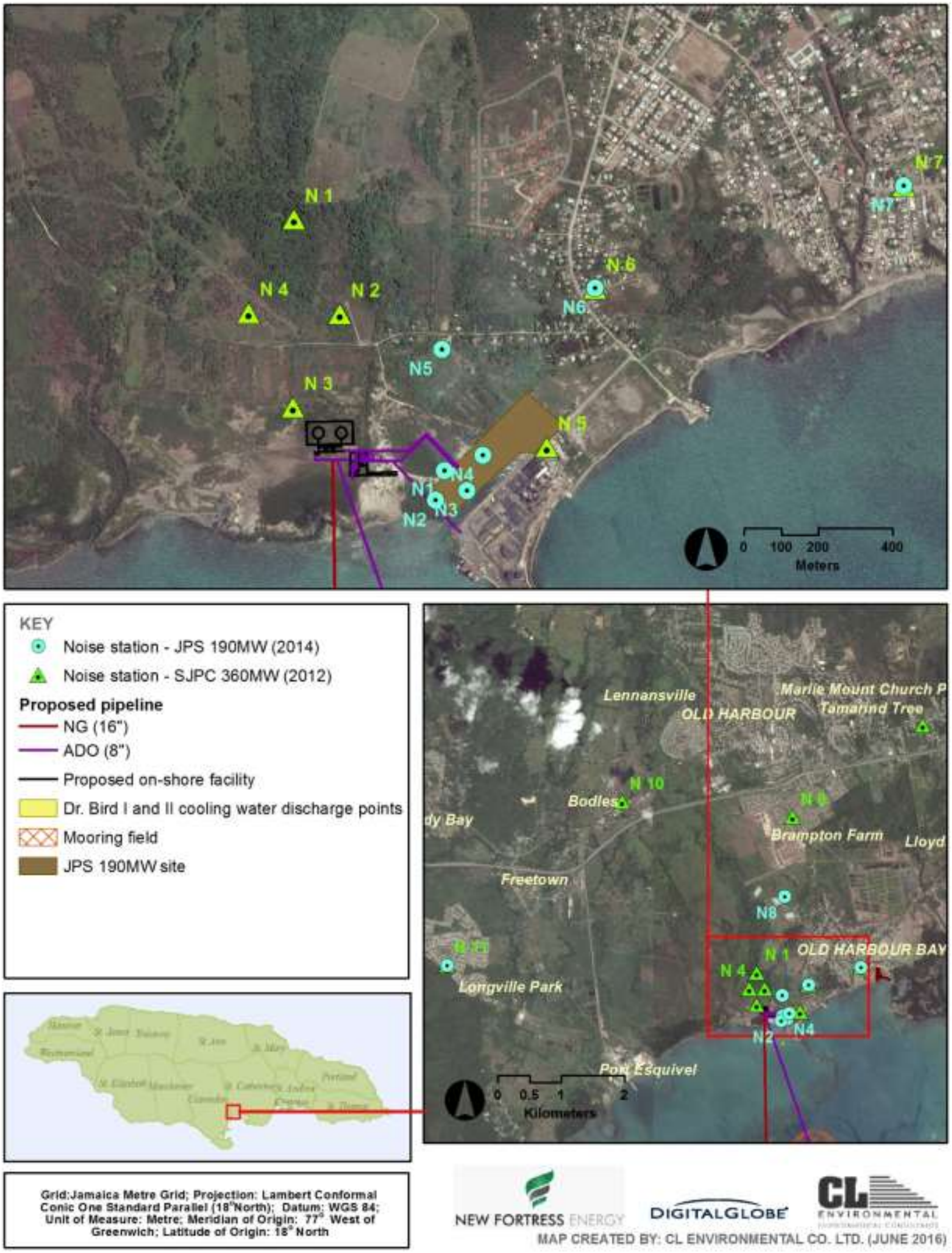


Figure 5-92 JPS 190MW and SJPC 360MW noise survey stations

5.1.12.2 Results

Table 5-61 shows the average, daytime and night time noise levels at the various stations and their comparison with NEPA noise guidelines for the JPS 190 MW EIA noise survey, while Table 5-62 shows the average, daytime and night time noise levels at the various stations and their comparison with NEPA noise guidelines for the SJPC 360 MW EIA noise survey.

The average noise levels for the three noise stations in common (Blackwood Gardens, Old Harbour Bay Police Station and Longville Park Housing Scheme) were lower for the 2014 noise survey. Average noise levels (dBA) decreased in the following ways:

- From 51.3 dBA in 2012 to 48.3 in 2014 at Blackwood Gardens.
- From 57.3 dBA in 2012 to 51.7 in 2014 at Old Harbour Bay Police Station.
- From 51.1 dBA in 2012 to 42.9 in 2014 at Longville Park Housing Scheme.

Table 5-61 Comparison of average, daytime and night time noise levels at the stations with the NEPA guidelines for the JPS 190 MW EIA

STN #	LOCATIONS	ZONE	Average Noise Level	Daytime 7 am. - 10 pm. (dBA)	NEPA Daytime Guideline (dBA)	Night Time 10 pm. - 7 am. (dBA)	NEPA Night Time Guideline (dBA)
N1	North-Western Property Boundary	Industrial	64.9	66.9	75	59.6	70
N2	South-Western Property Boundary	Industrial	60.7	62.4	75	56.5	70
N3	South-Eastern Property Boundary	Industrial	62.3	64.0	75	58.0	70
N4	North-Eastern Property Boundary	Industrial	61.8	62.9	75	59.8	70
N5	Informal Settlement Area	Residential	50.7	53.1	55	43.0	50
N6	Blackwood Garden Housing Scheme	Residential	48.3	50.5	55	42.4	50
N7	Old Harbour Bay Police Station	Residential	51.7	53.3	55	47.9	50
N8	New Harbour Village Phase II Housing Scheme	Residential	42.6	43.1	55	41.9	50
N9	Longville Park Housing Scheme	Residential	42.9	42.9	55	N/A	50

Table 5-62 Comparison of average, daytime and night time noise levels at the stations with the NEPA guidelines for the SJPC 360 MW EIA

STN #	LOCATIONS	ZONE	Average Noise Level	Daytime 7 am. - 10 pm. (dBA)	NEPA Daytime Guideline (dBA)	Night Time 10 pm. - 7 am. (dBA)	NEPA Night Time Guideline (dBA)
N1	Northern Property Boundary	Commercial	49.8	51.3	65	45.1	60
N2	Eastern Property Boundary	Commercial	52.4	53.1	65	51.1	60
N3	Southern Property Boundary	Commercial	57.9	58.7	65	56.4	60
N4	Western Property Boundary	Commercial	51.9	50.9	65	53.4	60
N5	JPS Guard House	Industrial	59.9	61.4	75	54.9	70
N6	Blackwood Garden Housing Scheme	Residential	51.3	52.6	55	48.1	50
N7	Old Harbour Bay Police Station	Residential	57.3	59.1	55	50.1	50
N8	New Harbour Village – Phase 1	Residential	58.7	59.9	55	55.8	50
N9	Church Pen	Residential	57.9	59.4	55	53.6	50
N10	Bodles	Commercial	52.6	53.5	65	50.6	60
N11	Longville Park Housing Scheme	Residential	51.1	51.7	55	49.9	50

NB. Numbers in red are non-compliant with the standard/guideline

5.1.13 Electromagnetic Fields (EMF)

Electromagnetic fields (EMF) are invisible, but exist everywhere on Earth. EMF radiation is mainly characterized by its frequency and its strength. The frequency is measured in the unit hertz, which means "cycles per second". The gauss meter measures the strength of the low-frequency EMF radiation, like that coming from electrical wires (50 or 60 hertz). The better models can also show some higher frequencies (thousands of hertz, kilo hertz), which come from some electronic appliances, such as power supplies.

5.1.13.1 Methodology

EMF was measured at the JPS 69 kV and 138 kV power lines in proximity to the proposed property and at approximately 10m intervals from the power lines to determine the impact of distance from the source on EMF strength using a TM 192 triaxial Gauss meter. These readings were taken during the SJPC EIA study on May 19, 2012 between 9:00 and 11 am. It is not anticipated that the results would have change.

5.1.13.2 Results

While there is still no internationally accepted limit for EMF, there are a number of guidelines that have been outlined by scientific bodies. In November, 2009, a scientific panel met in Seletun, Norway, for three days of intensive discussion on existing scientific evidence and public health implications. They recommended an Exposure Limit guideline of 1 mG for extremely low frequency (fields from electrical power) for all new installations, such as powerlines, indoor electric appliances, house-hold items, TVs, radios, computers, and telecommunication devices.

The data from the measurement exercise are depicted Figure 5-93 and Table 5-63.

5.1.13.3 Easement Guidelines

The data obtained has indicated that a buffer of approximately 10 m is needed from the 69 kV and approximately 62 m for the 138 kV power lines respectively at their present heights for the EMF values to fall within the guideline set by the Swedish scientists of 1 mG. Information obtained has indicated that a buffer of approximately 7.6 m on either side is required for the 69 kV and approximately 15.24 m for the 138 kV power lines as guidelines set by the Jamaica Public Service Co. Ltd.

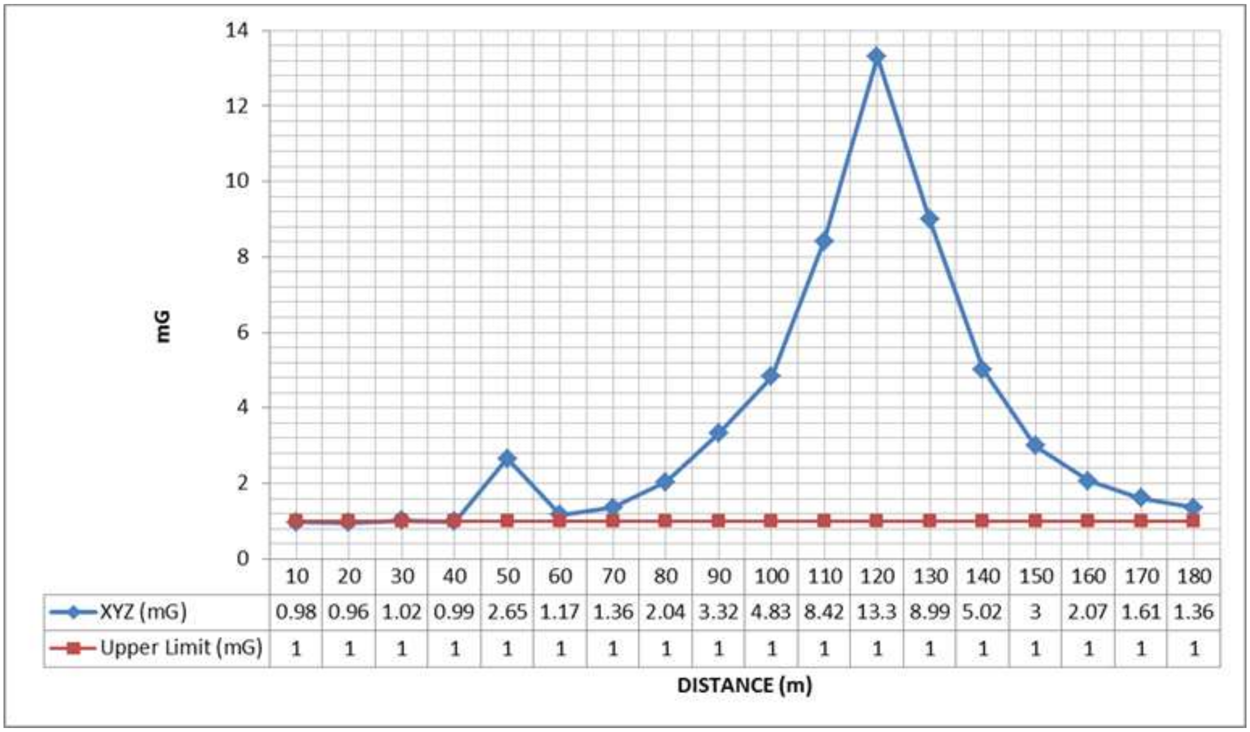


Figure 5-93 EMF measurement results in relation to distance

Table 5-63 EMF results by axis

DISTANCE (m)	DATE AND TIME	AXIS			XYZ (mG)
		X (mG)	Y (mG)	Z (mG)	
10	5/19/2012 9:00	0.52	0.81	0.2	0.98
20	5/19/2012 9:16	0.48	0.81	0.19	0.96
30	5/19/2012 9:24	0.52	0.85	0.24	1.02
40	5/19/2012 9:38	0.51	0.83	0.2	0.99
50	5/19/2012 10:31	0.93	0.97	2.29	2.65
60	5/19/2012 10:33	0.68	0.85	0.44	1.17
70	5/19/2012 10:34	0.93	0.82	0.57	1.36
80	5/19/2012 10:36	1.05	1.41	1.05	2.04
90	5/19/2012 10:39	1.14	1.97	2.43	3.32
100	5/19/2012 10:41	0.82	2.29	4.18	4.83
110	5/19/2012 10:42	1.72	2.32	7.91	8.42
120	5/19/2012 10:43	12.64	3.7	1.86	13.3
130	5/19/2012 10:45	0.65	5.44	7.13	8.99
140	5/19/2012 10:48	0.59	1.25	4.83	5.02
150	5/19/2012 10:49	0.47	1.56	2.52	3
160	5/19/2012 10:50	0.51	1.39	1.46	2.07
170	5/19/2012 10:51	0.48	1.27	0.87	1.61
180	5/19/2012 10:51	0.48	1.13	0.59	1.36

5.2 NATURAL HAZARDS

5.2.1 Flood Plain Modeling

5.2.1.1 Methodology

The flood plain analysis for the Bowers Gully River was executed for the following scenarios:

1. Calibration with Hurricane Ivan – 2004 (Figure 5-94)
2. Projections for:
    a. 1:2yr rainfall event (Figure 5-95);
    b. 1:5yr rainfall event (Figure 5-96);
    c. 1:10yr rainfall event (Figure 5-97);
    d. 1:25yr rainfall event (Figure 5-98);
    e. 1:50yr rainfall event (Figure 5-99);
    f. 1:100yr rainfall event (Figure 5-100).

Hydraulic analysis of the Bowers Gully was done using a transient state analysis of the peak flow condition for the various return periods. In order to run the analysis, boundary conditions needed to be established.

The boundary conditions were established as the inflow (upstream) for the start of the hydraulic model for all scenarios. Based on documented anecdotal information, the boundary condition at the end of the hydraulic reach (downstream) was defined as the predicted storm surge levels above mean sea level (MSL). This scenario of combined storm surge during peak runoff can be considered as the worst case as described by the residents during anecdotal interviews. See Table 5-64 below for the storm surge levels used for each scenario.

Table 5-64 Summary of storm surge levels above MSL.

Storm	Storm Surge (m)
Hurricane Ivan	3.25
2yr	0.58
5yr	1.29
10yr	1.80
25yr	2.44
50yr	2.96
100yr	3.49

The model had to be first calibrated using the anecdotal information collected for both Hurricanes. The pre-development scenario was then modelled changing only the rainfall depths to that of the 2, 5, 10, 25, 50 and 100 year return rainfall event with the consideration of climate change. The water surface results obtained were superimposed on the digital elevation model for a final determination of the flood depths.

5.2.1.2 Calibration

The flood plain model was first calibrated using the flooding and storm surge anecdotal information documented during field reconnaissance. Rainfall data recorded throughout the duration of the storm was obtained from available rainfall stations closest in proximity to the Bowers Gully catchment. Due to the magnitude of this storm event, not all rainfall stations within the network were utilized due to either the stations losing their gauges during Ivan, gauges being flooded or observers not able to record measurements because of the storm impact on the locations. The rainfall depths ranged from a minimum of 241 mm to a maximum of 560 mm which yielded an average value of 293 mm for the overall catchment. These rainfall depths yielded a peak runoff of 302.5 m^3/s at the outlet of the gully. Based on the depths of rainfall, the rainfall event Ivan can be classified as falling between the 1 in 25 and 1 in 50 year rainfall event.

The boundary condition was established as critical depth for the start of the hydraulic model during the simulation of Hurricane Ivan (2004). Based on documented anecdotal information, the boundary condition at the end of the hydraulic reach was defined as 2 meters.

The results indicate that for the hurricane Ivan event, the gully will overflow both its banks and flood in the following sections (see Figure 5-94):

1. *Northwest of The Whim to Southeast of Dorothy Lodge* - flood levels in this area are predicted to be up to 2.5m. The floodplain extents is estimated to be 587 m at its widest.
2. *Kelly's Pen to the JPS power station shoreline* - extensive flooding predicted which extends to within the footprint of the existing JPS site causing inundation levels of up to 3m.

In comparison to the anecdotal information received, the model predicted approximately the same flood levels as reported by residents. The flood plain map generated for Hurricane Ivan reflected both the 0.3 and 0.45 metre flood levels documented from interviewees. The curve numbers were slightly modified in order to achieve the flood levels as accurate to the anecdotal as possible. The model was rerun and the calibration was then verified using known data from Hurricane Gustav.

Table 5-65 Comparison of anecdotal information obtained and model predictions.

Full Name	Age (years)	Time in Area (years)	Storm	Year	Perceived water Depth (m)	Model Predicted Depth of water (m)
Shelly Brown	49	20	Ivan	2004	0.450	0.605
Stephanie Watt	34	25	Ivan	2004	0.300	0.415

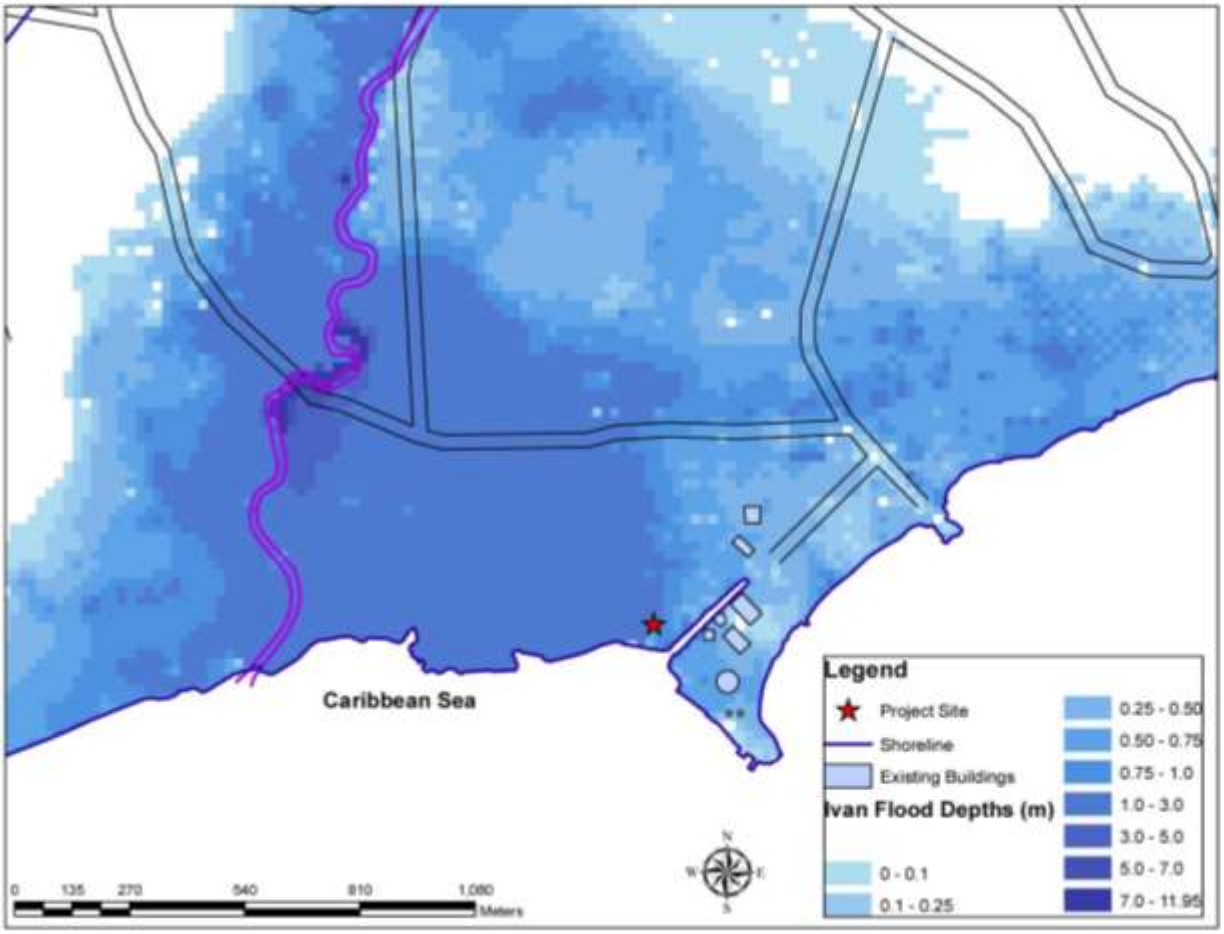


Figure 5-94 Flood levels generated while calibrating the model with Hurricane Ivan.

5.2.1.3 Results

Subsequent to the calibration and verification of the Bowers Gully floodplain model, the floodplain maps for future rainfall events with 10, 50 and 100 return periods were generated. The flood prone areas as well as their respective depths could be estimated. The analysis of the three different scenarios revealed that the proposed site (pre-development) will experience flooding even in the 10 year rainfall event.

It is important to note that the hydraulic models were run with the maximum storm surge. This was done because of the documented experiences of the residents in the Old Harbour area. They had reported simultaneous occurrences of overland flooding and storm surge for Ivan and Gustav. This is I strong indicator that it is possible for the 10, 50 and 100 year return storm to occur with the corresponding storm surges and should therefore be included in the flood plain mapping.

1:2yr Rainfall Event

The results indicate that for the 1 in 2 year rainfall event during pre-development conditions, the gully will overflow both its banks and flood in the following sections (see Figure 5-95):

1. *Western Banks of Bowers Gully to East of Dorothy Lodge* - flood levels in this area are predicted to be up to 1.1 m. The floodplain extents is estimated to be 893 m at its widest.
2. *Kelly's Pen to the JPS power station shoreline* - extensive flooding predicted which extends to within the footprint of the existing JPS site causing inundation levels of up to 1.04 m. The floodplain extents is estimated to be 3,606 m at its widest.
3. Proposed LNG site - considering that the proposed LNG site currently has an average elevation of 1.45 m above mean sea level (msl), water depths of up to 0.65 m was observed on the site for the 1 in 2 year rainfall event generating an average water surface elevation of 2.05 m.

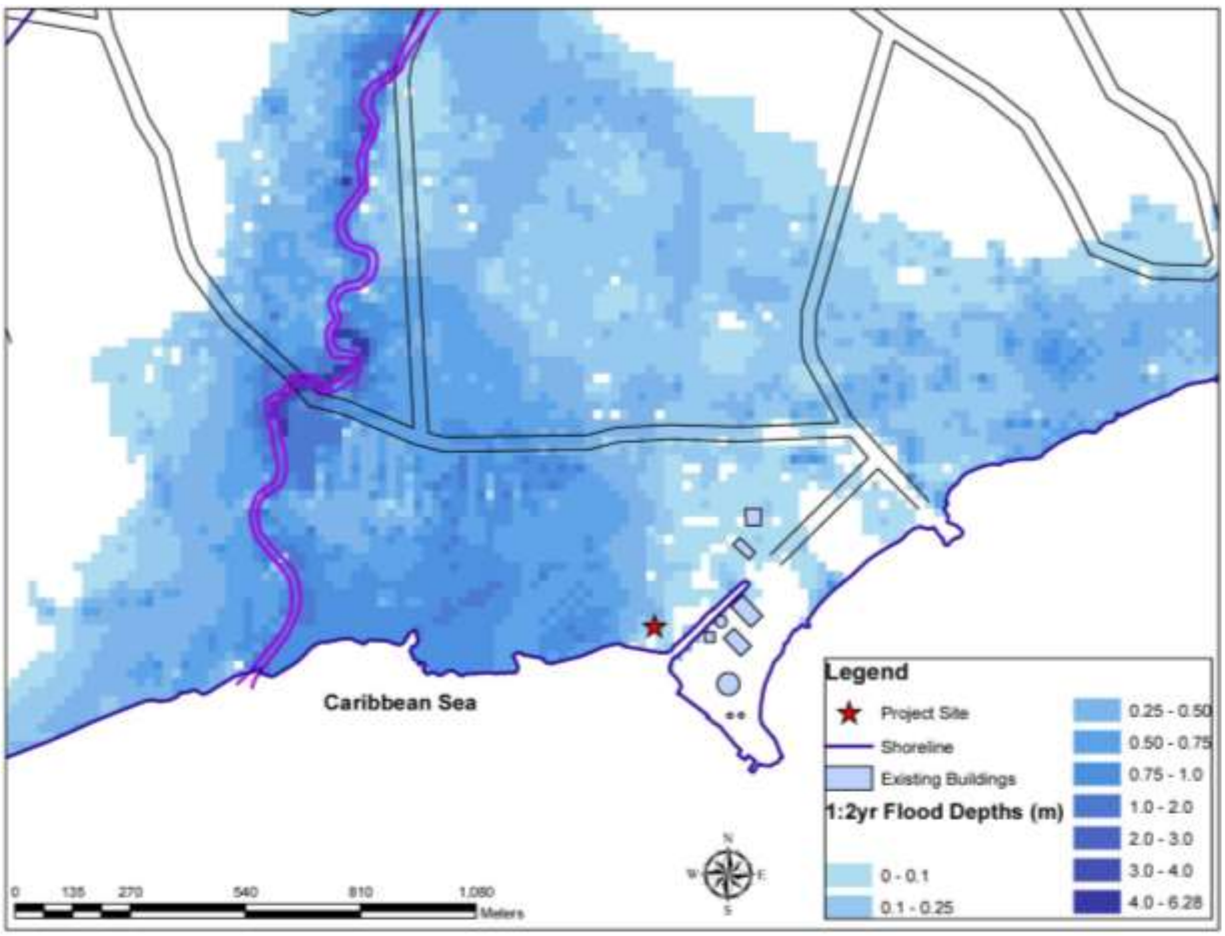


Figure 5-95 Floodplain map showing flood levels predicted for the 1:2yr rainfall event

1:5yr Rainfall Event

The results indicate that for the 1 in 5 year rainfall event during pre-development conditions, the gully will overflow both its banks and flood in the following sections (see Figure 5-96):

1. *Western Banks of Bowers Gully to East of Dorothy Lodge* - flood levels in this area are predicted to be up to 1.3 m. The floodplain extents is estimated to be 905 m at its widest.
2. *Kelly's Pen to the JPS power station shoreline* - extensive flooding predicted which extends to within the footprint of the existing JPS site causing inundation levels of up to 1.2 m. The floodplain extents is estimated to be 3,625 m at its widest.
3. Proposed LNG site - considering that the proposed LNG site currently has an average elevation of 1.45 m above mean sea level (msl), water depths of up to 0.93 m was observed on the site for the 1 in 5 year rainfall event generating an average water surface elevation of 2.31 m.

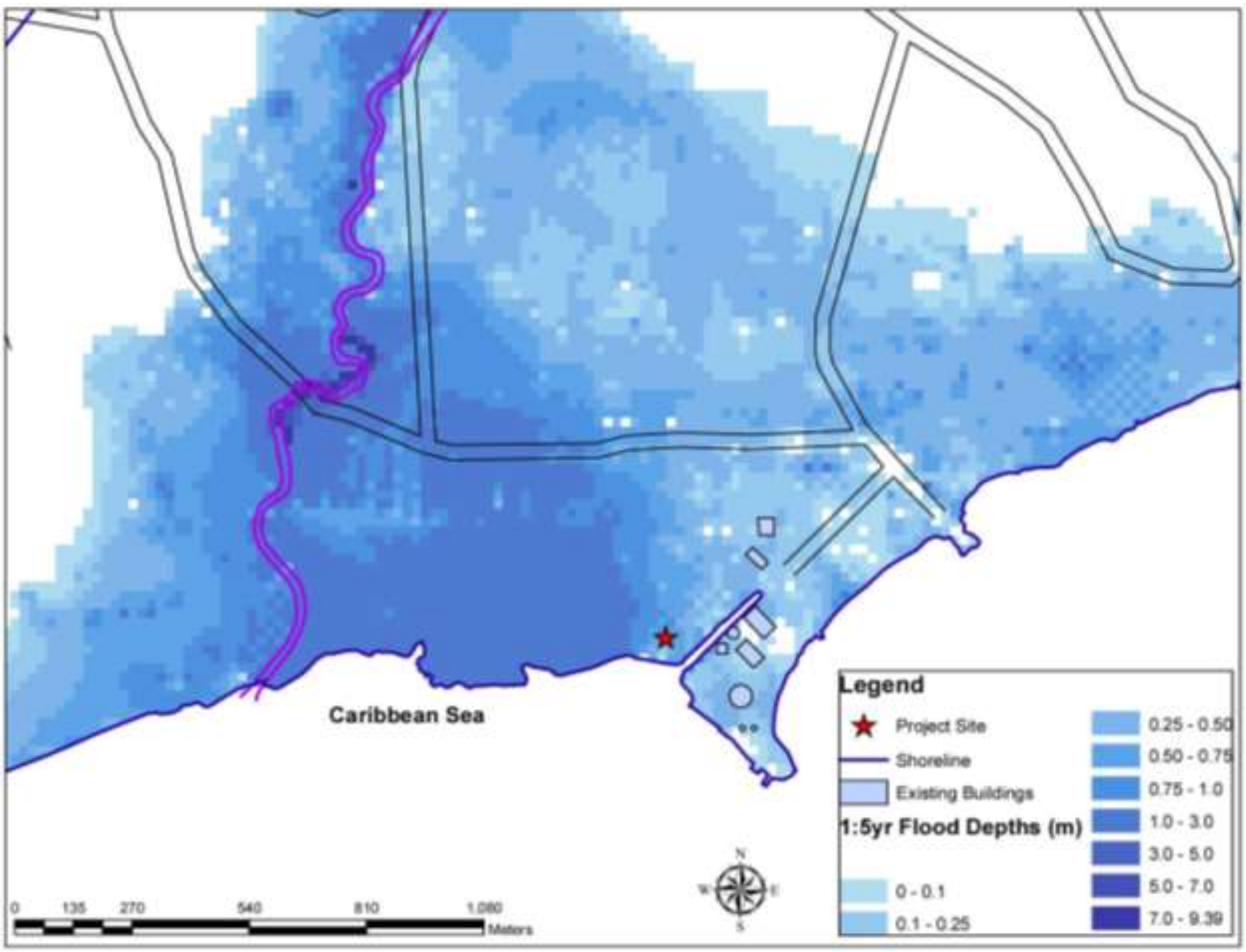


Figure 5-96 Floodplain map showing flood levels predicted for the 1:5yr rainfall event

1:10yr Rainfall Event

The results indicate that for the 1 in 10 year rainfall event during pre-development conditions, the gully will overflow both its banks and flood in the following sections (see Figure 5-97):

1. *Western Banks of Bowers Gully to East of Dorothy Lodge* - flood levels in this area are predicted to be up to 1.46 m. The floodplain extents is estimated to be 915 m at its widest.
2. *Kelly's Pen to the JPS power station shoreline* - extensive flooding predicted which extends to within the footprint of the existing JPS site causing inundation levels of up to 1.32 m. The floodplain extents is estimated to be 3,632 m at its widest.
3. Proposed LNG site - considering that the proposed LNG site currently has an average elevation of 1.45 m above mean sea level (msl), water depths of up to 1.03 m was observed on the site for the 1 in 10 year rainfall event generating an average water surface elevation of 2.46 m.

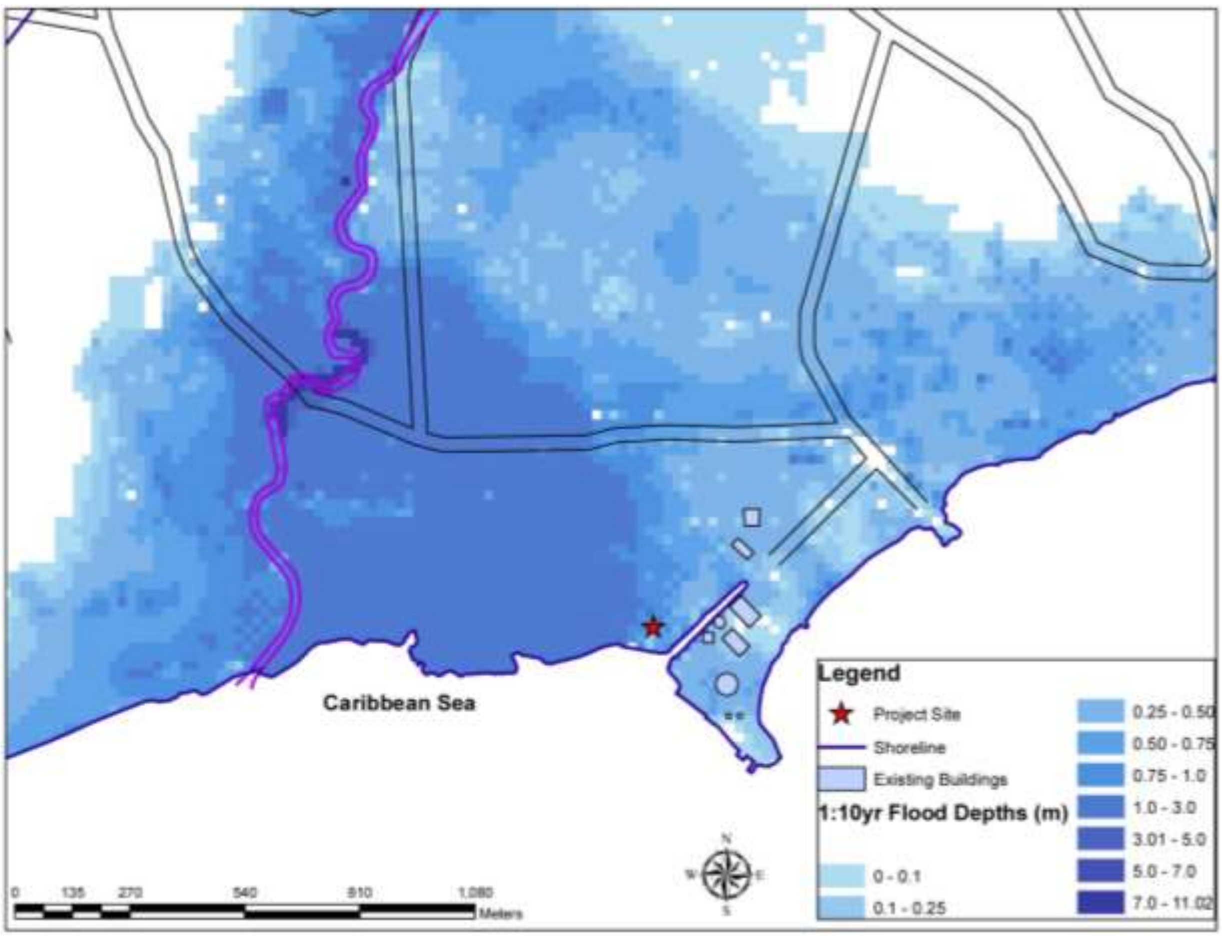


Figure 5-97 Floodplain map showing flood levels predicted for the 1:10yr rainfall event

1:25yr Rainfall Event

The results indicate that for the 1 in 25 year rainfall event during pre-development conditions, the gully will overflow both its banks and flood in the following sections (see Figure 5-98):

1. *Western Banks of Bowers Gully to East of Dorothy Lodge* - flood levels in this area are predicted to be up to 1.6 m. The floodplain extents is estimated to be 922 m at its widest.
2. *Kelly's Pen to the JPS power station shoreline* - extensive flooding predicted which extends to within the footprint of the existing JPS site causing inundation levels of up to 1.48 m. The floodplain extents is estimated to be 3,637 m at its widest.
3. Proposed LNG site - considering that the proposed LNG site currently has an average elevation of 1.45 m above mean sea level (msl), water depths of up to 1.30 m was observed on the site for the 1 in 25 year rainfall event generating an average water surface elevation of 2.60 m.

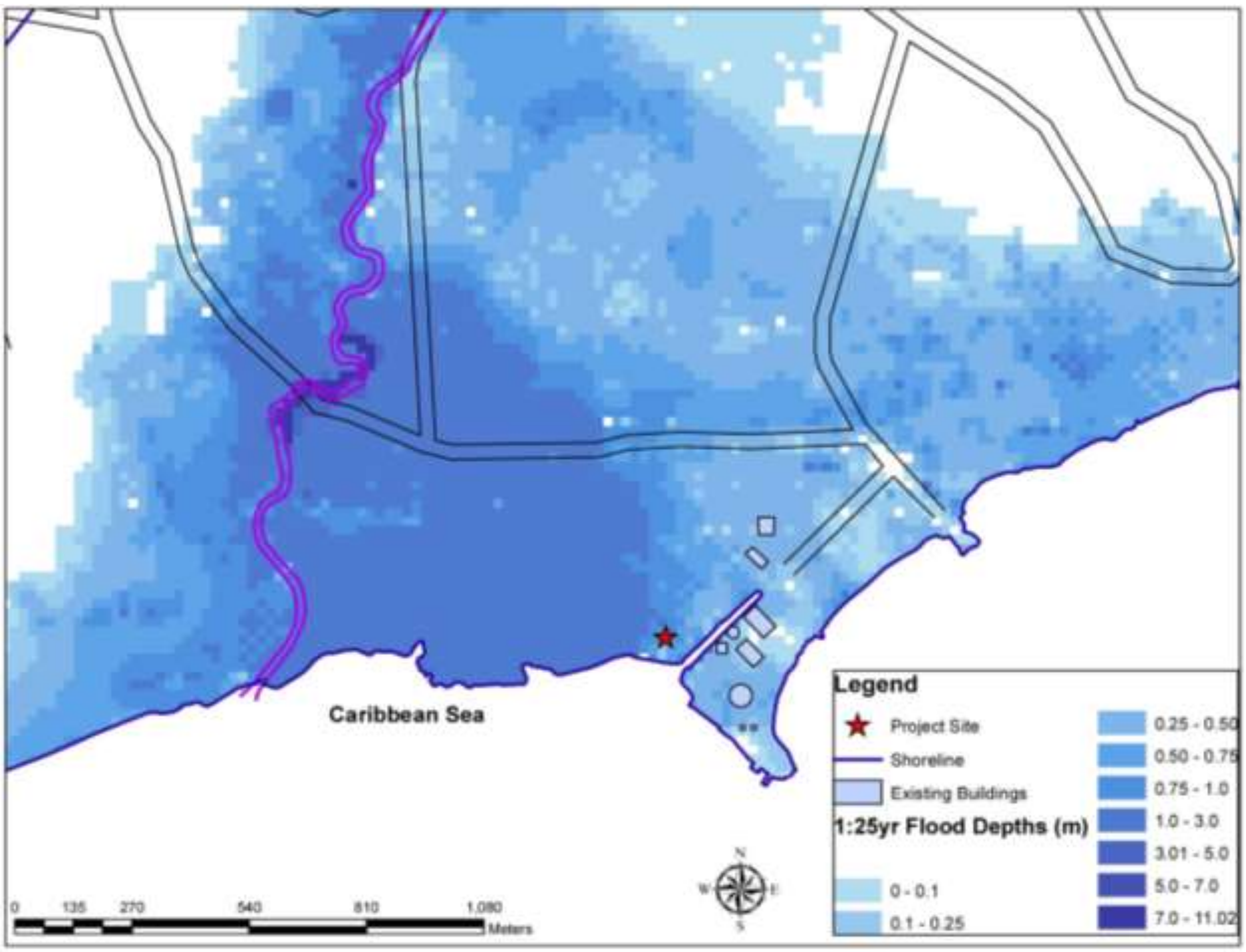


Figure 5-98 Floodplain map showing flood levels predicted for the 1:25yr rainfall event.

1:50yr Rainfall Event

The results indicate that for the 1 in 50 year rainfall event during pre-development conditions, the gully will overflow both its banks and flood in the following sections (see Figure 5-99):

1. *Western Banks of Bowers Gully to East of Dorothy Lodge* - flood levels in this area are predicted to be up to 1.72 m. The floodplain extents is estimated to be 925 m at its widest.
2. *Kelly's Pen to the JPS power station shoreline* - extensive flooding predicted which extends to within the footprint of the existing JPS site causing inundation levels of up to 1.59 m. The floodplain extents is estimated to be 3,639 m at its widest.
3. Proposed LNG site - considering that the proposed LNG site currently has an average elevation of 1.45 m above mean sea level (msl), water depths of up to 1.35 m was observed on the site for the 1 in 50 year rainfall event generating an average water surface elevation of 2.61 m.

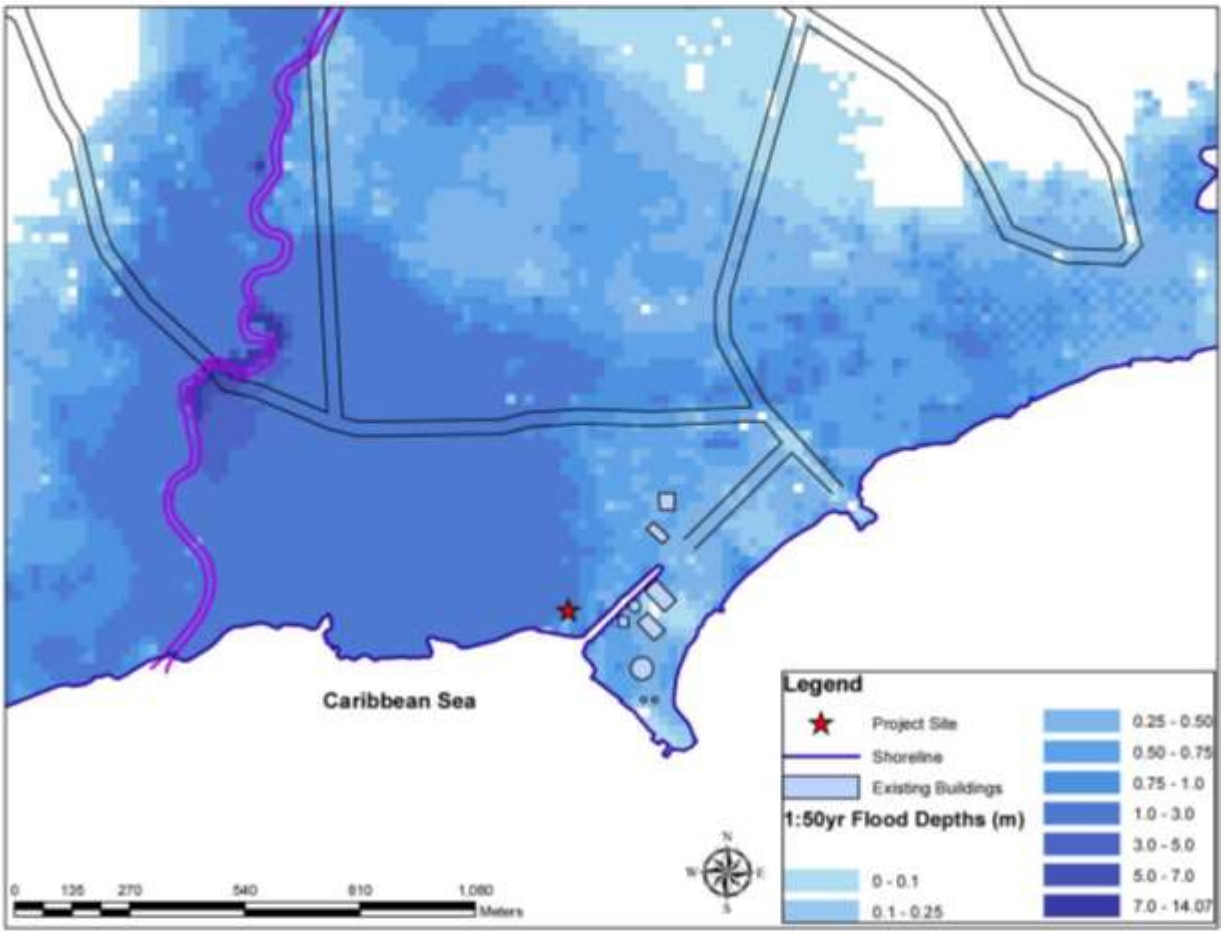


Figure 5-99 Floodplain map showing flood levels predicted for the 1:50yr rainfall event.

1:100yr Rainfall Event

The results indicate that for the 1 in 100 year rainfall event during pre-development conditions, the gully will overflow both its banks and flood in the following sections (see Figure 5-100):

1. *Western Banks of Bowers Gully to East of Dorothy Lodge* - flood levels in this area are predicted to be up to 1.85 m. The floodplain extents is estimated to be 927 m at its widest.
2. *Kelly's Pen to the JPS power station shoreline* - extensive flooding predicted which extends to within the footprint of the existing JPS site causing inundation levels of up to 1.74 m. The floodplain extents is estimated to be 3,641 m at its widest.
3. Proposed LNG site - considering that the proposed LNG site currently has an average elevation of 1.45 m above mean sea level (msl), water depths of up to 1.53 m was observed on the site for the 1 in 100 year rainfall event generating an average water surface elevation of 2.79 m.

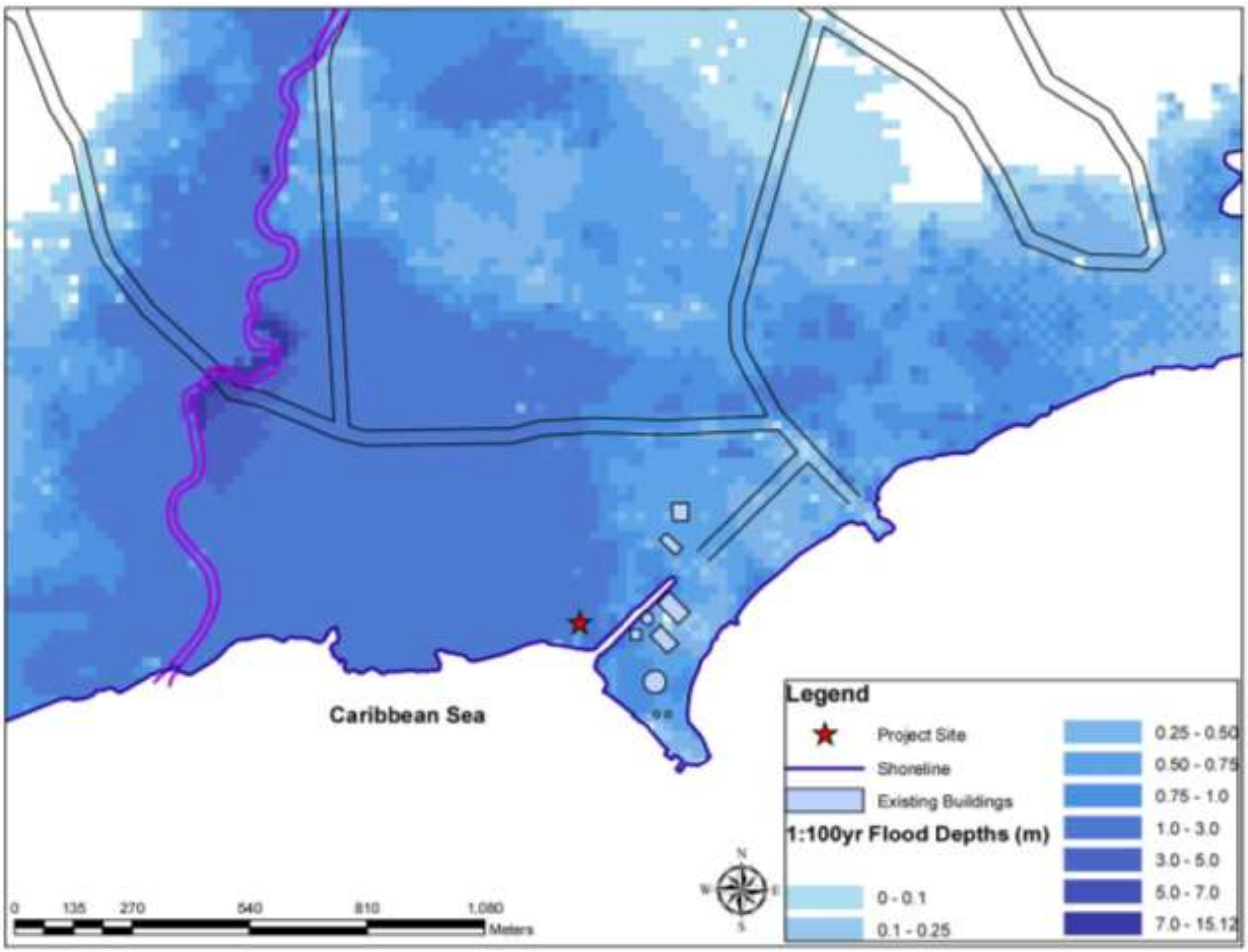


Figure 5-100 Floodplain map showing flood levels predicted for the 1:100yr rainfall event.

5.2.2 Hurricane Waves

Storm surge at the project site was determined by modelling the offshore conditions using mike21 fm. Mike21 fm includes a hurricane module that creates a hurricane wind field based on storm parameters. The information necessary to generate the hurricane wind fields was obtained from the NOAA historical hurricane tracks website. Using Hurricane Dean, storm surge values of 1.73m and 1.90m were predicted for the Old Harbour Site 1 and Site 2 respectively.

Figure 5-101 Historical path of Hurricane Dean showing various stages of development

5.2.3 Storm Surge and Coastal Inundation

Wave run-up is the maximum elevation of wave uprush above still-water level. Wave uprush consists of two components: super elevation of the mean water level due to wave action (setup) and fluctuations about that mean (swash). Wave run-up will depend on wave height and period but also on the beach slope. Since the slopes in the project site vary considerably, 4 transects were considered for the run-up analysis. Each transect is represented in Figure 5-102 with the corresponding average slope. Additionally, 1 data point is included in the figure. This point represents a location where the nearshore extreme wave parameters derived from the nearshore modelling are known. These nearshore parameters (significant wave height, peak period and mean wave direction) are used for the calculation of wave run-up for each of the transects.

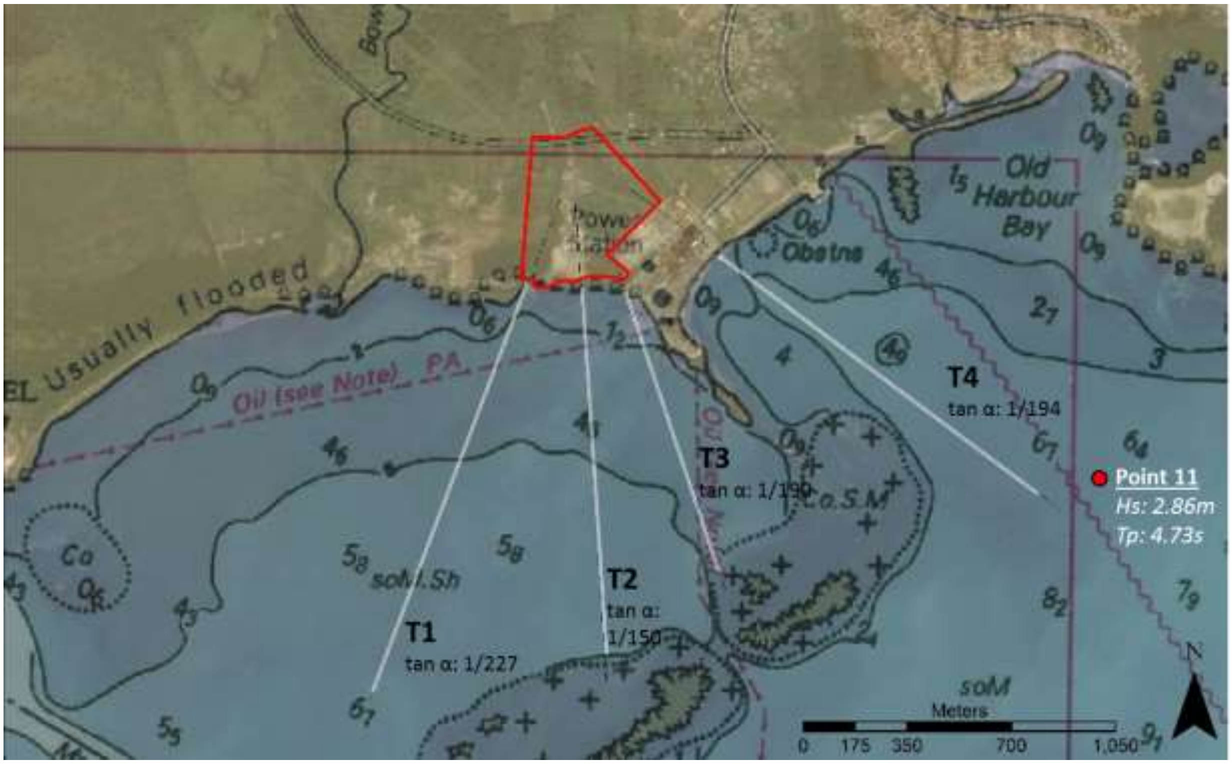


Figure 5-102 The wave runup calculation was obtained following the van der Meer formulation provided by the Costal Engineering Manual (CEM). Runup results for each transect are provided in Table 5-66.

Table 5-66 Wave runup results summary

Transect	H_s [m]	T_p [s]	slope	$R_{u2\%}$ [m]
1	2.86	4.73	1:227	0.27
2	2.86	4.73	1:150	0.37
3	2.86	4.73	1:189	0.31
4	2.86	4.73	1:193	0.30

Wave overtopping takes place when waves meet a structure and wave transmission and the passing of water over the structure occurs. For the overtopping calculation, the van der Meer formulation provided by the CEM was used and the results are given in Table 5-67.

Table 5-67 Wave overtopping results summary

Transect	H_s [m]	T_p [s]	slope	Discharge [m3/s/m]			
				R_c=0 (+1.90m)	R_c=0.5 (+2.4m)	R_c=1.0 (+2.9m)	R_c=1.5 (+3.4m)
1	2.86	4.73	01:12.5	0.21	0	0	0
2	2.86	4.73	01:16.1	0.26	0	0	0
3	2.86	4.73	1:20	0.23	0	0	0
4	2.86	4.73	0.10417	0.23	0	0	0

5.2.4 Coastal Erosion Hazard and Vulnerability

5.2.4.1 Long Term Coastal Erosion Trends

A study was conducted by CEAC Solutions in 2015 to determine the vulnerability of the Old Harbour Bay shoreline to erosion (CL Environmental Co. Ltd., 2015). The study entailed shoreline data spanning 42 years (1968-2010) which was used to do a comparative analysis. The shoreline positions over a number of years were plotted and compared in order to determine the long-term spatial and temporal erosion trends across the bay; this was important in order to identify the erosion hotspots.

The overall long-term erosion trend was estimated by:

1) Observation of actual long-term shoreline positions from dated aerial photography.
2) The global sea level rise component was estimated to determine the erosion that was due to chronic global trends versus event based erosion events (i.e. hurricanes and swell events).

Historical Shoreline Assessment

Figure 5-103 shows satellite imagery (March 2010) over which the observed shorelines from Aerial photos of the area obtained from the Survey department for the years 1968, 1991, and 2000. Close examination of the image in Figure 5-103 reveals a general trend of erosion occurring along the shoreline of the proposed site from 1968 to 2010. The central section of the shoreline between chainage 0+450 and 0+700 shows a general pattern of accretion. Table 5-68 summarizes the results of measuring and noting the displacements of the shoreline at intervals of 50m along the shoreline. The rates of accretion and or erosion between the time intervals and the overall time interval were determined using the following relationship:

$$E_y^1 = \frac{D}{N},$$

Where:
E = the rate of erosion or accretion between two successive intervals (metres per year)
D = the displacement between two intervals (metres)
N = the number of years between two successive intervals (years)

and

$$E_y^0 = \frac{D_T}{N_T},$$

Where:
E_y^0 = the rate of erosion or accretion from the datum year to the final interval
D_T = the displacement from the datum to the final interval
N_T = the number of years from datum year to final interval

Table 5-68 Summary of shoreline changes

Year	Shoreline Intervals										
	1968	1991			2000			2010			Overall	
Chainage	Datum	Process	Accretion/Erosion Rate (m/year)	distance from datum (m)	Process	Accretion/Erosion Rate (m/year)	distance from datum (m)	Process	Accretion/Erosion Rate (m/year)	distance from datum (m)	Process	Rate
0+000	0	erosion	-1.366	-31.41	accretion	0.803	-24.18	erosion	-0.448	-28.21	erosion	-0.672
0+050	0	erosion	-0.727	-16.71	accretion	0.752	-9.94	erosion	-1.743	-25.63	erosion	-0.610
0+100	0	erosion	-0.664	-15.27	accretion	0.298	-12.59	erosion	-1.458	-25.71	erosion	-0.612
0+150	0	erosion	-0.815	-18.74	accretion	0.550	-13.79	erosion	-1.032	-23.08	erosion	-0.550
0+200	0	erosion	-0.654	-15.04	accretion	0.501	-10.53	erosion	-0.812	-17.84	erosion	-0.425
0+250	0	erosion	-1.657	-38.1	accretion	0.420	-34.32	erosion	-0.359	-37.55	erosion	-0.894
0+300	0	erosion	-1.833	-42.15	erosion	-1.564	-56.23	erosion	-0.851	-63.89	erosion	-1.521
0+350	0	erosion	-1.967	-45.23	erosion	-3.820	-79.61	erosion	-3.803	-113.84	erosion	-2.710
0+400	0	erosion	-0.606	-13.94	accretion	0.924	-5.62	accretion	0.403	-1.99	erosion	-0.047
0+450	0	erosion	-0.618	-14.21	accretion	1.704	1.13	accretion	0.598	6.51	accretion	0.155
0+500	0	accretion	0.189	4.34	accretion	1.211	15.24	erosion	-0.047	14.82	accretion	0.353
0+550	0	accretion	0.041	0.95	accretion	1.278	12.45	erosion	-0.076	11.77	accretion	0.280
0+600	0	accretion	0.022	0.5	accretion	1.903	17.63	erosion	-0.286	15.06	accretion	0.359
0+650	0	accretion	0.451	10.37	accretion	0.669	16.39	accretion	0.910	24.58	accretion	0.585
0+700	0	accretion	0.903	20.77	erosion	-0.061	20.22	erosion	-0.700	13.92	accretion	0.331
0+750	0	accretion	0.205	4.72	erosion	-2.490	-17.69	accretion	0.034	-17.38	erosion	-0.414
0+800	0	accretion	0.454	10.44	erosion	-1.808	-5.83	erosion	-1.467	-19.03	erosion	-0.453
0+850	0	erosion	-0.489	-11.25	erosion	-0.603	-16.68	erosion	-1.618	-31.24	erosion	-0.744
0+900	0	erosion	-0.610	-14.04	erosion	-0.006	-14.09	erosion	-1.380	-26.51	erosion	-0.631
0+950	0	erosion	-0.447	-10.29	accretion	0.354	-7.1	erosion	-0.667	-13.1	erosion	-0.312

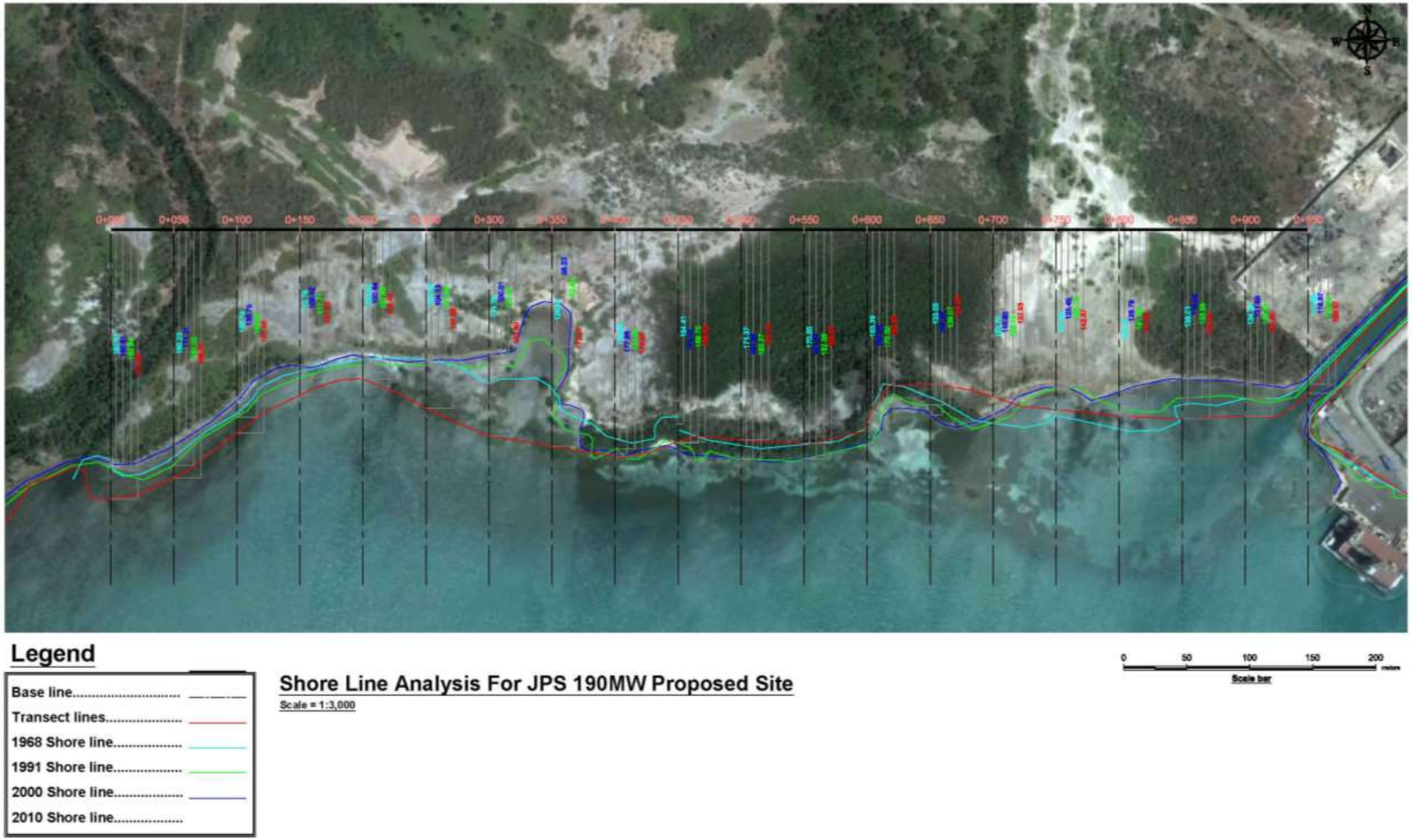


Figure 5-103 Historical Shoreline positions plotted over a satellite image of the area. The red, cyan green and blue lines represent the 1968, 1991, 2000 and 2010 shoreline positions respectively.

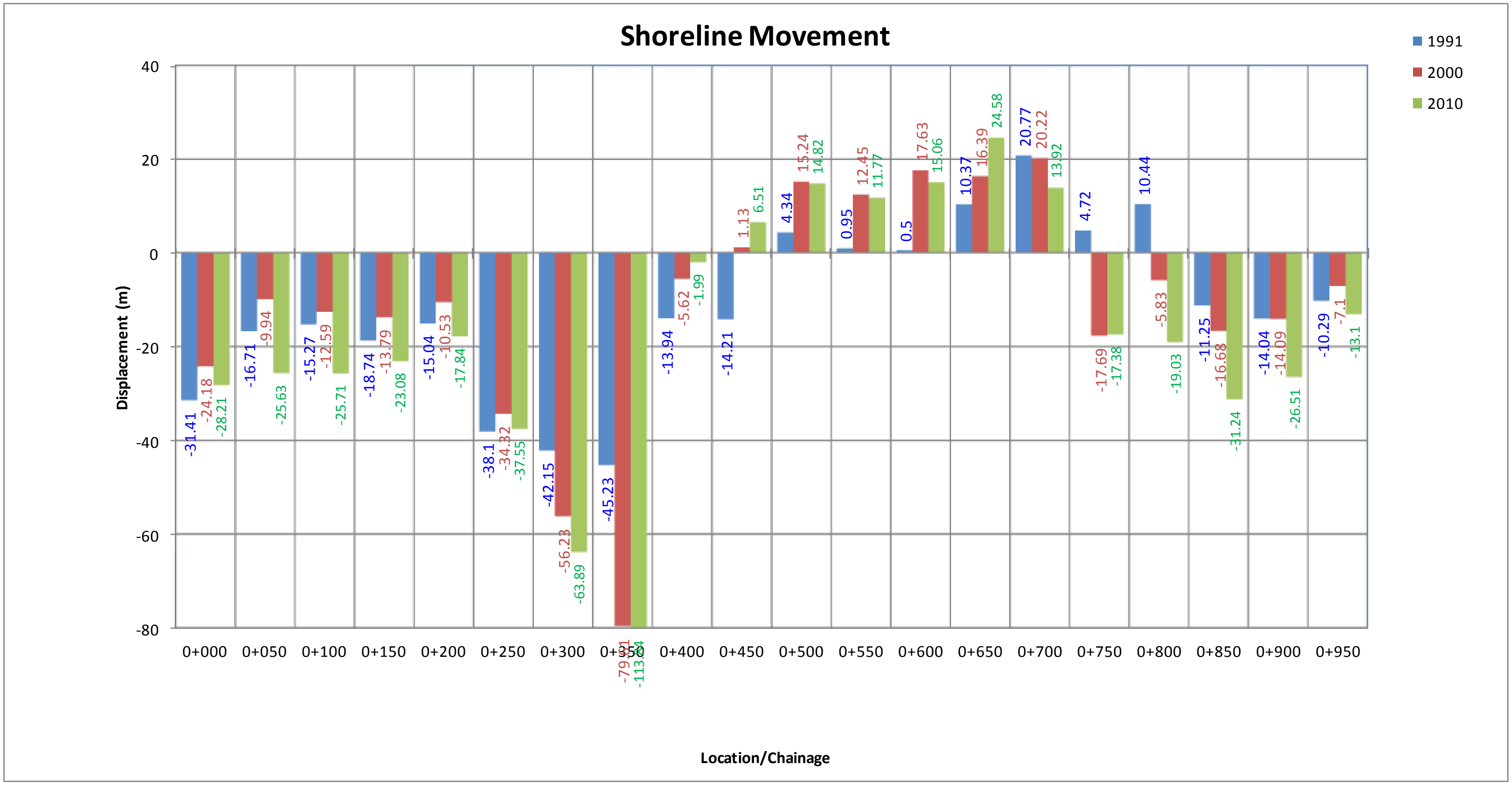


Figure 5-104 Graph showing the displacements of the shoreline for different years about the 1968 shoreline for Old Harbour Bay (1964 to 20010)

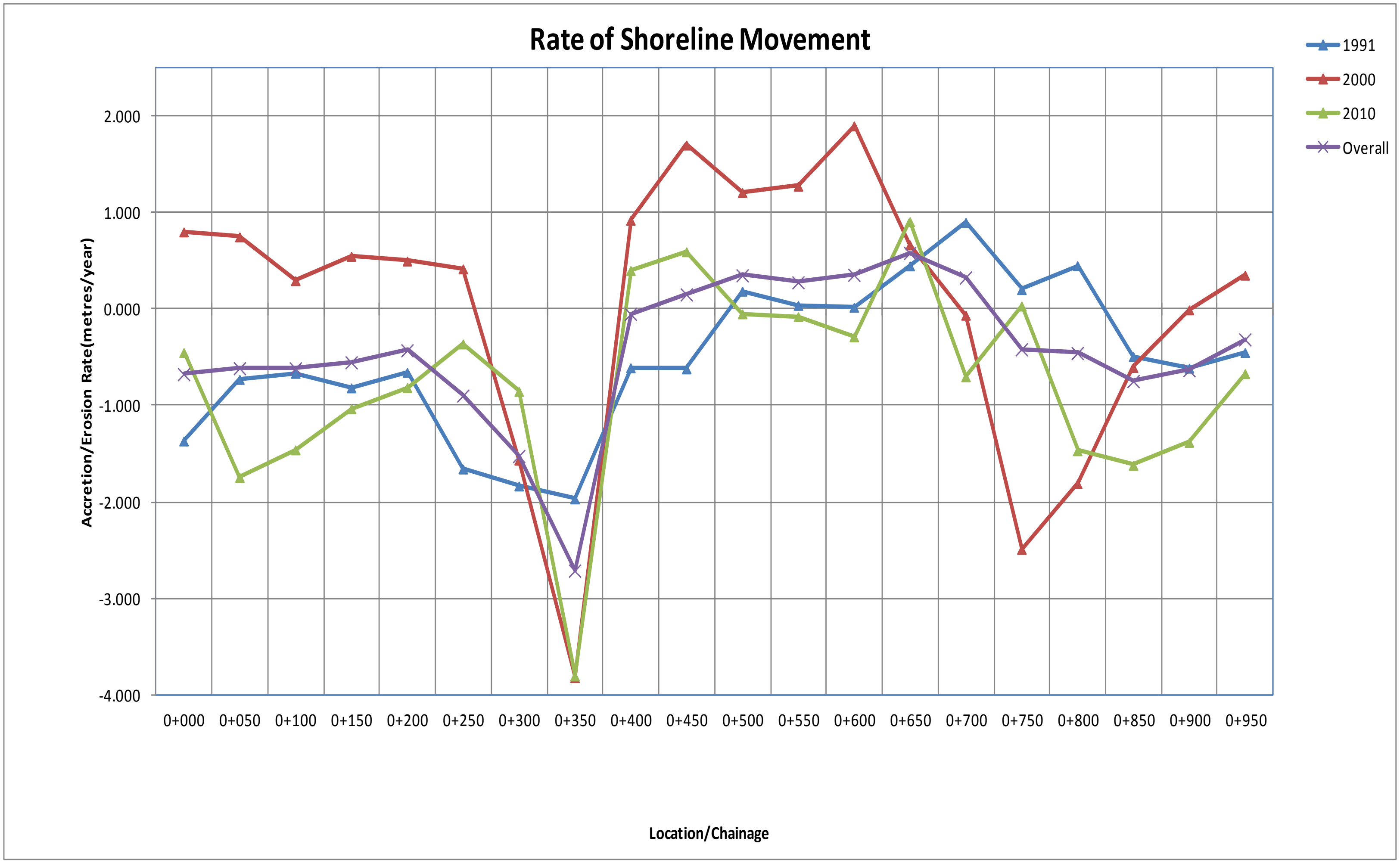


Figure 5-105 Graph showing the rates of erosion/accretion for the shoreline about the 1968 shoreline for different time intervals for Old Harbour Bay (1964 to 2010)

Estimation of Shoreline Retreat

The Bruun model is perhaps the best-known and most commonly used of the models that relate shoreline retreat to sea level rise. This two-dimensional model assumes an equilibrium profile. Thus, it inherently assumes that the volume of sediment deposited is equal to that eroded from the dunes and that the rise in the nearshore bottom as a result of the deposited sediment is equal to the rise in sea level. The original Bruun model is expressed below, and this mathematical relationship was the basis for estimating shoreline retreat within the study area.

$$\Delta y = \frac{\Delta s \cdot l*}{h*}$$

Where:

Parameter	Description	Units
Δy	Dune line erosion	m
Δs	Rate of sea level rise	m
*l**	Length of the offshore profile out to a supposed depth, h*, of the limit of material exchange from the beach and the offshore	m
*h**	Depth at offshore limit of l*, to which nearshore sediments exist (as opposed to finer-grained continental shelf sediments)	m

RATE OF SEA LEVEL RISE, ΔS

Inspection of research in this area revealed that global sea level may rise as a result of greenhouse gas-induced global warming at a rate of 5 mm/year over the next 100 years. Indeed, there will be regional variation in the sea level rise signal, and for this reason regions may undertake sea-level rise scenario modelling, which takes into account various factors such as land movement and region-specific oceanographic data.

For the purposes of this project, a simple scenario, based on one estimate of sea level rise will be utilized (not taking into account any vertical tectonic movements of the shoreline nor any discernible change in the ocean geodynamic surface). Typically, a mid-range or upper estimate is chosen for such types of scenarios. The Intergovernmental Panel on Climate Change's (IPCC) Special Report on Emissions Scenarios (SRES) estimate global sea-level to rise 9-88 cm in the next 100 years (McCarthy et al, 2001) was considered for the calculations, and specially the upper limit of this range, 8.9 cm by 2025 (0.00445 m/yr) was utilized.

Sea-level rise is projected to the year 2025, as the shelf life of the project was chosen to be 20 years. Using the upper limit value of 8.9 cm by 2025 allowed this analysis to test whether the coastal region of Old Harbour Bay is vulnerable to a plausible upper limit of climate change and simultaneous storm-induced short-term erosion for the 100-year return period.

DEPTH TO WHICH NEARSHORE SEDIMENTS EXIST, H*

A beach profile has a practical seaward limiting depth, where the wave conditions can no longer change the profile. Sand may move back and forth along this equilibrium profile, but there is no perceptible change in depth. This seaward limiting depth is equivalent to the depth at which nearshore sediments exist (*h**). Hallermeier (Hallermeier, 1981 in Kamphuis, 2000) refers to this depth as the critical or closure depth (d_c), and approximates it using the following equation.

$$d_c = 1.6 H_{s,12}$$

Where:

$H_{s,12}$ = significant wave height which occurs 12 hrs/yr on average

It was therefore necessary to determine the operational wave climate within the study area between the shoreline and the reefs in order to estimate the critical depth. Long term wave data available for the south of Portland Bight was analysed to determine the 12 hour wave ($H_{s,12}$). The $H_{s,12}$ was determined to be a 11.5 second, 2.5 metre swell wave.

LENGTH OF OFFSHORE PROFILE, L*

The calculated critical depth (or *h**) was used to estimate the length of the offshore profile. This was done by inspecting each of the three (3) profiles cut for the REFDIF modelling and obtaining profile lengths for the corresponding critical depth. These profile lengths obtained were incorporated into the Brunn Model equation.

Calculations

Table 5-69 shows the calculation of the long term trends expected in 25 years along the Old Harbour Bay beaches. As seen in this table, the following input values were incorporated into the Bruun Model to arrive at an estimate for the long-term erosion trend at each of the six (6) profile shoreline positions:

- Rate of sea-level rise = 0.0047 m/yr (IPCC 2007)
- Depth to which nearshore sediment exists (*h**, d_c) = 2.5 m

It should be emphasized here that the results of these calculations are an estimate of the projected shoreline retreat using a simplistic approach with an upper limit of global sea level rise. Indeed, the changes in beach profile over the years may have been impacted by the annual sea level rise as well as operational and storm-induced erosion estimated. This estimation of the sea level rise will assist in the determination of the true impacts that are due to operational a storm induces erosion.

The shoreline along the study area was estimated to retreat at varying rates between 0.4 and 0.6 metres per year as a result of global sea level rise. Profiles 1 and 3 are seen to have the longest distances of 317 and 271 metres, whilst profile 2 was seen to have the shortest distance of 208 metres.

Table 5-69 Estimation of long-term erosion trends for Old Harbour Bay beaches using Bruun Model.

Parameter	**Profile**			
	1	**2**	**3**	**4**
	0+250	**0+550**	**0+750**	**1+600**
Rate of sea level rise, Δ*s* *(mm/yr)*	0.0047	0.0047	0.0047	0.0047
Offshore profile, l (m)*	317	208	271	549
depth of offshore limit, h (m)*	2.5	2.5	2.5	2.5
Dune line Erosion, Δy (m)	0.60	0.39	0.51	1.03
Estimated change in 42 years (m)	25.03	16.42	21.40	42.32
Projected change in 25 years (m)	14.90	9.78	12.74	51.61

Limitations

Estimating long-term erosion trends as result of global sea level rise was not the main focus of this section. Given the anecdotal information in the area, it was important to know how the area is affected by long term and short term weather/climate events. The two most applicable approaches were chosen in order to arrive at a shoreline retreat rate which may be useful in determining how much of the observed erosion as actually due to events and short term erosion. The maps obtained were only snapshots at a moment in time that cannot be manipulated to show years or times of interest. Therefore some of the maps may be displaying short term shoreline configurations while others long term. The accuracy of the rates is therefore subjected to the use of more aerial photos at strategic times which cannot be sourced. Bruun model gives an estimate of the dune line erosion rate, however does not implicitly explore the possible changes in the profile owing to this retreat. These profile changes would have undoubtedly had an effect on any predicted storm-induced erosion on the shoreline and may certainly have explained why there is accretion at profile #2 and erosion for profiles 1 and 2.

5.2.4.2 Event Based Short Term Coastal Erosion

Model Description

SBEACH is an empirically based numerical model for estimating beach and dune erosion due to storm waves and water levels. The magnitude of cross-shore sand transport is related to wave energy dissipation per unit water volume in the main portion of the surf zone. The direction of transport is dependent on deep water wave steepness and sediment fall speed. SBEACH is a short-term storm processes model and is intended for the estimation of beach profile response to storm events. Typical simulation durations are limited to hours to days (1 week maximum).

Model Input

Profiles were cut from deep water to land up to a maximum elevation of approximately 10 metres from four Profiles spanning the entire shoreline. The wave data from the deep water hurricane model were utilized for this analysis. The wave characteristics used in this model are the same as those used for the wave transformation modelling.

Table 5-70 Input parameters for 50 year return storm.

Return Period	Direction	Hs (s)	Tp (s)	Setup (m)	Storm Duration (days)
50	S	7.2	13.3	2.15	2
	SE	7.2	13.3	2.15	2
100	S	7.7	13.7	2.44	2
	SE	7.7	13.7	2.44	2

Results

No erosion was shown for the 50 and 100 year storm at the four locations analyzed along the JPS shoreline. These results are consistent with the previous cross shore sediment transport model and wave transformation results that indicate the shoreline is stable for the 50 year and 100 year wave conditions.

5.2.4.3 Terrestrial Erosion

Methodology

One of the most widely used and accepted equations for estimating soil erosion is the Universal Soil Loss Equation (USLE), an empirical equation developed by the U.S. Department of Agriculture. The USLE estimates the annual tonnage of soil eroded from the site attributed only to a sheet and rill erosion. However, not all eroded soil qualifies as soil loss due to the fact that eroded soil may be redeposited before it leaves a slope and therefore does not factor into soil loss quantity. The formula for USLE is:

$$A = R \times K \times LS \times C \times P$$

Where A is the average annual soil loss measured in tons/acre, R is the rainfall erosion index, K is the soil erodibility factor, LS is the length-slope factor, C is the cover factor and P is the erosion control practice factor.

The rainfall erosion index (R) is a measure of the rainfall and runoff by geographic location:

$$R = 0.0483 \times p^{1.61}$$

Where p is the average annual precipitation measured in mm.

Rainfall data throughout the island was extracted from the rainfall stations database and the average annual precipitation was determined; the monthly precipitations were used to determine the respective annual precipitations. The greater the intensity and duration of the rain storm, the higher the erosion potential.

The *K factor* is an empirical value representing both susceptibility of soil to erosion and the amount and rate of runoff (i.e.) the erodibility per rainfall erosion unit. The soil texture, organic matter, structure, and permeability determine the erodibility of a particular soil. Generally, soils with K < 0.23 are low-erodibility soils and soils with K > 0.41 are considered highly erodible. The factors implemented within the GIS model ranged from 0.01 for almost no erosion to 0.65 for soils which are highly vulnerable to soil erosion. These values are summarized in Table 5-71.

Table 5-71 K-Factors associated with respective erosive soil properties.

Erosion Number	K Factor
0	0.01
1	0.1
2	0.125
3	0.35
4	0.5
5	0.65

The combined topographic effects of length and steepness of a slope are accounted for in the *LS factor*. The *S factor* is related the slope gradient factor while the *L factor* is the length of that slope; both factors being closely related with each other. The slope was calculated from a 30 meter DEM. In order to fit into the equation in terms of units, the slope was calculated using percent rise (s). This percent was then plugged into the formula to compute the *S factor*:

$$S = \frac{0.43 + 0.30s + 0.043s^2}{6.613}$$

Where s = percent rise of the calculated slope. The USLE was created to predict soil erosion delivered to the base of a 22-meter agricultural plot. As applied in this study, the cell's flow length was calculated as 30 meters and plugged into the following formula to compute the *L factor*:

$$L = \left(\frac{30}{22}\right)^m$$

Where m = 0.5 for slopes ≥ 5%, m = 0.4 for slopes 3.5% and 4.5% and m = 0.3 for slopes ≤ 3%. The *S factors* and *L factors* were then combined to form the *LS factors* using the following formula:

$$LS = L \times S\left(\frac{10000}{10000 + s^2}\right)$$

LS values range from less than 1 for short, flat slopes to nearly 50 for long, steep slopes, as demonstrated by the equation.

The *C factor* represents the effect of plants, soil cover, below-ground biomass, and soil-disturbing activities on soil erosion. It is essentially a ratio of the soil loss from a specific cover condition to the soil loss from a clean, tilled, fallow condition for the same soil, slope and rainfall conditions. It is an index of the type of ground cover and the condition of the soil over the area. Table 5-72 summarizes the *C factors* implemented in the GIS model.

Table 5-72 C-factors associated with specific land uses

Land Use	C Factor
Agriculture	0.07
Less cultivated lands	0.3
Bauxite Extraction	0.5

The *P* factor is defined as the ratio of soil loss with a given surface condition (contouring, control structures, roughening the soil) to soil loss with up-and-down hill ploughing. This factor accounts for ground surface conditions that affect the runoff velocity. This was assigned a constant value of 1.

Results

The average annual soil loss measured in tons/acre was determined using a GIS calculator and a soil erosion hazard map created based on the existing conditions such as land use and level of development within the Old Harbour Bay area. The proposed site is predicted to experience erosion rates of up to 0.45 Tones/acre/year.

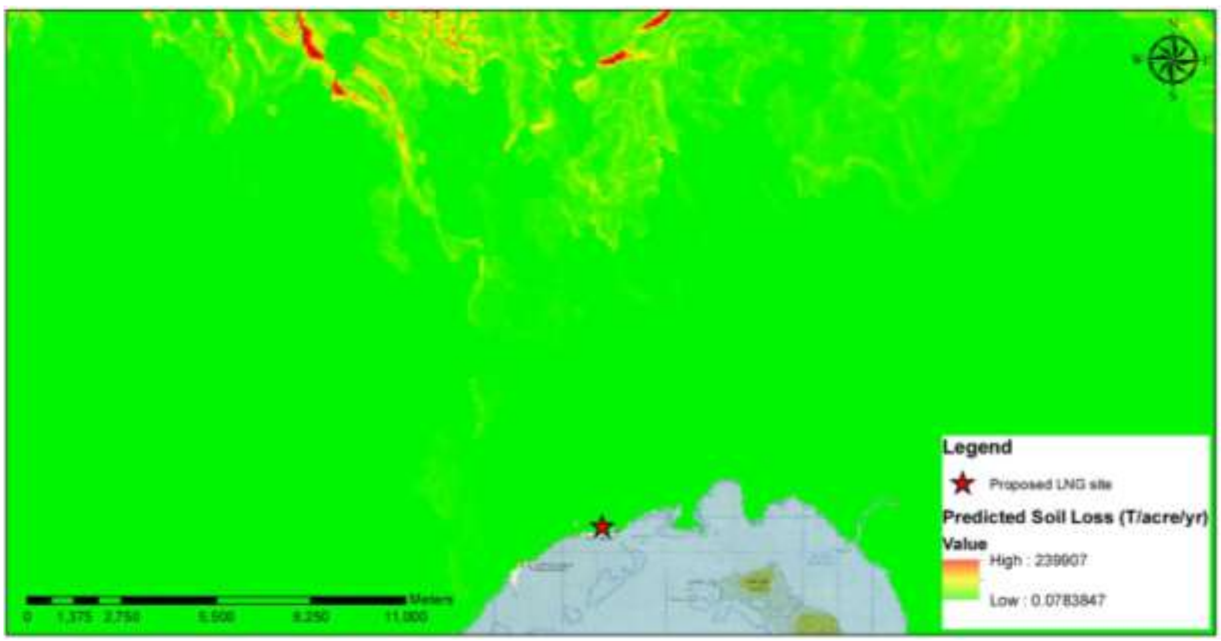


Figure 5-106. Soil loss hazard map showing the magnitude of soils loss within the proposed site and the wider Bowers Gully catchment.

5.2.5 Seismicity and Earthquakes

A probabilistic seismic assessment was recently conducted for Jamaica by The University of the West Indies (Salazar, et al 2013). This study found that Jamaica is characterized by medium-high seismic hazards due to the location of the Island on the Gonavave microplate bounded by the Oriente Fracture Zone to the North, the Cayman Spreading Center to the west, the Enriquillo Plantain Garden and the Walton Fault zones to the south. The horizontal peak ground acceleration (measured as “g” = gravity) on solid ground during a seismic event with a 10% probability of exceedance in 50 years, which corresponds to a 475 year return period (RP), ranges between 0.24 g and 0.30 g in eastern portions of the Island in the Blue Mountain region and 0.18 g in the western part of Jamaica (Salazar et al 2013).

The computation of spectral acceleration (what is what a building experiences during an earthquake) at periods of 0.2 second (s) and 1.0 s at RPs of 2,475 and 4,975 years, assures compatibility with requirements in the International Building Codes (IBC 2012) (Salazar, et al 2013). In the Old Harbour area for example, the spectral response acceleration at 0.2 s and 1.0 s was found to range from 15% of g to more than 40% of g, respectively, for a RP of 2,475 (Brown, 2010); values ranged from less than 0.2 g to a more than 1.4 g for various RPs in Salazar et al (2013). These studies, demonstrate good agreement between the computed hazard spectra and the spectra adopted by IBC (Salazar et al 2013).

5.2.6 Tsunami

5.2.6.1 Data Collection and Analysis

Earthquakes

The selected earthquake sources used for the tsunami modeling exercise for Old Harbour Bay originated off the coast of Panama. These earthquakes originate off the north coast of Panama and subsequently generate waves which will be calculated along the finite mesh to the selected destination, Old Harbour Bay, Jamaica. The following data sources were used in the modelling exercise[6]:

i) Magnitude: 6.5; Coordinates: 9.582°N 78.979°W;
ii) Magnitude: 7.0; Coordinates: 9.423°N 77.182°W;
iii) Magnitude: 7.5; Coordinates: 9.590°N 78.966°W;

Topography and Bathymetry

Topographic information for the nearshore was obtained from bathymetric studies as described in previous sections as well as from the British Admiralty charts.

5.2.6.2 Methodology

Tsunami Simulation

Tsunami Simulation consist of three distinct steps; they are generation, propagation and run-up or inundation. Three discreet tsunami events were modelled from the same general location off the northern coast of Panama.

The generation defines how the tsunami waves were generated – in this case they were tectonic tsunamis generated by the displacement of the continental plates off the coast of Panama. The

[6] United States Geological Survey (USGS), 2014 (http://earthquake.usgs.gov/earthquakes/map/)

location under consideration has a convergent plate boundary (also known as a reverse fault). An elastic half-plane model was used to estimate the water surface displacement due to the movements at the fault. The elastic half plane model was configured using data collected for each earthquake event; they are outlined in Table 5-73 below.

Table 5-73 Summary of earthquake characteristics implemented

Dip Angle [°]	84	72	74
Slip Angle [°]	-15	-32	138
Strike Angle [°]	248	96	133
Depth [km]	21	26	32
Latitude [°]	9.582	9.423	9.590
Longitude [°]	-78.979	-77.182	-78.966
Mw [-]	**6.5**	**7.0**	**7.5**

Propagation

The second step involved the propagation of the waves from the area of disturbance caused by the seafloor displacement. This disturbance creates a series of waves having various frequencies which cause the different elements to separate (disperse) as the waves propagate. Wave propagation modelling essentially estimates the movement of the wave(s) across the sea surface while considering seafloor bathymetry and how it affects amplitude, wavelength and speed, and dispersion. In terms of tsunami modelling the speed and amplitude are especially important in assessing the time of arrival to the area of interest and the amplitude as it approaches the shoreline. Tsunami waves are classified as shallow water waves because their wavelength in comparison to depth general exceeds a value of two (2). Shallow water wave equations were used to simulate the wave propagation; these classes of models are described by Klein (1998).

Tsunami Run-up

Tsunami Run-up estimates the inland limits of the flooding caused by the wave as it approaches the shoreline. The simulations were done utilizing the shallow water wave equations based on a moving boundary setting or scheme. Though time consuming and limited in area, this method general produces more better results than most other formulations such as the formulation described in Synolakis (1987).

Models Used

Numerical simulations of the Tsunamis were performed using the C3-COMCOT suite which simulates all three stages of the Tsunamis process; generation, propagation and inundation or run-up. The tsunami generation within COMCOT was carried out using the The elastic crust half plane model proposed by (Okada 1985), for tsunamis generated by earthquake triggered displacement at faults. This was developed following a review of the available tsunami generation methods. (Okada 1985) formulation is now the model of choice of most modellers as it is simple and gives reasonable good estimations in a variety of fault conditions. (Dmowska and Saltzman 1998) indicated the fault displacement (and water surface displacement) is a function of the amount of slip (uplift), dip, dislocation, strike width and length among others as shown in Figure 5-107 below taken from (Kongko 2011).

The C3 model is a hybrid of the Cantabria, COMCOT and Tsunami-Claw models; Álvarez-Gómez, Otero et al. (2009). It uses a finite differencing scheme in deep water and a finite volume scheme in the nearshore or coastal areas. This allows it to be efficient on both large offshore grids as it relates to computational speed and accuracy, without sacrificing the nearshore accuracy for wave transformation and run-up. Model testing and validation for several different problems, including for breaking and nonbreaking waves, has been documented by (Olabarrieta, Medina et al. 2011) as being satisfactory. The wave propagation part of the hybrid relies on the Shallow Water Equations models embedded with in COMCOT which has been utilized extensively for tsunami modelling with good results.

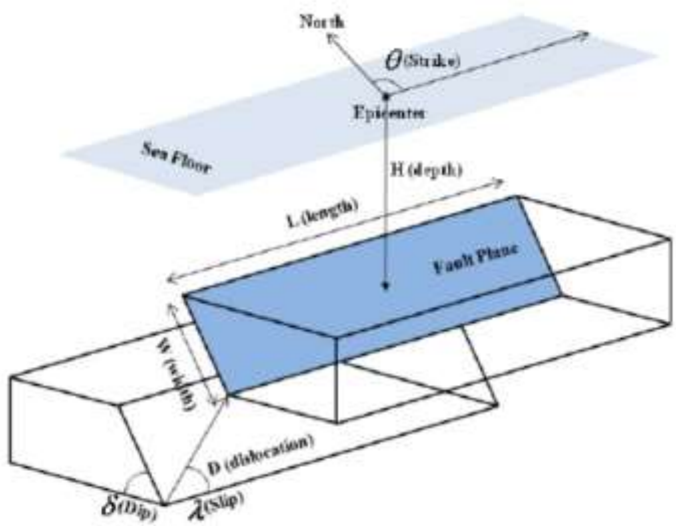


Figure 5-107 Fault Parameters: L is the fault length, H is depth from surface to epicenter, W is the width, strike is THE ANGLE in degrees from north, dip is the angle downwards measured FROM THE horizontal plane, AND SLIP angle is counterclockwise from horizontal.

5.2.6.3 Results and Discussions

From the simulation result, the first tsunami waves arrive at Old Harbour Bay, Jamaica (Layer 4) approximately 420 min after the earthquake. Afterward, successive attacks by a long train of tsunami waves caused a significant disturbance inside and immediately near the harbour. The coupled model system appears to be able to represent these chaotic dynamics. Along the coastline, the tsunami generates minimal eddies of various sizes, and the flow is muddled. Vorticity evolution as the tsunami propagates into the bay has been reasonably captured by the COMCOT model and is depicted in Table 5-74 through Table 5-76.

The wavelength of the tsunami waves and their period will depend on the generating mechanism and the dimensions of the source event. If the tsunami is generated from a large earthquake over a large area, its initial wavelength and period will be greater. If the tsunami is caused by a local landslide, both its initial wavelength and period will be shorter. The tsunami modelled for Old Harbour Bay, Jamaica was originated from a source off the coast of Panama where seismic activity is rather frequent. The simulation results indicate that the tsunami wave arrives at the Old Harbour Bay fishing village, Jamaica Public Service (JPS) power plant and JAMALCO (Salt River Bay) approximately 135, 120 and 108 minutes after the earthquake, respectively.

In the deep ocean, the height of the tsunami from trough to crest may be only a few centimetres to a meter or more - again depending on the generating source. Propagated tsunami wave crests were observed to be in the order of 0.15 to 7 meters high for deepwater wave climate, simulated with seismic magnitudes of 6.5, 7.0 and 7.5. Nearshore wave climate predicted crests ranged between 1.9 and 3.4 meters during wave actions within the Old Harbour Bay for a simulated seismic magnitude of 6.5. For a greater magnitude (7.0), nearshore wave heights ranged from 2.1 to 3.5 meters while speeds of 2.1 to 3.7 m/s were observed for a seismic activity of magnitude 7.5.

Tsunami waves in the deep ocean can travel at high speeds for long periods of time for distances of thousands of kilometres and lose very little energy in the process. For propagated tsunamis, with seismic magnitudes of 6.5, 7.0 and 7.5, the wave speeds ranged from 0.1 to 0.4 m/s for deepwater wave climate. Nearshore wave climate predicted speeds ranged between 0.5 and 1 m/s during wave actions within the Old Harbour Bay for a simulated seismic magnitude of 6.5. For a greater magnitude (7.0), nearshore wave speeds ranged from 0.57 to 1 m/s while speeds of 0.6 to 1 m/s were observed for a seismic activity of magnitude 7.5.

Table 5-74 Maximum wave elevations and velocities generated during simulation of 6.5 magnitude earthquake originating off panama coast: Deepwater wave elevations (Top Left), Nearshore wave elevation (Top right), Deepwater wave velocity (Bottom left), Nearshore wave velocity (Bottom right)

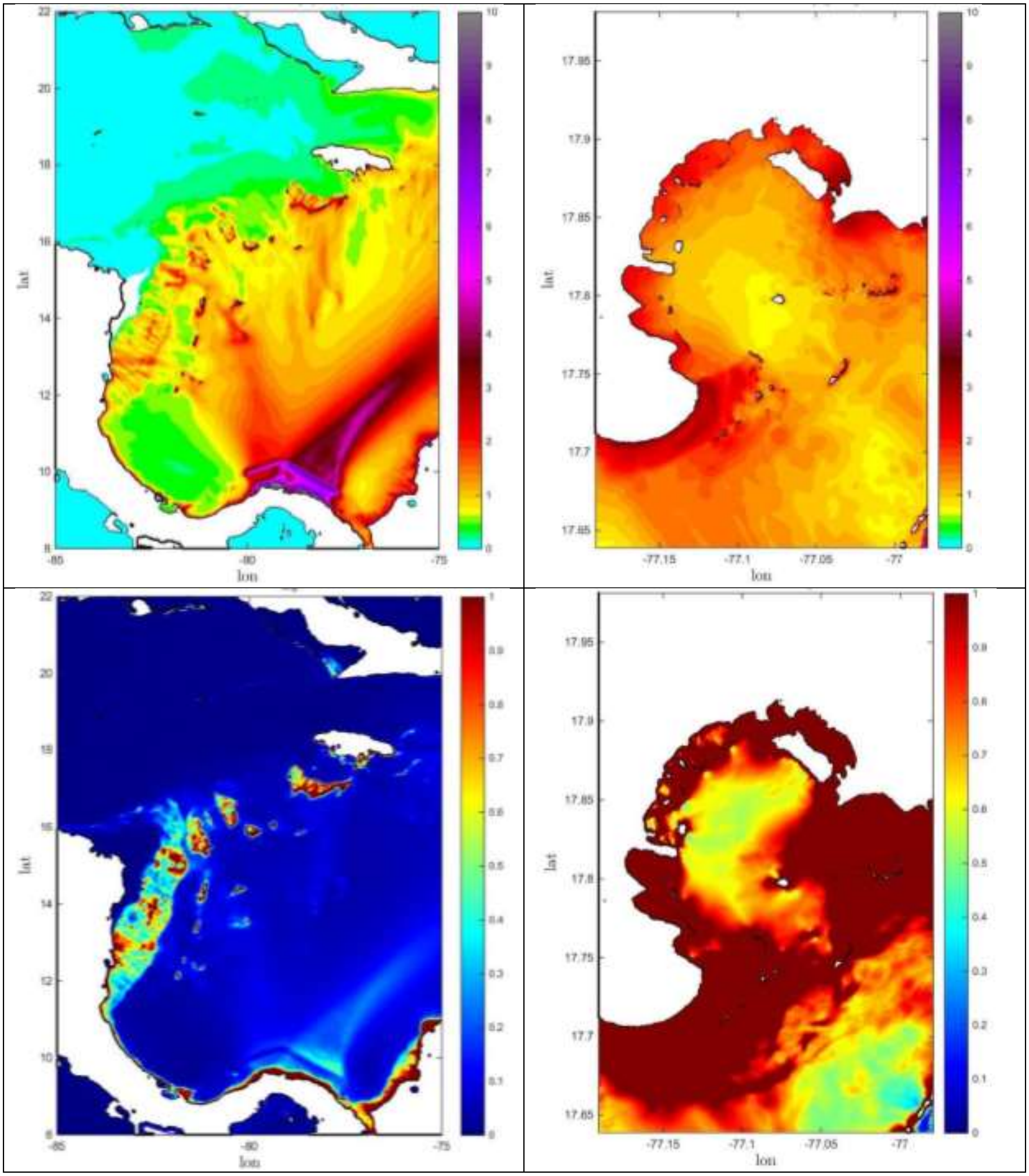


Table 5-75 Maximum wave elevations and velocities generated during simulation of 7.0 magnitude earthquake originating off panama coast: Deepwater wave elevations (Top Left), Nearshore wave elevation (Top right), Deepwater wave velocity (Bottom left), Nearshore wave velocity (Bottom right)

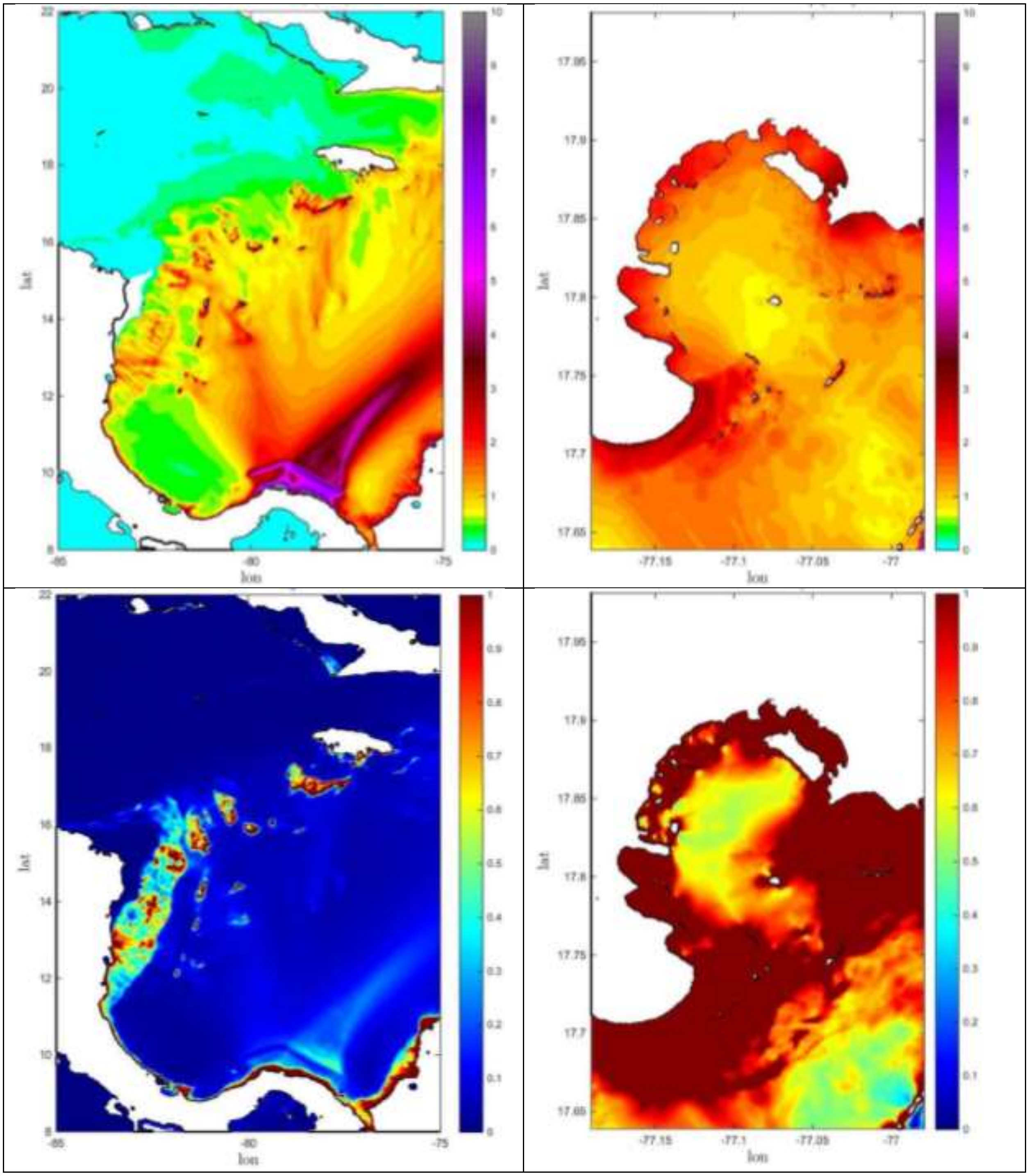
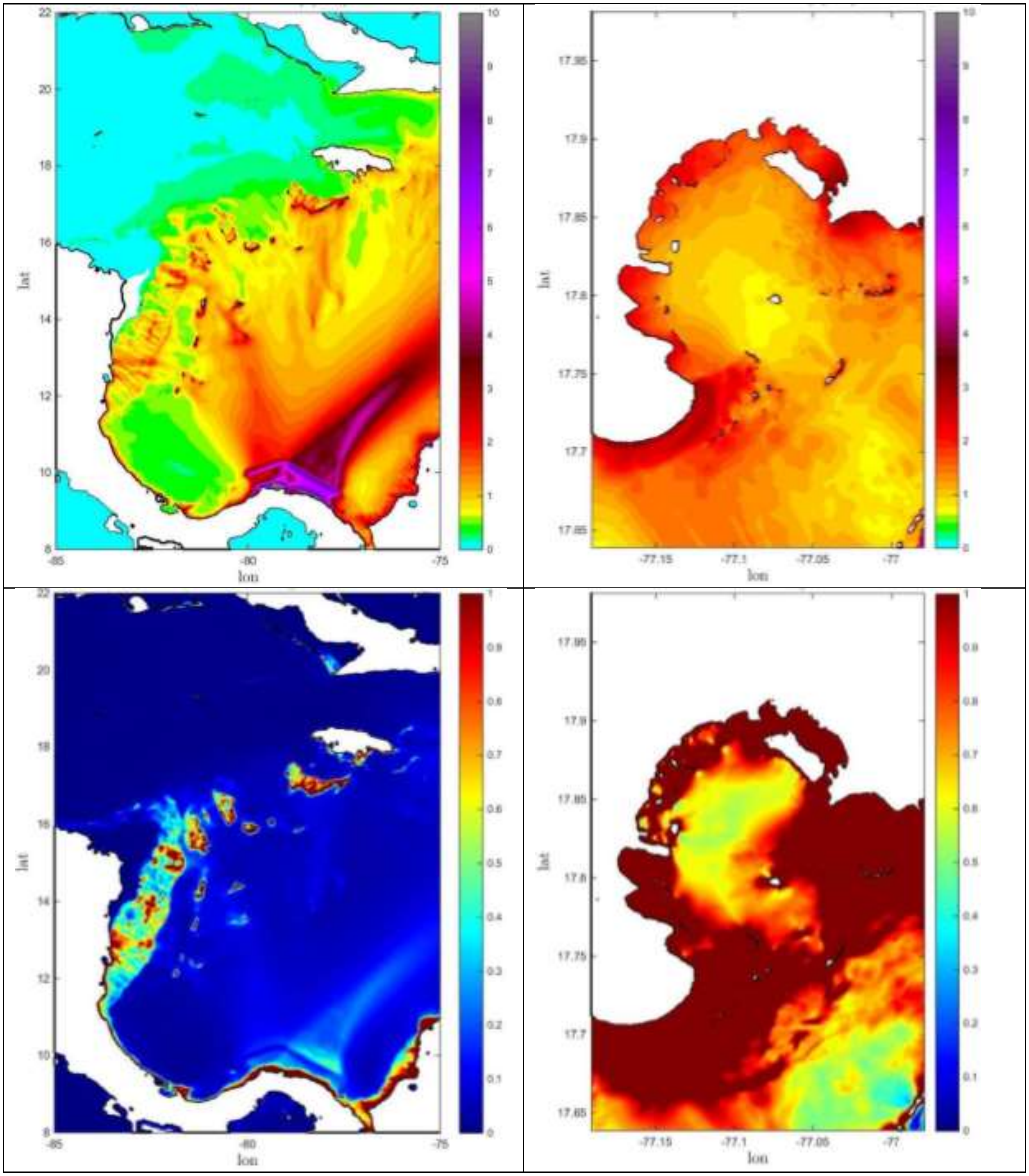


Table 5-76 Maximum wave elevations and velocities generated during simulation of 7.5 magnitude earthquake originating off panama coast: Deepwater wave elevations (Top Left), Nearshore wave elevation (Top right), Deepwater wave velocity (Bottom left), Nearshore wave velocity (Bottom right)



5.3 BIOLOGICAL

5.3.1 Overview

5.3.1.1 Protected Area Status

The proposed project site is located in the Portland Bight Protected Area (PBPA), totalling 1,876.2 km^2 in area, approximately 4.7% of the island of Jamaica. The PBPA is an environment management zone encompassing large sections of southern St. Catherine and Clarendon, totalling 519.8 km^2 of land (IVM, 2000). PBPA also encompasses a marine area of 1,356.4 km^2, which is a significant part of Jamaica's shallow shelf. Together, the marine and terrestrial sections of PBPA make it the largest protected area in Jamaica (C-CAM, 2012). The boundaries of the PBPA delineate 82.0 km^2 of wetland and 210.3 km^2 of forest, which is known for its pockets of ecologically important flora and fauna communities. According to the Portland Bight Sustainable Development Area Management Plan (C-CAM, 1999), the development site falls within an industrial zone of the PBPA.

Due to the size and diversity of the PBPA, baseline data is sparse and specific to entities/habitats identified as sensitive and of either national or international significance. Large expanses of the area have no baseline data and only generalizations of the identified ecosystems have been used for designated zoning/land uses guidelines. The zonation in this area ranges from the protection of critically endangered species, the Jamaican Iguana which was once thought to be extinct and now has been rediscovered in the Hellshire Hills. These hills represent the only known habitat of the iguana and are a dry limestone forest of global significance. This is in stark contrast to Old Harbour Bay - an area zoned for industrial activities which includes an Ethanol plant, JEP barges and the JPS Power-plant within disturbed coastal systems. The marine environment in the area has also suffered from severe anthropogenic influences, including dynamiting and over fishing as well as hurricane damage. The coral cays in the Bight also suffer from similar pressures but again in contrast are home to important birds, turtles and potentially manatees.

5.3.1.2 Habitats within Project Area

The proposed project area includes both a terrestrial and marine environment. The various habitats include old ponds, mudflats, mangrove wetland, coastal and the temporary wetlands (CL Environmental Co. Ltd., 2015). These although modified, are important habitat for wetland birds and several coastal species. Over 26 wetland bird species have been reported utilizing these areas.

The benthic community includes a nearshore lagoon, reef crest and forereef. The lagoon has a patchy distribution of various seagrasses, with a *Halodule* patch within the pipeline route. Several algal patches and meiofauna are also found in this area. The reef crest is composed of mainly unconsolidated material (coral skeletons/rubble and rocks) and held together by seagrass and various encrusting and fouling species. Diversity was low and the community dominated by macroalgae with few fish and invertebrates. Directly in front of the reef crest extends a silty and sandy bottom composed mainly of small patch reefs and dead coral heads. Some live coral was noted in the area along with several sponges and encrusting species and large amounts of macro algae. The proposed location of the offshore facility is a large silty sand patch, similar to other survey areas, with poor visibility, few fish, meiofauna and other invertebrates.

5.3.1.3 Ecosystem Services and Functions

Ecosystem functions are the conditions and processes through which natural ecosystems and their constituent species sustain and fulfil human life (Daily 1997). Ecological services are those ecosystem functions that are perceived to support human welfare (de Groot 1992; Ehrlich & Ehrlich 1992; Barbier et al. 1994; Costanza et al. 1997a; de Groot et al. 2002).

Natural processes tend to vary over time and space, as well as between species. The ecosystem services these natural processes provide are therefore also highly variable. It is often assumed that ecosystem services are provided linearly (unvaryingly, at a steady rate), but natural processes are characterized by thresholds and limiting functions. In order to refine ecosystem-based management practices, it is essential that natural variability and cumulative effects be considered in the valuation of ecosystem services.

It is therefore essential for any proposed mitigation measures to include, the current type and state of any existing system as well as attempting to understand the main roles that particular forest type may be playing in the natural environment. That is do not assume that all mangroves provide the equal or the same goods and services.

Further to this concept is that the common assumption that ecosystem services respond linearly to changes in habitat size (Edward B. Barbier, 2008). Ecosystems goods, services, form and function fluctuate naturally over time, that is they go through periods of die back, regrowth and other natural processes which in turn affects the services they provide at any given time.

5.3.2 Onshore Facility

5.3.2.1 Terrestrial Flora

Background

This section aims to present information regarding the floral composition of the general project area from previous studies and specifically between 1998 and 2014.

The Hellshire Hills, Brazilletto Mountains, Portland Ridge and Kemps Hill are localities known to possess significant stands of dry limestone forest; however, the two proximal areas, Brazilletto Mountains and Hellshire Hills, are far removed: approximately 4.5 km west and 10.5 km east of the study site respectively. Furthermore, the site is centred on an alluvial plain and not highland, limestone substratum. These factors, combined with the severity of disturbance observed on the current development site, have given rise to vegetation that differs notably in stature, structure and composition when compared to the forest flora in the Brazilletto Mountains and Hellshire Hills (Halcrow and Associates, 1998; C-CAM, 1999).

Approximately 3.0 km north of the Jamaica Broilers Ethanol Plant (Port Esquivel) site is the New Harbour Housing Development, located on lands which were originally occupied by scrub savannah and abandoned pasture (ESL, 2006a); vegetation types similar to those existing on the study site. The flora of the surrounding areas was described by the housing development's EIA as being severely disturbed and incapable of providing an easy source of re-colonising constituents (ESL, 2006a). No threatened or endangered plants were found on that site, which was primarily occupied by African Star Grass (*Rhynchospora* sp.) and trees such as Guango (*Samanea saman*) and Cashaw (*Prosopis juliflora*).

The closest industrial infrastructure to the study site is the ethanol processing facility at Port Esquivel, which is located approximately 2.3 km to the southwest of the JPS 190MW plant. Environmental Solutions Ltd. (ESL, 2006b) reported that the vegetation was disturbed and consisted of several types such as, coastal mangrove, coastal thorn scrub, salt flat and residential (cultivated) vegetation. During that expedition, two endemic species were encountered, *Opuntia jamaicensis* and *Hylocereus triangularis* (God Okra).

According to the South Jamaica Power Company Limited (SJPC) 360 MW Combined Cycle Plant EIA (CL Environmental, 2012), the lands could be delineated into three contiguous zones based on the community-types present. The first community type was a degraded Silt Mangrove wetland towards the southern perimeters. *Avicennia germinans* (Black Mangrove) was the dominant mangrove species encountered and was often associated with *Acacia tortuosa* (Wild Poponax) and *Harrisia gracilis* (Torchwood Dildo). The herb, *Eleocharis* sp. was a very common ground-layer constituent during this wet period, as well as the halophytic scrambler, *Sesuvium portulacastrum* (Seaside Purslane) (CL Environmental, 2012). Further north, there occurred a disturbed Salina, consisting mainly of herbaceous, secondary pioneer species that inhabited an area once used for inland aquaculture (CL Environmental, 2007 & 2012). The halophyte, *Batis maritima* (Jamaican Sapphire) and the grass, *Sporobolus* sp. were primary constituents of former pond basins where there appeared to be an accumulation of clay soil. The occurrence of *Sida acuta* (Broomweed) and *Urena lobata* (Ballard Bush) was also common near the edges and banks of pond-depressions (CL Environmental, 2012).

The northern half of the SJPC property was occupied by a Thorn Savannah that consisted mainly of large stands of the thorny leguminous phanerophyte, *A. tortuosa* surrounded by several introduced grass species. Apparently during the wetter months, expansive swards of *Panicum maximum* (Guinea Grass), *Adropogon* sp., *Cynodon dactylon* (Bermuda Grass) and *Paspalum* sp. occur abundantly. Sedges, namely *Cyperus* spp. and *Rhynchospora nervosa* (Star Grass), and weeds, such as *Bidens pilosa* (Spanish Needle), *Sida* spp., *Asclepias curassavica* (Red Top) and *Rivina humilis* (Bloodberry), were common. Where water tended to collect in small or gentle depressions *Typha domingensis* (Reedmace) and *Commelina diffusa* (Water Grass) were frequent (CL Environmental, 2012). The flora of the northern-most sector was found to be notably different from the surrounding flora, where several large stands of *Samanea saman* (Guango) and *Guzuma ulmifolia* (Bastard Cedar) trees were observed. These trees had an average DBH of 52.4 cm and 28.4 cm and an average height of 11.3 m and 6.7 m respectively (CL Environmental, 2012). Overall, the SJPC area appeared to be affected by high levels of anthropogenic influence. This was evidenced especially by coppicing (tree cutting), charcoal burning and grazing by domestic livestock. Paths had also been created through sections of the vegetation, indicating repeated human access.

For purposes of the JPS190 MW EIA, a survey executed in 2014 revealed a plant community conditioned to endure continuous anthropogenic activity, prolonged drought and some minor flooding (CL Environmental, 2015). The flora consisted of a mosaic of severely disturbed, secondary-succession vegetation types. These terrestrial communities included a salina that appears to transition into a severely degraded wetland, as well as a patchwork of savannah and thorn savannah flora. Figure 5-108 shows the zones established from this survey and the following are the areas calculated for each zone:

- Salina (including remnants of mangrove community) = 16,737 m^2 or 0.016 km^2
- Thorn savannah
    - Adjacent to JPS 190 MW site = 109,622 m^2 or 0.109 km^2
    - East of project area = 47,338 m^2 or 0.047 km^2

Method

Previous studies found that both the project area and the surrounding lands were highly disturbed. The areas could therefore be effectively surveyed using a series of walk-though floral inventories. The 2012 SJPC 360 MW Combined Cycle Plant EIA provided the most recent background information (CL Environmental Co. Ltd., 2012). Belt transects of the coastal forest were conducted within the impact areas (1. Metering station, 2. Pipeline and 3. Storage tank) to determine the vegetation characteristics: species presence/absence, mangrove tree/seedling density, height and percentage cover.

Results and Discussion

Previous studies include surveys conducted in 2012 (CL Environmental Co. Ltd., 2012) and 2014 (CL Environmental Co. Ltd., 2015) and described the area as having 3 distinct communities, which were severely disturbed secondary-succession vegetation types: Mangrove (degraded wetland near the coast); Salina and Thorn savannah. These types were also reported during the survey for this project, with approximate survey zoned areas shown in Figure 5-108 and as follows:

- Mangrove forest:
    - Black mangrove zone = 24,776.4 m^2 or 0.025 km^2
    - Disturbed mixed mangrove/pastoral zone = 30,831.9 m^2 or 0.031 km^2
    - Red mangrove zone = 3,143.3 m^2 or 0.003 km^2
- Salt marsh/salina zone = 17,761.60 m^2 or 0.003 km^2

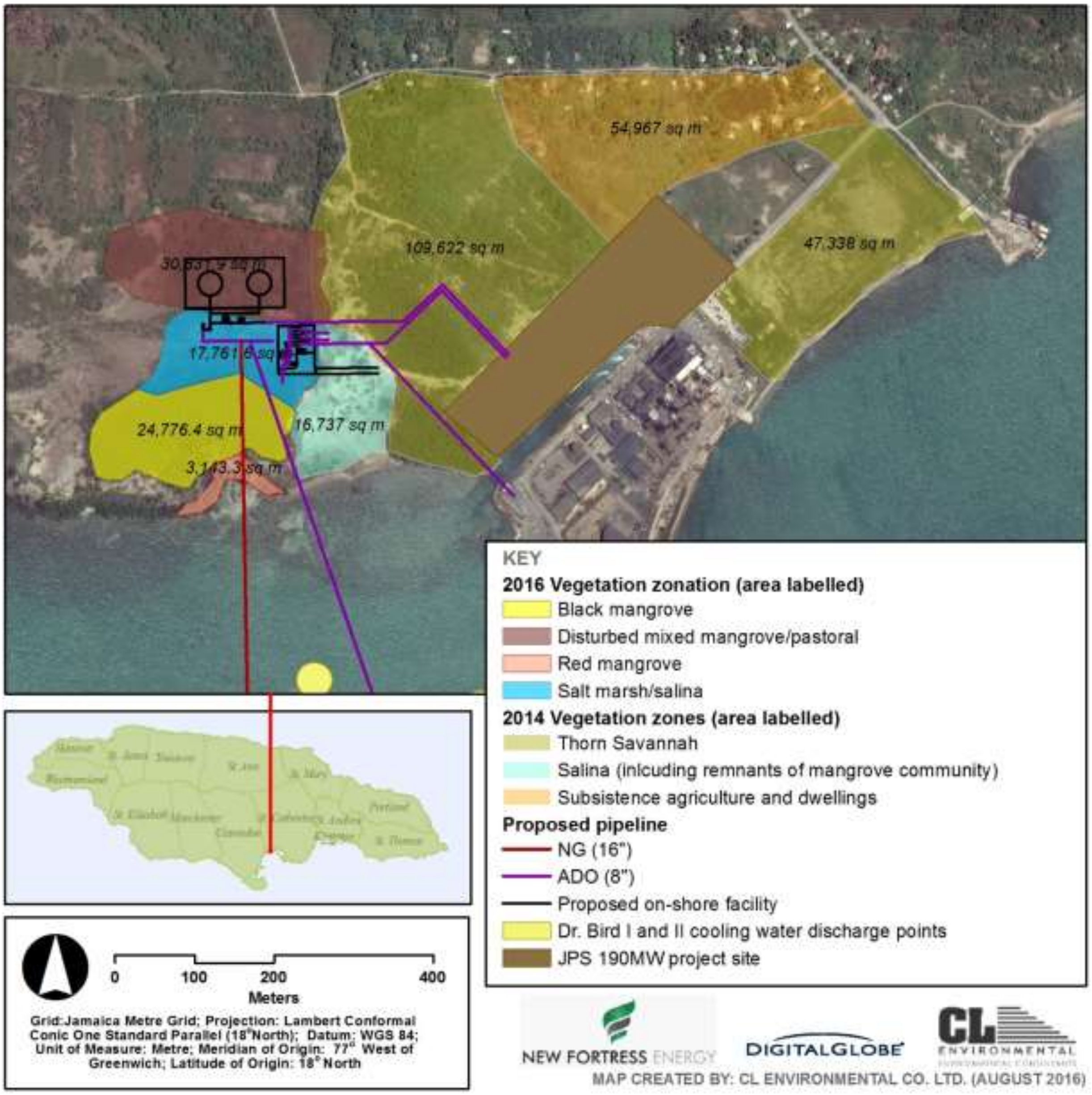


Figure 5-108 Vegetation zones mapped in 2014 for the JPS 190MW project as well as in 2016 for the purposes of this project.

THE PIPELINE ROUTE

The proposed pipeline route runs underneath a degraded mangrove forest through the salt marsh/ salina, where it enters the tank area. Pipelines also are connected to the metering centre area, which continues towards the JPS power plant through savannah and thorn savannah. The mangrove transitions from a red mangrove (*Rhizophora mangle*) dominated area along the coastline to a black mangrove (*Avicennia germinans*) area further inland.

Plate 5-2 Red mangroves at proposed entry point of pipeline

Plate 5-3 Black mangrove forest showing dense breathing roots (often extend 1-3 m deep within substrate) 25m north of shoreline- along proposed pipeline footprint

Plate 5-4 Salt marsh/wetland area with back mangrove trees- northern end of proposed pipeline footprint

TANK FARM AREA AND METERING STATION

The tank farm area is 110m x 65m and is proposed to be constructed in the northernmost area which is dominated by black mangrove plants. This disturbed mangrove forest did not exhibit standing/tidal water during the surveys and thus exhibited moderate level of disturbances from anthropogenic factors (fire, evidence of grazing by animals, solid waste disposal). The mid-section of the proposed site showed significant historical disturbance by fire. Despite this, the average density of the plants was 0.33 black mangrove plants per m^2.

Measuring 65m x 50m and located east of the pipeline, the metering station is proposed to be constructed in the disturbed mangrove/salt marsh zone area. This buildings footprint would be constructed in an area having an average mangrove density of 0.21 black mangrove plants per m2.

The proposed fuel storage tanks and metering station are located near the Thorn Savannah ecosystem. This ecosystem is comprised mainly of *Acacia* sp. trees and stands and is made up in three main ways: (i) the under storey vegetation tends to be more pioneer, monocotyledonous, vegetation (i.e. grass, etc.), (ii) the canopy is more open, and (iii) the trees are more low-profile (i.e. only a couple of meters high).

Appendix 6 gives a species list of vegetation encountered in the project area and according to the 2012 SJPC study.

Plate 5-5 View of tankfarm footprint area

Plate 5-6 Transect 2 –middle of tankfarm footprint: evidence of burning of Sporobolus grass and black mangroves

Plate 5-7 Disturbed mangrove forest with salt marsh under-brush –footprint of western end of tankfarm

Ecosystem Services

As these mangroves are protected under the Ramsar convention and require site specific mitigation, it essential that any such mitigation consider the type of ecosystem services and value that this forest provides. The goods and services that mangrove forests provide to society are widely understood but may be too generally stated to serve as useful guidelines in decision-making (Hussain & Badola, 2005). For example, in general biodiversity at genetic, species, population and ecosystem levels contributes to maintaining these functions and services. Mangrove ecosystems (Ewel, et al., 1998) are widely recognized as providers of a great variety of goods and services, for example (all cited in (Hussain & Badola, 2005):

1. Optimal breeding, feeding and nursery grounds for many ecologically and economically important fish and shellfish species (Macnae, 1974).
2. Feeding habitats for resident and migrant water birds.
3. Protect freshwater resources against saltwater intrusion.
4. Erosion control and storm protection - Protect the land from eroding waves and winds (Semesi, 1998) and stabilize the coastal land (Carlton 1974 cited in (Ewel, et al., 1998)). Mangrove forests can be considered as natural barriers protecting the life and property of coastal communities from storms and cyclones.
5. The above-ground root system retards water flow that not only encourages sediment to settle, but also inhibits its resuspension (Gilbert & Janssen 1998).
6. Climate stability

7. Maintenance of biodiversity and beneficial species.
8. Flood mitigation.
9. Groundwater recharge and pollution control.

However, to refine this idea even further is the knowledge that different kinds of mangroves provide different types of services (Barbier, 2007). Understanding the differences between fringe, riverine, and basin forests may help to focus these guidelines and to determine the best use of a particular forest. Fringing forests are primarily most important in shoreline protection, Riverine forests, which are very productive, are particularly important in animal and plant productivity, perhaps because of the high nutrient conditions associated with sediment trapping. Basin forests serve as nutrient sinks for both natural and anthropogenic enhanced ecosystem process (Ewel, et al., 1998). Exploitation of a forest for one particular reason may make it incapable of providing other goods and services.

The black mangrove forest is likely to provide important habitat for wetland species, in particular birds (due to the distance from shore, this area maybe less used by waterfowl than other nearby coastal flora); however, these mangroves are also unlikely to provide a major benefit as nursery habitat for marine species. They may also provide flood protection, reduce erosion and aid in climate stability but are not likely to provide coastal or shoreline protection or help the stabilization and resuspension or sediments.

5.3.2.2 Fauna

Introduction

The terrestrial invertebrate fauna was found to be limited with fifty-four (54) species of insects, five (5) species of spiders and two (2) species of land snails identified in 190 MW study. No sea turtles nor crocodiles or signs of their presence have been documented within the property boundaries. However, crocodile's nests and juveniles have been reported in lower sections of Bowers Gully.

The sample sites for the avifauna survey were zoned according to vegetation and habitat types, which includes acacia woodland, fish ponds, mangrove wetlands, mudflats and salinas which are described below. The old fish ponds on the property were all dried at the time both studies were carried out. The vegetation within the ponds consists of grasses, sedges and small shrubs. In addition, several land crab holes were observed in the ponds. There was also a belt of large acacia trees along the banks of the ponds.

Method

A modified line transect bird survey method was used for the study along the established trails on the property. The method entailed walking slowly for a given distance along selected routes and noting all the birds seen or heard in the area (Wunderle, 1994). The trails were used as transects due to the size of the area and the easy accessible trails which pass through the different vegetation types. It should be noted that there was no need to create new trails because there was a network of trails on the property; no area was more than a few meters from a trail. In addition, new trails would further disturb the fauna in the area. In addition, additional time were spent at the water bodies and the salinas to note wetland birds present.

The bird survey was also carried out in the night for the nocturnal bird species. The studies were carried out in August 2012 (CL Environmental Co. Ltd., 2012) and July 2014 (CL Environmental Co. Ltd., 2015).

Results and Discussion

FISH PONDS, WETLAND, COAST AND SALINA

The old ponds, mudflats, mangrove wetland, coast and the temporary wetland within the study area provide important habitat for wetland birds and several coastal species. Over 26 wetland bird species were observed on the coast, fish ponds, mangrove forest and Salina which include Heron and Egrets (n=7), Pelicans (n=1), Ibises (n=2), Plovers (n=7), Sandpipers (n=4), stilts (n=1), warblers (n=1) and Frigate birds (n=1); 16 residents and 5resident/ migrants. The most abundant bird present in the area was the Cattle egrets.

FISH PONDS

Only a few birds were observed foraging in the old fishponds, which were mainly herons. It should be noted that the fish ponds were dry when the surveys were carried and this could be the main reason why the wetland bird numbers were low.

MANGROVE WETLAND

A few birds were observed in the mangroves, such as the Yellow Warblers, Kingfisher, White Winged Doves and the Black Crowned Night Heron. The Yellow Warbler was the most common bird in the mangroves. No migrant warblers were seen as result at the time both surveys were carried out.

COASTAL BIRDS

On the coast, birds such as the Brown Pelican, Laughing Gull and Frigate Bird were observed. The most common species seen on the coast was the Frigate Bird. The Semipalmated Plover and the Sandpiper were seen foraging on the coast during low tide and on the coastal mudflats.

MUDFLAT AND SALINAS

The majority of the wetland birds were observed in the mudflats and the Salinas such as Plovers, Herons, and Sand Pipers. The Cattle Egret was the most abundant bird species seen foraging in the mudflats and Salinas. Resident/ migrant wetland birds which can be categorised as mudflat and salina specialist such as the Long-billed Curlew, Semipalmated Plover and the Spotted Sand Pipers were also seen foraging in the mudflats. It should be noted that the mudflats are an important habitat on the property for mudflat and salina specialists. In addition, during the rainy reason several areas in the Salina floods creating temporary ponds.

The Salinas and mudflats provide an important habitat for several crustaceans, and are also an important habitat for the several wetland birds that specialize in foraging on these crustaceans and other arthropods in the area, such as such as Plovers, Herons, and Sand Pipers. The mudflats and Salinas are located near the Bowers Gully, where crocodiles were observed. However, no crocodiles were observed in the Salinas and Mudflats. The crocodile surveys conducted during the 190MW EIA were conducted during the daytime and night time.

BOWERS GULLY

The riverine system provides a habitat for crocodiles; it is known to be a nesting area for crocodiles, where, the network of mangroves roots protects the hatchlings until they reach maturity. Bowers Gully is the largest fresh water source the area, other than the old fishponds which are usually dry. It is an important refuge for fresh water birds such as Herons, Egret, Common Moorhen and Ducks and as such it became a popular spot for birding. It is also an important fish nursery.

Great Egret, Little Blue Heron and Yellow- crowned night Heron were the only birds seen in the river. Birds such as the Coots, Common Moorhen or Grebes, which are common in fresh water bodies and rivers, were not seen. It is possible that the flow and the salinity of the river could have been attributing to their absence. It is also possible that crocodile predation in the river is another factor which could contribute to the low numbers of wetland birds in the river.

Overall, the number of wetland birds seen was very low and this could be as a result of the time of the year both surveys was carried out. The survey was carried out during the dry season where water levels are low. During the rainy season, the wetland floods and the old fish ponds floods, providing habitats for waterfowls such as ducks, moorhens and Coots. It should be noted that both surveys were conducted before the arrival of the migrant wetland birds from North America.

Only a few migrant warblers were seen in the study which is as a result of the time of the year the study was carried out before the arrival of the migrants from North America. Studies have shown that dry forest, acacia forest, and scrubland vegetation are prime habitat for migrant warblers (Douglas, 2002). Of the 200 bird species found on the island, there are 74 winter visitors (Ann Haynes-Sutton, 2009)). Overall, migratory birds account for a large number of Jamaica's avifauna, which is almost doubled during winter season from August to May. The acacia woodland is relatively small therefore only a few bird's species which are typical of dry limestone forest were observed during the study. There were also a few Acacia trees along the banks of the abandoned fish ponds that provide a habitat for the terrestrial bird species encountered on the property.

Appendix 7 gives a species list of both wetland birds and terrestrial birds observed in the project area, during the JPS 190 MW EIA study. It also lists the winter migrants that were not observed during this study due to the time of year the study was conducted, as well as the species list from the nearby Jamaica Broilers Ethanol Plant site (ESL, 2006b).

5.3.3 Offshore Facility and Pipeline Route (Benthic Community)

5.3.3.1 Introduction

The benthic community of the proposed project area and area of influence has been reported in previous studies. This report will include both previous studies as well as current data collected. Areas which may be directly in the proposed project footprint were assessed in greater detail where possible or necessary.

Previous studies include benthic assessments conducted in May 2012 (CL Environmental Co. Ltd., 2012) and October 2014 (CL Environmental Co. Ltd., 2015). The study area extended approximately 2 kilometres, from the shoreline to the reef area. Two distinct zones were identified during the survey: 1) Fore Reef; and 2) Reef Crest and Lagoon. The proposed project footprint was then re surveyed (by various methods) as part of the current study.

5.3.3.2 Method

Using the results and data from the 2012 and the 2014 survey of the areas, surveys and ground truthing activities in the proposed footprint and area of influence, were conducted in order to describe both the proposed impact areas as well as the surrounding areas of influence. The study area can be characterised by poor visibility and dominated by soft, silty sediment which is easily disturbed and extremely poor visibility in many areas. As such, the following survey types were employed:

- **Roving SCUBA Survey**
  Roving SCUBA surveys were conducted. A photo inventory of sensitive species such as coral and seagrass were recorded along with general observations.
- **Grab Sample**
  Grab samples were used in a ground truthing exercise. This was then used to help describe each environment/sediment type.
- **ROV Survey**
  A ROV (VideoRay Remotely operated vehicle) was used when environmental conditions prevented the typical roving survey, such as; extremely poor visibility, shallow, easily disturbed soft sediment, and personnel hazards (crocodiles). The images and video captured with the ROV were used to help describe the substrate type and conditions.

5.3.3.3 Results

During the 2012 and 2014 studies (CL Environmental Co. Ltd., 2015, CL Environmental Co. Ltd., 2012), the benthic community was found to have low abundance and diversity. The reef crest was found to be composed of mainly unconsolidated material (coral skeletons/rubble and rocks) and held together by seagrass and various encrusting and fouling species. Diversity was low and the community dominated by macroalgae with few fish and invertebrates. The Forereef (directly in front of these patch areas) is a silty and sandy bottom composed mainly of small patch reefs and dead coral heads. Some live coral was noted in the area along with several sponges and encrusting species and large amounts of macro algae. The lagoon area continues to have low light, high turbidity, warm waters, a silty sediment and very little substrate. These conditions are not ideal for the recruitment and growth of corals and other sessile reef invertebrates. As a result, the lagoon is not typical of other lagoon environments in the PBPA.

Seagrass occurs in the both the lagoon and sections of the reef crest (Figure 5-109). The proposed pipeline will run underneath sections of the lagoon and reef crest which contain seagrass and other sensitive flora and fauna. These are not expected to be impacted by the pipeline as it will be drilled bellow these systems.

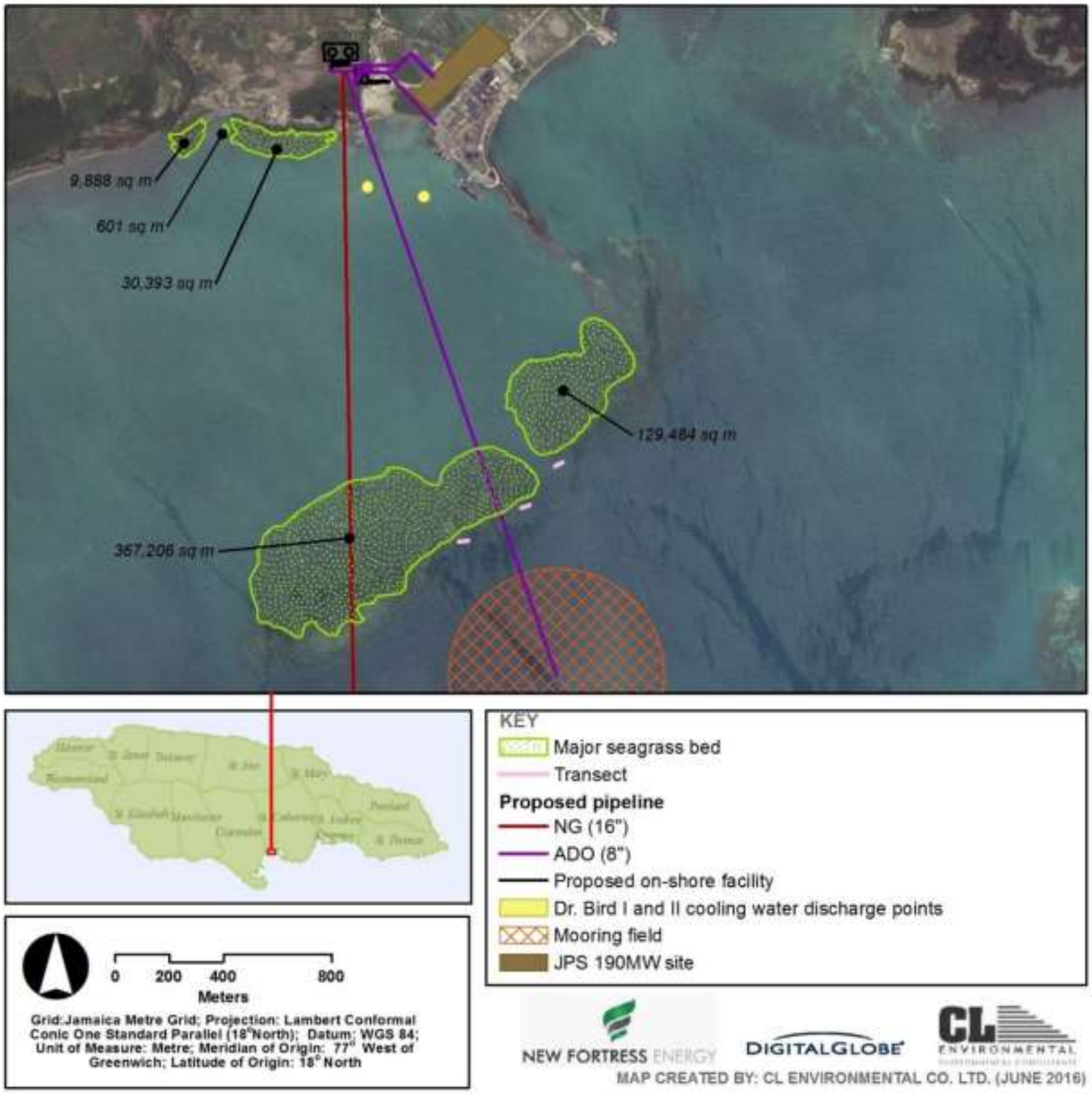


Figure 5-109 Seagrass beds mapped in 2015 for the JPS 190MW project

Community Types

CORAL AND SEAGRASS COMMUNITY

As reported in previous studies, the fringing reef system was reported approximately 3km from the shoreline (CLE, 2005), but no distinct coral reef communities were observed (CLE, 2005; ESL, 2006b, CLE 2012 and CLE 2015). The area was dominated by seagrass, *Thalassia testudinum*, and macroalgae with mounds of coral heads and coral rubble interspersed throughout (ESL, 2006b). The shoreline there is a patchy distribution of *Halodule*. The poor visibility and patchy distribution made mapping this bed impossible; however major seagrass beds successfully mapped in 2014 totalled 0.54 km² in area (Figure 5-109). The coral community occurs in an area with available substrate, which includes rubble, rock and dead patch reefs.

The unconsolidated substrate continues to be dominated by various fleshy macro algae. The 2014 study lists the following types of algae seen in the area; *Sargassum* sp., *Caulerpa* sp., *Dictyota* sp. Some calcareous species were also identified; *Halimeda* spp. and *Galaxura* spp. and small amounts of turf algae. Figure 5-110 shows the distribution of algae seen in 2014.

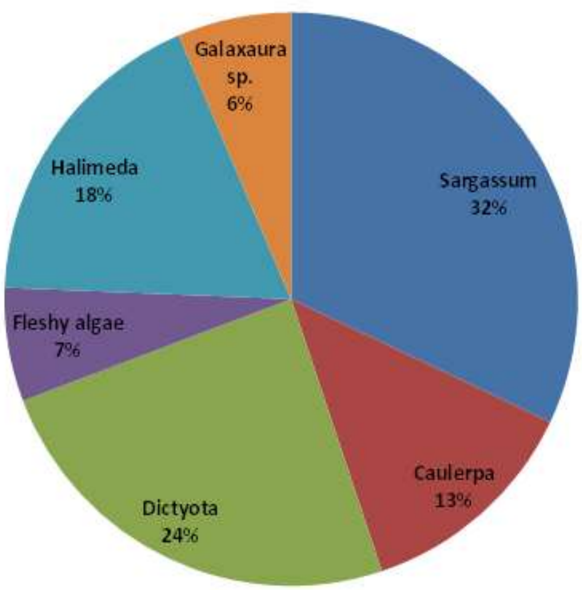


Figure 5-110 Algal Composition of the Backreef Area

The general reef conditions including the dominant algal species (Plate 5-8and Plate 5-9). Some sponges were also seen holding the substrate together (Plate 5-10), however the typical nuisance sponges such as the 'chicken liver' *(Chondrilla nucula*) were not observed, during previous surveys.

Plate 5-8 Algae covering the substrate (*Caulerpa sp.*)

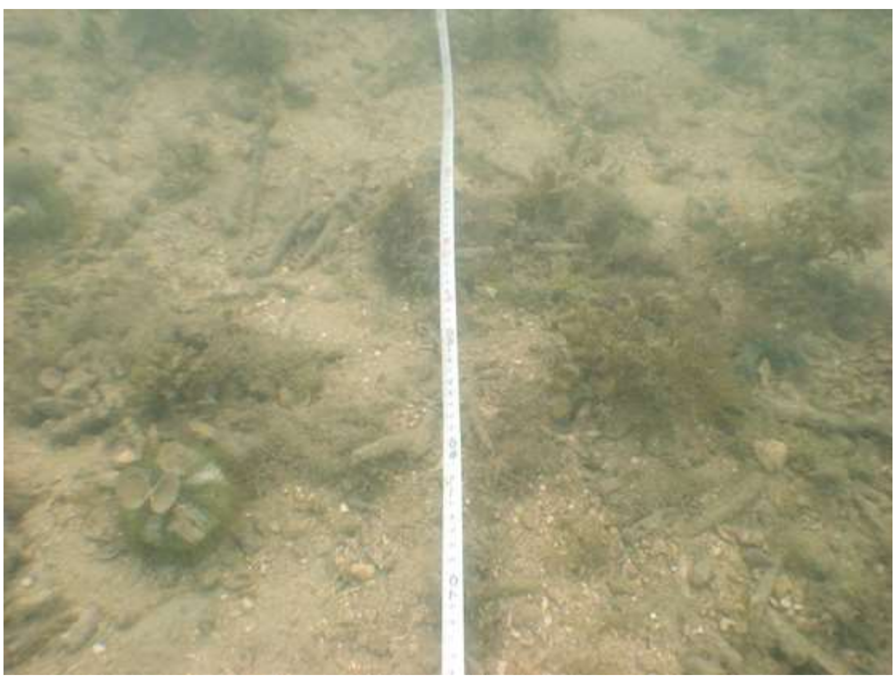


Plate 5-9 Sandy/rubble substrate with some macro algae in survey area

Plate 5-10 An example of sections of the substrate held together by sponges and algae

A total of seven hard coral species identified in the 2014 study (Table 5-77). These include *Colophyllia natans*, *Oculina sp*., *Porites asteroides*, *Stephanocenia intersepta* and *Mancinia areolata* and *Montastrea annularis*. Some soft corals (Sea whips) were also identified. The sample area of 90 m^2 was found to be a sufficient sample area for hard corals (Figure 5-111). The pictures below (Plate 5-11 - Plate 5-15) are examples of corals seen in previous studies in the area.

Table 5-77 Table showing the live hard coral species observed in the project area

Source: CL Environmental Co. Ltd., 2015

Species	Family	Frequency	Relative abundance (%)
Oculina sp.	Oculinidae	5	11.36
Porites asteroides	Poritidae	5	11.36
Stephanocoenia sp.	Astrocoeniidae	8	18.18
Favia sp.	Favidae	1	2.27
Mancinia sp.	Favidae	21	47.72
Montastraea annularis	Favidae	3	6.82
Colophyllia natans	Favidae	1	2.27

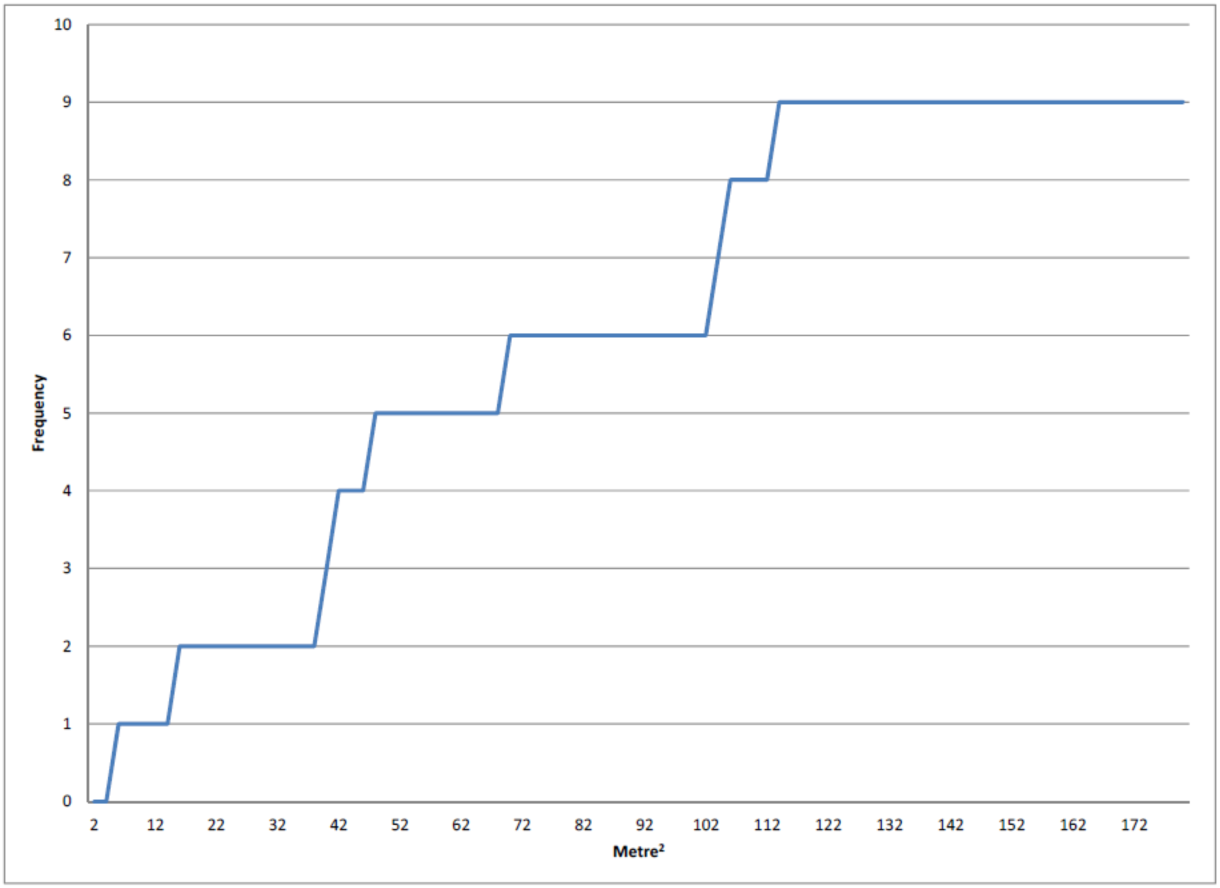


Figure 5-111 Species-Area curve for hard coral species in Study Area

Plate 5-11 *Colpophyllia sp.*

Plate 5-12 *Oculina* sp.

Plate 5-13 Porites asteroides.

Plate 5-14 Stephanocenia sp. and Mancinia sp.

Plate 5-15 Montastrea annularis colony

The results of the previous surveys were also compared to other surveys conducted in the PBPA; 2005 JCRMN (Jamaica Coral Reef Monitoring Network) report, surveys were conducted by the JCRMN in conjunction with CCAM during 2004 and 2005 at nine sites associated with the cays and shoals. The results from these assessments showed variable hard coral cover ranging from 0% to 34% with a mean of 20%. Between 8 and 13 coral species were identified and the most common species were those of *Porites spp* and *Montastrea spp*. At the site with no hard coral present, the substrate was dominated by algae (48%). These results are similar in the study area which is an algal dominated reef with low hard coral cover and diversity.

The reef appears to have suffered severe damage as a result of natural and anthropogenic impacts, including wave damage during storms and hurricanes, possible dynamiting, nutrient loading and unsustainable fishing practices. The reef has shifted from a coral dominated reef to an algal dominated reef, resulting in the low coral cover and low species diversity. No disease or bleaching was observed during the survey. The poor substrate condition makes the settlement/recruitment of coral larvae difficult; that is unconsolidated substrates are not ideal for coral recruitment compounded by the large algal mats, sponges and other encrusting organisms which prevent the settlement of larvae. Crustose coralline algae were observed but the occurrence was low. Encrusting coralline algae makes a more suitable environment for coral recruitment.

FISH COMMUNITY

The 2014 study reported a historically that a total of 98 species were found within the Portland Bight with sites in the east having higher species richness than the sites in the west of the Bight, despite nearly identical ecology and physio-chemical characteristics. Fish size, diversity and abundance were found to be low in the 2014 study (Table 5-78). Fish diversity and abundance were low, suggesting the area continues to be overfished while the low occurrences of juveniles may be due to the extremely poor visibility in nursery areas as well as a general reduced nursery function of damaged systems.

Table 5-78 Table showing a summary of the fish survey

Source: CL Environmental Co. Ltd., 2015

Fish	Genus/Family	Frequency		Adult/ Juvenile	Feeding Habit
		≤5cm	≥10cm		
Dusky damselfish	*Stegastes adusus*	8		A	Herbivore
Threespot damselfish	*Stegastes planifrons*	1		A	Herbivore
Surgeon Fish	*Acanthuridae*	1		A	Herbivore
Parrot fish	*Scaridae*	4	4	J	Herbivore
Wrasse	*Labridae*	5		A	Omnivore
Remora	*Echeneis neucratoides*		1	J	Planktivore

INVERTEBRATE COMMUNITY

Large section of the benthic environment of the study area consists mainly of a soft silty sediment and therefore is dominated by an invertebrate community more specifically meiofauna. Meiofauna can be described mainly as animals that live in or on the benthos. Important taxa of meiobenthos in shallow water estuarine and coastal marine habitats include harpactacoid copepods, nematodes, ostracods and Foraminfera. Some animals, such as annelids and bivalves that typically grow larger are meiofaunal size as juveniles. They are known as "temporary meiofauna." (Department of Biological Sciences | School of Marine Science, n.d.).

Meiofauna are an important component of benthic habitats due to their small size, abundance and rapid turnover rates. They exhibit high abundance, diversity and productivity in many sedimentary habitats and play important roles in benthic food webs. The secondary production of meiofauna may equal or exceed that of macrofauna. Meiofauna feed on benthic microalgae, other microbes, and detrital food sources and are, in turn, important food resources for grass shrimp and a variety of juvenile fish that utilize shallow water nursery habitats. Through their feeding and burrowing activities, meiofauna help to keep microbial communities active, which serves to enhance productivity and the recycling of nutrients.

In general, meiofauna inhabit either the upper oxic zone of sand while some live in the anoxic or sulphur rich lower layer. The depth of each o0f these zones is site specific. The proposed pipeline is to be deep enough to minimally (if at all) impact the anoxic zone (Mark B. Meyers, 1987).

The current study identified a similar invertebrate and meiofauna (Plate 5-16 - Plate 5-18) community to previous studies. These included; brittle stars and star fish (*Oreaster sp.*) (Plate 5-19), sea cucumbers such as Donkey Dung (*Holothuria mexicana*) and sea urchins (*Echinometra sp* and *Lytechinus sp.*).

Plate 5-16 Sea cucumber on a soft silty substrate in the survey area in the current study

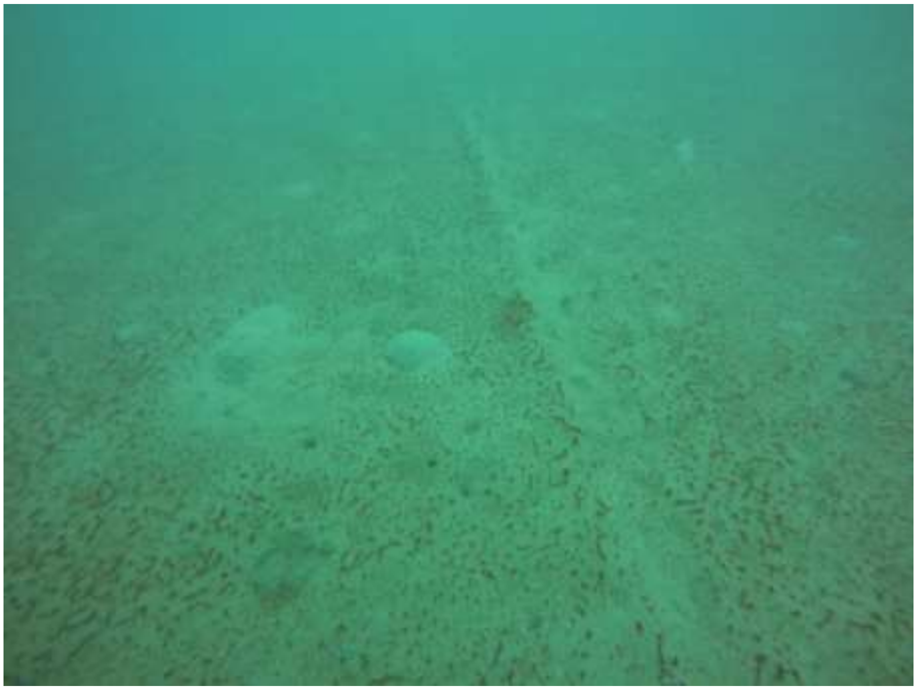


Plate 5-17 Holes and tracks in the substrate caused by various meiofauna (similar to previous studies)

Plate 5-18 Starfish, commonly seen in pervious and current surveys

Plate 5-19 Starfish from previous surveys, also seen in current study

The study area has also been noted to be heavily fished for sea cucumbers by local fisherman. This is an unregulated industry and the impacts to the existing community are not known.

Project Locations

OFF SHORE PIPELINE ROUTE

The proposed pipeline route runs (below ground) via the lagoon area and reef crest of the near shore environment to an offshore facility beyond the forereef. The current survey included grab samples of the nearshore environment were a patchy distribution of Halodule was identified

The nearshore environment/lagoon area is composed mainly of a soft silty sediment with pockets of shelly grey sand. The water here is warm as a result of the nearby Power Plant outfall pipe. The proposed pipeline route runs underneath sections of *Halodule* and large macroalgal patches (Plate 5-20) near the shoreline. The visibility here is extremely poor. The warm waters here are also favoured by crocodiles who utilize this area as well as sections of the beach.

Further away (southwards) from the shoreline, the seafloor is composed mainly of a soft silty sediment, with some meiofauna in and on the sand (Plate 5-21). Similar to the lagoon area, the existing channel is composed mainly of a soft silty sediment. The patch reef on either side are actually piles of coral skeleton and rock, rubble held together by encrusting organisms (sponges, algae, bivalves) and seagrass. Sparse hard coral colonies and small patch reefs are also found in this area. The proposed pipeline will run underneath sections of these sensitive areas but is not expected to impact any of these systems. A section of the proposed pipeline route is shown in Plate 5-22.

Plate 5-20 Halodule, Macroalgae and a silty sand in the nearshore environment.

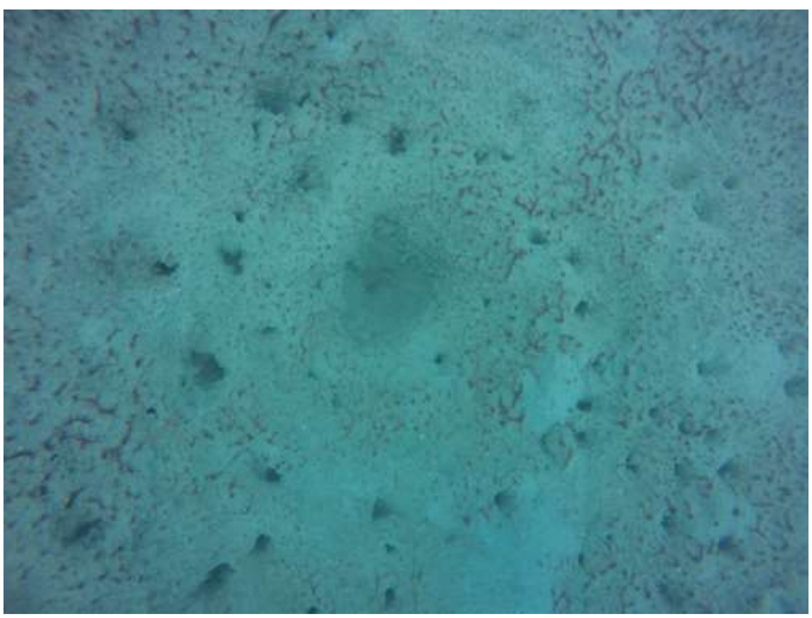


Plate 5-21 Evidence of Burrowing animals in the soft silt sediment

Plate 5-22 Section of the proposed pipeline route passing below patch reef and looking towards the JPS 190 MW site

As identified in previous and current studies the pipeline route will be constructed underneath a patchy *Halodule* bed in the nearshore environment, as well as some meiofauna and other invertebrates in sand patch areas. Several hard and soft coral colonies were seen in the immediate forereef and crest areas (Plate 5-23-Plate 5-28) and lees further out to sea. Most of the pipeline runs underneath an area dominated by a soft silty sediment with several species of meiofauna living in or on the sediment. These include starfish, fish, crabs, sea cucumbers and a few sponges and macroalgae, similar to other environments previously and currently described.

Plate 5-23 Large, encrusting *Solenastrea bournoni* on patch reef

Plate 5-24 *Montastrea cavernosa* colony

Plate 5-25 *Porites sp.*, and a variety of soft corals along the Forereef

Plate 5-26 Large *Montastrea flaveolata* colony with an angel fish

Plate 5-27 Seagrass, rubble and a small *Mancenia areolata* colony in the reef crest area

Plate 5-28 Gorgonians, seagrass, rubble and macroalgae in the reef crest area.

OFF SHORE FACILITY

The proposed pipeline route continues out towards the off shore terminal area. This also has a soft silty sediment with some meiofauna in on the sediment (Plate 5-29 - Plate 5-31). Visibility here is also poor. Past and current surveys indicate an extremely low fish diversity and count in the survey areas, which likely caused by poor visibility, little to no structures suitable for habitat (low ecological volume) overfishing and other human activities in the area.

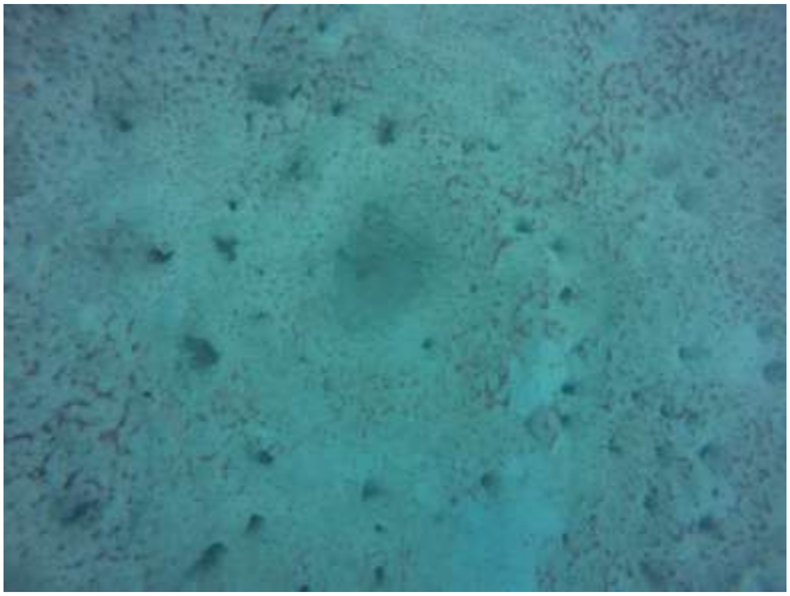


Plate 5-29 Burrowing meiofauna in the foot print of the Off Shore Facility

Plate 5-30 Burrowing meiofauna in the foot print of the Off Shore Facility

Plate 5-31 Starfish commonly found all along the pipeline route and in the terminal area

Plate 5-32 Sea cucumber common in the project area

5.4 EXISTING POLLUTION SOURCES

5.4.1 Cooling Water Discharge

The marine area in proximity to the JPS power plant is used for cooling water discharge by the existing JPS Old Harbour Power Plant (Plate 5-33) and the JEP Doctor Birds 1 and 2 Power Barges (Figure 5-112). These three sources represent potential thermal pollution to the marine environment.

Plate 5-33 Drone aerial showing the JPS cooling channel

Over the years the cooling water discharge from the JPS Old Harbour plant flume has been a source of concern as it was a source of elevated water temperature which tended to hug closely to the shoreline in a westerly direction. The JPS has worked consistently to improve this situation and while not in total compliance with the NEPA standard (± 2 ^{o}C of ambient water temperature) or World Bank guidelines (> 3^{o}C at 100m from the point of discharge), has improved the situation tremendously.

The existing JPS power plant will however be decommissioned and the new 190 MW power plant will be built. The resulting cooling water discharge will become compliant with NEPA standards.

The JEP barges cooling water discharges since their commissioning have been compliant with the World Bank guidelines, however, at times they are non-compliant with the NEPA standard at certain depths but in compliance most times at the surface.

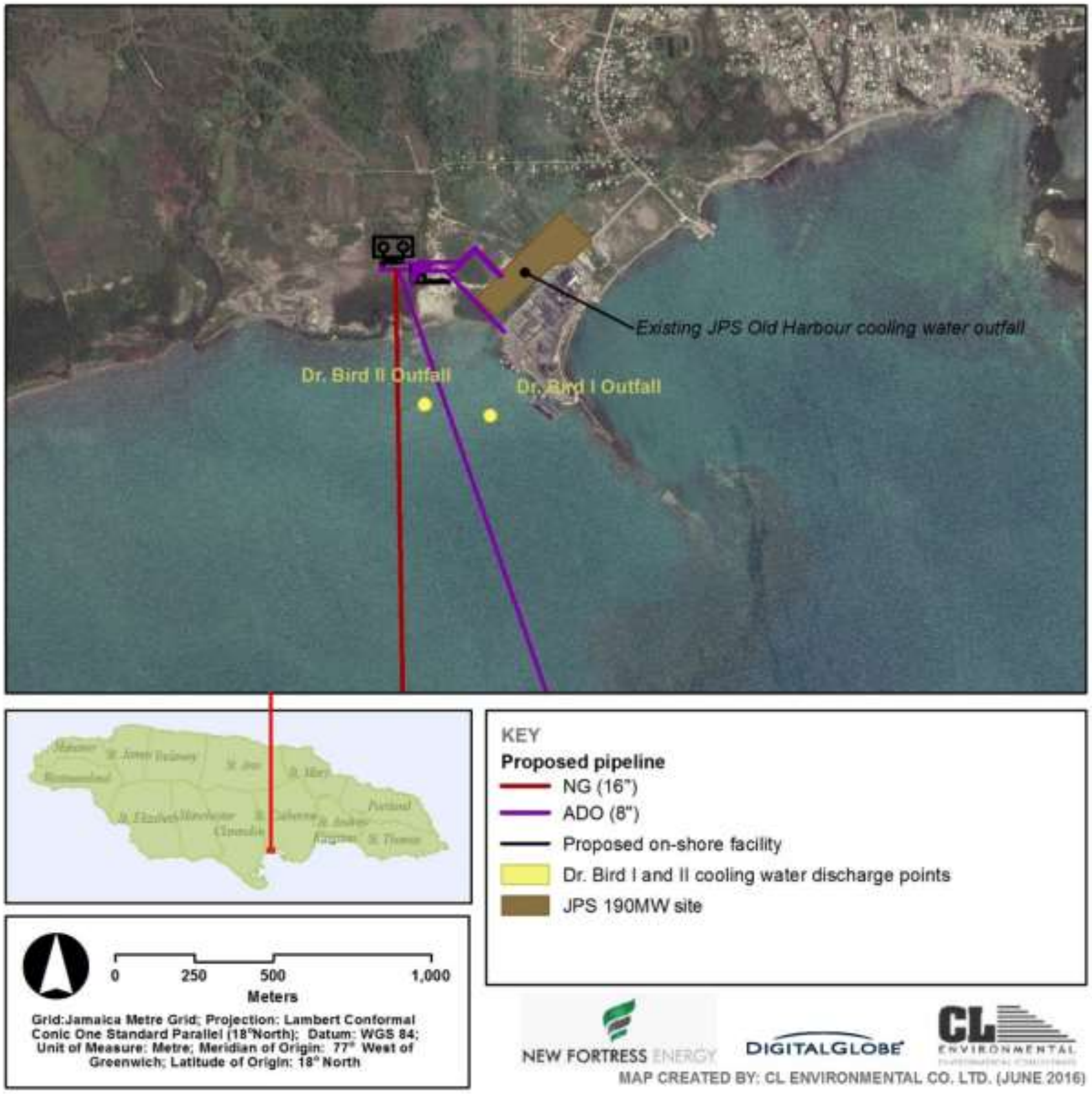


Figure 5-112 Map depicted JPS and JEP Doctor Birds cooling water discharges

5.4.2 Runoff from the Bowers Gully

Bower's Gully, which is located 850m west of the proposed site area has water depths exceeding 1.5 meters towards the sea and is affected by tidal influences from the sea. A sediment bar at the mouth of the Gully reduces channel depths to less than 0.5 meters. The influence of the Gully and the sediment type results in water that is very turbid resulting in poor visibility (Plate 5-34) as shown in the 2012 SJPC EIA study. During heavy rains, the water becomes very turbid owing to sediment resuspension. The sediments from the Bowers Gully also influence silting in the bay, evidenced by the increased maintenance dredging frequency of the Windalco Port Esquivel facility.

Plate 5-34 Photograph showing general conditions of Bowers Gully

5.4.3 Air Pollutants

The proposed LNG Terminal will be located in the vicinity of existing (JPS and JEP) and proposed power plants. The air pollutants of concern that are typically discharged from power plants into the ambient air are TSP, NOx, SO_2, CO and various priority air pollutants (including acetaldehyde, acrolein, benzene, formaldehyde and xylenes). Some of the other air pollution sources within the air shed include a feed mill, as well as the alumina handling activities at Port Esquivel.

5.5 HERITAGE AND CULTURE

The Jamaica National Heritage Trust (JNHT) conducted an Archaeological Impact Assessment (AIA) on the site of the proposed SJPC 360MW Power Plant. The field survey was conducted over a 2-day period, May 16 and 17, 2012. A non-technical summary page of this report can be found in Appendix 8.

Historically, the area contains historic and archaeological sites dating back to Jamaica's first known inhabitants (The Taíno) and later the Spanish, the Africans and the British. The area has seen various land uses over the past centuries. Cattle rearing was the main activity in the area during pre and post emancipation periods. It should be noted that all the plantations, pens and estates in the area had plantation houses and enslaved villages. In the more recent past, aquaculture was done on some areas of the property. Sections of the property are in ruinate with charcoal burning occurring.

No pre-historical or historical cultural material or feature was observed in the area. It is worth noting, however, that survey of the area was restricted by the dense vegetation cover. Pre historical cultural material in the form of pottery shards, both Spanish and English bricks and concrete troughs associated with cattle rearing were found immediately east and west of the site.

5.6 HUMAN/SOCIAL

5.6.1 Demography, Services and Infrastructure

5.6.1.1 Approach

Social Impact Area

In order to assess the various social elements of the proposed project, a Social Impact Area (SIA) is established. An SIA may be described as the estimated spatial extent of the proposed project's effect on the surrounding communities. Demographic analyses are carried out utilising this SIA demarcation, and social services, infrastructure and industrial facilities are described in relation to this area as well.

For the purposes of this project, it was believed important to encompass a two (2) kilometre buffer around the proposed development area, as well as a similar two (2) kilometre buffer around the Old Harbour Bay fishing village to ensure the inclusion of all potentially affected fisher folk (Figure 5-113). The SIA is located within two communities; primarily Old Harbour Bay, surrounded by sections of the Old Harbour community. Located approximately 5 km from the town of Old Harbour, the Old Harbour Bay community consists of twenty-four (24) small communities, which include Blackwood Gardens, Kelly Pen, Thompson Pen, Bay Bottom, Terminal, Dagger Bay, More Pen Lane, Peter's Land, Sal Gully, Cross Road and Panton Town. The southern half of the SIA falls over the Caribbean Sea and specifically Old Harbour Bay and the Portland Bight area.

Demographic Analyses and Census Database

Population data were extracted from the Statistical Institute of Jamaica (STATIN) 2011 Population Census database for the SIA by enumeration district (ED). This was undertaken using Geographic Information Systems (GIS) methodologies, which were also used to derive visual representations of the data. It should be noted that all Census data relates to the resident population and does not take into consideration persons working in or visiting the ED.

In order to derive information from the census data the following computations were made:

- ***Population growth*** - was calculated using the formula [$i_2 = i_1 (1 + p)^x$]; where i_1 = initial population, i_2 = final population, p = actual growth rate and x = number of years.
- ***Population density*** – was derived by dividing the population by the land area. This is useful for determining the locations of greater concentrations of population.
- ***Dependency ratio*** – was calculated using the formula [child population + aged population /working population X 100], where the child population is between ages 0-14, the aged population is 65 & over and the working population is between ages 15-64 years. This ratio is useful for understanding the economic burden being borne by the working population.
- ***Male sex ratio*** – was calculated by using the formula [male population / female population X 100]. This in effect denotes the amount of males there are to every 100 females and is useful for determining the predominant gender in a particular area.

- ***Domestic water consumption*** - was calculated based on the assumption that water usage is 227.12 litres/capita/day and sewage generation at 80% of water consumption. Water consumption for workers in Jamaica is calculated at 19 litres/capita/day and sewage generation at 100% water consumption.
- ***Domestic garbage generation*** - was calculated at 4.11 kg/household/day (National Solid Waste Management Authority).

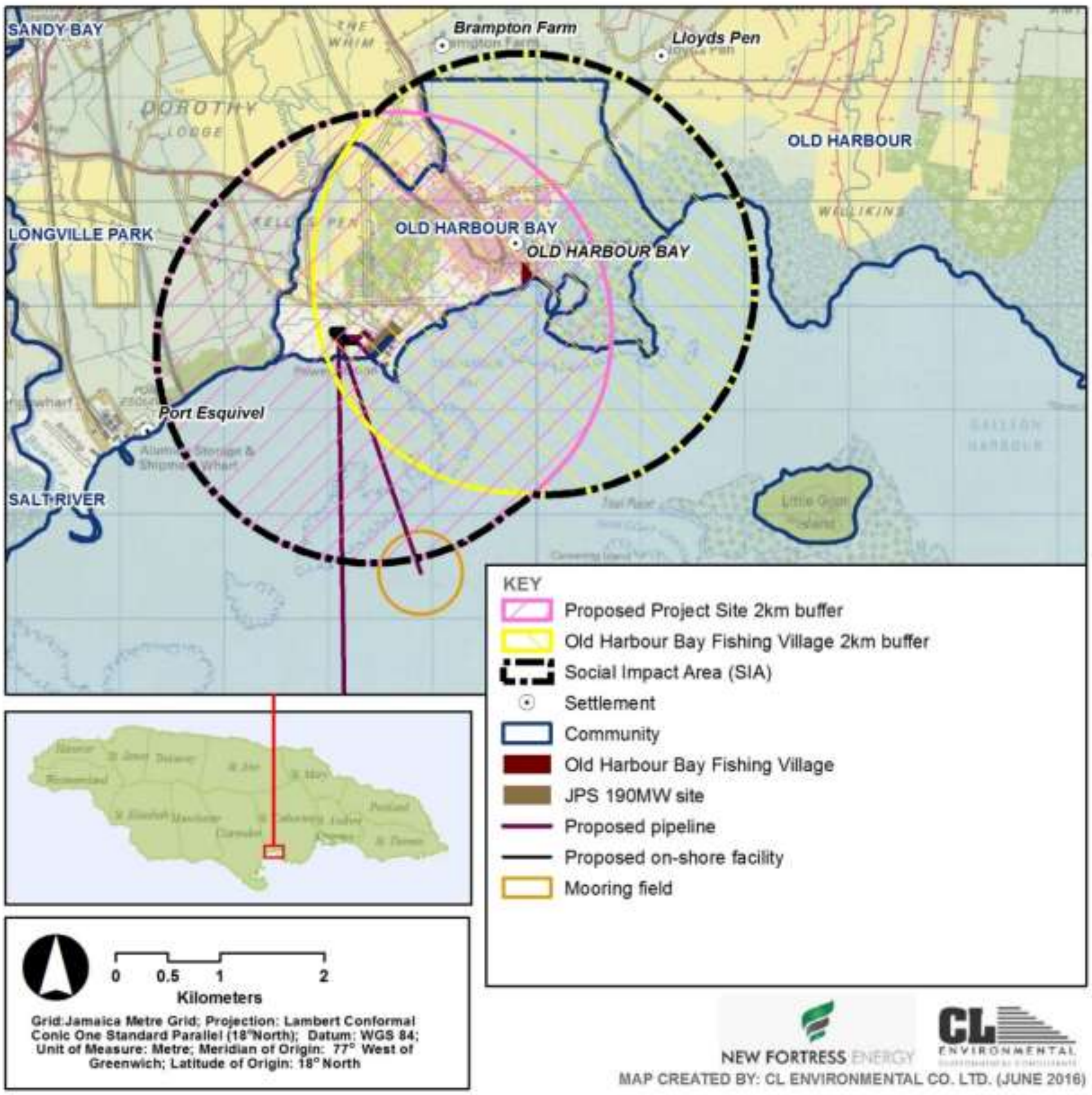


Figure 5-113 Map showing the Social Impact Area (SIA)

Other GIS Data

Geospatial data for various services and infrastructure, including schools, health centres, hospitals, police stations, fire stations and post offices were obtained from the Mona GeoInformatics Institute. Additional data were also gleaned from the 1984 national topographic maps (metric series) and satellite imagery available for the project. Other data sources are stated where applicable throughout

5.6.1.2 Demography

Population Growth

The total population within the SIA in 2011 was approximately 5,771 persons (STATIN 2011 Population Census). Examination of the 2001 population data showed that there were approximately 6,635 persons within the SIA in 2001. From this population, and that calculated for the year 2011 (5,771 persons), it was estimated that the actual growth within the SIA between 2001 and 2011 was approximately -1.39% per annum. Based on this growth rate, at the time of this study (2016), the population was approximately 5,382 persons and is expected to reach 3,796 persons over the next twenty-five years if the current population growth rate remains the same.

The annual growth rate for the SIA (-1.39%) differs from than that for the parish of St. Catherine (0.72%), as well as the island (0.36%) between 2001 and 2011 (STATIN, 2011). Using the regional rate for St. Catherine, the population in 2016 is estimated to be 5,981 persons, and in 2041, 7,156 persons.

Figure 5-114 depicts the population within each enumeration district (ED) for the years 2001 and 2011. As seen here, decreases in the ED population occurred in Old Harbour Bay, whilst increases in the population occurred on the outskirts of the SIA.

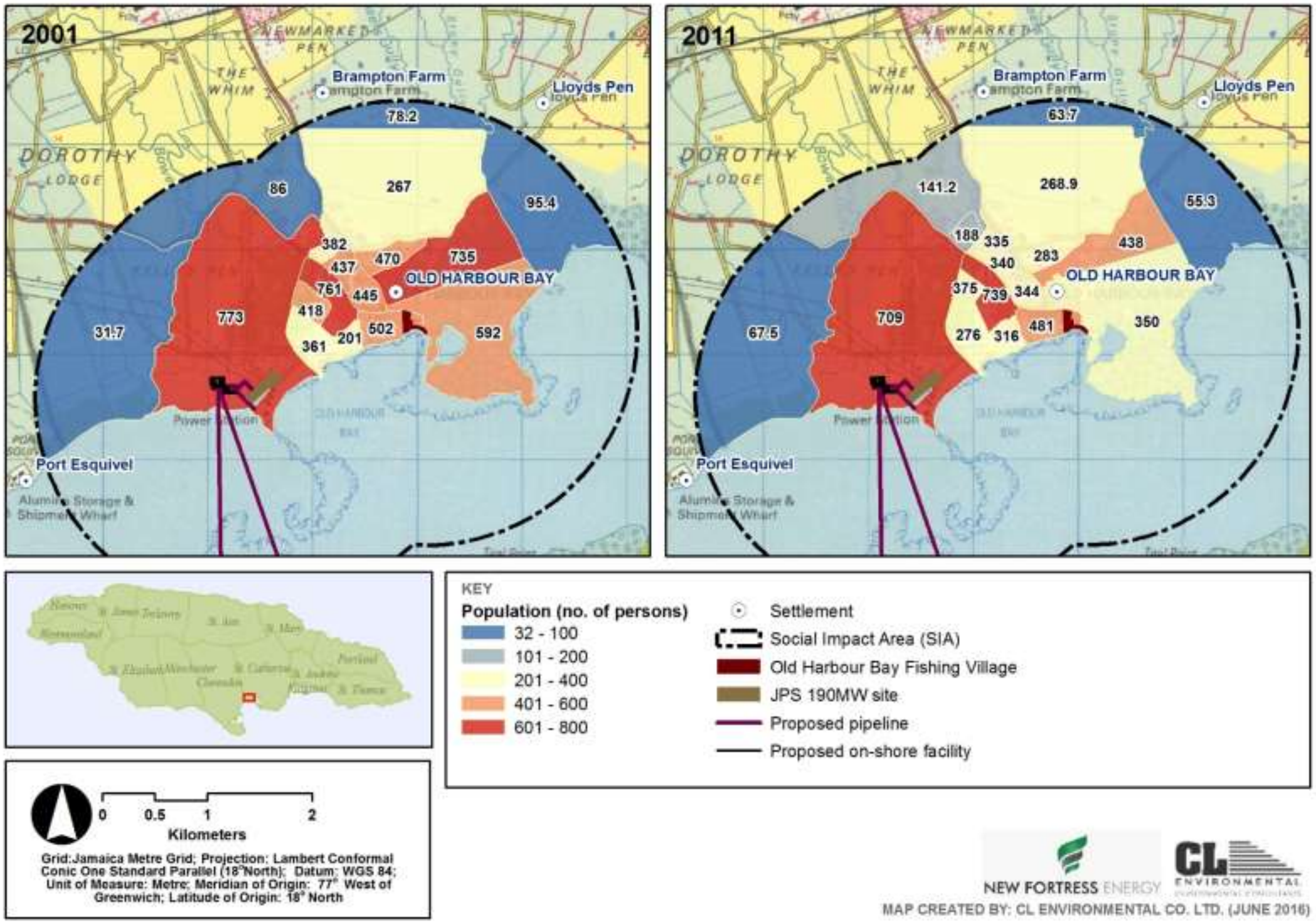
Population Density

The land area within the SIA was calculated to be approximately 10.97 km^2. With a population of 5,771 persons, the overall population density was calculated to be 526 persons/km^2. This population density is higher than the national level (245 persons/km^2) and the St. Catherine regional density of 434 persons/km^2 respectively (Table 5-79).

Table 5-79 Comparison of population densities for the year 2011

Source: STATIN Population Census 2011

Category	Jamaica	St. Catherine	SIA
Land Area (km^2)	10,991.0	1,190.6	11.0
Population	2,697,983	516,218	5,771
Population Density	245	434	526



Data source: STATIN Population Census 2011 and 2001

Figure 5-114 SIA 2001 and 2011 population data represented in enumeration districts

Age & Sex Ratio

The segment of a population that is considered more vulnerable are the young (children less than five years old) and the elderly (65 years and over). In the SIA population, 8.7% comprised the vulnerable young category, whilst 5.6% comprised the elderly.

Table 5-80 shows the percentage composition of each age category of the population. This is compared on a national, regional and local (SIA) level. Percentage age distribution in the SIA for the 0-14 years' age cohort (28.5%) is slightly greater than the parish and island figure (26.1%). As mentioned preciously, elderly persons aged 65 years and greater make up 5.6% of the SIA population; and this value is lower than other extents investigated. Within the SIA, the 15-64 years' age category accounted for 65.9% and can therefore be considered a working age population, similar to that for the nation (65.9%) and the parish of St. Catherine (66.9%) (Table 5-80).

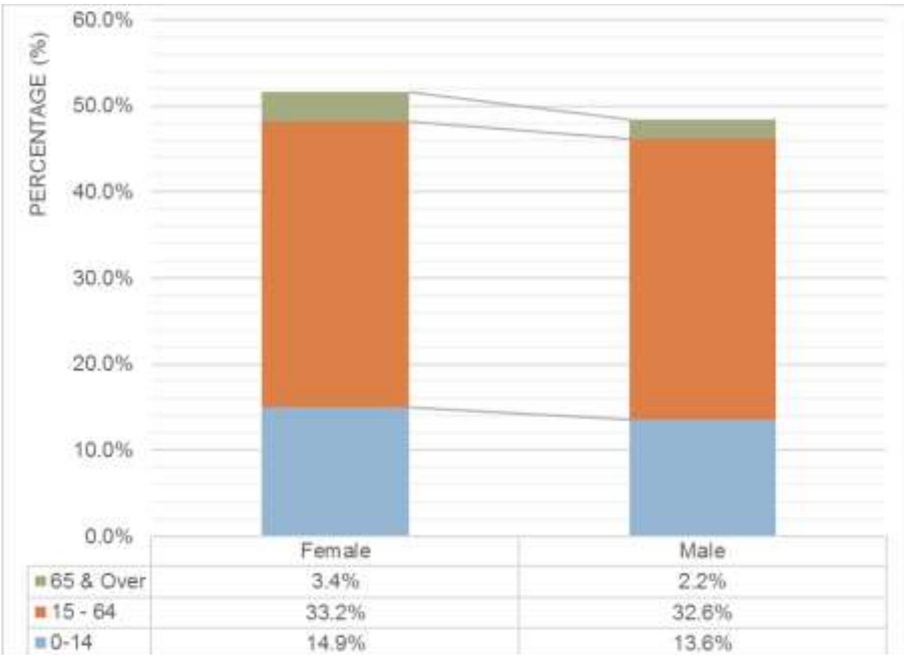
Table 5-80 Age categories as percentage of the population for the year 2011

Age Categories	Jamaica	St. Catherine	SIA
0-14	26.1%	26.1%	28.5%
15 - 64	65.9%	66.9%	65.9%
65 & Over	8.1%	7.0%	5.6%

Source: STATIN Population Census 2011

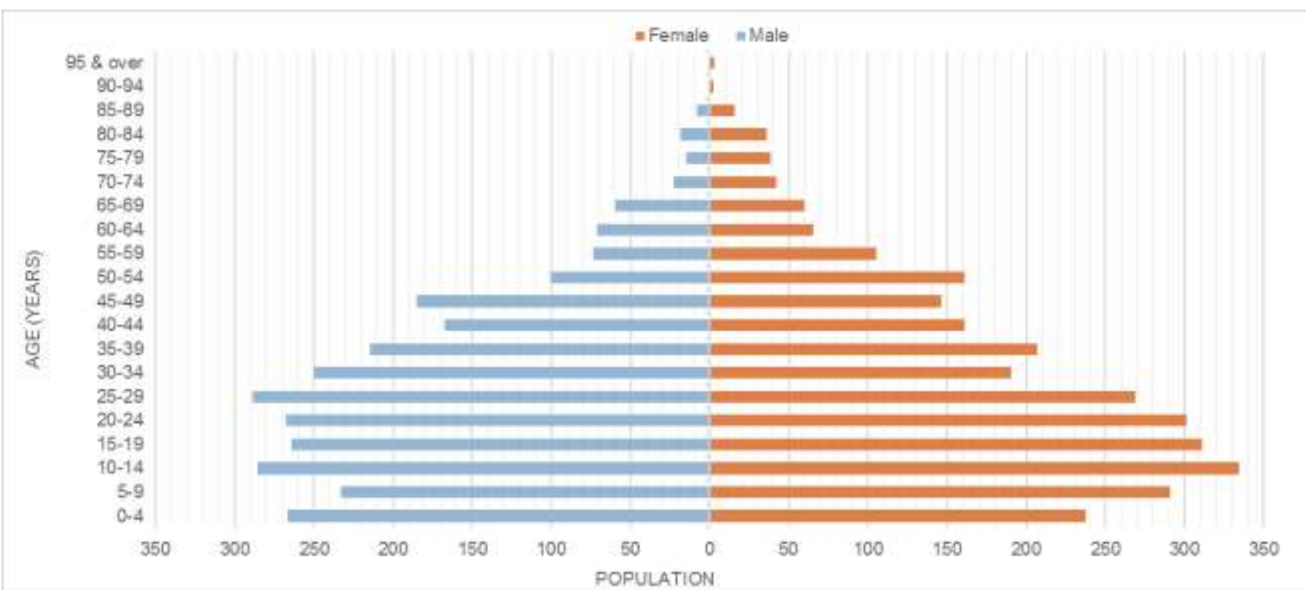
As seen in Figure 5-115, Census 2011 data indicated that there were more females within each age cohort when compared to males. However, when these age groupings are further divided using a population pyramid, other patterns emerge. As seen in Figure 5-116; a greater number of females is easily discerned particularly between the ages of 5 and 24 years, 50 and 59 years and greater than 65 years. On the contrary, there are considerably more males aged between 25 and 49 years.

Sex ratio for all age cohorts within the SIA was calculated to be 93.8 males per one hundred females; this ratio however varies spatially across the SIA (Figure 5-117).



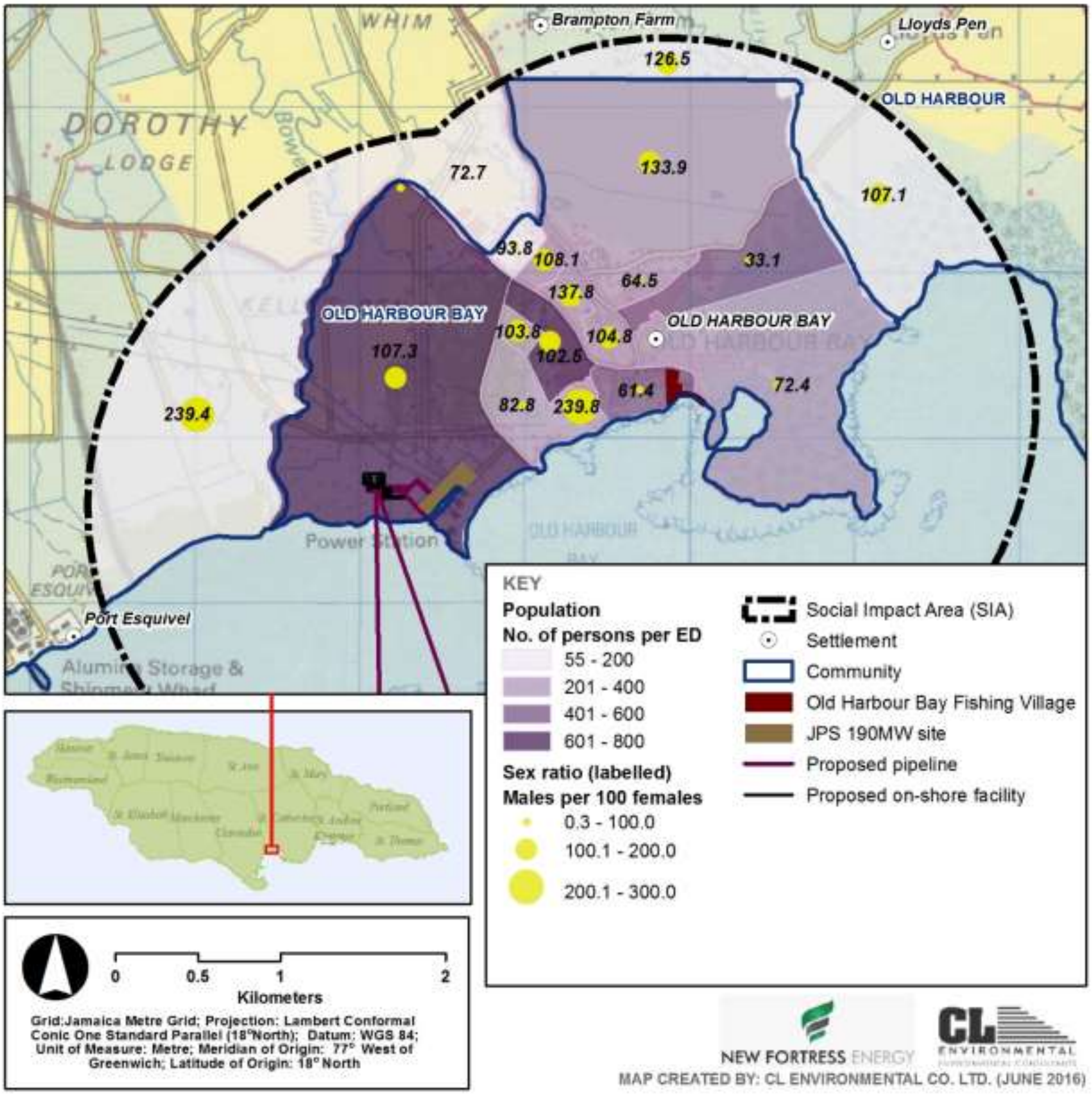
Source data: STATIN Population Census 2011

Figure 5-115 Male and female percentage population by age category for the SIA in 2011



Source data: STATIN Population Census 2011

Figure 5-116 Population pyramid for the SIA in 2011

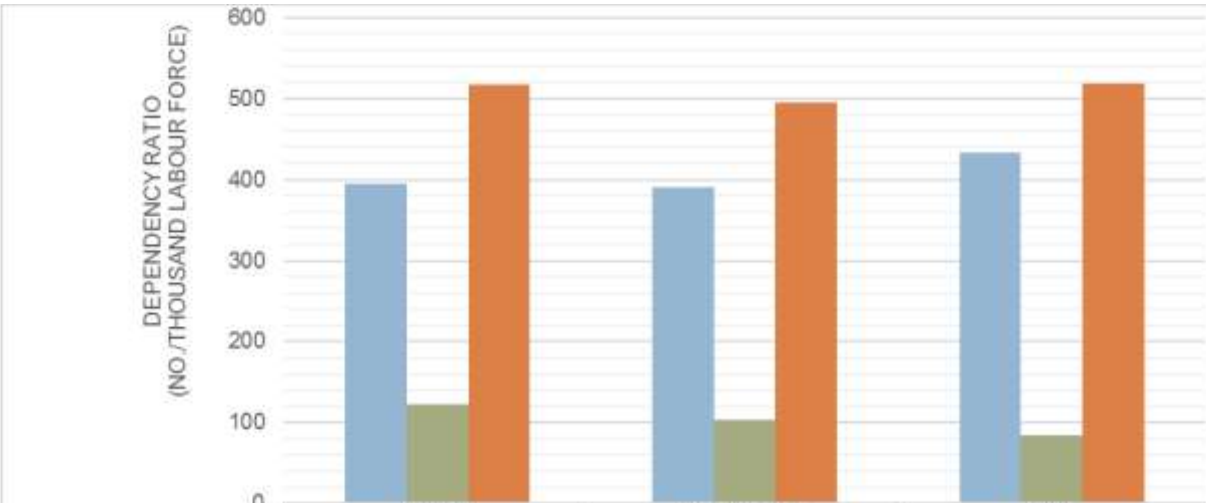


Source data: STATIN Population Census 2011

Figure 5-117 Sex ratio by ED within the SIA

Dependency Ratios

The child dependency ratio for the SIA in 2011 was 433.3 per 1000 persons of labour force age; old age dependency ratio stood at 84.9 per 1000 persons of labour force age; and societal dependency ratio of 518.3 per 1000 persons of labour force. This indicates that the youth (child dependency) are far more dependent on the labour force for support when compared with the elderly in the SIA. The SIA child dependency is higher than the figures for the parish of St. Catherine and the island (Figure 5-118), whilst old age dependency is lower in the SIA when compared to the nation and parish extents.



	Jamaica	St. Catherine	SIA
Child Dependency	395.4	390.8	433.3
Old Age Dependency	122.4	104.0	84.9
Societal Dependency	517.8	494.8	518.3

Source: STATIN Population Census 2011

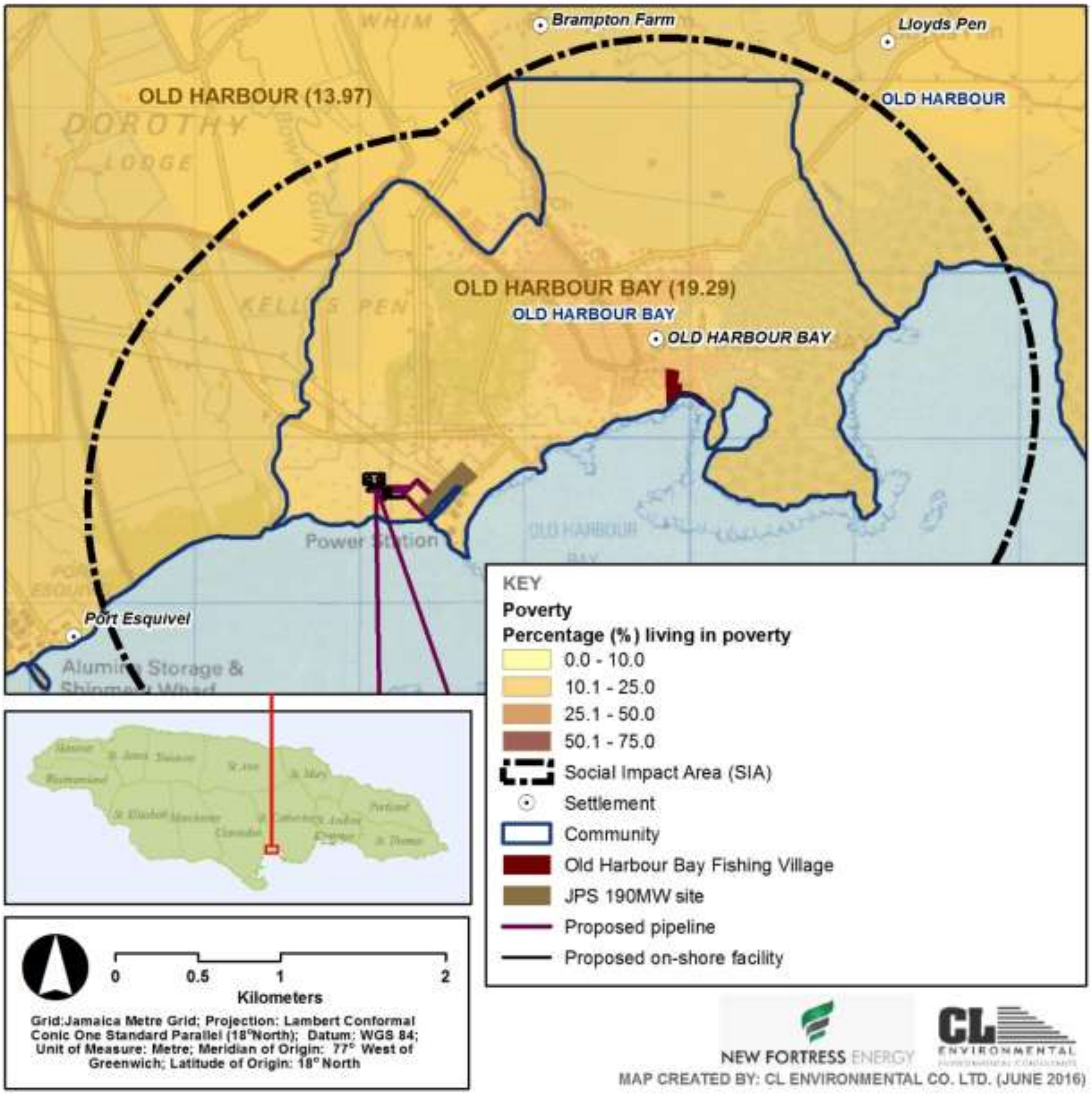
Figure 5-118 Comparison of dependency ratios for the year 2011

5.6.1.3 Poverty

The poverty GIS dataset developed by the Planning Institute of Jamaica (PIOJ) (with contributions from STATIN, Social Development Commission (SDC) and the University of Technology), primarily identifies areas of poverty by community. As described by PIOJ, for the 2002 poverty map:

> The indicators utilized were those that best predicted per capita consumption levels in households based on data from the Jamaica Survey of Living Conditions (JSLC) 2002. Relevant variables that were common to this survey and the Population Census 2001 were selected and tested for similarity. The satisfactory variables were then applied to the census data to obtain estimates of the consumption levels of the households that had consumption levels islandwide. Members of households that had consumption levels below the poverty line for the region in which their household was located were deemed to be in poverty. The proportion of persons in poverty in each community was used to rank the 829 communities.

As seen in Figure 5-119, the SIA population generally has less than 20% of persons living in poverty.



Data source: PIOJ (with contributions from STATIN, SDC and the University of Technology

Figure 5-119 Proportion of persons in poverty in each community

5.6.1.4 Education

In 2012, the ODPEM reported that the Old Harbour Bay area had an educational institution enrolment rate of 70.9% of school aged residents (Office of Disaster Preparedness and Emergency Management, 2012). For 2011, the highest level of educational attainment for the national, regional and SIA extents are represented in Table 5-81. When the highest level of educational attainment within the SIA is calculated as a percentage, it becomes evident that there is a propensity towards the attainment of primary and secondary education. Fifty-one percent of the SIA population attained a secondary school education as the highest level, followed by 33.3% attaining primary education. SIA secondary educational attainment is highest amongst the extents investigated (Jamaica, 45.7% and St. Catherine, 44.7%), whilst primary education in the SIA is comparable (Jamaica, 34.4% and St. Catherine, 32.0%). Tertiary education attainment (university and other) as the highest level of education is lowest in the SIA (6.1%), compared to the island (9.9%) and St. Catherine parish (12.7%).

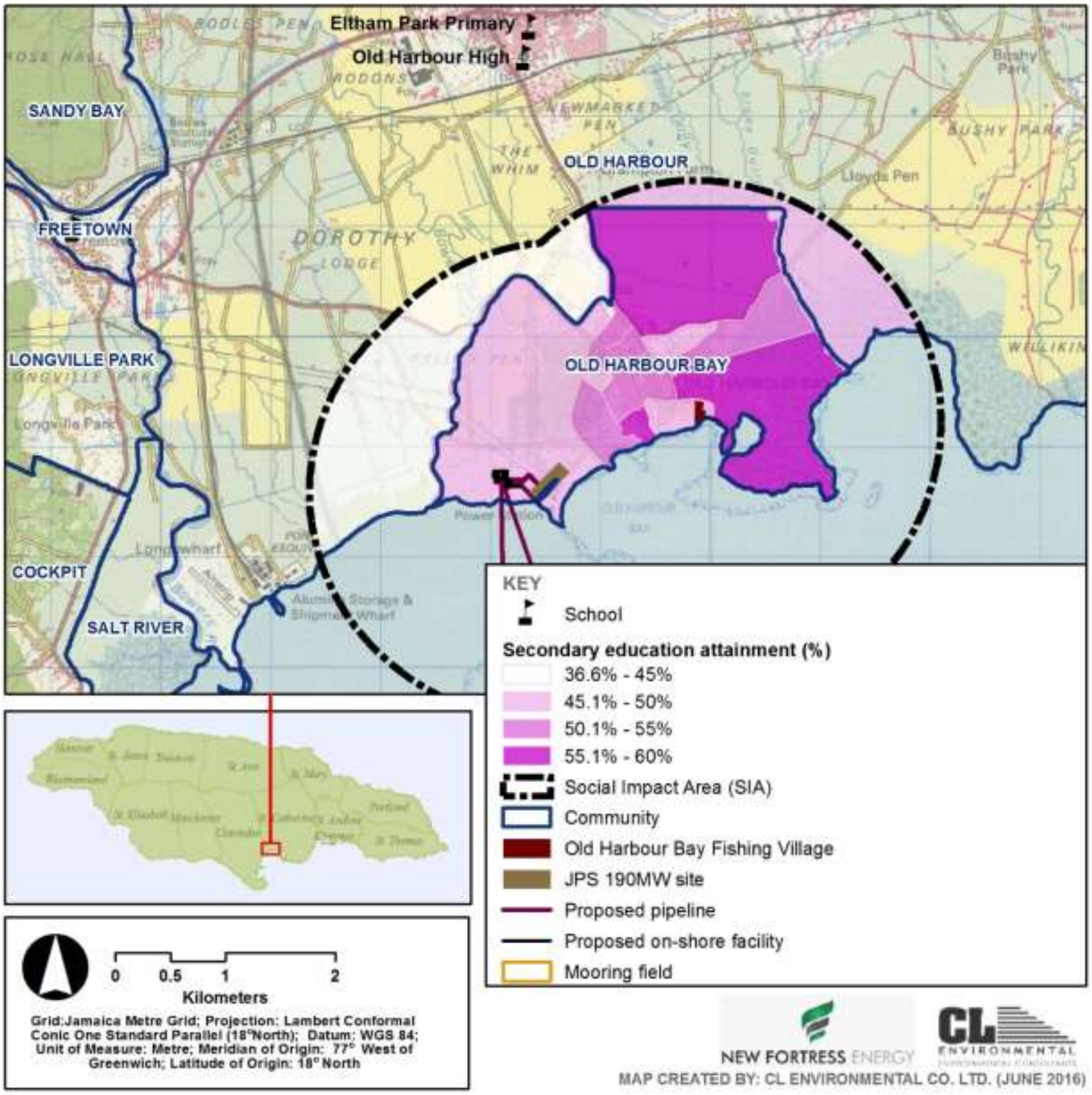
Table 5-81 Population 3 years old and over by highest level of educational attainment as a percentage, for the year 2011

	Jamaica	St. Catherine	SIA
No Schooling	0.7%	0.6%	0.5%
Pre Primary	4.8%	4.9%	4.9%
Primary	34.4%	32.0%	33.3%
Secondary	45.7%	44.7%	51.1%
University	4.7%	5.9%	1.8%
Other Tertiary	5.2%	6.8%	4.3%
Other	0.5%	0.7%	0.4%
Not Stated	0.0%	4.4%	3.6%

Source: STATIN Population Census 2001

The relatively high proportion of the population in proximity to the project location attaining a secondary education, as well as tertiary education suggests that the labour pool is relatively educated, and as such, there should be no problem in obtaining non-technical workers from the community. Figure 5-120 depicts secondary education attainment within the SIA and the location of schools in proximity to the proposed development. No schools are located within the demarcated SIA; the closest school is Old Harbour Bay High, approximately 3.8 km north of the proposed development area. Additionally, three primary schools are located between 4 and 4.7 kilometres (approximately) of the project site, namely Eltham Park Primary, Old Harbour Bay Primary and Freetown Primary.

In 2007, a large majority of the household heads had attained some level of education (93.5%). This was either, pre-primary, primary, secondary, all age, university, vocational, other tertiary or post-secondary. Similar to the 2011 Census data, the highest educational level attained by most household heads was secondary (51.1%). Only 3.3% of the household heads obtained university level education and 0.8% received vocational training (SDC 2007). Approximately 83% of the household members in the community of Old Harbour Bay had no academic qualification. When further broken down it can be seen that 83% of the male and 84% of the female population had no qualification (SDC 2007) (Table 5-82).



Source: Education (STATIN Population Census 2011), Schools (MGI)

Figure 5-120 Percentage population attaining a secondary education within the SIA

Table 5-82 Educational attainment as a percentage of household members in the community of Old Harbour Bay (2007)

Source: SDC 2007

QUALIFICATIONS	%MALE	%FEMALE
None	83.3	83.5
CXC Basic, JSC, JHSC, JSCE, SSC,JC or 3rd JLCL	3.3	1.7
CXC General, GCE 'O', AEB 1-2 Subjects	0.8	0.8
CXC General, GCE 'O' , AEB 3-4 Subjects	1.7	3.3

QUALIFICATIONS	%MALE	%FEMALE
CXC Gen, GCE 'O', AEB 5+ Subjects	0.8	0.8
GCE 'A' Level/ Cape 1-3 Subjects, HSC	0.8	0.8
College Certificate/Diploma	1.7	0.8
Vocational (Certificate)	1.7	1.7
Associate Degree / Diploma / Other Certificates and Degrees MOE Recognized	0.0	0.8
Degree / Postgraduate Degree/Professional Qualification	0.8	0.8
Other	3.3	1.7
Not Stated	1.7	3.3
Total	100.0	100.0

5.6.1.5 Employment

Overview

The SDC 2007 Community Profile data revealed that 63% of the Old Harbour Bay Community population falls within the working age group (15 – 64). Approximately 56.3% of the labour force population in the community was employed at the time of the survey (2007), while 43.8% were unemployed. The data also revealed that on average two persons in each household were employed. Of the employed persons in the community, the main categories of employment were full time (33%) and self-employed (50%). Of the remaining employed household members, 8.9% were seasonally employed, 5.2% employed part time and 3% contractually employed. The highest percentage of employed persons throughout the cohorts fell between the ages of 35-39 years (21.5%), whereas, notable percentages were within the age range 40- 44 years (16.3%), 30-34 years (14.8%), 25-29 years (12.6%) and 45-49 years (12.6%). Approximately 61.6% of household heads were employed (SDC 2007); this is similarly reported by ODPEM (2012).

For household heads who stated their monthly income, the most common income bracket reported was JMD $6,000-$24,999 monthly which accounted for 56.8% of employed residents. This was followed by the income brackets of JMD $25,000-$39,999 which accounted for 25.7% of employed residents, JMD $40,000 – 79,999 (9.5%), $3,201 – 5,999 (4.1%), $80,000 – 129,999 (2.7%) and $250,000 and over (1.4%). The main additional source of income for household heads was from remittance (17.6%) (Table 5-83). However, a large amount of persons (35.2%) reported having no source of income (SDC 2007).

Table 5-83 Additional Financial Support received by Household Heads

SOURCES	%PERCENT
State Assistance	1.6
Remittances	17.6
Support from local network of family and friends	6.4
Salaries from other members your household	7.2
No additional sources	35.2

Questionnaire allowed for multiple responses (SDC 2007)

UNEMPLOYED PERSONS

Males accounted for 33.3% and females 66.7% of the unemployed persons in the community of Old Harbour Bay. Unemployment was highest among cohorts 20-24 years and 60+ years accounting for 22.9% respectively. Unemployed persons were among the cohorts 30-34 years (13.3%), 14-19 years (9.5%), 25-29 years (7.6%) and 35-39 years (7.6%) (SDC 2007) (Table 5-84). Among the unemployed persons sixty years and older, females accounted for 15.2% and males 7.6%, while the cohort 20-24 years was equally distributed between males and females. Overall youth unemployment accounted for 32.4% of the total unemployed population (SDC 2007).

Table 5-84 Unemployment Status of Household Members by Gender

Source: SDC 2007

AGE COHORTS	%MALE	%FEMALE	%TOTAL
14 – 19	5.7	3.8	9.5
20 – 24	11.4	11.4	22.9
25 – 29	3.8	3.8	7.6
30 – 34	1.0	12.4	13.3
35 – 39	0.0	7.6	7.6
40 – 44	1.0	3.8	4.8
45 – 49	1.0	3.8	4.8
50 – 54	1.0	4.8	5.7
55 – 59	1.0	0.0	1.0
60 +	7.6	15.2	22.9

The findings of the SDC profile are comparable to those of ODPEM (2012). The most common employment category was full time employment which accounted for 51% of all employed persons. The highest rate of unemployed males was 20-24 years accounting for 9.6% of unemployed males while for females the highest level of unemployment could be seen in the 60+ age cohort accounting for 12.8% of unemployed males.

A somewhat significant amount of unemployed persons had been unemployed for five years or more accounting for 7.2% of males and 18.4% of females. For household heads that were unemployed, the reasons given for their unemployment were:

- Other reason "not specified (15.2%)
- Trying to find work but do not have the necessary skills or qualifications (12%)
- No Reason (9.6%)
- Illness (5.6%)
- Awaiting a promised job (3.2%)
- Amount of pay (0.8%)
- Have to stay with sick parent/child/elderly relative (0.8%)

For unemployed family members the main reason for unemployment was lack of skills/qualification (19.2%), no reason (9.6%), illness (4.8%), attending school (2.4%), amount of pay and awaiting promised job (1.6% respectively) and have to stay with sick parent/children/elderly (0.8%). The percentages may not add up to 100% due to the fact that persons were allowed multiple responses.

MAIN OCCUPATIONS BY GENDER

The most common occupation group among household members was service, shop and market sales, which accounted for 50%. This was followed by agriculture and fishery, craft and related trades work and elementary occupations with 18.6%, 12.7% and 10.2% respectively. Females dominated the area of service, shop and market sales, while agriculture and fishery craft and related trade work had male dominance (Table 5-85).

Table 5-85 Main Occupations by Gender

Source: SDC 2007

OCCUPATION GROUP *(Categorizations Taken from STATIN Labour Force Survey)*	%MALE	%FEMALE	%TOTAL
Professional	3.4	8.3	5.9
Service workers and shop and market sales workers	32.8	66.7	50.0
Skilled agricultural and fishery	34.5	3.3	18.6
Craft and related trades workers	24.1	1.7	12.7
Elementary occupations	5.2	15.0	10.2
Clerks	0.0	5.0	2.5

EXISTING SKILLS

The data representing the skill sets present among household members in the community of Old Harbour Bay shows that the dominant areas were construction and cabinet making (19.2%), agriculture/farming (15.4%), beauty care and service (9.6%) and hospitality (9.6%). Most males had an aptitude in construction and cabinet making (33.3%) and agriculture/farming (27.8%), while most of the females were skilled in hospitality (20%), beauty care and service (18%) and commercial and sales (12%) (SDC 2007) (Table 5-86).

Table 5-86 Skill Distribution by Gender

Source: SDC 2007

SKILLS	%MALE	%FEMALE	%TOTAL
Beauty care and service	1.9	18.0	9.6
Hospitality	0.0	20.0	9.6
Construction and cabinet making	33.3	4.0	19.2
Machine and appliance	9.3	0.0	4.8
Commercial and sales	0.0	12.0	5.8
Professional and technical	11.1	6.0	8.7
Agricultural/farming	27.8	2.0	15.4
Secretarial/office clerk	0.0	4.0	1.9
Art and craft	1.9	0.0	1.0
Apparel and sewn products	3.7	8.0	5.8
Other	9.3	20.0	14.4
Not specified	1.9	6.0	3.8
Total	**100.0**	**100.0**	**100.0**

BENEFICIARIES SOCIAL SAFETY NET PROGRAMMES

Approximately 9.5% of the households within the Community had members benefitting from Social Safety Net Programmes. Of the 9.5% households with beneficiaries approximately 4.8% were on the Programme of Advancement through Health and Education (PATH programme), 0.8% for the National Health Fund (NHF) and 0.8% other (SDC 2007).

5.6.1.6 Housing

Housing Units, Dwellings and Households

For the purposes of this study, the definition of housing unit, dwelling and household are those used in the population census conducted by the Statistical Institute of Jamaica (STATIN). The definition states that:

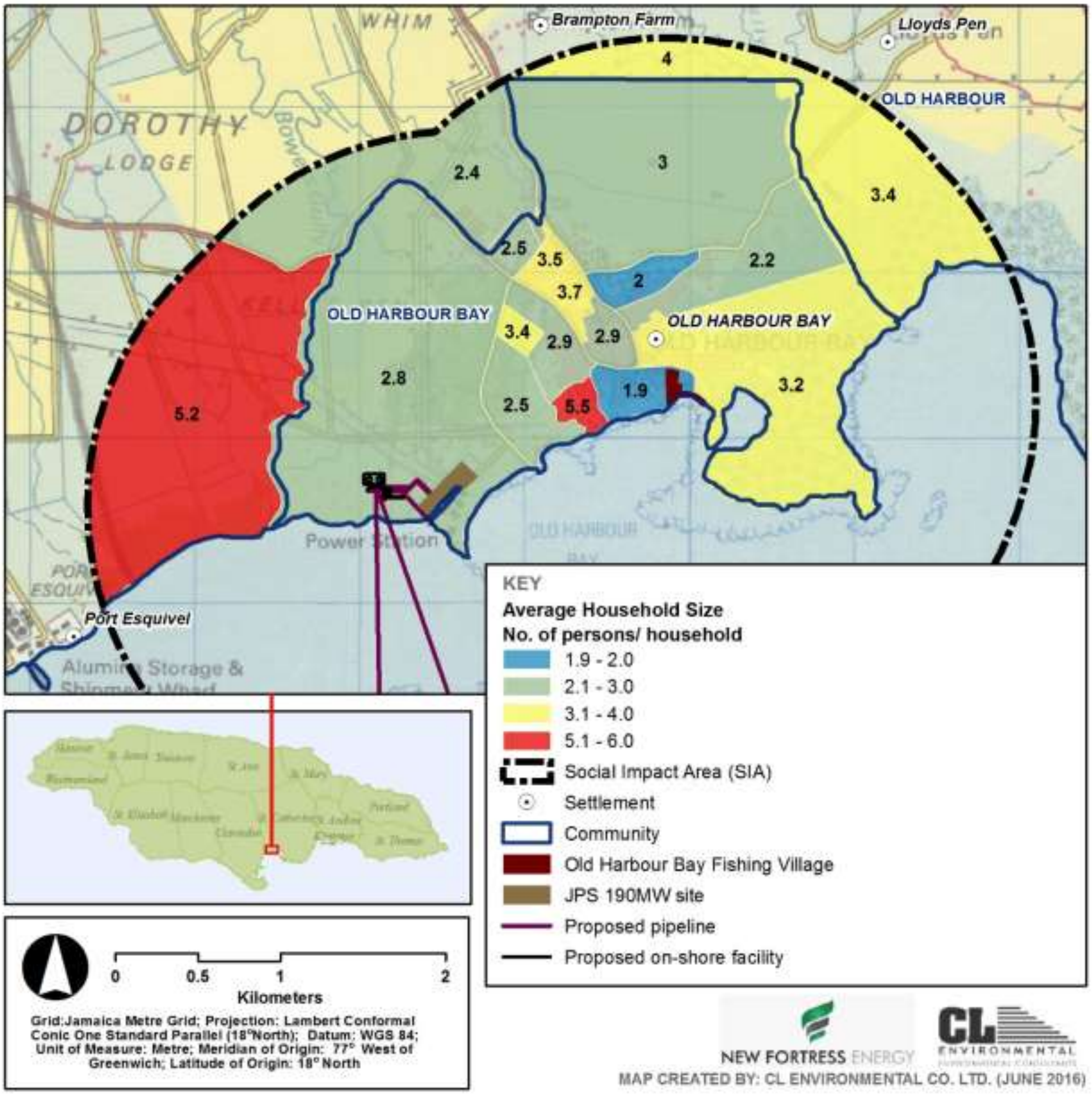
- A **housing unit** is a building or buildings used for living purposes at the time of the census.
- A **dwelling** is any building or separate and independent part of a building in which a person or group of persons lived at the time of the census". The essential features of a dwelling unit are both "separateness and independence". Occupiers of a dwelling unit must have free access to the street by their own separate and independent entrance(s) without having to pass through the living quarters of another household. Private dwellings are those in which private households reside. Examples are single houses, flats, apartments and part of commercial buildings and boarding houses catering for less than six boarders.

There were 1,687 housing units, 1,997 dwellings and 2,083 households within the SIA in 2011. The average number of dwellings in each housing unit was 1.2 and the average household to each dwelling was 1.0 (Table 5-87). The average household size in the SIA was 2.8 persons/ household and varies spatially by ED (Figure 5-121). Comparisons of the SIA with national and regional ratios indicate that the SIA had comparable household/dwelling and dwelling/housing unit ratios, however the lowest average household size.

Table 5-87 Comparison of national, regional and SIA housing ratios for 2011

	Jamaica	St. Catherine	SIA
Dwelling/Housing Unit	1.2	1.2	1.2
Household/Dwelling	1.0	1.0	1.0
Average Household Size	3.1	3.2	2.8

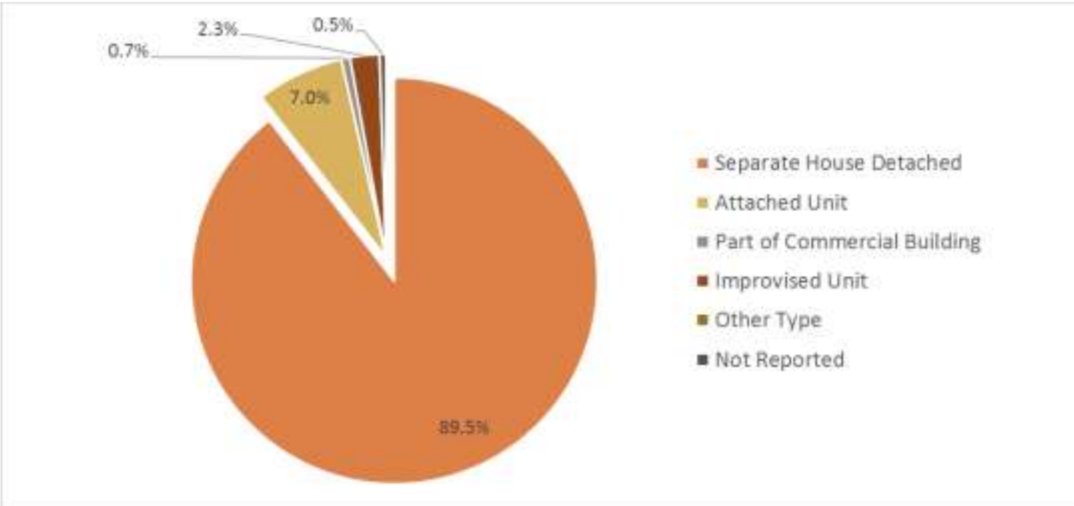
Source: STATIN Population Census 2001



Source: Education (STATIN Population Census 2011), Schools (MGI)

Figure 5-121 Household size by ED within the SIA for 2011

Approximately 89.5% of the housing units in the SIA were of the separate detached type, 7.0% were attached, 2.3% improvised unit, 0.7% part of a commercial building, 0.5% not reported (Figure 5-122).



Source: STATIN Population Census 2011

Figure 5-122 Percentage of housing units by type within the SIA

Household Headship

The percentage of male household heads to female household heads in the community of Old Harbour Bay was equally distributed at 50% respectively. This finding slightly contrasts with national presentation in the Jamaica Survey of Living Conditions (JSLC) 2007, where slightly more males (53.4%) than females (46.6%) were heading households in Jamaica (SDC 2007).

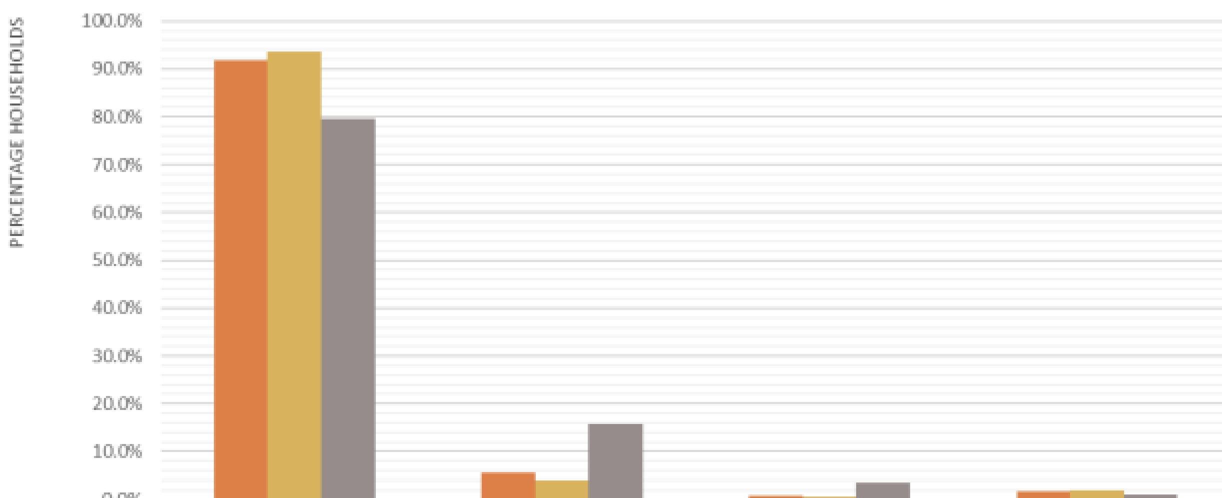
Informal Settlements

Terminal is part of the wider Old Harbour Bay community, which was originally known as Burkesfield. The name Terminal came into existence due to the construction of the Marine Terminal by the United States Marine Corps in the 1940's. The topography is generally flat and is characterized by ponds and swamps. This informal settlement has a street pattern that is made up of unpaved roads and footpaths. This informal residential area has 41 houses and assets such as three (3) shops and three (3) livestock farms (CLE 2007). The building typology and particularly housing in the area were predominantly poor structures built with temporary materials This is evident in the fact that 42% were very poor while only 7% were deemed very good, 24% were poor, 17% were good and 10% were fair. Another finding was that of the forty-one (41) houses identified, thirty-eight (38) were occupied while three (3) were unoccupied. Five (5) houses were abandoned and/or derelict and three houses were under construction.

The materials of housing construction ranged from a few well-built block and steel structures to a plethora of poorly built wooden houses. Only 24% of houses were made of block and steel while 66% were made of wood. 10% were constructed of mixed materials, most of which were a combination of block and steel, and wood. According to statistics, the population of the original study boundary was 144 persons, while the average household size was 3.97 persons per household. This statistic is slightly higher than the average household size for Jamaica and that of rural areas within Jamaica which stands at 3.4 and 3.6 persons per household (PIOJ, 2002) respectively.

Lighting

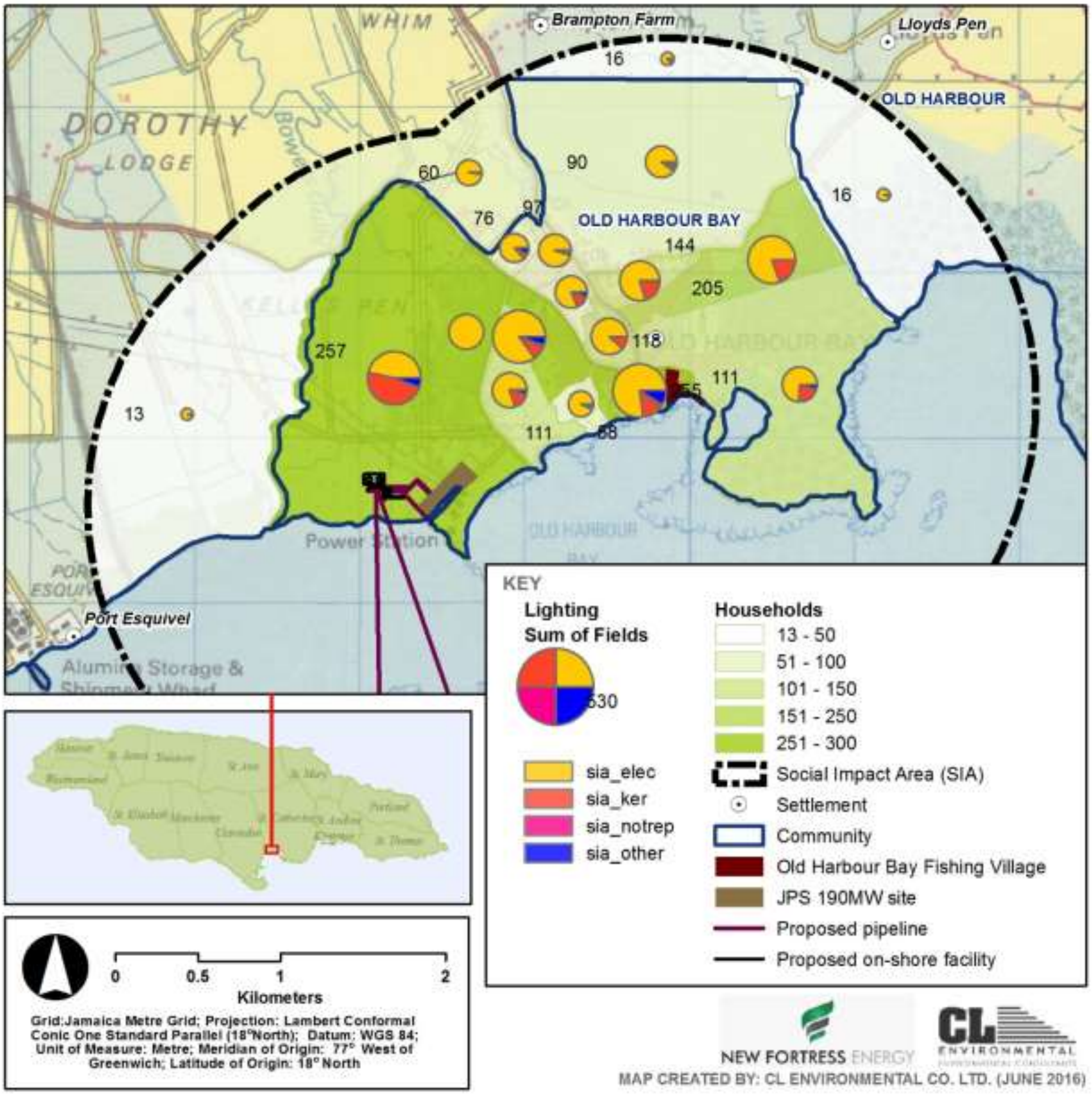
Figure 5-123 details the percentage of households using a particular category of lighting and Figure 5-124 depicts the differences in lighting source by ED within the SIA. Data for all extents (SIA, parish and national) reveal that the majority of the population utilise electricity as their main source of lighting. Approximately eighty percent (79.7%) of households within the SIA use electricity, this lower than the percentages for St. Catherine figure (93.6%) and the island (91.6%). The use of electricity is not consistent throughout the SIA; kerosene is used more than electricity as a source of lighting within the ED in which the proposed development is situated. The percentage of households using kerosene as their main means of lighting in the SIA (15.8%) was considerably greater than that for St. Catherine (4.0%) and the Jamaica (5.5%).



	Electricity	Kerosene	Other	Not Reported
Jamaica	91.9%	5.5%	0.8%	1.8%
St. Catherine	93.6%	4.0%	0.6%	1.9%
SIA	79.7%	15.8%	3.6%	0.9%

Source: STATIN Population Census 2011

Figure 5-123 Percentage households by source of lighting



Source: STATIN Population Census 2011

Figure 5-124 Households by source of lighting within the SIA for the year 2011

Domestic Water Supply

The National Water Commission (NWC) is the public agency responsible for providing Jamaica's domestic water supply. The majority of the households within the SIA (89.6%) received their domestic water supply from a public source; this similar to other extents investigated that had the majority of the population's water supply from a public source (Table 5-88).

Table 5-88 Percentage of households by water supply for the year 2011

Source: STATIN Population Census 2011

	Category	Jamaica	St. Catherine	SIA
Public Source	Piped in Dwelling	49.7%	63.5%	43.4%
	Piped in Yard	16.5%	16.1%	41.3%
	Stand Pipe	7.1%	1.8%	0.8%
	Catchment	2.2%	0.9%	4.1%
Private Source	Into Dwelling	6.4%	4.4%	3.1%
	Catchment	9.8%	3.6%	2.5%
	Spring/ River	3.0%	3.1%	0.0%
	Trucked Water/Water Truck	2.1%	3.7%	0.3%
	Other	1.8%	1.6%	3.5%
	Not Reported	1.3%	1.2%	1.0%

Water demand for the SIA in 2016 is estimated to be 1,222,256.3 litres/day (~322,886.0 gals/day) and is expected to decrease to 862,195.2 litres/day (~227,767.9 gals/day) over the next twenty-five years based on population growth rates calculated previously.

Wastewater Generation and Disposal

It is estimated that approximately 977,805.1 litres/day (~258,308.8 gals/day) of wastewater is generated within the study area (for 2016) and is expected to decrease to 689,756.2 litres/day (~182,214.3 gals/day) over the next twenty-five years based on calculated growth rates.

Census 2011 data for wastewater disposal methods was not available. However, according to the SDC 2007 Community Profile of Old Harbour Bay, a significant number of households in the Community used pit latrine (48%), water closet linked to sewer (36%), water closet not linked to sewer (13.6%) and 6.4% soakaways (percentage won't add up to 100% as multiple responses were allowed). Sixteen percent (15.7%) of the households shared toilet facilities. On average these facilities were shared with approximately four other families.

Solid Waste Generation and Disposal

It is estimated that at the time of this study (2016), approximately 7,984.36 kg (~8.0 tonnes) of solid waste was being generated.

The National Solid Waste Management Authority (NSWMA) is responsible for domestic solid waste collection within the study area and specifically, MPM Waste Management Ltd. covers the parish of St. Catherine. In residential areas, garbage is collected once per week. This service is provided free (partial covered by property taxes) for the households within the area. The waste is transported to the Riverton Waste Disposal Site (landfill) located in southeast St. Catherine, approximately 29 km northeast of the proposed development area. Riverton Waste Disposal Site is approximately 1.19 m^2 (119 hectares). It receives approximately 60% of the island's waste. Solid waste collection for commercial and industrial facilities is done by arrangements by these entities with private contractors. Solid waste at the site will be collected on as needed basis by a private company.

5.6.1.7 Transportation

Airfields, Aerodromes and Airports

Air transport facilities do not exist within the SIA; the closest facility is an airfield, namely Port Esquivel Airfield situated 3 km southwest from the development area. The Norman Manley International Airport (NMIA) is the closest airport, approximately 35 km east of the development area. The NMIA is the primary airport for business travel to and from Jamaica and for the movement of air cargo. There are 13 scheduled airlines serving many international destinations and the average daily aircraft movement is 67 flights. In 2013, total passenger movements were approximately 1.37M and freight (cargo/mail) was 11,503 metric tonnes.

Road Network

The existing road network within and surrounding the SIA is depicted in Figure 5-125. Roads within the social impact area are in various states of repairs. ODPEM (2102) stated that one of the top five developmental challenges reported by respondent sin the Old Harbour Bay area are poor roads. Access to the Project site is the Old Harbour to Old Harbour Bay main road which may be entered from the Old Harbour square (beside the police station) or from Highway 2000 exit ramp. From Old Harbour, one would travel approximately 2.5km along the road to the turn off at the outskirts of the town of Old Harbour Bay. This section of the road is in need of repairs. There are sections along the asphaltic concrete surface where the surface becomes undulating (CLE, 2007). Some interior roads are unpaved such as Terminal Lane as well as there are paths which are in poor condition. A Parish Council roadway runs through the site.

The public transportation system within the community was considered to be reliable as there are a number of licensed and unlicensed taxis available for commute throughout the community.

A large majority of the Old Harbour Bay Community utilized licensed taxis as their main type of transportation, accounting for 93.6% of residents. Other means were unlicensed taxis (“robot”), bicycles and private motor cars (SDC 2007).

5.6.1.8 Social, Health and Emergency Services

Telecommunication

The parish of St. Catherine and the study area are served with landlines provided by Flow Jamaica Limited (formerly LIME Jamaica Limited). Wireless communication is provided by Digicel Jamaica Limited and Flow; a network to support internet connectivity is also provided by Flow.

Post Offices

Post offices are not found within the demarcated SIA; one in Old Harbour is the closest to the proposed development area (approximately 4.2 km north of the project area).

Market/Shopping

There are two markets in proximity of the proposed site, namely the Old Harbour market and the Old Harbour Bay market.

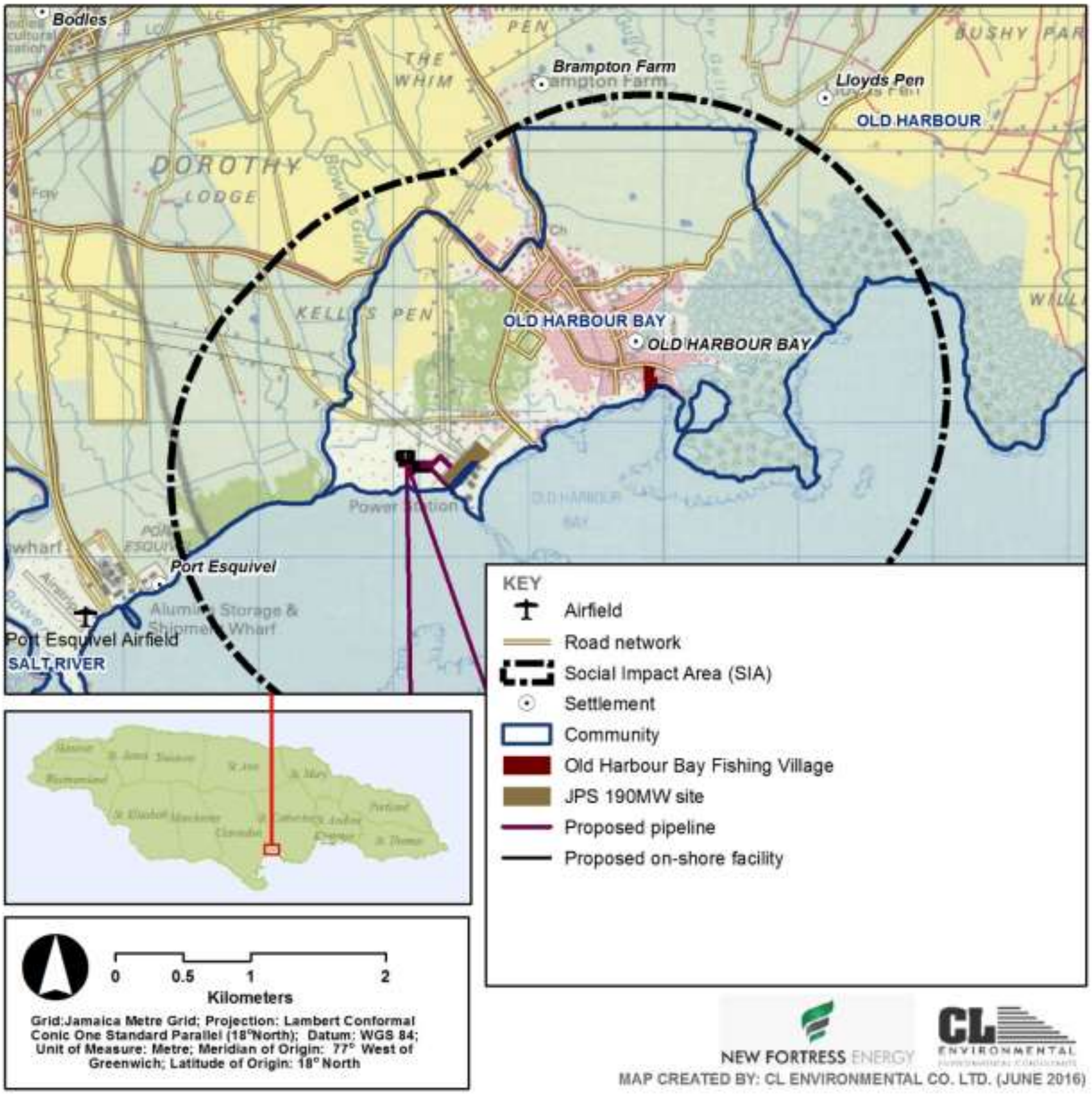


Figure 5-125 Road network and transportation infrastructure located in the SIA

Health

COMMUNITY HEALTH PROBLEMS

ODPEM (2012) reported that a significant amount of the respondents involved in the Old Harbour Bay Community Disaster Risk Management Plan project reported the presence of a longstanding health problem within their household (35.5%). Among household heads and family members, hypertension was the most common illness. There are no health care facilities present within the Community as such residents usually travel to Old Harbour to access these services. The main difficulty to accessing health care reported by respondents was financial constraints (40%).

HEALTH CENTRES

One health centre exists within the SIA, namely the Old Harbour Bay Health Centre situated approximately 1.25 km northeast of the project area. This health centre, along with others situated in the parish of St. Catherine and depicted in Figure 5-126, (e.g. Old Harbour and Church Pen) fall under the responsibility of the Southeast Regional Health Authority (SERHA). The centre is a Type II Health Centre; it is serviced by a visiting Doctor and Nurse Practitioner and serves a population of about 12,000 persons. Family health (including antenatal, postnatal, child health, nutrition, family planning & immunization); curative, dental, environmental health, Sexually Transmitted Infections (STIs) treatment, counselling & contact investigation; child guidance, mental health and pharmacy are the services provided (Western Regional Health Authority). The main types of problems are asthma, diabetes and arthritis. It has a seating capacity of 150 persons; however, the facility experiences overcrowding when at times more than 400 patients are present. The public health facilities are without an ambulance; however, in case of emergencies, help is sought from the Jamaica Public Service, JAMALCO, WINDALCO or from the Spanish Town Hospital.

HOSPITALS

There are currently no public or private hospitals within the SIA; May Pen Hospital and Lionel Town Hospital are the closest to the site. Both are located approximately 18 km from the project area (northwest and southwest respectively) and belong to the Southern Regional Health Authority (SRHA). The Lionel Town Hospital is a ‘Type C’ hospital. These are the basic district hospitals which interface with the Primary Health Care system at parish level. Inpatient and outpatient services are provided in general medicine, surgery, child and maternity care (Southern Regional Health Authority, b). The Lionel Town Hospital is a 45 bed facility staffed by approximately 96 clinical, administrative and support staff. It provides services in the disciplines of Minor Surgery and General Medicine along with a monthly clinic in the area of Mental Health. May Pen Hospital be considered a ‘Type C’ hospital, however is being transitioned to a ‘Type B’ hospital. The following clinics and services have been put in place: medical, nutrition, ante-natal, gynaecological, blood centre, ECG, central sterilization, opening of an additional ward and 24-hour service in A&E, O.T., laboratory, radiography and Patient Admission System. The final expansion strategies for the hospital to be officially declared a Type "B" are the recruitment of a Paediatric Consultant and the opening of the sixth ward.

Spanish Town Hospital belongs to the SERHA and is located approximately 20 km northeast of the project area. It is the largest 'Type B' Hospital in the island and services include medicine, surgery, urology, radiology, paediatrics, pathology, orthopaedics, laboratory and obstetrics and gynaecology. Demands on these services has increased owing to growing communities in St. Catherine such as Portmore, Eltham and Ensom City which access the hospital, as well as increased numbers of motor vehicle accident victims from nearby highways. In response to these demands, improvements to the hospital were made. For example, in 2008, the Katie Hoo Haemodialysis Centre was officially opened and is equipped with seven (7) machines, six (6) stations as well as other dialysis equipment. One year following this, the King of Spain Wing opened; this is a 34 bed facility which also hosts the Physiotherapy Department.

Ambulance

The public health facilities are without an ambulance; however, in case of emergencies, help is sought from the Jamaica Public Service, JAMALCO, WINDALCO or from the Spanish Town Hospital.

Fire Stations

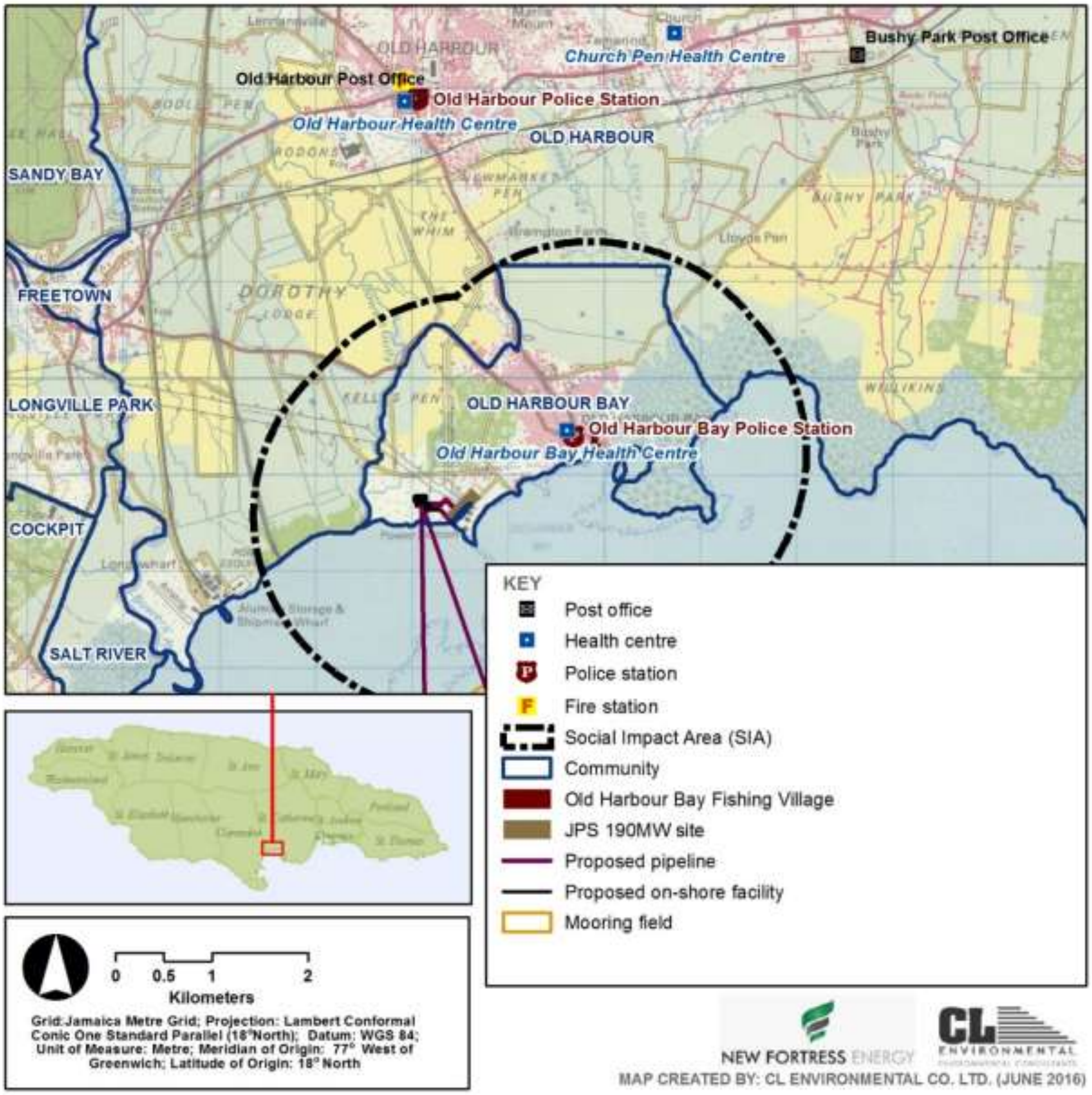
The Old Harbour Fire Station is the closest fire station to the proposed development area and is situated outside the 2 km SIA, approximately 4.4 km north of the project area (Figure 5-126). This station falls under Area III. This station has one fire engine with a water capacity of 1,818 – 2,273 litres (400-500 imperial gallons). If additional help is needed, backup would be called from the Spanish Town Fire Station, some 20 km away or May Pen Fire Station some 17 km away. Fire stations islandwide are served by a fleet of 91 operational firefighting and rescue vehicles and 58 utility vehicles. There are also 3 fire boats, one each assigned to the harbours in Kingston, Montego Bay and Ocho Rios. The Fire Prevention and Public Relations Division and the Emergency Medical Service (EMS) provide fire prevention services and emergency medical rescue/ paramedic services (Jamaica Fire Brigade, 2012). The fire department is equipped to fight an LNG fire (pers. comm.).

Police Stations

One police station exists within the SIA surrounding the proposed development area, namely Old Harbour Bay Police Station, 1.2 km northeast of the project area. It is part of the Saint Catherine North division (Police Area Five). It is this station that would respond to any events at the proposed site. In the Old Harbour Bay area, the main crimes are related domestic disputes. The police station is adequately staffed and is in possession of a police vehicle.

5.6.1.9 Industry and Economy

The Old Harbour Bay community is one of many residential fishing villages found along the coast in Jamaica, and is considered the largest fishing village on the island. The other industries and sources of employment include mining, manufacturing, small retail shops and subsistence farming.



Data source: Mona GeoInformatics Institute

Figure 5-126 Social. health and emergency services located in and around the SIA

5.6.2 Land Use and Zoning

5.6.2.1 Land Use

Past

Historically, the area contains historic and archaeological sites dating back to Jamaica's first known inhabitants (The Taíno) and later the Spanish, the Africans, and the British. The area has seen various land uses over the past centuries. Cattle rearing was the main activity in the area during pre and post emancipation periods. It should be noted that all the plantations, pens and estates in the area had plantation houses and enslaved villages. In the more recent past, aquaculture was done on some areas of the property. Pre historical cultural material in the form of pottery sherds, both Spanish and English bricks and concrete troughs associated with cattle rearing are found to the immediate east and west of the proposed site (Jamaica National Heritage Trust, 20012).

Existing Land Use

The proposed site is adjacent (west) to JPS' proposed 190 MW Power Plant and the Old Harbour facility, which currently has 220 MW of generation and houses major transmission and distribution operation along with a privately owned diesel power plant (Doctor Bird I & II). The proposed project site is bounded on the east by the existing Old Harbour Power Plant, to the northeast by the existing switch yard, to the west by Thorn Savanna and to the south by the ocean. The Parish Council roadway runs north of the proposed site.

Existing land use in the study area is agricultural, commercial, industrial, residential, educational and recreational (Figure 5-127). Other uses include a cemetery (Old Harbour Bay Cemetery), telecommunication modules and cellular towers, an airstrip and informal solid waste disposal. Agricultural facilities dominate the land use of the study area. Sugar cane farming, fishing and aquaculture (pond fish) are the major agricultural activities; however, subsistence farming also occurs in the area. There is also the Bodles Research Facility which conducts agricultural research activities. The Old Harbour Bay community is one of many residential fishing villages found along the coast in Jamaica, and is considered the largest fishing village on the island.

Commercially, the study area has restaurants, bars, a market and a fishing village (Old Harbour Bay), factories such as the Caribbean Boilers Hatchery, car wash, charcoal burning and scrap metal recovery operations. Industrial facilities include the Jamaica Energy Partners "Doctor Bird" power barges, Jamaica Public Service Company Ltd. Old Harbour Bay electric power station, Windalco's Port Esquivel Alumina Storage and Port and Jamaica Broilers Ethanol Dehydration Plant (Figure 5-128). Major residential areas within the area include sections of Old Harbour, New Harbour Village Phase I and II, Free Town and Longville Park Estates (Longville Park Phase III was recently built), Belmont Park Community and Old Harbour Bay. Other areas include Kellys Pen and an informal community. Recreational facilities are located at Old Harbour Bay where there is a community centre, which has a football field and a hard court for netball and basketball. There are also areas within the community where individuals set up for their recreational activities.

Future Land Use

Proposed land use on the site was previously described in section 3.0. Future developments in the wider area are shown in Figure 5-128 and include:

- Cement and Quarry Operations and 39MW Coal-fired Power plant (Cement Jamaica Limited)
- Salt Harbour Special Fishery Conservation Area

5.6.2.2 Protected Areas

Protected areas examined here include all areas of land or water protected by various laws in Jamaica, as well as international agreements that fall within or in proximity to the project area. These may include, but are not limited to, fish sanctuaries or Special Fisheries Conservation Areas (SFCA), protected areas, national parks, forest reserves, marine parks, game reserves and national heritage and monuments. Figure 5-127 gives an overview of the location of these protected areas in relation to the project area and SIA. The proposed development falls directly within the Portland Bight Protected Area (declared April 22, 1999 under Natural Resources Conservation Authority (NRCA) Act) and the Portland Bight Wetlands and Cays Ramsar Site. About 1.2 km outside the SIA are two game reserves to the southwest and southeast, namely Long Island Game Reserve (declared August 21, 1998 under Wild Life Protection Act (WLPA)) and Amity Hall Game Reserve (declared August 22, 1997, amended July 28, 2004) respectively. In addition, the Galleon Harbour SFCA and the Salt Harbour SFCA are also located to the southwest and southeast of the project area. Also protected by law is the Great Goat Island forest reserve, 4km southeast of the project area (Figure 5-127).

Portland Bight Protected Area

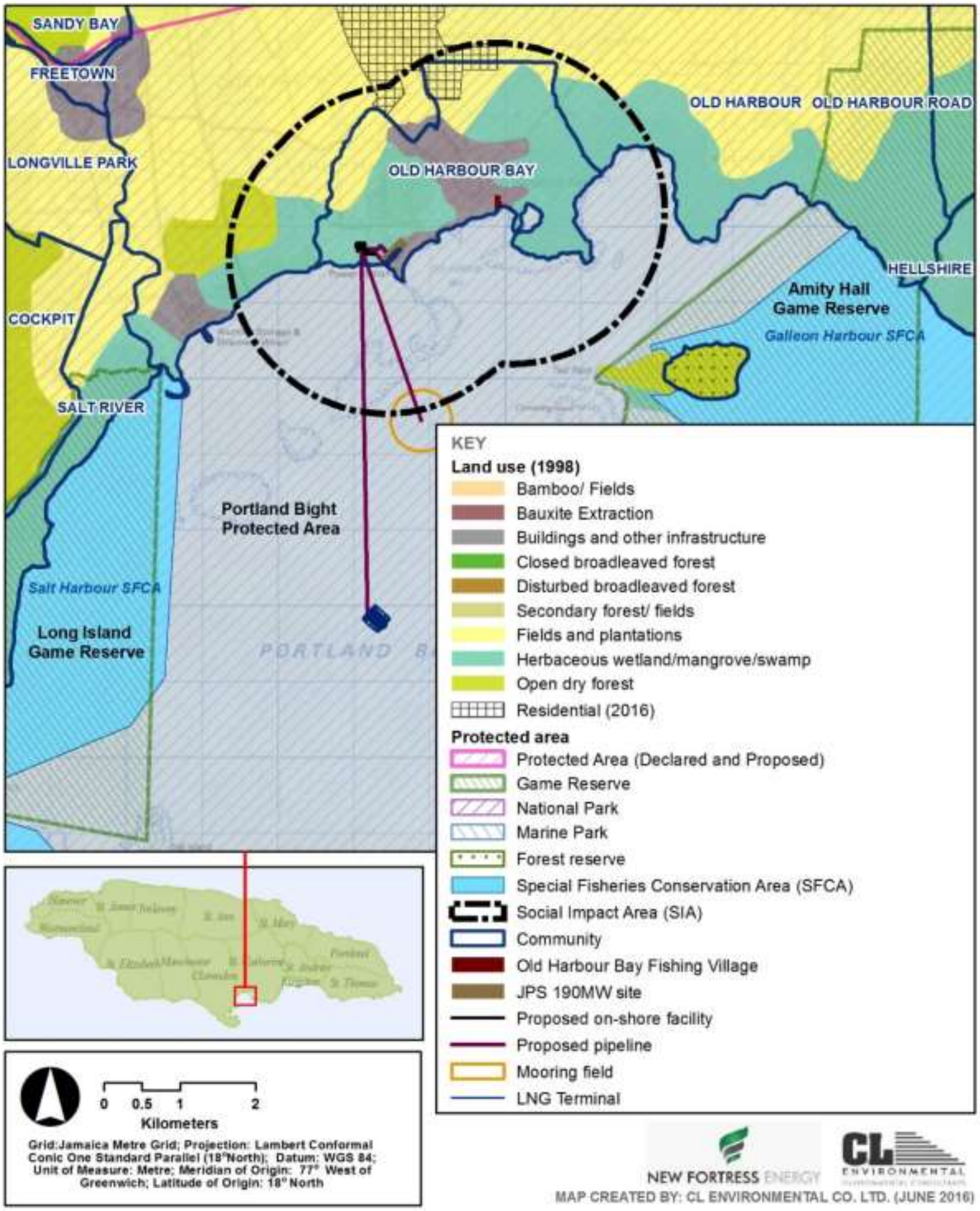
The proposed project falls within the Portland Bight Protected area, co-managed by the Caribbean Coastal Area Management Foundation (CCAM) and the National Environment and Planning Agency (NEPA). The PBPA is the largest protected area in Jamaica enclosing 1,876 km^2 of coastal land and sea between Portland Ridge and Hellshire Hills, and including nearby cays such as Little Goat Island. More than half of the land area of the PBPA exists in its natural state, and includes dry limestone forests (210.3 km^2) and wetlands (82.0 km^2). The remainder of land is used for the cultivation of sugar cane or human settlement (Caribbean Coastal Area Management (C-CAM) Foundation, 2007). Regionally important examples of dry forest and nationally important areas of coral reef, mangrove wetland and seagrass occur within this area, which also provides habitat for at least 20 globally threatened species (Caribbean Coastal Area Management Foundation). A management plan was prepared by the Caribbean Coastal Area Management Foundation (C-CAM) supported by a team of the major stakeholders.

Portland Bight Wetlands and Cays Ramsar Site

Jamaica has four designated Ramsar sites, one of which is the Portland Bight Wetlands and Cays, declared on February 2, 2006. The Portland Bight Wetlands and Cays run through the southern regions of St. Catherine and Clarendon in areas such as Old Harbour Bay (location of project area and SIA), Lionel Town and Hayes. The site is described to be of significant value for the country, as there are a range of endemic and rare plants, extensive fish life and several small coral cays existing within the site.

5.6.2.3 Zoning

The SIA falls within the St. Catherine Coastal Development Order 1964 boundary (Figure 5-129). Further, the proposed site falls within the boundaries of the Old Harbour/ Old Harbour Bay Local Planning Area of the emerging St. Catherine Area Development Order in an area zoned for heavy industrial use. Another important zonation map to be considered is that arising from the development of Highway 2000 - 'Portmore to Clarendon Park Highway 2000 Corridor Development Plan 2004 – 2025'. This plan was developed by the Government of Jamaica to guide development along the H2K corridor and may be seen Figure 5-130. The proposed project area falls within an area zoned for "heavy industry". Hence, the proposed development is in conformity with both proposed zonings.



Data sources: Land use (Forestry Department, 1998) and protected areas (NEPA and MGI)

Figure 5-127 Land use and protected areas within the SIA

Figure 5-128 Existing and future land use

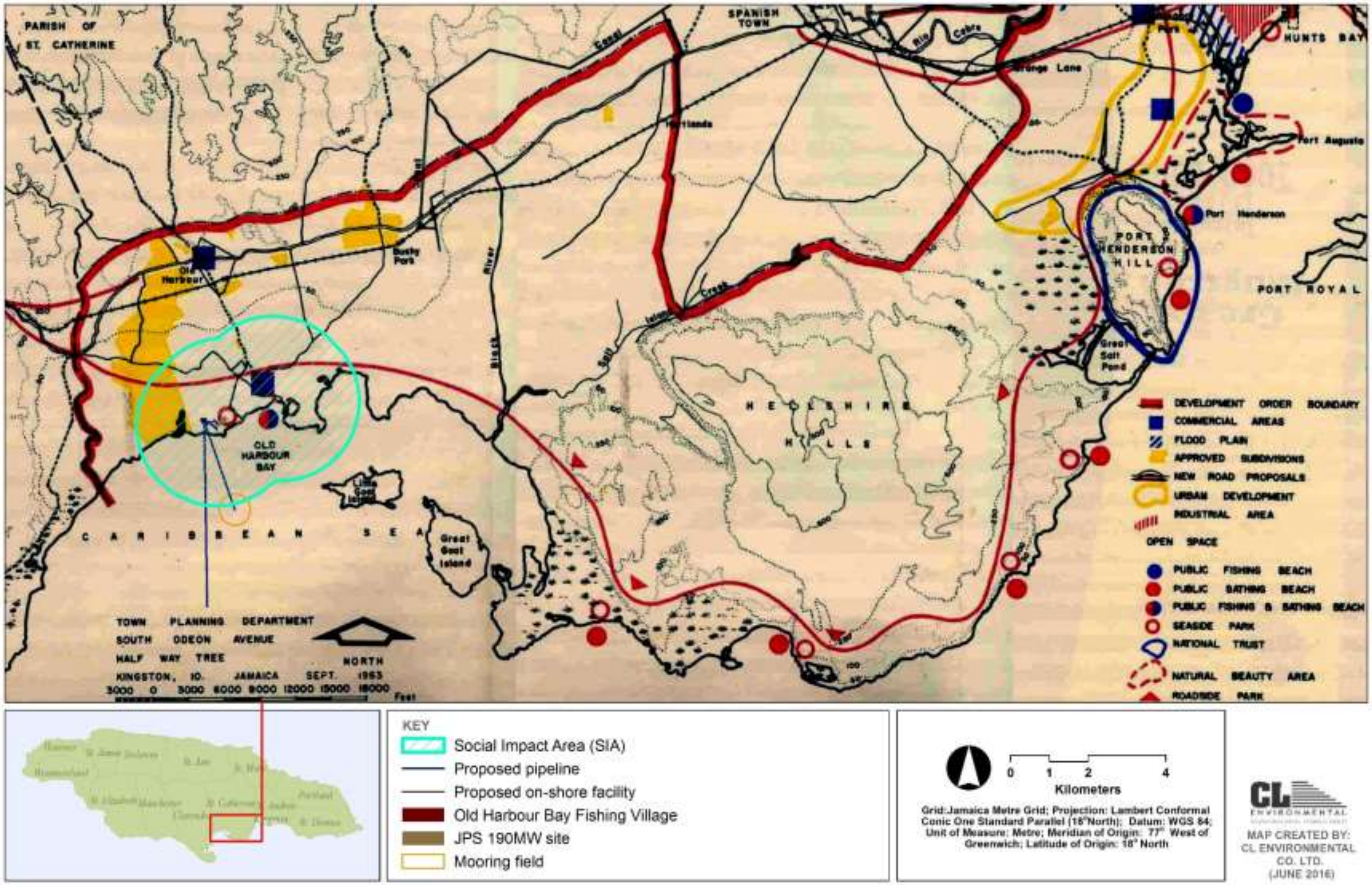


Figure 5-129 St Catherine Coastal Development Order map

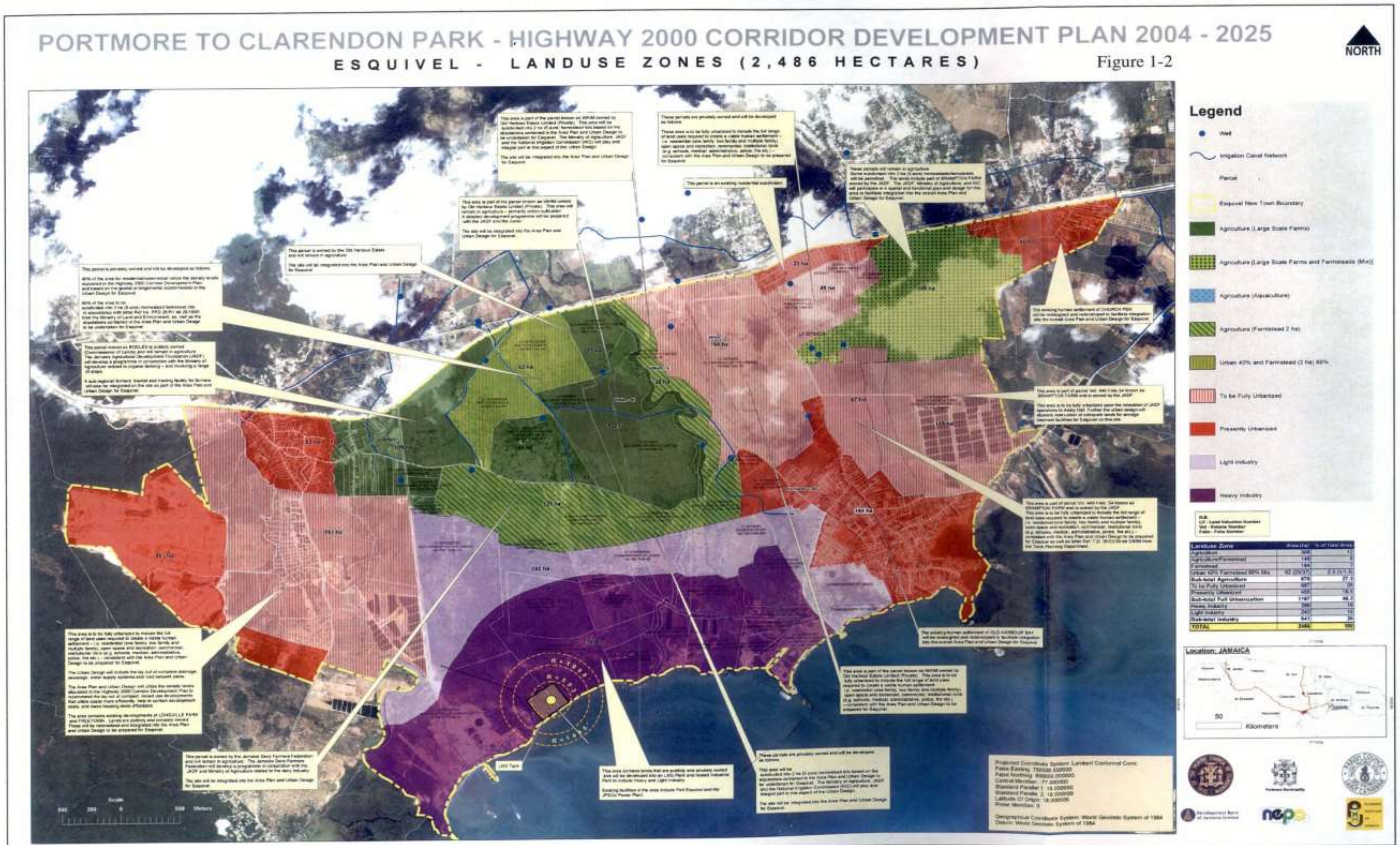


Figure 5-130 Highway 2000 Corridor Development Plan (Portmore to Clarendon Park)

5.6.3 Aesthetics and Landscaping

The area of the proposed development is an industrialized area with the existing JPS Old Harbour Bay power plant, Port Esquivel, Best Dressed Chicken Feed Mill, Jamaica Energy Partners Dr Bird I and II Barges and Jamaica Broilers Ethanol Dehydration Plant in close proximity. Overall, the proposed development will improve the visual impact of the site (Figure 5-131).

5.6.3.1 Off Shore

The marine facility will be constructed off shore on the western side of Portland Bight at a distance about 200 meters from the shipping channel to Port Esquivel in about 14 meters of water depth. This facility will contain an unloading area, control room, power distribution center, boil-off-gas compressor skid, LNG pump skid, vaporizer and process skid, flare skid including drain tank and igniter, flare, nitrogen generator skid, seawater pumps, mixing tank, air burst system, crane, and launcher area. The facility will be designed so it can be readily expanded as demand for LNG grows in the region.

Phase 1 of the project includes one vessel berth consisting of an unloading and regasification platform, metering and pig launch platform, four (4) breasting dolphins and six (6) mooring dolphins. The dolphins and the process platforms are connected for access using nine truss spans and four catwalks. Phase 2 of the project includes a second berth, an extension to the Phase 1 unloading and regasification platform and installation of four (4) additional breasting dolphins. The structures will be constructed using steel pipe piles, steel framing, steel superstructure and concrete deck slabs on the platforms. The dolphins will include a fender system and quick release hooks for vessel mooring and berthing. The berths are designed for LNG vessel sizes ranging from 140,000 m^3 up to 175,000m^3 capacity with an approximate vessel length of 280m to 300m and draft of approximately 12.5m. The structures are designed to resist mooring and berthing loads under operational conditions, as well as seismic and hurricane/tropical storm conditions.

The tallest structure or piece of equipment on the Platform is likely to be the crane which could be +/- 7.6 m (25 ft) above the deck (the deck elevation is + 10m). The Flare Stack, which will be located on one of the mooring dolphins is +/- 13.7 m (45 ft) tall. Therefore, no structure or equipment will extend more than 17.6 m in height above the horizon and will not be visually obtrusive from shore or from the sea. The offshore facilities will be buffered by a 500 m zone in which navigation will be restricted. All safety and navigational lighting will be in place 24/7 in an effort to insure sufficient navigational warning for vessels using this area (Figure 5-132).

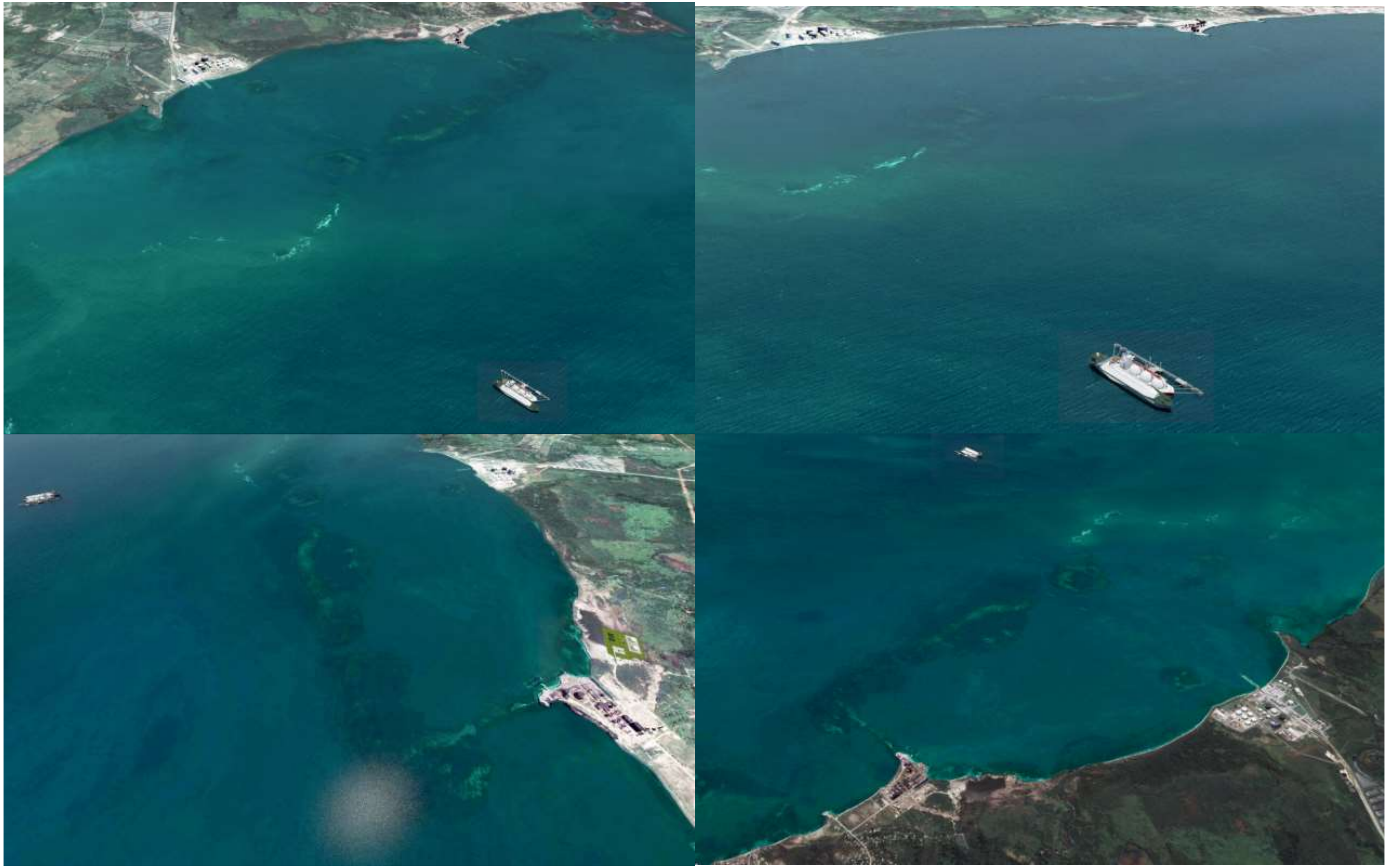


Figure 5-131 Collage showing views of the proposed project area

Figure 5-132 Collage showing an artis rendition of the offshore marine facility of the NFE South Holdings Limited LNG Terminal and Regassification Project

5.6.3.2 On Shore

On shore facilities will be located on a 25,000 m^2 plot located in the Old Harbour Bay community near the JPS plant.

The onshore facilities will have equipment for both the natural gas and Automotive Diesel Oil (ADO) systems. The Natural Gas (NG) equipment will include the end of the pipeline, a pig receiver skid (50' x 10'), filter skid (20' x 10'), meter/regulator skid (40' x 10'), and control building (8' x 10'). The ADO equipment will include the end of the pipeline, a pig receiver skid (41' x 8'), receiving meter/regulator skid (20' x 10'), two (2) 50,000 BBL storage tanks inside containment (110% of volume of one tank), pump skid (20' x 10'), delivery meter/regulator skid (20' x 10'), electrical services building (20' x 10') and an on-site stormwater management facility (Figure 5-133).

Visually, the on shore facilities will be compatible other industrial development in the area, notably the existing JPS plant. The BBL storage tanks represent the largest components on the site, averaging approximately 14.6 m (48 ft) in height. Landscaping will be undertaken along the margins of the property to improve aesthetics.

Figure 5-133 Collage showing an artis rendition of the onshore marine facility of the NFE South Holdings Limited LNG Terminal and Regassification Project

6.0 PUBLIC PARTICIPATION AND CONSULTATION

6.1 PURPOSE OF THIS SECTION

The National Environment and Planning Agency (NEPA) recognizes the critical role played by the public, including civil society, community-based and non-governmental organizations (CBO's and NGO's). The process of public sensitization is designed to enhance the awareness of stakeholders and/or the general public in an open sphere. This helps to ensure that persons who are likely to be impacted are knowledgeable and therefore able to implement precautionary measures to safeguard their interest. It also seeks to facilitate stakeholder participation in the monitoring and enforcement of the conditions under which approvals are being granted.

This section outlines the results of the stakeholder consultation programme for this project and summarizes the key stakeholder issues arising to date.

Appendix 3 provides the public guidelines prepared by NEPA.

6.2 APPROACH

The NRCA guidance on EIAs states that this process "should involve some level of stakeholder consultation in either focus groups or using structured questionnaires." As such, stakeholder consultation included the following mechanisms.

1. **Perception Survey**
   A survey was conducted within the Old Harbour Bay area. The Perception Survey questionnaire (Appendix 9) administered addressed the extent to which responding residents relied on the environment for their livelihood and the respondents' perception of the Project's impact.
2. **Consultation with Stakeholders**
   Consultations were held with Caribbean Coastal Area Management (C-CAM) Foundation on June 17, 2016; The Jamaica Constabulary Force's Marine Police Division on June 13, 2016 and the Office of Disaster Preparedness and Emergency Management (ODPEM) on July 12, 2016.

6.3 PERCEPTION SURVEY

6.3.1 Introduction and Approach

During June 2-4, 2016, a survey was undertaken in the Old Harbour Bay (OHB) area to glean their perception of the proposed project. A total of 349 residents were surveyed; this represents approximately 6.5% of the population estimated to be living in this SIA in 2016 (5,382 persons, see section 5.6.1.2). Respondents to the survey came from the following communities of Old Harbour Bay:

1. Bay Bottom
2. Norrine/Hell Gate
3. Old Harbour Bay
4. Station Lane
5. Buddho
6. Burkesfield
7. Settlement
8. Dagger Bay
9. New Road
10. Park Land
11. Blackwood Gardens
12. Main Street
13. Terminal/Terminal Road/Cross Roads
14. Kelly Pen
15. Panton Town
16. New Harbour[7]
17. Milk River, Porus, Manchester, Kingston[8]
18. East Bay Drive
19. Peters Lane
20. New Market Street
21. Thompson Pen

The survey instrument (Appendix 9) focused on three main areas:

a) The extent to which respondents relied on the environment for their livelihood
b) Respondents' perception of the Project's impact on the environment; and
c) General background information about respondents.

6.3.2 Survey Findings and Results

6.3.2.1 Employment

In response to the question on whether respondents were employed full time, part time or "other", the majority of the respondents surveyed - 56.3% indicated they were "otherwise" employed. There were 29% who said they were employed on a full time basis and 14.7% said they were employed part time.

[7] Fisher who recently moved from Old Harbour Bay.

[8] They have moved into the area for fishing spells. Because fishing has been depleted in other fishing areas, for the past years they have moved to OHB and will move again to better fishing area if/when needed.

6.3.2.2 Engaged in Fishing

Only 153 of the 349 respondents opted to respond to the question of whether or not they relied on the OHB Area as their primary source of Fishing. Not surprisingly 88% of the 153 respondents to this question indicated that they rely heavily on the OHB Area as their primary source of fish. 95% of those who responded rely heavily (more than 75%) on fishing for their income. It is clear therefore that for fisherfolk, the OHB area is an important catchment for their livelihood.

6.3.2.3 Awareness of NFE and the Project

The majority of the respondents had neither heard of NFE South Holdings Limited (NFE) (New Fortress Energy) nor of the specific Old Harbour Floating Storage Unit and Pipeline Project. 79.8% of the respondents indicated they had never heard of NFE and of those who responded to the question specifically about the project only 35.3% said they were aware of the project, 64.7% had no prior knowledge or awareness of the project. Those who were aware of the project had heard about it predominantly by word of mouth as opposed to television, radio, newspapers or community meeting.

6.3.2.4 Potential Impact of the Project

There was a general feeling among respondents (who are fisherfolk dependent on the OHB Area for their livelihood) that the project could have a negative impact on their fish catch. 296 (of the 349) persons responded to this question and of that number 184 of them thought the project could negatively affect their fish catch. The responses regarding the negative impact ranged from possible restrictions to the fishing area, pollution of the waters which would reduce the fish stock, reduced fishing area for small boat fishers who cannot go to deep sea and fish migration during construction. Notwithstanding the potential impact of the project on the fish catch the majority of respondents, 74.2%, thought the proposed project site was appropriate.

6.3.2.5 Concerns about the Project

In spite of the concerns about fish catch, fewer respondents had any other general concerns about the project. 331 respondents answered this question and only 145 (43.8%) had any concerns. 186 (56.2%) had no other concerns about the project. Some of the concerns expressed were

a) Safety of the project,
b) How will it affect the elderly and sickly? Will it kill them?
c) Environmental impacts
d) The effect any oil spill will have on the fish habitat & if jobs will be provided,
e) What are the safety precautions to be put in place.
f) Destruction of the fish habitat.
g) Water contamination .
h) Loss of livelihood/earning for fisherfolk of Old Harbour Bay.
i) Development may result in a change in the authenticity/character of Old Harbour Bay; and
j) Whether the project would present job opportunities.

6.3.2.6 Suitability of the Project Site

When the location of the proposed project was explained to respondents, the majority (74.2%) had no problem per se with the project site. Those who expressed concern about the site (25.8%) suggested alternative sites such as.

- Pigeon Island
- JPS Mooring Bouy
- Rocky Point Area
- Build it in Kingston & Truck it
- Another Cay, Portland Hill or Rocky Point
- Build it behind the present power station
- Build it behind the present power station on waste land
- OHB cannot take anything more
- Further away from the proposed location, the line is the problem
- On land where it can be better monitored
- Would be better on land near to coast to prevent leaks
- Down at JPS
- Rocky Point
- Further out to sea or Goat Island
- Further to sea where depth is 16 fathoms
- West behind the existing barge
- Closer to the already dredged channel
- Closer to the barge

6.3.2.7 Social Profile of the Respondents

The majority of the respondents were male (75.7%) and between the ages of 26 and 60 (74.4%) (Table 6-1 and Table 6-2)[9]. All respondents had some level of education, the majority (62%) attained secondary education; few respondents (6%) had completed tertiary education (Table 6-3).

Table 6-1 Survey respondents' age

LESS THAN 25	49	14.1%
26-40	105	30.3%
41-60	153	44.1%
GREATER THAN 60	40	11.5%

Table 6-2 Survey respondents' sex

MALE	262	75.7%
FEMALE	84	24.3%
TOTAL	346	100.0%

[9] It should be noted that percentages shown are of those that responded to the question, and therefore will not always be equal to the total survey population (349 residents).

Table 6-3 Survey respondents' educational attainment

NONE	0	0.0%
PRIMARY	73	21.0%
SECONDARY	212	62.0%
TERTIARY	22	6.0%
TECHNICAL VOCATIONAL	28	8.0%
OTHER	8	2.0%
TOTAL	343	100.0%

The majority of the respondents (61.3%) are home owners in the OHB area (Table 6-4), which means they would have vested interest in the project and how it might affect their property and community. Many of the respondents (greater than 80%) are longstanding residents of OHB with vested interest in their property and community (Table 6-5). This suggests that there is likely to be much interest in the changes that the project may bring to the community.

Table 6-4 Home owners and renters in survey group

	Home Owners		Renters	
YES	209	61.3%	54	16.3%
NO	132	38.7%	277	83.7%
TOTAL	341	100.0%	331	100.0%

Table 6-5 Number of years respondents have been living in area

LESS THAN 1 YR	5	1.5%
1 – 10 YRS	21	6.2%
11 – 20 YRS	31	9.1%
GREATER THAN 20 YRS	282	83.2%
TOTAL	339	100.0%

As expected, a few respondents (10%) were not keen to answer questions about the amount of money they earned. Of those who responded however, 43% earned over J$8,000 per week or more than J$32,000 per month. Given that the minimum wage in Jamaica is J$26,400.00 per month, this suggests that respondents were low- to mid-income earners.

Table 6-6 Income earnings of survey respondents

$2,000-$3,000	51	16.0%
$3,001-$4,000	30	10.0%
$4,001-$5,000	54	17.0%
$5,001-$6,000	34	11.0%
$6,001-$7,000	8	3.0%
$7,001-$8000	0	0.0%
$8,001 AND OVER	135	43.0%
TOTAL	312	100.0%

6.3.2.8 Overarching Comments on the Project.

Table 6-7 provides a summary of the responses provided. When asked to provide final thoughts on the project respondents' comments ranged from those of an economic nature, to social issues to environmental issues. Also raised were issues of governance – the fact that persons were not consulted about the project so they were unaware of such a plan that might impact on their community.

6.3.3 Conclusion

The comments from respondents reflected in the survey suggest that their overarching concerns are economic and environmental i.e. how the project will impact their livelihoods as fishermen/women and whether the project will provide employment opportunities for the community. The other major concern, which is linked to the economic impact, is that of pollution from the project which might affect fish catch and ultimately livelihoods.

The concerns expressed by respondents should be factored into the project design to ensure that appropriate safety measures are taken to minimise the likelihood of any negative environmental impact.

Table 6-7 Summary comments from respondents in respect of the proposed project in Old Harbour Bay

Social/Economic	Environmental	Other
Hope for fisher folk to get jobs	If the line cracks all the fish will be affected	Discussion needed with OHB residents
How will project impact the fishing industry	Uncertain of how the environment will change	Now work is available at the JPS. Plant is noisy
Employment Opp. for community people	If built there will be more pollution - bacteria & oil in the sea	hope the project will benefit all persons in the community
Hoping to get a job	If built natural vegetation & Goat island will be affected	Development is good but jobs are needed for the community
Can you fish around it, will there be more charges or penalties for fishing in the channel	How will people be affected if there is a gas leak	Fishing in inner reef prohibited, Port Esquivel to JPS line abandoned due to leak, no wood cutting at Goat Island
Fishers do not want project	Leak will affect swimming beach	Object to the project. How will the community benefit?
More people in community will be employed	Uncertain about how the FSU will impact to the sea	the project is great and will help the residents of Old Harbour Bay
Hoping for community work opportunity during operation and construction	Don't know how the fish will be affected	Information on the success/ failure/risks/ health effects/ Mitigation plans of LNG & FSU elsewhere. Details on pumps/ free flow systems, pipeline types & quality & how all compare to international standards. How will community benefit.
	Oil from the ship damages the nets which affects income	
	There is a lot of pollution and bacteria in the area	
	Hope there are no spills	
	Hope it is not hazardous to health	

6.4 CONSULTATION WITH STAKEHOLDERS

Discussions and interviews were held with various stakeholders with regard to the proposed project. Comments/queries arose from these discussions and are outlined below. It should be noted that responses to these issues are dealt with in a subsequent section (section 6.5).

6.4.1 Caribbean Coastal Area Management Foundation (C-CAM)

The following queries/comments arose from communication with Donovan Brandon Hay and Ingrid Parchment of Caribbean Coastal Area Management (C-CAM) on 17 June, 2016:

- How will the 500m exclusion zone be demarcated?
- How solid waste and sewage are going to be disposed of?
- Proposed platform area is a red snapper feeding ground
- Engage marine police in the monitoring of the 500m exclusion zone.
- Discuss tsunami drills with ODPEM for the Old Harbour Bay area.
- Where do facilities like these exist and where have they worked before?

6.4.2 Office of Disaster Preparedness and Emergency Management (ODPEM)

The following queries/comments arose from communication with Richard Thompson and Chris Gayle of the Office of Disaster Preparedness and Emergency Management (ODPEM) on 12 July 2016:

- Onshore and offshore infrastructure vulnerability to hurricanes.
- Onshore and offshore infrastructure vulnerability to seismic activity.
- What are the shutdown arrangements and evacuation protocols for the onshore and offshore facilities in the event of a disaster/emergency?
- How will workers be shuttled/transported to land in the event of a disaster/emergency?
- Information from this study regarding Emergency Response Protocol of LNG-related facilities will have to be included as part of the country's respective Disaster Management Plans.

6.4.3 Marine Police Division

The Jamaica Constabulary Force's Marine Police Division (Sergeant Reynolds) was also interviewed on 27 June 2016 with respect to patrolling the project area to which they responded that they conduct daily patrols within the Old Harbour Bay area and have no issue patrolling beyond the exclusion zone. The request tat they be involved and up to date on project progress and details. The Marine Police boat stays docked at the JEP Dr Bird power barge facility.

6.4.4 Ministry of Industry, Commerce, Agriculture & Fisheries (Fisheries Division)

The Ministry of Industry, Commerce, Agriculture & Fisheries (Fisheries Division) Lieutenant Commander (Ret'd) Paul Wright (C.E.O. – Fisheries Division) was consulted on 26 August, 2016 in order to garner feedback regarding the location of the proposed Project and the potential impact it might have on fishers. Further, information pertaining to the proposed terminal site being a Red Snapper feeding ground (noted by C-CAM, see section 6.4.1) was also sought. Responses made by the Fisheries Division are outlined in a letter dated 2 September 2016 (Appendix 10).

6.5 INDEX OF TECHNICAL RESPONSES TO STAKEHOLDER ISSUES

Tables were created in order to explicitly provide responses to issues raised through public consultation and particularly by means of the perception survey, stakeholder consultations and also from previous projects. Where applicable, reference to relevant sections in the EIA report are also included in order to provide more in depth explanation of the respective issue. The concerns raised by the respondents, in particular the social implications for livelihood and character of the community are addressed in Table 6-8 . Table 6-9 gives the responses to various stakeholder issues and Table 6-10, responses to concerns raised on a previous LNG project in Jamaica.

Table 6-8 Responses to concerns raised by the respondents during the perception survey

Stakeholder Issues	Response
Sect. 6.3.2.4 62% of respondents thought project could negatively affect fish catch	Pilings and other in-water features associated with the offshore platform and pipeline will act as FADs (Fish Aggregation Devices) as well as providing suitable substrate and habitat for faunal colonization and recruitment. Furthermore, the 500m exclusion zone will help prevent the fishing of fish species in the area. Section 7.2.2.2 –The loss of fish eggs and larvae as a result of both the intake system as well as the cooling system should be minimal on the fish stocks as these planktonic stages have a high natural mortality rate. The loss of plankton (the base of the fish food web) is also expected to be minimal and as a result have a minimal impact on the existing system. The Fisheries Division believes that the potential impact on the majority of fishers and fishing activities should be minimal. However, there are some fishers, particularly those who use smaller non-mechanized vessels with oars, who fish in the area for small demersal and pelagic fish species using nets and hand lines who will be adversely impacted. These fishers may be somewhat displaced, particularly if there is a large sterile zone around the proposed FSU. As recommended by the Fisheries Division, we are willing to reduce the 500m restricted/exclusion zone to 200m so as to minimize the possible displacement of these fishers only (see Appendix 10).
Oil spill effect on fish habitat	Section 7.2.1.2 identifies and discusses all possible water-related impacts. Specifically related to Automotive Diesel Oil (ADO), the NOAA states that diesel oil has a very low viscosity and is readily dispersed into the water column with moderate winds (5 -7 knots) or with

Stakeholder Issues	Response
	breaking waves. Diesel oil is much lighter than water and it is not possible for this oil to sink and accumulate on the seafloor as pooled or free oil unless adsorption occurs with sediment. The NOAA also states that in terms of toxicity to water-column organisms, diesel is considered to be one of the most acutely toxic oil types. Fish, invertebrates, and seaweed that come in direct contact with a diesel spill may be killed. However, small spills in open water are so rapidly diluted that fish kills have never been reported. Fish kills have been reported for small spills in confined, shallow water.
Safety precautions to be put in place	See Section 3.4.10 (Safety and Fire Protection) and Section 12.0 (Emergency Preparedness and Response).
Water contamination issues	Section 7.2.1.2 identifies and discusses in detail all possible water-related impacts.
Suitability of Project Site	Section 10.3 identifies and discusses in detail all Alternative Project Sites and Layouts. Further, the Fisheries Division offer no objection to the proposed locations for the Marine Terminal and FSU. The area leading to Salt River is traversed by only a few fishers who may fish just outside the Salt River SFCA (Sanctuary), and further South towards the Bluff. The fishers from the Old Harbour Bay Fishing Beach tend to exit the Bay in a South Easterly direction, away from the proposed FSU (see Appendix 10).

Table 6-9 Responses to stakeholder issues raised about the proposed project

Stakeholder Issues	Response
How will the 500m exclusion zone be demarcated?	Buoys will be used to demark the area
How solid waste and sewage are going to be disposed of?	Any domestic (non-hazardous) garbage from the ship will be collected and taken to shore for proper disposal. All food waste which is from locally obtained produce will also be collected and taken to shore for proper disposal. Hazardous waste will be managed according to applicable rules and regulations (section 7.2.1.1)
Proposed platform area is a red snapper feeding ground	Feeding habits of juvenile snapper shift based on size and plankton structure (Stephen T. Szedlmayer). A large section of the open area with minimal relief will remain while the addition of the platform should act more as a reef type plankton community and may serve to diversify and increase feeding resources. Further, the exclusion zone will help prevent the fishing of juvenile red snapper and other juvenile species in the area. The Fisheries Division added that the proposed site for the FSU is a feeding ground not just for the Red Snapper, but for several other demersal species, coastal pelagics and invertebrates such as Sea Cucumbers. The Fisheries Divison's expectation is that the installation and operation of the proposed FSU should have minimal medium to long term negative impacts on the ecology of the proposed site (given on the basis that effluents, noise, vibrations and other pollutants are kept within standards or eliminated where possible around the proposed FSU facility during installation and longer Iterm operations) (Appendix 10).

Stakeholder Issues	Response
Engage marine police in the monitoring of the 500m exclusion zone.	Patrol daily –boats docked at the Doctor Bird barge facility. Seargent Reynolds- 997-7412 papparatsi@yahoo.com
Where do facilities like these exist and where have they worked before?	The more popular choice of an FSRU system was not chosen for this project. Majority of the FSRU's today under construction or delivered are already committed and therefore is more practical to utilize the available FSU delivery system with regasification at the off shore facility (which is similar to any land based regasification facility).
What are the shutdown arrangements and evacuation protocols for the onshore and offshore facilities in the event of a disaster/emergency?	See Section 3.4.10 (Safety and Fire Protection) and Section 12.0 (Emergency Preparedness and Response).
How will workers be shuttled/transported to land in the event of a disaster/emergency?	Although the FSU will be moored at the off-shore facility, it will be able to undock and move to shelter in case of pending hurricane conditions. The Marine Police and JDF Coastguard will also be on hand to assist with any emergency transport needed. In the event of a disaster or emergency, workers will be transported to land via small boat either owned or contracted by New Fortress Energy. Such vessels will either be moored at the platform, on shore in close proximity to the platform or nearby at designated location available in the case of a disaster of emergency. The platform will be equipped with an accommodation ladder positioned on the platform that can be immediately lowered in case of emergency to where lifesaving equipment (small boat, lifeboats and rafts) at embarkation level are located. In addition, the FSU and the Liquefied Natural Gas Carrier (LNGC) will have emergency motor life boats (MLB). A similar dedicated craft should be on the platform.

Table 6-10 Concerns raised on a previous LNG project in Jamaica (Responses geared toward the current project).

Stakeholder Issues	Response
How many resources will be used from the Old Harbour Bay area?	There is the potential for increased employment during the pre-clearance, construction and operational phases. In addition, it is anticipated that indirect and induced jobs are expected to be created
What kind of safety precautions are being put in place?	All safety related issues are described in Section 3.4.10 Safety and Fire Protection
What is the schedule of delivery and how will this impact other maritime activities	Delivery should be approximately once every 25 days for approximately 40 hours per offloading time
What are examples of entrepreneurial use of LNG/NG?	LNG is principally used for transporting natural gas to receiving terminals and/or various markets, where it is regasified and distributed as natural gas through pipeline systems. It can also be used to power natural gas vehicles.
How are potential leaks in the pipeline address to ensure community safety?	The pipeline will be designed and constructed to include gas chromatograph analysis and a 24/7 acoustic leak detection/monitoring system.
Possibility of run off and from construction activity affecting business (fishing etc.)?	Appropriately sized stormwater management will be incorporated into the design of this on shore facility to manage stormwater runoff (Section 7.2.1.1).

Stakeholder Issues	Response
Will the area become restricted?	Yes- 500 m Exclusion Zone around the off shore facility. Due to usage by fishers and concerns expressed during stakeholder consultation, we are willing to reduce the 500m restricted/exclusion zone to 200m so as to accommodate the local fisherfolk only.
Increased industrialization of the area may cause species migration.	Area is already heavily industrialized. Pilings and other in-water features associated with the offshore platform and pipeline will act as FADs (Fish Aggregation Devices) as well as providing suitable substrate and habitat for faunal colonization and recruitment.
What are the Possible dangers of LNG?	Section 7.3 LNG specific impacts and mitigation
What are the Possible long term changes in the balance of marine life because of change in ambient water temperature?	See Section 7.2.2.2 – No effect on sensitive benthic systems such as coral or seagrass because of distance. The loss of fish eggs and larvae as a result of both the intake system as well as the cooling system should be minimal on the fish stocks as these planktonic stages have a high natural mortality rate. The loss of plankton (the base of the fish food web) is also expected to be minimal and as a result have a minimal impact on the existing system.
What specification are the LNG storage tanks designed to?	LNG storage will be primarily on the FSU, which have been designed and maintained in accordance with international standards and best practices
What is the estimated throughput of LNG/NG?	Up to 3m gpd on full build out (both phases)
There is a shortage of firefighting equipment and monitors. What can/will be done to address that?	LNG specific training and equipment will be provided to the local fire departments
What kind of training will be provided especially for the Fire Department?	LNG specific training and equipment will be provided to the local fire departments
The Fire Department needs to know the steps of the development as that they can do the fire activities/monitoring.	LNG specific training and equipment will be provided to the local fire departments

7.0 IDENTIFICATION AND ASSESSMENT OF POTENTIAL DIRECT AND INDIRECT IMPACTS AND RECOMMENDED MITIGATION

Impact matrices for the Site preparation/construction and operational phases were created utilising the following criteria taken from Ogola (2007):

- **Direction of Impact:** This describes the nature of the potential impact; positive, negative or no impact of a particular activity on a receptor.
- **Magnitude of Impact:** This is defined by the severity of each potential impact and indicates whether the impact is irreversible or, reversible and the estimated potential rate of recovery. The magnitude of an impact cannot be considered high if a major adverse impact can be mitigated.
- **Extent of Impact:** The spatial extent or the zone of influence of the impact should always be determined. An impact can be site-specific or limited to the Project Site; a locally occurring impact within the locality of the proposed project; a regional impact that may extend beyond the local area and a national impact affecting resources on a national scale and sometimes trans-boundary impacts, which might be international.
- **Duration of Impact:** Environmental impacts have a temporal dimension and needs to be considered in impact assessments. Impacts arising at different phases of the project cycle may need to be considered.
- **Significance of the Impact:** This refers to the value or amount of the impact. Once an impact has been predicted, its significance must be evaluated using an appropriate choice of criteria. The most important forms of criterion are:
    - Specific legal requirements e.g. national laws, standards, international agreements and conventions, relevant policies etc.
    - Public views and complaints
    - Threat to sensitive ecosystems and resources e.g. can lead to extinction of species and depletion of resources, which can result in conflicts.
    - Geographical extent of the impact e.g. has trans- boundary implications.
    - Cost of mitigation
    - Duration (time period over which they will occur)
    - Likelihood or probability of occurrence (very likely, unlikely, etc.)
    - Reversibility of impact (natural recovery or aided by human intervention)
    - Number (and characteristics) of people likely to be affected and their locations
    - Cumulative impacts e.g. adding more impacts to existing ones.
    - Uncertainty in prediction due to lack of accurate data or complex systems. A precautionary principle is advocated in this scenario.

In addition to the criteria listed previously for identifying potential impacts, those were supplemented by:

- The Consultants' experience,
- Documented impacts from similar projects,
- The data collected,
- Analysis of the processes in the proposed project,
- Information generated from models,
- Concerns raised from stakeholders; and
- Discussions held among the Study team.

Table 7-1 Impact assessment criteria for potential environmental impacts

SCORE	0	1	2	3
CRITERIA	Negligible	Minor	Moderate	Significant
DURATION	None	Physical impacts lasting less than a few months before recovery occurs. Impact does not persist after the activity ends.	Physical impacts lasting from a few months to two years before signs of recovery. It is not inter-generational.	Physical impact is persistent after 2 years. Impacts on a biological population over a number of recruitment cycles or generations of the population.
MAGNITUDE	No measurable change in availability of resources or function of systems. No measurable effect on people.	Changes in form and/or ecosystem function and/or a resource. The system maintains the ability to support ecosystem/ resource functions with only minor changes in community value and no overall loss/gain. Only a small fraction of the local community is affected.	Changes in form and/or ecosystem function and/or a resource. The system's ability to support ecosystem/ resource functions and economic benefit is affected but not lost. Only a moderate fraction of the local community is affected.	Changes in form and/or ecosystem function and/or a resource. The system's ability to support ecosystem/resource functions and economic benefit is highly affected. A large fraction of the local community is affected.
EXTENT	None	Isolated effects within activity site.	Localized area close to borders or offsite dispersion pathways.	Widespread: offsite regional effects

A total of four impact matrices were created for the following major activites/ phases:

- Natural Gas Pipeline Horizontal Directional Drilling (Table 7-2)
- Offshore Terminal Platform Construction (Table 7-3)
- Onshore Metering Centre (Table 7-4)
- Operation Phase (Table 7-5)

Table 7-2 Impact Matrix for Natural Gas Pipeline Horizontal Directional Drilling

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG			
Biological Impacts	Marine Invertebrates (Meiofauna)	Directional Drilling	Species loss and displacement	X				X	1	1	-1
	Terrestrial Invertebrates	Land Works/Activity	Species loss and displacement	X				X	1	1	-1
		Directional Drilling		X				X	1	1	-1
	Fish and filter feeders	Directional Drilling	Species displacement	X				X	1	1	-1
			Sedimentation; Smothering and/or clogging of gills and/or feeding apparatus	X				X	1	1	-1
	Reptiles-Turtles and Crocodiles	Directional Drilling	Displacement	X				X	1	1	-1
		Land Works/Activity	Displacement, and disruption of nesting	X				X	1	1	-1
	Avifauna	Land Works/Activity	Displacement disruption of nesting	X				X	1	1	-1
		Directional Drilling		X				X	1	1	-1
	Marine Mammals	Directional Drilling	Increased noise pollution – displace sensitive fauna	X				X	1	2	-1.33
	Coral Reef and Seagrass Communities	Directional Drilling	Sedimentation; Smothering	X				X	1	2	-2
	Mangrove (Red and Black) (dominant species)	Land Works/Activity	Habitat Disruption	X				X	1	1	-1
		Directional Drilling	N/A				X				
	Salina/Salt Marsh (Cacti, Black Mangrove) (dominant species)	Land Works/Activity	Habitat Disruption	X				X	1	1	-1
		Directional Drilling	N/A				X				
	Thorn Savannah (Acacia, Grasses) (dominant species)	Land Works/Activity	Habitat Disruption	X				X	1	1	-1
		Directional Drilling	N/A				X				
Physical Impacts	Air Shed	Land Works/Activity	Increased noise and dust pollution	X				X	1	1	-1
		Directional Drilling	Increased noise pollution	X				X	1	1	-1
	Water Quality	Directional Drilling	Suspension of heavy metals	X				X	1	2	-1.33
			Increased water pollution (oils, solid waste etc.)	X				X	1	2	-1.67
			Potential for major spills	X				X	2	2	-2.33
			Increased TSS and Turbidity	X				X	1	2	-1.67
		Land Works/Activity	Increased TSS and Turbidity	X				X	1	1	-1
	Maritime Traffic	Directional Drilling	Increased maritime accident potential	X				X	1	1	-1
			Disrupts marine traffic flow in the area.	X				X	1	1	-1
Social Impacts	Local fishing community	Directional Drilling	Reduced catch	X				X	1	1	-1
			Increased maritime accident potential	X				X	1	1	-1
	Labour Force/Local Economy	Land Works/Activity	Decreased air quality	X				X	1	1	-1
			Increased employment	X		X			1	3	2.33
		Directional Drilling	Increased employment	X		X			1	3	2.33
	Users and Residents	Land Works/Activity	Decreased air quality	X				X	1	1	-1
			Decreased water quality	X				X	1	1	-1
			Decreased aesthetic appeal	X				X	1	1	-1
		Directional Drilling	Decreased water quality	X				X	1	1	-1
			Increased traffic during transport of HDD equipment	X				X	1	1	-1
			Decreased aesthetic appeal	X				X	1	1	-1
		Land Works/Activity	Increased accidental potential of labourers	X				X	1	1	-1.33

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG			
	Existing natural and social environment		Increased solid waste generation	X				X	1	1	-1.33
			Increased noise exposure of labourers	X				X	1	1	-1.33
		Directional Drilling	Increased solid waste generation	X				X	1	1	-1.33
			Increased accidental potential of labourers	X				X	1	1	-1.33
			Increased noise exposure of labourers	X				X	1	1	-1.33

Table 7-3 Impact Matrix for Offshore Terminal Platform Construction

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG				
Biological Impacts	Marine Invertebrates (Meiofuana and Plankton)	Pile Installation	Species loss, Sedimentation and Smothering	X				X	3	1	1	-1.67
		General Construction Activity	Species loss, Sedimentation and Smothering	X				X	1	1	1	-1
	Fish and Filter Feeders	Pile Installation	Sedimentation - clogging of gills	X				X	1	2	1	-1.33
		General Construction Activity	Sedimentation - clogging of gills	X				X	1	2	1	-1.33
	Marine Mammals	Pile Installation	Increased noise pollution – displace sensitive fauna	X				X	1	2	2	-1.67
		General Construction Activity	Increased noise pollution – displace sensitive fauna	X				X	1	2	2	-1.67
	Nearby Coral Reef and Seagrass Communities	Pile Installation	Sedimentation and Smothering	X				X	1	2	2	-1.67
		General Construction Activity	Sedimentation and Smothering	X				X	1	2	2	-1.67
Physical Impacts	Air Shed	Pile Installation	Increased noise pollution	X				X	1	1	1	-1
		General Construction Activity	Increased noise pollution	X				X	1	1	1	-1
	Water Quality	Pile Installation	Suspension of heavy metals	X				X	1	1	2	-1.33
			Increased water pollution (oils, solid waste etc.)	X				X	1	2	2	-1.67
			Potential for major spills	X				X	2	3	3	-2.67
			Increased TSS and Turbidity	X				X	1	2	2	-1.67
		General Construction Activity	Potential for major spills	X				X	2	3	3	-2.67
			Increased TSS and Turbidity	X				X	1	1	1	-1
	Maritime Traffic	Pile Installation	Increased maritime accident potential	X				X	1	1	1	-1
		General Construction Activity	Increased maritime accident potential	X				X	1	1	1	-1
Social Impacts	Local Fishing Community	Pile Installation	Damage to fishing equipment	X				X	1	1	1	-1
			Increased maritime accident potential	X				X	1	1	1	-1
		General Construction Activity	Increased maritime accident potential	X				X	1	1	1	-1
	Labour Force/Local Economy	Pile Installation	Increased employment	X		X			1	3	3	2.33
		General Construction Activity	Increased employment	X		X			1	3	3	2.33
	Users of Area	Pile Installation	Decreased water quality	X				X	1	1	1	-1
			Decreased aesthetic appeal	X				X	1	1	1	-1
		General Construction Activity	Decreased water quality	X				X	1	1	1	-1
			Decreased aesthetic appeal	X				X	1	1	1	-1
	Existing natural and social environment	Pile Installation	Increased accidental potential of labourers	X				X	1	2	1	-1.33
			Increased noise exposure of labourers	X				X	1	2	1	-1.33
		General Construction Activity	Increased solid waste generation	X				X	1	2	1	-1.33
			Increased wastewater generation	X				X	1	2	1	-1.33
			Increased accidental potential of labourers	X				X	1	2	1	-1.33
			Increased noise exposure of labourers	X				X	1	2	1	-1.33
			Increased water usage	X				X	1	2	1	-1.33

Table 7-4 Impact Matrix for Onshore Metering Centre

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG				
Biological Impacts	Terrestrial Invertebrates	Land Clearance	Species loss , displacement and loss of habitat	X				X	3	1	1	-1.67
		General Construction Activity		X				X	3	1	1	-1.67
	Reptiles- Turtles and Crocodiles	Land Clearance	Displacement	X				X	3	2	1	-2
		General Construction Activity	Displacement, loss of habitat and disruption of nesting, Noise Pollution and vibration	X				X	1	2	1	-1.33
	Avifauna	Land Clearance	Displacement, loss of habitat and disruption of nesting, Noise pollution and vibration	X				X	3	1	1	-1.67
		General Construction Activity	Increased noise pollution – displace sensitive fauna	X				X	1	1	1	-1
	Mangrove (Red and Black) (dominant species)	Land Clearance	Species Loss, Habitat Destruction	X				X	3	3	1	-2.33
		General Construction Activity	Dust pollution affecting remaining plants	X				X	1	1	1	-1
	Salina/Salt Marsh (Cacti, Black Mangrove) (dominant species)	Land Clearance	Species Loss, Habitat Destruction	X				X	3	3	1	-2.33
		General Construction Activity	Dust pollution affecting remaining plants	X				X	1	1	1	-1
	Thorn Savannah (Acacia, Grasses) (dominant species)	Land Clearance	Species Loss, Habitat Destruction	X				X	3	3	1	-2.33
		General Construction Activity	Dust pollution affecting remaining plants	X				X	1	1	1	-1
Physical Impacts	Air Shed	Land Clearance	Increased noise and dust pollution	X				X	1	1	1	-1
		General Construction Activity	Increased noise and dust pollution	X				X	1	1	1	-1
	Water Quality	Land Clearance	Increased water pollution (oils, solid waste etc.)	X				X	1	1	1	-1
			Increased TSS and Turbidity from run-off	X				X	1	1	1	-1
		General Construction Activity	Increased water pollution (oils, solid waste etc.)	X				X	1	1	1	-1
			Increased TSS and Turbidity	X				X	1	1	1	-1
Social Impacts	Existing natural and social environment	Land Clearance	Increased solid waste generation	X				X	1	2	1	-1.33
			Increased accidental potential of labourers	X				X	1	2	1	-1.33
			Increased noise and dust exposure of labourers	X				X	1	2	1	-1.33
		General Construction Activity	Increased solid waste generation	X				X	1	2	1	-1.33
			Increased wastewater generation	X				X	1	2	1	-1.33
			Increased accidental potential of labourers	X				X	1	2	1	-1.33
			Increased noise and dust exposure of labourers	X				X	1	2	1	-1.33
			Increased water usage	X				X	1	2	1	-1.33
	Labour Force/Local Economy	Land Clearance	Increased employment	X		X			1	3	3	2.33
		General Construction Activity	Increased employment	X		X			1	3	3	2.33

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG				
	Users and Residents	Land Clearance	Decreased air quality and noise pollution	X				X	1	1	1	-1
			Decreased water quality	X				X	1	1	1	-1
			Decreased aesthetic appeal	X				X	1	1	1	-1
		General Construction Activity	Decreased air quality and noise pollution	X				X	1	1	1	-1
			Decreased water quality	X				X	1	1	1	-1
			Decreased aesthetic appeal	X				X	1	1	1	-1

Table 7-5 Operations Impact Matrix

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG				
Biological Impacts	Fish and filter feeders	Shipment/Transit/Receipt	Mortality resulting from spills		X			X	1	1	1	-1
		Regassification	Entrainment		X			X	3	1	1	-1.67
		Pipeline/Platform Operation and Maintenance	N/A				X					
		General Operations	Decreased water temperature	X				X	3	1	1	-1.67
	Reptiles- Turtles and Crocodiles	Shipment/Transit/Receipt	Collision with fauna, Mortality resulting from spills		X			X	1	3	1	-1.67
		Regassification	Entrainment		X			X	3	1	1	-1.67
		Pipeline Operation and Maintenance	Disturbance of nesting		X			X	1	1	1	-1
		General Operations	Decreased water temperature	X				X	3	1	1	-1.67
	Avifauna	Shipment/Transit/Receipt	N/A				X					
		Regassification	N/A				X					
		Pipeline Operation and Maintenance	N/A				X					
		General Operations	N/A				X					
	Marine Mammals	Shipment/Transit/Receipt	Collision with fauna, Mortality resulting from spills		X			X	1	3	1	-1.67
		Regassification	N/A				X					
		Pipeline Operation and Maintenance	N/A				X					
		General Operations	Decreased water temperature	X				X	3	1	1	-1.67
	Mangrove (Red and Black) (dominant species)	Shipment/Transit/Receipt	N/A				X					
		Regassification	N/A				X					
		Pipeline Operation and Maintenance	Species loss of newly recruited mangrove saplings	X				X	1	2	1	-1.33
		General Operations	N/A				X					
	Salina/Salt Marsh (Cacti, Black Mangrove) (dominant species)	Shipment/Transit/Receipt	N/A				X					
		Regassification	N/A				X					
		Pipeline Operation and Maintenance	Species loss of newly recruited seedlings/saplings	X				X	1	2	1	-1.33
		General Operations	N/A				X					
	Thorn Savannah (Acacia, Grasses) (dominant species)	Shipment/Transit/Receipt	N/A				X					
		Regassification	N/A				X					
		Pipeline Operation and Maintenance	Species loss of newly recruited seedlings/saplings	X				X	1	2	1	-1.33
		General Operations	N/A				X					
	Nearby Coral Reef and Seagrass Communities	Shipment/Transit/Receipt	Damage from potential groundings		X			X	1	3	1	-1.67
		Regassification	N/A				X					
		Pipeline Operation and Maintenance	Sedimentation of seagrass from pipeline maintenance nearshore	X				X	1	2	1	-1.33
		General Operations	Decreased water temperature				X					
Physical Impacts	Water Column	Shipment/Transit/Receipt	LNG release		X			X	2	2	1	-1.67
			Oil/fuel spills		X			X	2	3	2	-2.33

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG				
		Regassification	LNG release		X			X	2	2	1	-1.67
		Pipeline Operation and Maintenance	LNG release		X			X	2	2	1	-1.67
			Anti-Fouling pollutants	X				X	1	1	1	-1
		General Operations	Decreased water temperature				X					
			Oil/fuel spills		X			X	2	3	2	-2.33
			Increased BOD/decreased dissolved oxygen from treated wastewater effluent	X				X	2	1	2	-1.67
			Oily water draining into marine enviroment	X				X	2	3	2	-2.33
	Air Shed	Shipment/Transit/Receipt	Exhaust emissions	X				X	1	1	1	-1
		Regassification	LNG Release		X			X	2	2	1	-1.67
		Pipeline Operation and Maintenance	N/A				X					
		General Operations	Fugitive Air Emissions from diesel generator	X				X	1	1	1	-1
	Coastline	Shipment/Transit/Receipt	N/A				X					
		Regassification	N/A				X					
		Pipeline Operation and Maintenance	N/A				X					
		General Operations	N/A				X					
	Maritime Operations	Shipment/Transit/Receipt	Increased maritime accident potential	X				X	3	2	1	-2
			Disrupts marine traffic flow	X				X	1	1	1	-1
		Regassification	N/A				X					
		Pipeline Operation and Maintenance	N/A				X					
		General Operations	Increased maritime accident potential	X				X	1	1	1	-1
Social Impacts	Local fishing community	Shipment/Transit/Receipt	Oil/fuel spills / LNG release		X			X	2	3	2	-2.33
		Regassification	N/A				X					
		Pipeline Operation and Maintenance	N/A				X					
		General Operations	Oil/fuel spills		X			X	2	3	2	-2.33
	Users and Residents	Shipment/Transit/Receipt	Fire hazard		X			X	2	3	1	-2
			INcreased Aesthetic appeal	X		X			3	3	1	2.33
			LNG/methane release		X			X	2	2	1	-1.67
		Regassification	INcreased Aesthetic appeal	X				X	3	3	1	2.33
		Pipeline Operation and Maintenance		X				X	3	3	1	2.33
		General Operations		X				X	3	3	1	2.33
	Local Economy/Labour Force	Shipment/Transit/Receipt	Increased employment	X		X			3	3	3	3
		Regassification	Increased employment	X		X			3	3	3	3
		Pipeline Operation and Maintenance	Increased employment	X		X			3	3	3	3
		General Operations	Increased employment	X		X			3	3	3	3

7.1 SITE PREPARATION AND CONSTRUCTION

7.1.1 Physical

7.1.1.1 Land Impacts

Noise

Site clearance for the construction of the metering facility necessitates the use of heavy equipment to carry out the job. Equipment to be used include bulldozers, backhoes etc. which have the potential to cause a direct negative impact on the noise climate. Noise directly attributable to site clearance activity should not result in noise levels in the residential areas to exceed 55dBA during day time (7am – 10 pm) and 50dBA during night time (10 pm – 7 am). Where the baseline levels are above the stated levels, then it should not result in an increase of the baseline levels by more than 3dBA at the nearest residence.

Construction noise can result in short-term impacts of varying duration and magnitude. Construction noise levels are a function of the scale of the project, the phase of the construction, the condition of the equipment and its operating cycles, the number of pieces of construction equipment operating concurrently.

To gain a general insight into potential construction noise impacts that may result from the project, the typical noise levels associated with various types of construction equipment are identified in Table 7-6.

Table 7-6 Typical construction equipment noise levels

Type of Equipment	Typical Sound Level at 50 ft. (dBA Leq.)
Dump Truck	88
Portable Air Compressor	81
Concrete Mixer (Truck)	85
Jackhammer	88
Scraper	88
Bulldozer	87
Paver	89
Generator	76
Pile driver	101
Rock Drill	98
Pump	76
Pneumatic Tools	85
Backhoe	85

Adapted from - Route 101A Widening and Improvements, City of Nashua Hillsborough County, New Hampshire; McFarland-Johnson, Inc. May 30, 2007

The proposed project has the potential to be a noise nuisance during the construction phase. However, with the proper mitigative steps the proposed project will have minimal (if any) impact on the surrounding community.

RECOMMENDED MITIGATION

i. Use equipment that has low noise emissions as stated by the manufacturers.
ii. Use equipment that is properly fitted with noise reduction devices such as mufflers.
iii. Operate noise-generating equipment during regular working hours (e.g. 7 am – 7 pm) to reduce the potential of creating a noise nuisance during the night.
iv. Construction workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.
v. Management controls will be used to mitigate the potential noise impacts along the access route. These are;
    a. Trucks and other heavy duty vehicles will be required to travel at no more than 30 km/h along the access route.
    b. Truck and heavy duty vehicles should travel along the access route only during day time hours 7 am – 5 pm.

Vibration

Construction activities often generate vibration complaints. This may be as a result of interfering with person's normal routines/activities. This can become more acute if the community has no understanding of the extent and duration of the construction. This can lead to misunderstandings if the contractor is considered to be insensitive by the communities although he may believe he is in compliance with the required conditions/ordinances.

Construction activities can result in various degrees of ground vibration. This is dependent on the type of equipment used and the methodologies employed.

Various governmental agencies have criteria regarding architectural and structural damage, as well as annoyance and acceptability of vibration. In general, most of the criteria specify that for a Peak Particle Velocity (PPV) less than approximately 3.048 mms-1 (0.12 inches per second), the potential for architectural damage due to vibration is unlikely. With a PPV of approximately 3.048 mms-1 (0.12 inches per second) to 12.7 mms-1 (0.50 inches per second), there is potential for architectural damage due to vibration, and for a PPV greater than approximately mms-1 (0.50 inches per second), the potential for architectural damage due to vibration is very likely.

Human beings are known to be very sensitive to vibration, the threshold of perception being typically in the PPV range of 0.14 mms-1 to 0.3 mms-1 (British Standard BS 5228-2:2009). An indication of the effects of ground vibration on humans is detailed by the standard and detailed in Table 7-7.

Table 7-7 Guidance on the effects of vibration

VIBRATION LEVEL	EFFECT
0.14 mms^{-1}	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mms^{-1}	Vibration might be just perceptible in residential environments.
1.0 mms^{-1}	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mms^{-1}	Vibration is likely to be intolerable for any more than a brief exposure to this level.

The effects of construction vibration (both on humans and buildings) is summarized in Table 7-8.

Table 7-8 Effects of Construction Vibration

PEAK PARTICLE VELOCITY (mm/sec)	EFFECTS ON HUMANS	EFFECTS ON BUILDINGS
< 0.127	Imperceptible	No effect on buildings
0.127 – 0.381	Barely perceptible	No effect on buildings
0.508 – 1.27	Level at which continuous vibrations begin to annoy in buildings	No effect on buildings
2.54 – 12.7	Vibrations considered unacceptable for people exposed to continuous or long-term vibration	Minimal potential for damage to weak or sensitive structures
12.7 – 25.4	Vibrations considered bothersome by most people, however tolerable if short-term in length	Threshold at which there is a risk of architectural damage to buildings with plastered ceilings and walls. Some risk to ancient monuments and ruins.
25.4 – 50.8	Vibrations considered unpleasant by most people	U.S. Bureau of Mines data indicates that blasting vibration in this range will not harm most buildings. Most construction vibration limits are in this range.
>76.2	Vibration is unpleasant	Potential for architectural damage and possible minor structural damage

Vibrations from various types of construction equipment under a wide range of construction activities have been measured by the Federal Transit Administration (FTA) in the United States. The data in Table 7-9 provides a reasonable estimate for a wide range of soil conditions. Additional data on other equipment are represented in Table 7-10, which were obtained from measurements on several projects including the Central Artery/Tunnel Project in Boston and from several published sources including the FTA Manual and Dowding's Textbook.

Table 7-9 Vibration source levels for construction equipment (from measured data)

Table 12-2. Vibration Source Levels for Construction Equipment (From measured data.[7,8,9,10])

Equipment		PPV at 25 ft (in/sec)	Approximate L_v† at 25 ft
Pile Driver (impact)	upper range	1.518	112
	typical	0.644	104
Pile Driver (sonic)	upper range	0.734	105
	typical	0.170	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Vibratory Roller		0.210	94
Hoe Ram		0.089	87
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

† RMS velocity in decibels (VdB) re 1 micro-inch/second

Source: FTA (2006)

To predict the vibration at a receptor from the operation of the equipment listed in Table 7-9, the following equation is used:

$$PPV_{equip} = PPV_{ref} \times (25/D)^{1.5}$$

where: PPV (equip) is the peak particle velocity in in/sec of the equipment adjusted for distance

PPV (ref) is the reference vibration level in in/sec at 25 feet from Table 12-2

D is the distance from the equipment to the receiver.

Table 7-10 Equipment Vibration Emission Levels

Equipment Description	Vibration Type Steady or transient	Ref PPV at 100 ft.
Auger Drill Rig	Steady	0.011125
Backhoe	Steady	0.011
Bar Bender	Steady	N/A
Boring Jack Power Unit	Steady	N/A
Chain Saw	Steady	N/A
Compactor	Steady	0.03
Compressor	Steady	N/A
Concrete Mixer	Steady	0.01
Concrete Pump	Steady	0.01
Concrete Saw	Steady	N/A
Crane	Steady	0.001
Dozer	Steady	0.011
Dump Truck	Steady	0.01
Excavator	Steady	0.011
Flat Bed Truck	Steady	0.01
Front End Loader	Steady	0.011
Generator	Steady	N/A
Gradall	Steady	0.011
Grader	Steady	0.011
Horizontal Boring Hydraulic Jack	Steady	0.003
Hydra Break Ram	Transient	0.05
Impact Pile Driver	Transient	0.2
Insitu Soil Sampling Rig	Steady	0.011125
Jackhammer	Steady	0.003
Mounted Hammer hoe ram	Transient	0.18975
Paver	Steady	0.01
Pickup Truck	Steady	0.01
Pneumatic Tools	Steady	N/A
Scraper	Steady	0.000375
Slurry Trenching Machine	Steady	0.002125
Soil Mix Drill Rig	Steady	0.011125
Tractor	Steady	0.01
Tunnel Boring Machine (rock)	Steady	0.0058
Tunnel Boring Machine (soil)	Steady	0.003
Vibratory Pile Driver	Steady	0.14
Vibratory Roller (large)	Steady	0.059
Vibratory Roller (small)	Steady	0.022
Welder	Steady	N/A
Concrete Batch Plant	Steady	N/A
Pumps	Steady	N/A
Blasting	Transient	0.75
Clam Shovel	Transient	0.02525
Rock Drill	Steady	0.011125
3-ton truck at 35 mph	Steady	0.0002

To predict the vibration at a receptor from the operation of the equipment listed in Table 7-10 the following equation is used:

$$PPV_{equipment} = PPV_{ref}\ (100/D_{rec})^{n}$$

Where:

PPV_{ref} = reference PPV at 100 ft.
D_{rec} = distance from equipment to the receiver in ft.
n = 1.1 (the value related to the attenuation rate through ground)

The closest receptors to the onshore LNG Metering Facility are: a wooden shack (211m away) and a house made of block and steel (310m away).

The vibration impact was predicted on these receptors with the use of ten (10) pieces of construction equipment (Table 7-11).

The results show that both structures (wooden shack and house made of block and steel) will be unaffected by vibrations as a result of the onshore construction activity. Vibrations will be imperceptible by residents living at these two closest receptors.

Table 7-11 Predicted vibration levels at the closest receptors to the Onshore Metering Facility in PPV in/sec and PPV mm/sec in brackets

EQUIPMENT	RECEPTOR VIBRATION	
	Wooden Shack	Block and Steel House
Vibratory Roller	0.001 (0.036)	0.001 (0.02)
Large Bulldozer	0.001 (0.015)	0.000 (0.008)
Loaded Truck	0.001 (0.013)	0.000 (0.007)
Jack Hammer	0.000 (0.006)	0.000 (0.003)
Back Hoe	0.001 (0.033)	0.001 (0.021)
Dump Truck	0.001 (0.03)	0.001 (0.019)
Frontend Loader	0.001 (0.033)	0.001 (0.021)
Grader	0.001 (0.033)	0.001 (0.021)
Paver	0.001 (0.03)	0.001 (0.019)

RECOMMENDED MITIGATION

Although structures nearby will be unaffected by vibrations and imperceptible by residents, construction crews should still take the following into consideration. In general, during construction pile driving on shore and at the platform will be necessary. Efforts will be made to minimize these temporary vibration effects on marine mammals and reptiles. During operation, minor amounts of vibration and noise will be present but minimized through the design of the facility and every effort will be made to minimize the noise and vibration effects. In terms of workers at the facility, workers will be provided with appropriate personal protection equipment to minimize the effect of noise.
:

- Avoid night time construction activities. People are more aware of vibration in their homes during the night time hours.
- Have regular meetings or devise a communication strategy to inform the residents nearby of construction activities.

Noise and Vibration (Terrestrial and Marine Mammals and Reptiles)

TERRESTRIAL

The construction/installation of the proposed project has the potential to have a negative impact on terrestrial and marine mammals and reptiles albeit on a short term basis. The potential impact to terrestrial fauna is expected to be minimal as the proposed area is closed to an industrialized area (JPSCo power plant) and is already experiencing he noise from that facility. It is anticipated that any fauna remaining in that area has adapted to the noise climate in the area. The increase in noise and vibration during the construction of the facility will temporarily increase which has the potential to cause alertness and avoidance (such as birds flying away) of the high noise and vibration areas by fauna that are currently using the area.

MARINE

While not observed during the fieldwork, we were told that the area is a Red Snapper breeding ground and that turtles, manatees and dolphins use the bay (pers. comm).

The construction of the marine terminal will necessitate the driving of piles. Typically, pile driving sounds underwater are characterized by multiple rapid increases and decreases in sound pressure over time. Very fast, high-level acoustic exposures can cause physical damage and/or mortally wound fishes (Bagocius, 2015).

When a pile driving hammer strikes a pile, sound from the impact radiates into the air, and a transient stress wave, or pulse, propagates down the length of the pile. The impact will also create flexural (or transverse) stress waves in the wall of the pile, which couple with the surrounding fluids (air and water) to radiate sound into the both media. Moreover, the pulse propagating down the length of the pile may couple with the substrate at the water bottom and the waves propagate outward through the bottom sediments. These substrate transient waves can be transmitted from the bottom into the water body at some distance away from the pile to create local areas of very low and, or very high sound pressure (Popper & Hastings, 2009).

A CALTRANS study in 2001 found that mortality caused by exposure to pile-driving sounds, with dead fish of several different species found within at least 50 m from the pile being driven. Nedwell *et al*. (2003) found that there were no indication of behavioural no reaction to vibropiling (i.e. where a pile is vibrated rather than hit with a hammer) for fish as close as 25 m to the source.

RECOMMENDED MITIGATION

There are a number of mitigation measures for underwater noise impacts associated with piling. Potential mitigation options are outlined below:

i. A soft start procedure can be used to cause marine animals to leave the immediate area of the piling. This involves starting the energy of the impact at approximately 1/10th of the desired level and progressively increasing the energy of the impact until the desired impact energy is achieved. The ramp up time should be determined by the time it would take the aquatic animal of interest to leave the high impact area.
ii. Impact cushions of plywood, nylon or other material can be placed between the top of the pile and the hammer. These cushions can reduce the sound pressure level by between 4-26dB at the cost of requiring slightly more impacts to achieve the same penetration depth.
iii. Bubble curtains may be used should noise mitigation be required for protection of marine animals. A bubble curtain is a vertical 'curtain' of bubbles that completely surrounds the pile while driving is in progress. The bubbles present an impedance mismatch which results in transmission loss of between 320dB. Bubble curtains are less effective in areas where there are strong currents or high turbulence as the transmission loss depends on the whole pile being encased in the bubble curtain.
iv. Use vibropiling where possible
v. Reduce piling during breeding season

Storage of Raw Material and Equipment

Any raw materials used in construction of the onshore metering facility will be stored onsite. There will be a potential for them to become air or waterborne. Stored fuels and the repair of construction equipment has the potential to leak hydraulic fuels, oils etc.

RECOMMENDED MITIGATION

vii. A central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of chemicals into the sediment.
viii. Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne.
ix. Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.
x. Raw material should be placed on hardstands surrounded by berms.
xi. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff.
xii. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage.

Transportation of Raw Material and Equipment

The transportation and use of heavy equipment and trucks is required during construction. Trucks will transport raw materials and heavy equipment. This has the potential to directly impact traffic flow along local roads.

RECOMMENDED MITIGATION

vii. Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
viii. Adequate and appropriate road signs should be erected to warn road users of the construction activities. For example, signs which require reduced speed near the construction site. Signage stating speed limits of 15-30 km/h should be erected.
ix. Raw materials such as marl and sand should be adequately covered within the trucks to prevent any escaping into the air and along the roadway.
x. The trucks should be parked on the proposed site until they are off loaded.
xi. Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
xii. The use of flagmen should be employed to regulate traffic flow.

Light Pollution

The platform and on-shore facility will be designed to minimize light pollution through the use of LED lights and shielding as required to minimize the spread of light in the nearby environment.

7.1.1.2 Water Impacts

Sea Water Quality

There are several potential pollution sources that have the potential to generate sediment plumes in the marine environment, both nearshore and offshore. They include; directional drilling nearshore for the pipeline, and driving of piles to build the offshore LNG platform. Trenching of the pipeline toward the offshore platform has the potential to increase turbidity, suspended solids and re-suspend heavy metals in the sediment, thus decreasing the water quality of the area and potentially impacting coral and seagrass where the reef crest is located, depending on wind speed and direction affecting currents.

There will be no dredging or associated spoil disposal or reclamation activities for this project. Therefore no dredge related impacts are expected.

RECOMMENDED MITIGATION

Turbidity barriers/silt screens are recommended to be used around LNG platform construction activities and pipeline directional drilling activities nearshore. These should be placed so as to reduce/contain the resultant sediment plume during these activities. Activities should only continue when these barriers are fully operational, that is; placed correctly; calm to moderate sea conditions; without damage. These barriers are particularly important when operations occur near or may influence sensitive ecosystems and species such as coral reefs and seagrass beds and or filter feeding organisms and fish. The silt screens should encircle the areas and be deep enough to contain the plumes so that plumes will not travel in the direction of the prevailing currents.

7.1.1.3 Air Impacts

Air Quality

Site preparation for the onshore metering facility has the potential to have a two-folded direct negative impact on air quality of the surrounding residential area. The first impact is air pollution generated from the construction equipment and transportation. The second is from fugitive dust from the proposed construction areas and raw materials stored on site. Fugitive dust has the potential to affect the health of construction workers, the resident population and the surrounding vegetation. In terms of air emissions and especially soot blowing, the FSU and the resupply ships will be state of the art design in order to meet all international and Jamaican standards.

RECOMMENDED MITIGATION

i. Areas should be dampened with freshwater every 4-6 hours or within reason to prevent a dust nuisance. On hotter days, this frequency should be increased.
ii. Minimize cleared areas to those that are needed to be used.
iii. Cover or wet construction materials such as marl to prevent a dust nuisance. Wetting should be done with freshwater.
iv. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.

Aircraft

Any impacts on aircraft will be minimal since the platform and on-shore facilities are in remote locations. In addition, the tallest structure will be the flare which will be under 30.5 m (100 ft) above the platform deck.

7.1.2 Biological

7.1.2.1 Pipeline Route

The pipeline will be directionally drilled several feet underground, below the seafloor and topsoil layers. Using this method of pipe installation, the impacts to the biological community are expected to be minimal.

Marine Invertebrates (Meiofauna and Plankton)

Minimal species loss and or displacement may occur deep in the anoxic sand layer where the pipeline will run however this is highly unlikely as most meiofauna can be found in the first two feet of sand/sediment. Some invertebrates may be displaced by associated construction activities in pipeline deployment. That is; additional noise, plumes, and the use of silt screens may temporarily displace some invertebrates from the seafloor, water column and in the sediment itself.

Terrestrial Invertebrates

Minimal species loss may occur in animals deep within the soil where the pipeline will run. Some species loss, displacement and loss of habitat may occur in the terrestrial environment. The proposed project footprint should be very small, with no need for vegetation clearance during pipeline deployment. The impact on the terrestrial invertebrate community should therefore be very small.

Fish and Filter Feeders

Fish and other mobile filter feeders may avoid areas of during construction activity as a result of noise, silt screens and plumes which may occur and as such may be temporarily displaced. Some sedimentation of the marine environment may occur during the pipeline installation and deployment. This is expected to be minimal and should be easily contained by the use of a silt screen in working areas. Excess sediment in the water can interfere or clog gill filaments and feeding apparatus (in particular bivalves which occur in dense numbers in sections of the unconsolidated rubble of the reef crest). The impact here is expected to be minimal as the pipeline is deep in the sediment and should not cause much if any impact on these species.

Reptiles- Turtles and Crocodiles

Large animals, such as crocodiles and turtles may be temporarily displaced from the working area and nearby areas which may have increased noise or other human activities. Lighting during night time construction have the potential to interfere with navigation of some species. These should be avoided when possible but also should not point directly out to sea if being used.

Construction activities and associated noise and vibration on land and in the nearshore environment may disrupt or even prevent activities such as nesting. Although turtles have been known to historically utilize nearby beaches, the project area has had no document turtle nesting or activity in several years.

Crocodiles have been document utilizing the coastal areas of the project for feeding, foraging and nesting. Crocodiles and turtles are protected species and both should only be interacted with and handled by trained professionals. Interference with any crocodile activity should be minimized, and all precautions taken to prevent any direct human interaction.

Avifauna

Birds which utilize project area or area of influence maybe temporarily displaced. This maybe as a result of noise and or other human activities. The removal of any vegetation or land clearance may cause some habitat loss and displacement. Land Clearance or the removal of vegetation is expected be very minimal, as a result any impact on the bird community is expected to be temporary and minimal.

Marine Mammals

Marine mammals (dolphins and manatees) may avoid areas of during construction activity as a result of noise, silt screens and plumes which may occur or used during the pipeline installation. These animals have historically been documented in nearby areas but are very unlikely to be in the area of influence of the proposed project. Any such disruptions or displacement by the project should be short, temporary and minimal.

Coral Reef and Seagrass Communities

Some sedimentation of the marine environment may occur during the pipeline installation and deployment. This is expected to be minimal and should be easily contained by the use of a silt screen in working areas. Excess sediment in the water can interfere with sensitive and sessile species such as coral reefs and seagrass beds. Smothering of corals and seagrass may occur if there is excess and prolonged sedimentation. Working areas or activities that maybe result in a plume should be avoided in these areas.

The Pipeline will run deep enough in the substrate so as not to interfere with the rooting system of seagrass. The seagrass here is adapted to lower light conditions and turbid water and therefore should not be affected by low temporary levels of sedimentation as a result of the project activities. The impact here is expected to be minimal as the pipeline is deep in the sediment and should not cause much if any impact on these species.

The reef community, mainly hard and soft corals, sponges and other invertebrates may temporarily and minimally be affected by sedimentation. Similar to the seagrass community, the reef community is adapted and shaped by several factors including low light levels and high turbidity. The visibility in this area is generally very poor. And as such any short temporary sedimentation should have a temporary and minimal impact on the community. The impact here is therefore expected to be minimal as the pipeline is deep in the sediment and should not cause much if any impact on these species.

Coral reef and seagrass communities will not be displaced directly as a result of horizontal directional drilling activities.

Mangrove, Salina/Salt Marsh and Thorn Savanah

The proposed pipeline would run from North to South underneath the narrow band of *Rhizophora mangle* (Red mangroves), a relatively dense stand of *Avicennia germinans* (Black mangrove) and terminates in the salina/salt marsh zone where it connects to the metering station. The entire footprint shows standing water with a high density of crabs and mosquito larvae. The area where the pipeline ends is dominated by Black mangroves and *Batis marina*.

The Mangrove (Red and Black are the dominant species), Salina/Salt Marsh (Cacti, Black Mangrove are the dominant species) and Thorn Savanah (Acacia, Grasses are the dominant species) are not expected to be majorly impacted by the pipeline deployment and installation. The pipe runs deep enough in the soil so as not to cause any interference with rooting systems.

Vegetation clearance here is expected to be minimal. Mangroves and other large, protected or endemic species will be avoided.

RECOMMENDED MITIGATION DURING PIPELINE INSTALLATION

I. Silt screens or other turbidity barriers should be used in any working area where a sediment plume may occur.

II. No work activities should occur in unfavourable or unsafe weather conditions. These include high winds, rough seas, heavy rainfall and any other natural event which may increase the risk of accidents or render silt screens and other mitigation tools ineffective.
III. No lights should be pointed out to sea or illuminate sections of the beach so as to cause confusion and disorientation of turtles or any other species that maybe affected by lunar activity.
IV. Fixtures in direct line-of-sight from the beach should be shielded down-light only fixtures or recessed fixtures having low wattage (i.e. 450 lumens or less) "bug" type bulbs and non-reflective interior surfaces.
V. Fixtures mounted as low in elevation as possible through use of low-mounted wall fixtures, low bollards and ground level fixtures.
VI. Floodlights, up-lights or spotlights for decorative and accent purposes that are directly visible from the beach or which indirectly or cumulatively illuminate the beach shall not be used.
VII. For high intensity lighting applications such as providing security and similar applications shielded low-pressure sodium vapour lamps and fixtures shall be used.
VIII. Avoid contact with sensitive, protected or hazardous species. These include turtles and crocodiles. Any unavoidable interaction with these species should be handled by the regulatory Agency and any incidents should also be reported to the Agency.
IX. Temporary fencing or relocation maybe needed in working areas if crocodiles are present and or any other recommendations by the Agency.
X. Workers should be sensitized to existence of hazardous animals as well as the procedure if one is encountered. Works should be properly educated to ensure no animals are caught, harmed, teased or otherwise harassed. Works should be aware of the reporting procedure in the event of an encounter with a protected species.
XI. Limit the vegetation clearance when possible. Mangroves and other large, protected or endemic species should not be removed.

7.1.2.2 Offshore Facility

Marine Invertebrates (Meiofauna and Plankton)

Minimal species loss and or displacement may occur in species found both in and on the sediment where piles will be driven. Most mobile fauna are expect to avoid/disperse from the working area. The density of macrofauna (such as starfish and sea cucumbers) is low, these maybe easily relocated prior to the start of any construction activity.

Some invertebrates may be displaced by associated construction activities. That is; additional noise, plumes, and the use of silt screens may temporarily displace some invertebrates from the seafloor, water column and in the sediment itself.

Piles and other in water features may provide additional habitat and recruitment.

Fish and Filter Feeders

Fish and other mobile filter feeders may avoid areas of during construction activity as a result of noise, silt screens and plumes which may occur and as such may be temporarily displaced. Some sedimentation of the marine environment may occur during these activities. This is expected to be minimal and should be easily contained by the use of a silt screen in working areas. Excess sediment in the water can interfere or clog gill filaments and feeding apparatus. The impact here is expected to be minimal.

Piles and other in-water features will act as FADs (Fish Aggregation Devices) as well as providing suitable substrate and habitat for colonization and recruitment.

Marine Mammals

Marine mammals (dolphins and manatees) may avoid areas of during construction activity as a result of noise, silt screens and plumes which may occur or used during construction activities. Manatees have historically been documented in nearby areas but are very unlikely to be in the area of influence of the proposed project. Dolphins maybe seen in the area and as such special care should be taken when dolphins or any other marine mammal are seen in the area. Disruptions or displacement by the project should be short, temporary and minimal

Seagrass Communities and Nearby Coral Reef

There is a potential for loss and damage from construction activities including: direct loss from the proposition of the mooring area and associated anchor points, as well as accidental damage or other incidents. This may result in death, habitat loss and fragmentation. There is a potential for habitat fragmentation both during and after the construction phases. This may occur between the seagrass beds in the lagoon and surrounding reefs. This may affect larval distribution, migration of juveniles or other mobile invertebrates.

Excess sediment in the water can interfere with sensitive and sessile species such as coral reefs and seagrass beds. Smothering of corals and seagrass may occur if there is excess and prolonged sedimentation, further resulting in habitat and species loss. Light penetration may also be reduced by the dredging activities. The reduced water quality may result in reduced photosynthesis of the seagrass beds. The offshore facility is far from these sensitive systems and should not have a major influence on any of these sensitive systems. The proper usage of silt screens or turbidity barriers is essential to any marine construction.

Both the seagrass and coral reef communities here area adapted to lower light conditions and turbid water and therefore should not be affected by low temporary levels of sedimentation as a result of the project activities. The impact here is expected to be minimal as the pipeline is deep in the sediment and should not cause much if any impact on these species. The reef community further seaward and around the associated cays should be unaffected by the construction activities.

RECOMMENDED MITIGATION

I. Avoid or relocate macrofauna such as starfish and sea cucumbers in working areas.
i. Silt screens or other turbidity barriers should be used in any working area where a sediment plume may occur. Further to this, special care should be taken in the placement of these screens around these systems, in particular where seagrass beds occur near to shoreline areas. Small sections of seagrass were found within the footprint near the shoreline. These areas should be avoided where possible.
II. No work activities should occur in unfavourable or unsafe weather conditions. These include high winds, rough seas, heavy rainfall and any other natural event which may increase the risk of accidents or render silt screens and other mitigation tools ineffective.
III. Night time activities should be limited or avoided when possible. No lights should be pointed out to sea confusion and disorientation of turtles or any other species that maybe affected by lunar activity.
IV. Fixtures should have low wattage (i.e. 450 lumens or less) "bug" type bulbs and non-reflective interior surfaces.
V. Fixtures mounted as low in elevation as possible through use of low-mounted wall fixtures, low bollards and ground level fixtures.
VI. For high intensity lighting applications such as providing security and similar applications shielded low-pressure sodium vapour lamps and fixtures shall be used.
VII. Avoid contact with sensitive, protected or hazardous species. These include turtles and crocodiles. Any unavoidable interaction with these species should be handled by the regulatory Agency and any incidents should also be reported to the Agency.
VIII. Workers should be sensitized to existence of sensitive and protected species as well as the procedure if one is encountered. Works should be properly educated to ensure no animals are caught, harmed, teased or otherwise harassed. Works should be aware of the reporting procedure in the event of an encounter with a protected species.

7.1.2.3 Onshore Facility

Terrestrial Invertebrates

Some Species loss, displacement and loss of habitat may occur in the terrestrial environment. The proposed project footprint should be very small, with limited vegetation clearance during construction activities. The impact on the terrestrial invertebrate community should therefore be very small.

Reptiles- Crocodiles and Turtles

Crocodiles may be displaced from nearby areas which may have increased noise or other human activities. Lights during night time construction have the potential to interfere with navigation of some species (such as turtles), these should be avoided when possible but also should not point directly out to sea if being used. Activities on land may disrupt or even prevent activities such as nesting. Crocodiles have been document utilizing the coastal areas of the project for feeding, foraging and nesting.

Avifauna

Birds which utilize project area or area of influence maybe temporarily displaced. This maybe as a result of noise and or other human activities. Land clearance is expected to be small, however this will likely result in some habitat loss and displacement.

The Metering Centre and Tank Farm

The tank farm is approximately 110m x 65m and is proposed to be constructed in the northernmost area which is dominated by black mangrove. The average density of the plants was 0.33 black mangrove plants per m^2. A development on this site may displace approximately 2,359 mangrove trees.

The metering centre (65m x 50m) located east of the pipeline is proposed to be constructed in the disturbed mangrove/salt marsh zone area. This buildings footprint would be constructed in an area having an average mangrove density of 0.21 black mangrove plants per m^2. This building would impact approximately six hundred and eighty-two (682) mangrove plants.

Other vegetated areas outside of the footprint of structures will remain undisturbed.

RECOMMENDED MITIGATION

I. A mangrove rehabilitation/replanting exercise should be conducted with the use of nursery-grown plants in an area approved by the Agency as a mitigation for the removal of mangroves as a result of the construction activities associated with the on-shore metering facility and tank storage area. Appendix 11 outlines the Draft Mangrove Rehabilitation/Replanting Plan Outline proposed. Appendix 12 displays NEPA's Draft Mangrove Monitoring Specifications and will be included as part of the completed Mangrove Rehabilitation/Replanting Plan for this project.
II. No lights should be pointed out to sea to cause confusion and disorientation of turtles or any other species that maybe affected by lunar activity.
III. Fixtures in direct line-of-sight from the beach should be shielded down-light only fixtures or recessed fixtures having low wattage (i.e. 450 lumens or less) "bug" type bulbs and non-reflective interior surfaces.
IV. Fixtures mounted as low in elevation as possible through use of low-mounted wall fixtures, low bollards and ground level fixtures.
V. Floodlights, up-lights or spotlights for decorative and accent purposes that are directly visible from the beach or which indirectly or cumulatively illuminate the beach shall not be used.
VI. For high intensity lighting applications such as providing security and similar applications shielded low-pressure sodium vapour lamps and fixtures shall be used.
VII. Avoid contact with sensitive, protected or hazardous species. These include turtles and crocodiles. Any unavoidable interaction with these species should be handled by the regulatory Agency and any incidents should also be reported to the Agency.
VIII. Temporary fencing or relocation maybe needed in working areas if crocodiles are present and or any other recommendations by the Agency.

IX. Workers should be sensitized to existence of hazardous animals as well as the procedure if one is encountered. Works should be properly educated to ensure no animals are caught, harmed, teased or otherwise harassed. Works should be aware of the reporting procedure in the event of an encounter with a protected species.

X. Limit the vegetation clearance when possible. Mangroves and other large, protected or endemic species should not be removed.

7.1.3 Human/ Social

7.1.3.1 Maritime Operations

The presence of marine vessels associated with offshore LNG platform construction and pipeline deployment activities has the potential to cause conflict with other marine vessels in the area.

RECOMMENDED MITIGATION

i. A safety plan should be developed in conjunction with NFE South Holdings Limited and the Port Authority of Jamaica.
ii. The use of marker buoys demarcating an exclusion zone should be used to keep out other marine traffic from the work area during construction and pipeline deployment activities.
iii. Ample notice must be placed in public media concerning the conducting of offshore construction and pipeline deployment activities.

7.1.3.2 Employment

There is the potential for increased employment during the pre-clearance and construction phases. Approximately 20 workers will be required for site preparation work for the on-shore facility, as well as 225 to 250 workers for the construction of the on-shore and off-shore facilities and pipelines. These positions will likely be a mix of off and on-island individuals with much of the construction being done by locally contracted individuals. Therefore, the construction of the facility will provide an additional source of jobs in the immediate area. In addition it is anticipated that indirect and induced jobs are expected to be created during the site clearance and construction phases respectively; thus further benefitting the community. This represents a significant level of employment within the study area and has the potential to be a significant positive impact.

RECOMMENDED MITIGATION

No mitigation required.

Solid Waste Generation

During the construction phase of the onshore metering facility, solid waste generation may occur mainly from:

i. From the construction campsite.
ii. From construction activities such as site clearance and excavation (vegetative debris).

iii. Construction materials packaging (cardboard, plastics, fencing material, wooden pallets, containers etc.)

RECOMMENDED MITIGATION

i. Skips and bins should be strategically placed within the campsite and construction site.
ii. The skips and bins at the construction campsite should be adequately designed and covered to prevent access by vermin and to minimise odour.
iii. The skips and bins at both the construction campsite should be emptied regularly to prevent overfilling.
iv. Disposal of the contents of the skips and bins should be done at an approved disposal site.

Wastewater Generation and Disposal

With every construction campsite comes the need to provide construction workers with showers and sanitary conveniences. The disposal of the wastewater generated at the construction campsite has the potential to have a minor negative impact on groundwater.

RECOMMENDED MITIGATION

i. Provide portable sanitary conveniences for the construction workers for control of sewage waste. A ratio of approximately 25 workers per chemical toilet should be used.
ii. Showers should be provided for the workers.

7.1.3.3 Housing

It is not expected that the structure of housing will be adversely impacted and as such relocation of residents is not a foreseen measure.

RECOMMENDED MITIGATION

None required.

7.1.3.4 Aesthetics

Solid waste generation during the construction period can have a potential negative impact on visual aesthetics if improperly collected and stored on site. There is also the potential for vermin infestation if discarded food and food containers are present.

RECOMMENDED MITIGATION

iii. Skips and bins should be strategically placed within the campsite and construction site.
iv. The skips and bins at the construction campsite should be adequately designed and covered to prevent access by vermin and minimise odour.

7.2 OPERATION

7.2.1 Physical

7.2.1.1 Land Impacts

Geotechnical (Depth and Type of Foundations)

The soils encountered were fairly variable in distribution vertically and horizontally across the site as shown in the figure below. The Top1 soils are very soft/loose with traces of peat and will undergo significant settlement under the proposed structure loads. The Mid1 and Bot 1 soils are stiff with significant plastic characteristics to exhibit high swell shrinkage and moderate compressibility. Consequently, the use of conventional shallow isolated pad and strip foundation within the upper strata is not recommended.

RECOMMENDATIONS

The following recommendations appear the most economical given the resources available;

i. Shift Structures away from Borehole Locations 1 and 2.
ii. For detail study of the area it is critical that further testing be performed in the vicinity of the proposed structures.
iii. Excavate and remove the TOP1soils in the vicinity of Boreholes 3 and 4 and replace with 0.7m of river shingle for pore pressure dissipation and 1m of compacted granular fill or to design level (invert) whichever is thicker. Use Shallow Mat/Raft foundation above the fill. Note excavation below the water table is anticipated.
iv. Use short driven or cast inplace pile foundation to a depth sufficient to safely carry the anticipated loads for the structures with pile caps interconnected to mitigate differential deformation.

Soil

No impacts are expected on the soil for the onshore metering facility. The ADO tanks will each be located inside containment sufficient to hold 110% of the volume of one tank. Each tank will have instrumentation to automatically shut down to prevent overfilling. The probability of a pipeline rupture on land is rare as the pipelines will be directionally drilled underground.

Noise

The predicted noise from the proposed LNG Regassification project was determined by using SoundPlan version 7.4. The noise spectrum for the major equipment provided by the manufacturer was used to calibrate the model. Once the model was calibrated then structures such as the tanks, ground and other buildings within the area were added. Within SoundPlan, the Industrial Noise Module was used to conduct the predictions. The first step was to select the standards that were going to be used to run the model. The General Prediction General Prediction Method was used for the modelling exercises. Within the standards, temperature was set at 26.64 ^{o}C, the relative humidity at 80.57 %

and air pressure 1013.3 mbar. These numbers were selected as they represented the averages obtained from the weather station that was installed at the Doctor Bird facility from January 6, 2011.

The predicted noise generated from the proposed LNG Terminal and Regassification project is illustrated in Figure 7-1 and Figure 7-2.

LANDSIDE

The noise model was used to generate the night time limit lines for Industrial facilities (70 dBA) and residential areas (50 dBA). This was done to determine the potential noise impact from the operation of the LNG Storage and Regasification Project. The night time noise level standards were chosen as if the noise generated met this standard it would automatically meet the day time standards of 75 dBA for industrial areas and 55 dBA for residential areas. The results of the predicted noise levels at various locations compared with the NEPA day and night time standards are outlined in Table 7-12 and Table 7-13. The results indicated that the noise on the landside would be compliant to NEPA night time standard for both residential areas (50 dBA) and industrial areas (70 dBA). The residential and industrial noise limit lines are depicted in Figure 7-3.

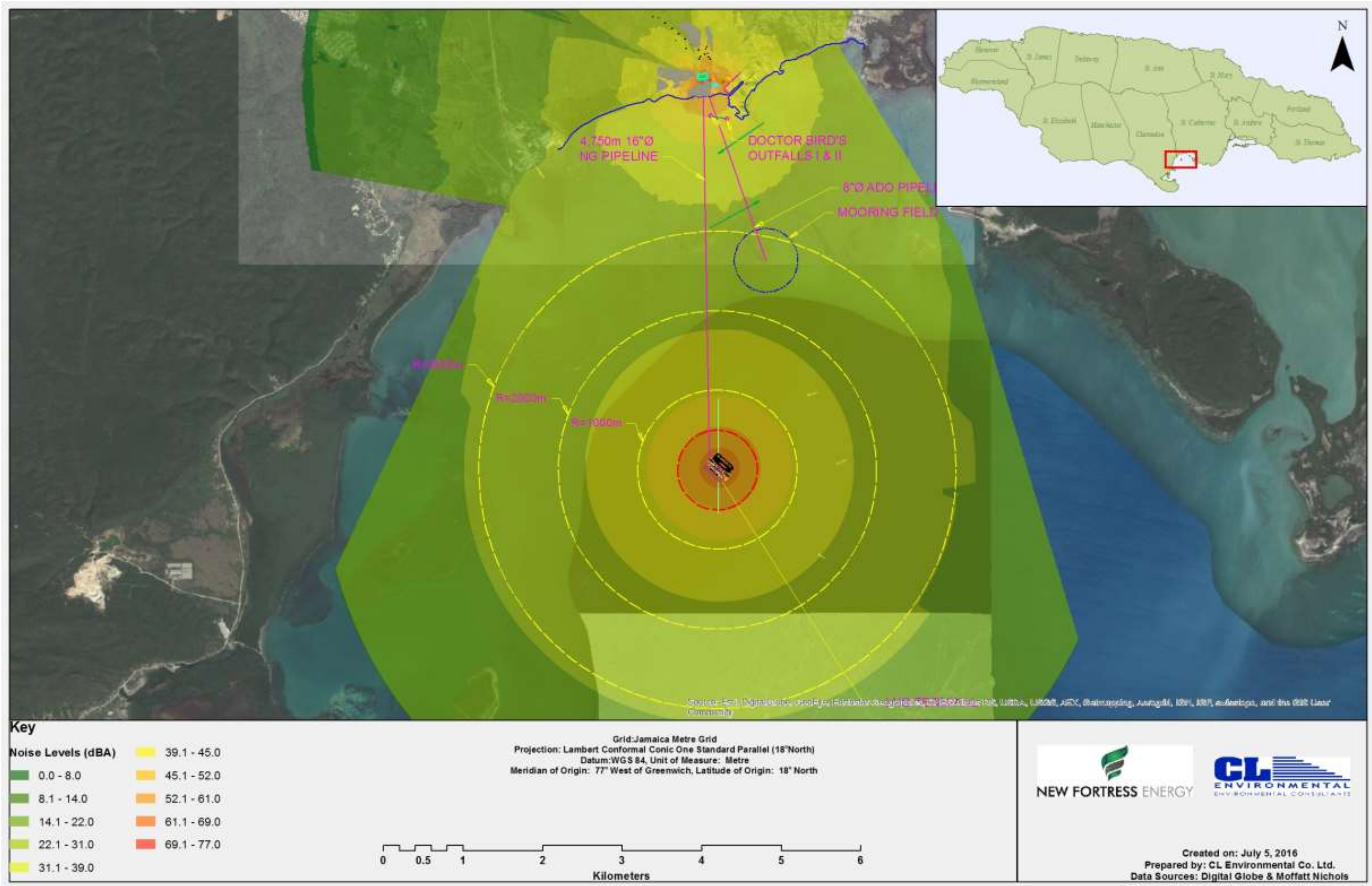


Figure 7-1 Noise contours for the proposed NFE South Holdings Limited LNG Terminal and Regassification Project

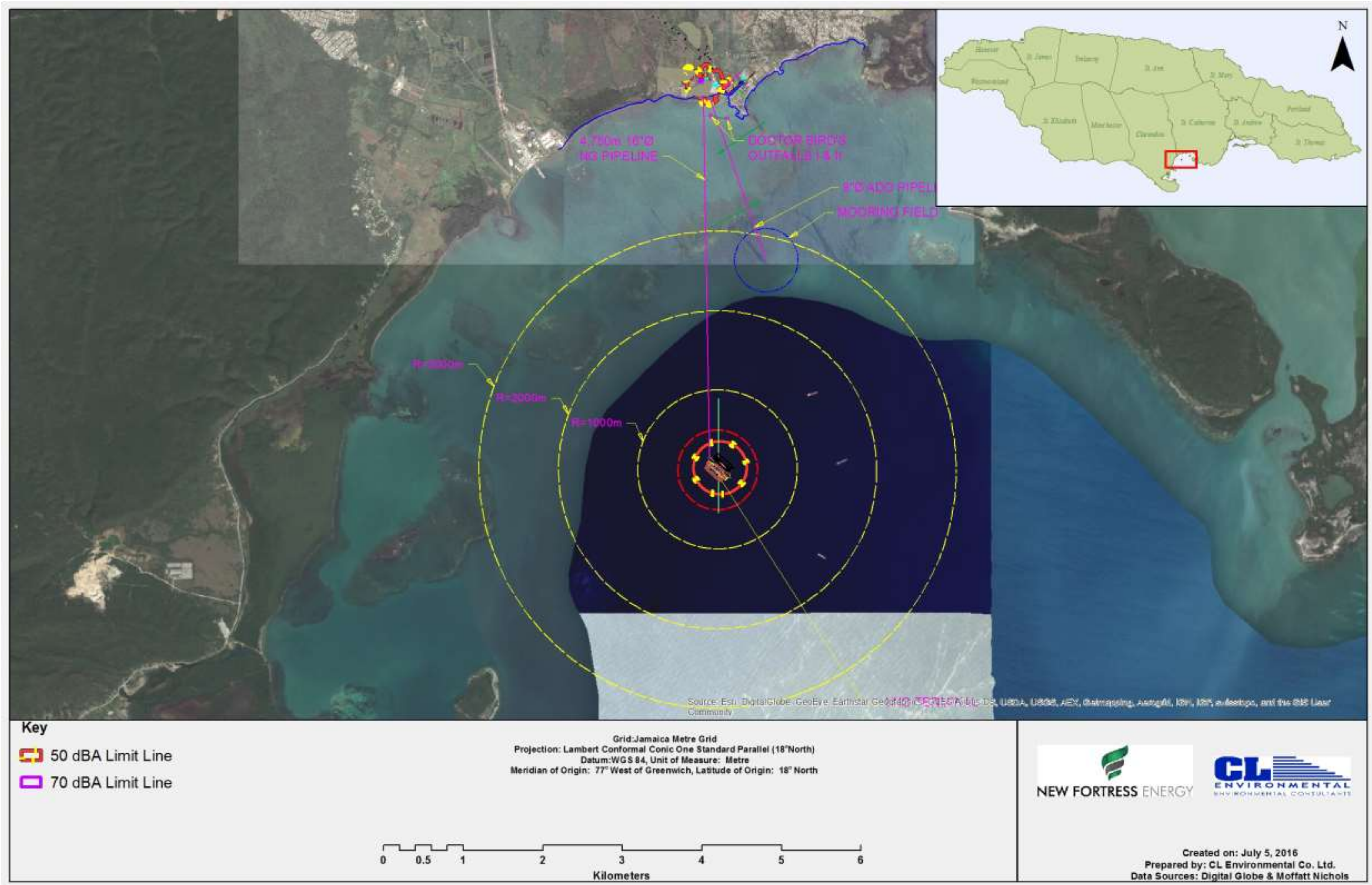


Figure 7-2 Noise limit lines for the proposed NFE South Holdings Limited LNG Terminal and Regassification Project

Table 7-12 Comparison of average, daytime and night time noise levels from the LNG Terminal and Regassification Project with the NEPA guidelines (JPS 190 MW EIA)

STN #	LOCATIONS	ZONE	Average Noise Level	Predicted Daytime Noise 7 am. - 10 pm. (dBA)	NEPA Daytime Std. (dBA)	Predicted Night Time Noise 10 pm. - 7 am. (dBA)	NEPA Night Time Std. (dBA)
N1	North-Western Property Boundary	Industrial	64.9	47.7	75	47.7	70
N2	South-Western Property Boundary	Industrial	60.7	36.9	75	36.9	70
N3	South-Eastern Property Boundary	Industrial	62.3	45.1	75	45.1	70
N4	North-Eastern Property Boundary	Industrial	61.8	47.8	75	47.8	70
N5	Informal Settlement Area	Residential	50.7	42.2	55	42.2	50
N6	Blackwood Garden Housing Scheme	Residential	48.3	36.0	55	36.0	50
N7	Old Harbour Bay Police Station	Residential	51.7	25.3	55	25.3	50
N8	New Harbour Village Phase II Housing Scheme	Residential	42.6	23.3	55	23.3	50
N9	Longville Park Housing Scheme	Residential	42.9	0.0	55	0.0	50

Table 7-13 Comparison of the predicted daytime and night time noise levels from the LNG Terminal and Regassification Project with the NEPA guidelines (SJPC 360 MW EIA)

STN #	LOCATIONS	ZONE	Daytime 7 am. - 10 pm. (dBA)	NEPA Daytime Std. (dBA)	Night Time 10 pm. - 7 am. (dBA)	NEPA Night Time Std. (dBA)
N1	Northern Property Boundary	Commercial	35.6	65	35.6	60
N2	Eastern Property Boundary	Commercial	43.5	65	43.5	60
N3	Southern Property Boundary	Commercial	47.1	65	47.1	60
N4	Western Property Boundary	Commercial	38.1	65	38.1	60
N5	JPS Guard House	Industrial	35.3	75	35.3	70
N6	Blackwood Garden Housing Scheme	Residential	36.0	55	36.0	50
N7	Old Harbour Bay Police Station	Residential	25.3	55	25.3	50
N8	New Harbour Village – Phase 1	Residential	16.7	55	16.7	50
N9	Church Pen	Residential	0.0	55	0.0	50
N10	Bodles	Commercial	9.9	65	9.9	60
N11	Longville Park Housing Scheme	Residential	0.0	55	0.0	50

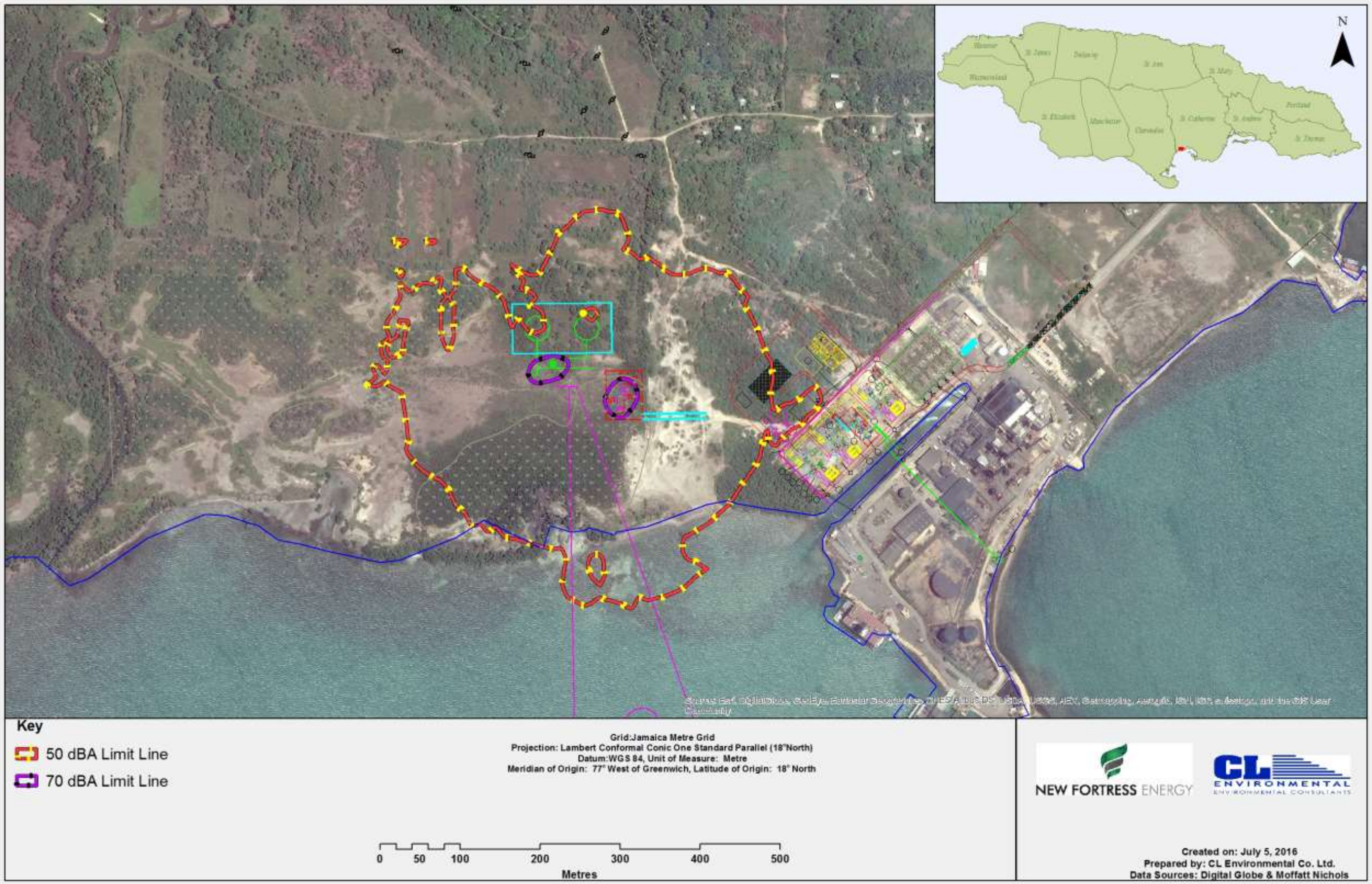


Figure 7-3 Noise limit noise for the landside infrastructure

MARINE INFRASTRUCTURE

The night time industrial noise standard (70 dBA) is met close to the equipment generating the noise resulting in the noise levels generated meeting the NEPA noise standard within the property boundary or on the regas facility (marine side) (Table 7-14 and Figure 7-4). When the NEPA night time noise standard was examined the noise limit line for the landside fell within the property and no residential areas were impacted. The noise level for the marine side fell within the NEPA night time standard (50 dBA) for residential areas within approximately 207 m of the marine facility.

Table 7-14 Predicted noise levels around the LNG Terminal and Regassification marine structure

LOCATION	PREDICTED NOISE LEVELS (dBA)	NEPA DAY TIME STD (dBA)	NEPA NIGHT TIME STD (dBA)	WORLD BANK GUIDELINE (dBA)
500-E	46.1	75.0	70.0	70.0
500-N	46.2	75.0	70.0	70.0
500-S	45.0	75.0	70.0	70.0
500-W	45.1	75.0	70.0	70.0
1000-E	38.5	75.0	70.0	70.0
1000-N	38.4	75.0	70.0	70.0
1000-S	37.9	75.0	70.0	70.0
1000-W	37.7	75.0	70.0	70.0
2000-E	29.0	75.0	70.0	70.0
2000-N	29.7	75.0	70.0	70.0
2000-S	28.6	75.0	70.0	70.0
2000-W	28.6	75.0	70.0	70.0
3000-E	23.2	75.0	70.0	70.0
3000-N	29.2	75.0	70.0	70.0
3000-S	22.9	75.0	70.0	70.0
3000-W	22.8	75.0	70.0	70.0

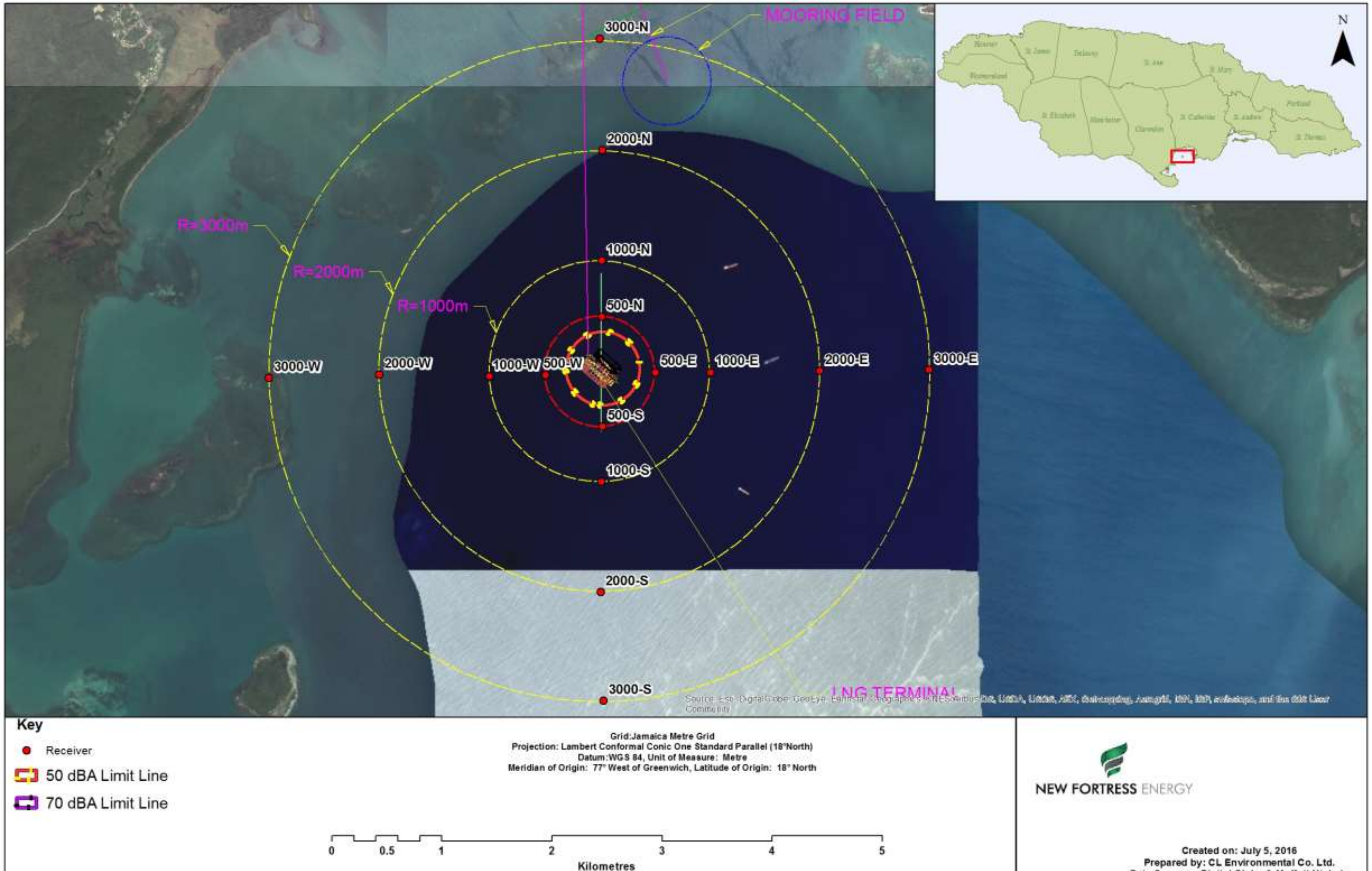


Figure 7-4 Noise station locations and limit lines for the marine terminal and regasssification structures

TERRESTRIAL AND MARINE MAMMALS AND REPTILES

In the last 10 years or so there has been increasing concern that noise from human activities may cause similar problems to marine animals. This has been heightened by the recognition of the importance of acoustic communication to marine animals in an environment where light has far less penetration than sound (Cato, et al., 2004).

The effects of noise on marine animals can be graded, generally in order from the least to greatest impact as follows:

1. Disturbance: inconsequential, with positive effect, with negative effect
2. Masking of sounds of interest to the animal
3. Hearing damage – through long term exposure
4. Hearing damage through high level short term exposure
5. Tissue damage other than hearing
6. For explosions: substantial damage or death

Studies reporting observations of behavioural changes in marine mammals in response to noise vary widely in the noise levels at which responses were observed. This wide variation illustrates the point that noise level alone is a very poor indicator of likely impact on behaviour. It becomes a much better indicator if different levels are established for each combination of source type, effect, species exposed, category (male, female, calf), behavioural context and current activity (migrating, resting, breeding, feeding). The duration of exposure and the frequency content of the noise are as important and need to be included.

For marine mammals, auditory perception plays a critical role in a variety of acoustically mediated behaviours, such as communication, foraging, social interactions, and avoidance of predators. Although auditory perception involves many other factors beyond merely hearing or detecting sounds, sound detection is a required element for perception (Finneran & Branstetter, 2013).

Auditory masking occurs when one sound (usually called noise) interferes with the detection, discrimination, or recognition of another sound (usually called the signal). The most obvious consequence of auditory masking is a reduction in the distance at which an animal could detect a sound of interest. Because sound absorption is frequency-dependent, with low frequencies traveling farther than higher frequencies, low-frequency noise has the potential to affect marine mammals at larger distances compared to higher frequency noise. The most obvious consequence of auditory masking is a reduction in the distance at which an animal could detect a sound of interest. Because sound absorption is frequency-dependent, with low frequencies traveling farther than higher frequencies, low-frequency noise has the potential to affect marine mammals at larger distances compared to higher frequency noise.

If an animal is able to leave, or avoid an area of potential masking there may be associated metabolic costs that are yet to be determined. In many circumstances, leaving a zone of auditory masking may not be an option (e.g., pervasive low-frequency shipping noise). Some areas may be too important to leave such as feeding and breeding grounds. In these cases, an animal may attempt to compensate for the noise by increasing its signal amplitude while communicating (Holt et al. 2008; Parks et al. 2011), shifting signal frequencies (McDonald et al. 2009), or increasing its repetition rate or duration (Miller et al. 2000).

What is known is that odontocetes appear to have the capability to modify their echolocation signal to compensate for noise levels. This was demonstrated when echolocation discrimination tasks were conducted in both San Diego Bay, California and Kaneohe Bay, Hawaii with the same beluga (Au et al. 1988). The ambient noise in both locations is dominated by snapping shrimp, although the noise spectral density levels in Kaneohe Bay were typically 15–20 dB greater than those of San Diego Bay. Beluga clicks recorded in San Diego bay typically had peak–peak (p–p) source levels between 201 and 202 dB re 1 IPa, with peak frequencies typically between 40 and 60 kHz. However, in Kaneohe Bay, which possessed higher ambient noise levels, the beluga clicks had p–p source levels between 210 and 214 dB re 1 IPa, with peak frequencies between 100 and 120 kHz. Apparently, the animal increased the level and peak frequency of its incident signal to compensate for the increased ambient noise in Kaneohe Bay.

The major findings to arise from marine mammal temporary threshold shift (TTS) experiments parallel findings from terrestrial mammal experiments. As in terrestrial mammals, the most significant factors that affect hearing loss are the exposure SPL, exposure duration, exposure frequency, temporal pattern, and recovery time (Finneran & Branstetter, 2013).

SENSITIVE RECEPTORS

Sensitive receptors (schools, churches and clinics) within 6 km were mapped. Note that this list is not exhaustive. The noise attributed to the operation of the LNG Terminal and Regassification Project alone at the various receptors was predicted using both the General Prediction Model.

Schools

A total of twelve schools were investigated (Table 7-15). The predict noise levels when the LNG Terminal and Regassification Project was operating alone, ranged from a low of 0.0 dBA (Old Harbour Early Childhood Institution and Old Harbour Primary) to a high of 26.0 dBA (Children First Basic). The predicted noise levels at the schools from the LNG Terminal and Regassification Project operating alone were all compliant with both the NEPA daytime standard and the World Bank guideline.

Table 7-15 Schools listed with the predicted noise LNG Terminal and Regassification Project operating alone

SCHOOLS	LNG TERMINAL AND REGASSIFICATION PROJECT (LAeq (16))	NEPA STD (dBA)	WORLD BANK GUIDELINE (dBA)
Blackwood Gardens Basic School	25.7	45	55
Children First Basic	26.0	45	55
Old Harbour Bay Primary	23.5	45	55
Baptist Early Childhood Centre	24.4	45	55
St. Wade Basic School	24.1	45	55

Old Harbour High School	12.1	45	55
Portmore Community College (Old Harbour)	10.9	45	55
Freetown Primary	9.9	45	55
Monsignor Colin Bryan Preparatory	8.2	45	55
Longville Park Early Childhood Centre	10.4	45	55
Old Harbour Early Childhood Institution	0.0	45	55
Old Harbour Primary	0.0	45	55

Churches

Predicted noise levels at eighteen churches were scrutinized LNG Terminal and Regassification Project was operating alone. The noise levels ranged from 0.0 dBA (St Dorothy's Anglican Church and Old Harbour Baptist) to 27.0 dBA (Mount Refuge Fire Baptize Holiness). All predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guidelines (Table 7-16).

Table 7-16 List of churches with the predicted noise from LNG Terminal and Regassification Project operating alone

CHURCHES	LNG TERMINAL AND REGASSIFICATION PROJECT (LAeq (16))	NEPA STD (dBA)	WORLD BANK GUIDELINE (dBA)
Mount Refuge Fire Baptize Holiness	27.0	55	55
Unnamed Church	26.0	55	55
St Phillips Anglican		55	55
Refuge Temple Old Harbour Bay	23.3	55	55
Old Harbour Bay Baptist	22.3	55	55
Old Harbour Bay SDA	10.5	55	55
Faith Bible Baptist Church	22.0	55	55
Old Harbour Evangelistic Centre	13.6	55	55
Church of Our Lord Apostolic Faith	12.1	55	55
Jehovah Witness	11.8	55	55
Hebron Gospel Hall	11.1	55	55
Old Harbour SDA	10.5	55	55
Holy Ghost Ministries Inc.	8.7	55	55
Church of the Holy Trinity	9.9	55	55
St. Michael & St. George Anglican	8.6	55	55
Longville Park Church	10.5	55	55
St Dorothy's Anglican Church	0.0	55	55
Old Harbour Baptist	0.0	55	55

Clinics

The noise levels at two clinics were examined when the LNG Terminal and Regassification Project was operating alone. The noise levels when the General Prediction model was used varied from 9.1 dBA (Old Harbour Health Centre) and 22.0 dBA (Bay View Medical Centre).

All predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guideline (Table 7-17).

Table 7-17 Noise levels at clinics with the predicted noise from LNG Terminal and Regassification Project operating alone

CLINICS	LNG TERMINAL AND REGASSIFICATION PROJECT (LAeq (16))	NEPA STD (dBA)	WORLD BANK GUIDELINE (dBA)
Bay View Medical Centre	22.0	55	55
Old Harbour Health Centre	9.1	55	55

RECOMMENDED MITIGATION

No mitigation required. The frequency of LNG delivery is inconsequential (1 ship per month), therefore, the potential to significantly increase the noise climate in the area is negligible. The operation of the pumps on the platform will not adversely influence the noise climate

Seismic Hazard

The facilities will be designed to meet the regulatory standards and is designed for an operating life of at least 30 years.

The offshore marine facilities shall be designed in accordance with API RP 2A: Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms – Working Stress Design, which constitutes a common basis covering those aspects that address design requirements and assessments of all offshore structures used by the petroleum and natural gas industries worldwide. For this site location, the two primary environmental concerns are ground accelerations caused by an earthquake, and high winds during severe tropical storms and hurricanes. Seismic design for the offshore marine structures shall follow the design procedures and criteria set forth within API RP 2EQ, using ground accelerations provided by the Geotechnical Engineer from a site specific study. Metocean design parameters, such as wind velocity, storm surge, wave height and period, for extreme (hurricane) and operational conditions shall be established according to API RP 2MET using a site specific metocean database, and numerical modeling/simulations as deemed appropriate.

The design of the civil structures (i.e. landside structures) will meet or exceed the requirements as established in the latest updates to the Jamaican Application document for the International Building Code and the Probabilistic Seismic Hazard Assessment for Jamaica, using ground accelerations provided by the Geotechnical Engineer, and maximum winds speeds per governing building design codes.

Storm Surge Hazard

IDENTIFIED IMPACTS

i. During a 1:50yr storm event, the mooring area is expected to experience wave heights of up to 3.16m while during a 100yr event, wave heights up to 3.41 will be observed. For the proposed LNG site on land, the vulnerability to storm surge was also investigated. It was determined that the expected storm surge inundation levels for the 50yr and 100yr events is 3.14m and 3.26m respectively.

ii. It is possible for storm surge to occur simultaneously with overland flooding in coastal areas such as along the shoreline. It is therefore crucial that this possibility be investigated with a view to mitigating possible flooding of the site and equipment during such an event.

iii. Steps to protect equipment from hurricane surge (2m to 4m during hurricane Dean in 2007) and possible tsunami should be taken. In addition, in the event of a storm surge hazard, the proposed site will be inundated and submerged in sea water (which can be corrosive).

iv. It was determined that the inundation levels generated from storm surge events exceed those levels generated by overland flow of Bowers Gully for the more extreme storm events.

RECOMMENDED MITIGATIONS

i. The floor levels can be set to 0.5m above the 50 or 100yr storm event, all critical components should be at a minimum elevation of 0.5m above the expected flood level for the 1 in 100 year rainfall event.

ii. All coastal protective works should be employed to protect the seaward edges of the site. Due consideration should be given to overtopping and direct wave damage. Such coastal protection works should be constructed to elevations determined by the 95% confidence limits of the storm surge re-analysis.

Tsunami Hazard

IDENTIFIED IMPACTS

Modeling suggests that the tsunami waves are expected to arrive at the Old Harbour Bay fishing village, Jamaica Public Service (JPS) power plant and JAMALCO (Salt River Bay) in approximately 135, 120 and 108 minutes after the earthquake, respectively.

i. The nearshore wave heights were determined as follows:

Parameter	Earthquake Magnitude		
	6.5	*7.0*	*7.5*
Wave Height (m)	1.9 - 3.4	2.1 - 3.5	2.1 - 3.7

ii. The nearshore wave speeds were determined as follows:

Parameter	Earthquake Magnitude		
	6.5	*7.0*	*7.5*
Wave Velocity (m/s)	0.50 – 1.0	0.57 – 1.0	0.60 – 1.0

iii. The result shows that the inundation depths are as follows:

Parameter	Earthquake Magnitude		
	6.5	*7.0*	*7.5*
Inundation Depth (m)	0.01 – 1.73	0.01 – 1.81	0.01 – 1.84

The inundation extended approximately 1 kilometre inland where it will affect residences and commercial establishments.

RECOMMENDED MITIGATIONS

i. Regulatory authorities should not only implement but enforce early and public warning systems inclusive of evacuation routes and assembly points throughout the Old Harbour Bay area.
ii. The implementation of coastal protection such as tsunami breakwaters, dikes and revetments.

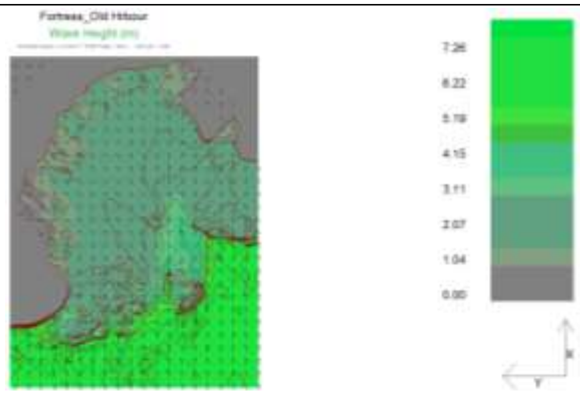
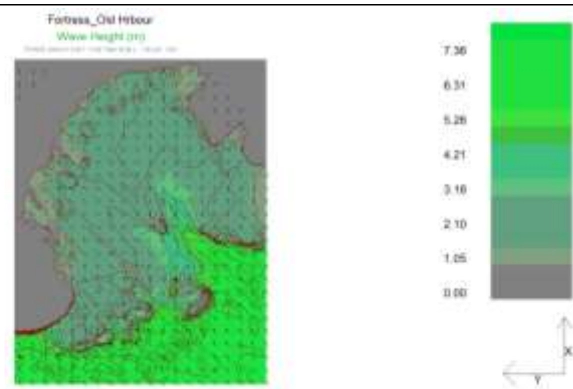
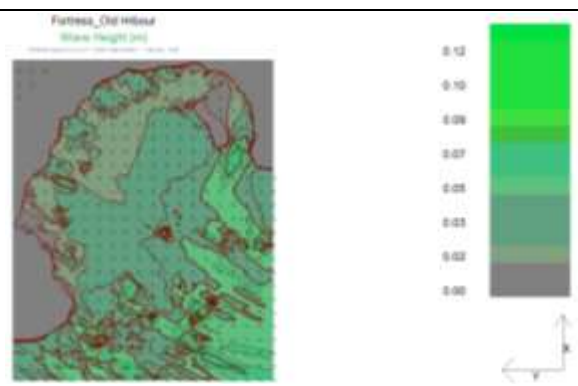
7.2.1.2 Water Impacts

Hurricane Wave Climate

HURRICANE WAVES, WATER LEVEL SETUP, SEA LEVEL RISE (2050 PROJECTION)

The worst case scenario (100yr storm event) was simulated, including estimated water setup and sea level rise projections for 2050, to determine the wave heights anticipated to reach the mooring area and pipelines. Inspection of the nearshore wave climate conditions revealed that the mooring point will experience wave heights of up to 0.03m, 1.50m and 1.78m for the eastern, southern and south-eastern directions, under hurricane wave climate conditions. The proposed pipeline will be exposed to similar wave heights for the eastern, southern and south-eastern directions.

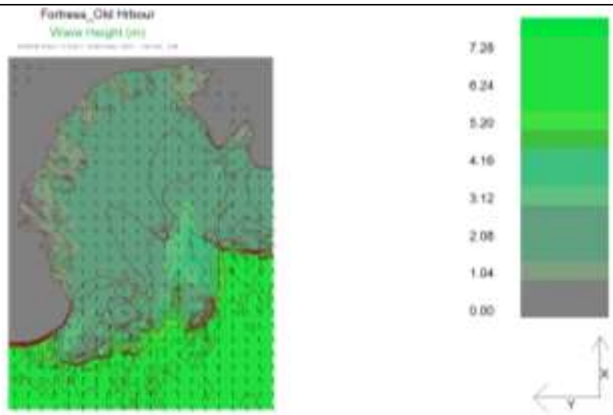
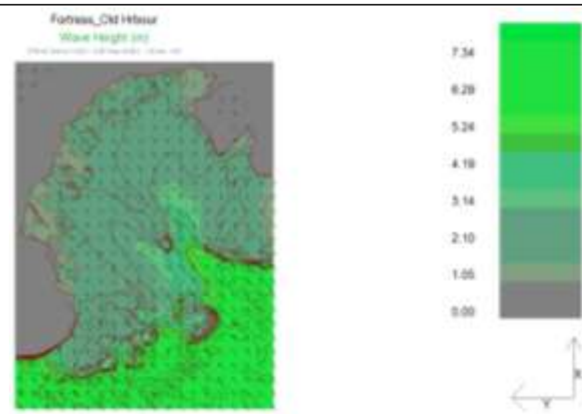
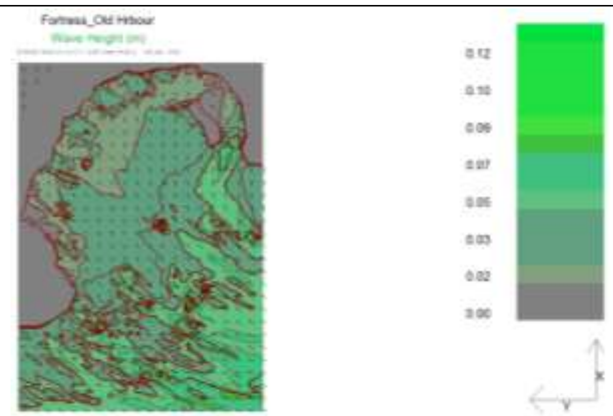
Table 7-18 Hurricane wave climate for waves entering Portland Bight

 *South*	 *South-East*
 *East*	

HURRICANE WAVES, WATER LEVEL SETUP, SEA LEVEL RISE (2100 PROJECTION)

The worst case scenario (100yr storm event) was simulated, including estimated water setup and sea level rise projections for 2100, to determine the wave heights anticipated to reach the mooring area and pipelines. Inspection of the nearshore wave climate conditions revealed that the mooring point will experience wave heights of up to 0.03m, 1.79m and 1.95m for the eastern, southern and south-eastern directions, under hurricane wave climate conditions. The proposed pipeline will be exposed to similar wave heights for the eastern, southern and south-eastern directions.

Table 7-19 Hurricane wave climate for waves entering Portland Bight

 *South*	 *South-East*
 *East*	

LOCALLY GENERATED WAVES, WATER LEVEL SETUP

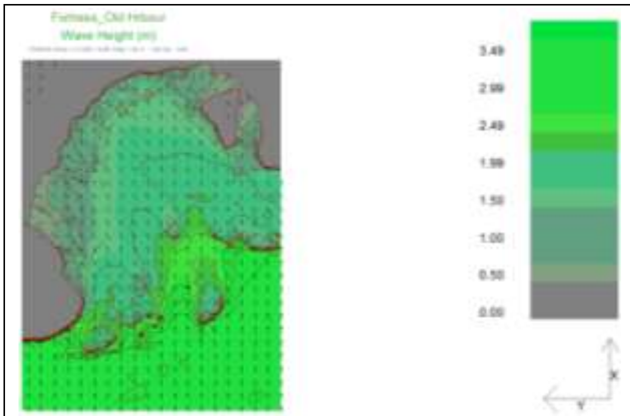
A JONSWAP spectrum model was used to simulate locally generated waves within the Old Harbour Bay area. This was executed using fetch (although limited to 9km) and the effect of wind speeds to determine the wave heights and periods for three (3) directions: east, east-south-east and south. This simulated includes estimated water setup (100yr) projections for the current period (2016), to facilitate the growth of waves reaching the mooring area and associated pipeline. The following wave heights and periods were determined from JONSWAP and implemented:

Table 7-20 Wave parameter input

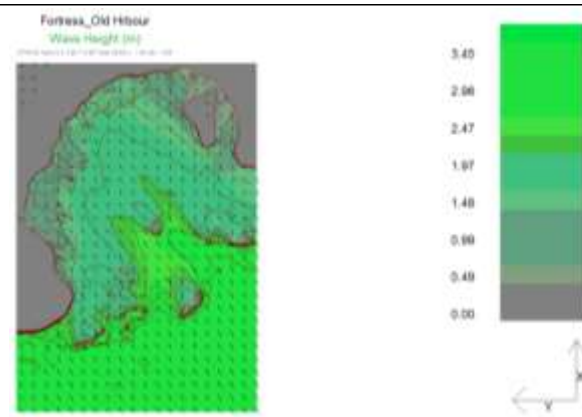
Direction	Wave Height (m)	Wave Period (s)
East	3.16	5.01
East South-East	3.58	5.45
South	3.58	5.45

Inspection of the nearshore wave climate conditions revealed that the mooring point will experience wave heights of up to 0.01m, 1.74m and 1.86m for the eastern, southern and East south-eastern directions, under hurricane wave climate conditions. The proposed pipeline will be exposed to similar wave heights for the eastern, southern and south-eastern directions.

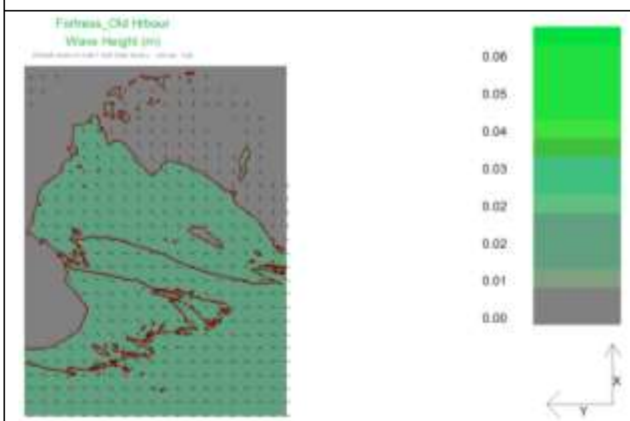
Table 7-21 Hurricane wave climate for waves entering Portland Bight



South



East-South-East

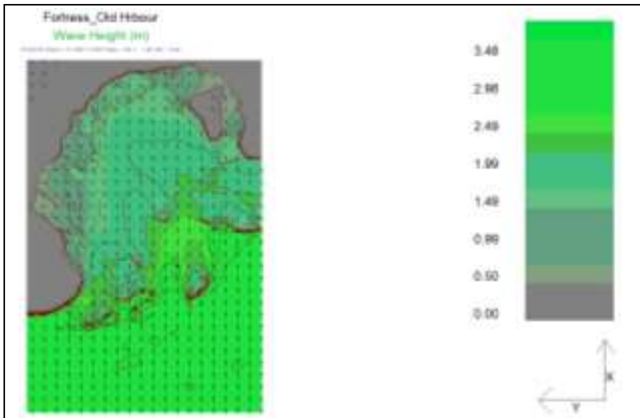
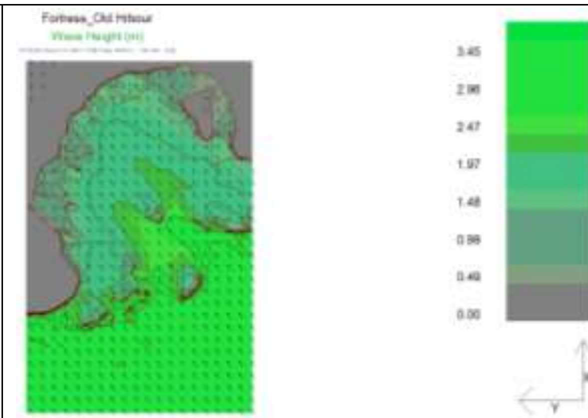
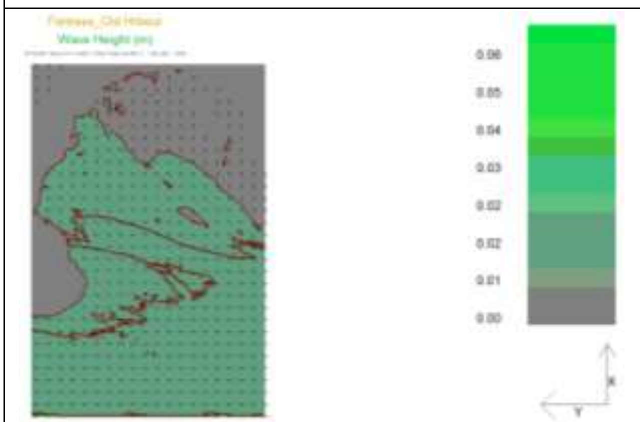


East

LOCALLY GENERATED WAVES + WAVE SETUP + SEA LEVEL RISE (2050 PROJECTION)

A JONSWAP spectrum model was used to simulate locally generated waves within the Old Harbour Bay area. This was executed using fetch (although limited to 9km) and the effect of wind speeds to determine the wave heights and periods for three (3) directions: east, east-south-east and south. This simulated includes estimated water setup (100yr) projections for the current period (2016), to facilitate the growth of waves reaching the mooring area and associated pipeline. Inspection of the nearshore wave climate conditions revealed that the mooring point will experience wave heights of up to 0.01m, 1.78m and 1.91m for the eastern, southern and south-eastern directions, under hurricane wave climate conditions. The proposed pipeline will be exposed to similar wave heights for the eastern, southern and south-eastern directions.

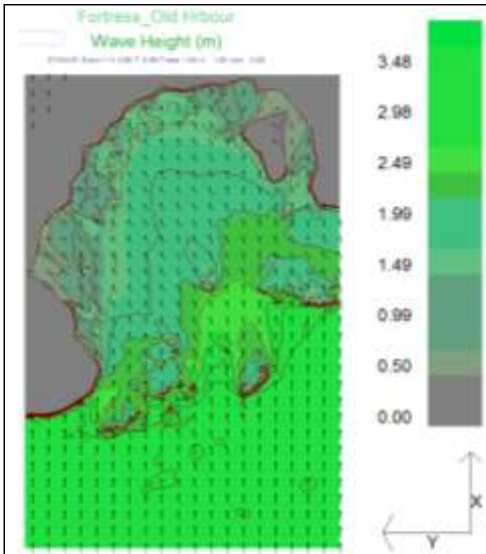
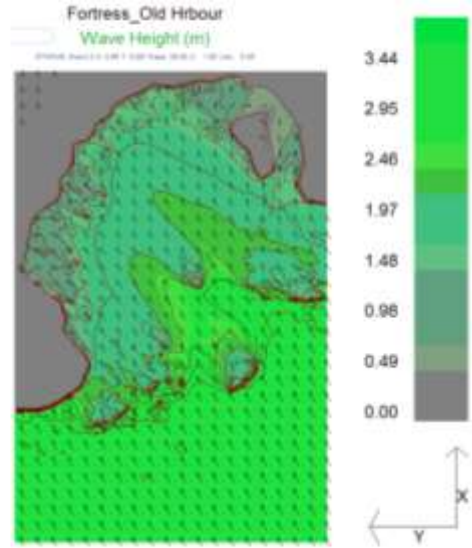
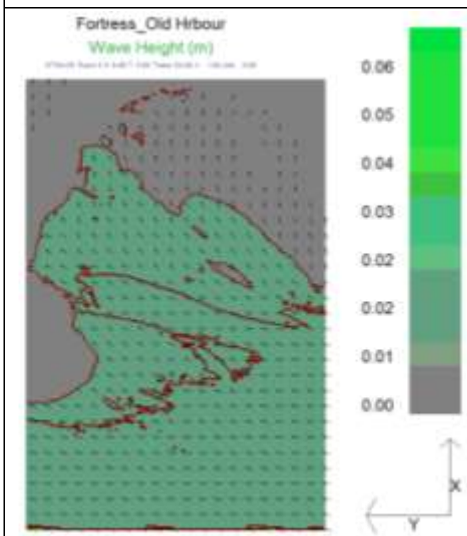
Table 7-22 Hurricane wave climate for waves entering Portland Bight

 *South*	 *East-South-East*
 *East*	

LOCALLY GENERATED WAVES + WATER LEVEL SETUP + SEA LEVEL RISE (2100 PROJECTION)

A JONSWAP spectrum model was used to simulate locally generated waves within the Old Harbour Bay area. This was executed using fetch (although limited to 9km) and the effect of wind speeds to determine the wave heights and periods for three (3) directions: east, east-south-east and south. This simulated includes estimated water setup (100yr) projections for the current period (2016), to facilitate the growth of waves reaching the mooring area and associated pipeline. Inspection of the nearshore wave climate conditions revealed that the mooring point will experience wave heights of up to 0.01m, 1.83m and 1.97m for the eastern, southern and south-eastern directions, under hurricane wave climate conditions. The proposed pipeline will be exposed to similar wave heights for the eastern, southern and south-eastern directions.

Table 7-23 Hurricane wave climate for waves entering Portland Bight

 *South*	 *East-South-East*
 *East*	

Wave Overtopping Platform

The wave heights we have been using thus far are the significant wave heights (H_s) which are described as the average of the 1/3 highest waves in a wave train. The Rayleigh distribution indicates a closer approximation to the H_{max} is $H_{0.01}$ which is related to H_s by the equation $H_{0.01} = 1.67Hs$. several scenarios were investigated given the possibility that a wave larger that H_s. The analysis indicates that, in a worst case scenario the mooring platform will see wave heights of up to 5.33m and 5.63m for the 50year and 100year respectively.

Table 7-24 Expected wave heights at the mooring location

Parameter	50 Yr return period			100 Yr return period		
	Storm surge (m)	1% Wave Height (m)	Storm Surge + Wave Height (m)	Storm surge (m)	1% Wave Height (m)	Storm Surge + Wave Height (m)
Water surface elevation (m)	2.14	3.19	5.33	2.34	3.29	5.63
Platform elevation (m)	9	9	9	9	9	9

Stormwater

On-shore stormwater potential will be minimal since the footprint of the metering facility is small. Stormwater from the off-shore platform and FSU will also be minimal and not result in violation of water quality standards at this location.

RECOMMENDED MITIGATION

Appropriately sized stormwater management will be incorporated into the design of this on shore facility to manage stormwater runoff. The drainage design criteria for this project will be guided by local requirements for permitting and international standards, including National Works Agency's (NWA's) Guidelines for Preparing Hydrologic & Hydraulic Design Reports for Drainage systems of Proposed Development Applications, (Guidelines) June 2015, the Government of Jamaica (GOJ) Development and Investment Manual, (Manual), Volume 3, Section 1 and the methodology of U.S. Department of Agriculture, Soil Conservation Service Technical Release No. 55 (TR-55), Urban Hydrology for Small Watersheds.

Thermal Outfall

The effluent of the power plant will be discharged through a thermal outfall. The effluent is expected to be of a lower temperature than the ambient surroundings. Additionally, these areas could be affected by wave action and currents resulting in the farfield dispersion of this thermal effluent. Regulations stipulate that the effluent from the thermal outfall must be mixed with the seawater until the temperature differences are within NEPA and EPA limits (< 2°C below ambient temperature) within a radius of 100m from the outfall. The model suggests that at the 100m extents, the temperature of the effluent will be less than 2 °C below the ambient temperature of the sub-surface waters.

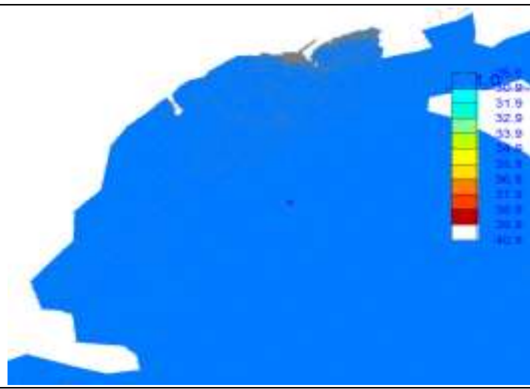
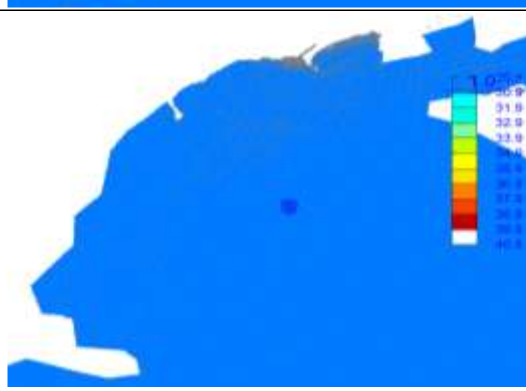
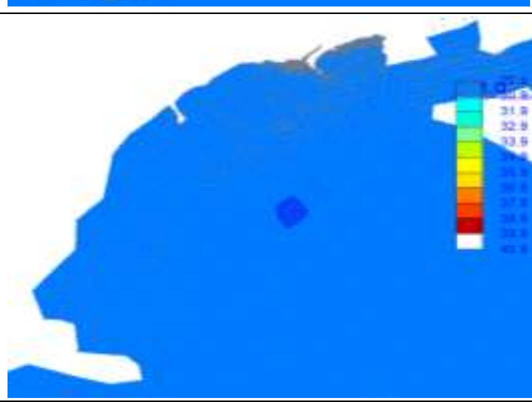
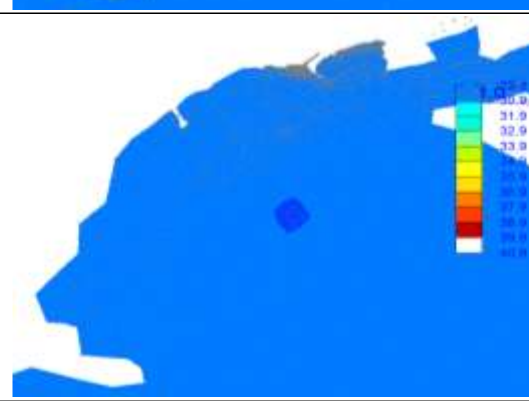
IDENTIFIED IMPACTS

i. Changes to the temperature regime of the water column in the receiving environment can have direct effects on planktonic species, as metabolic rates are dependent upon temperature. All species have upper thermal tolerance which when exceeded results in adverse impacts ranging from reduced productivity to mortality.
ii. Changes to salinity can play a significant role in the growth and size of aquatic life and the marine species disturbance. It is now widely recognized that extensive brine discharge, as it constitutes a hypersaline layer that sinks towards the seabed due to its greater density, has the potential to heavily affect local marine biota (Medeazza 2005). Changes of salinity

influence the propagation activity of the marine species and that consequentially affect their development and growth rate.

iii. Operationally, the colonization of marine organisms such as algae, bryozoans, molluscs and cirripedes within cooled water circuits could result in losses in thermal efficiency and reduced reliability of the system (including total shutdown). To counteract settling and growth of marine organisms, cooled water circuits are typically dosed with chemicals (usually sodium hypochlorite). Ultimately, this form of treatment is associated with the discharge of the treated seawater into the marine environment.

Table 7-25 Thermal modeling results (degrees) for rising and falling tides (proposed mooring area)

Wind Condition	Rising tide	Falling tide
Slow		
Average		
Fast		

RECOMMENDED MITIGATION

i. Once the effluent temperature adheres to the standards prescribed by the statutory authorities (NEPA, EPA, World Bank), no specific management measures will be required. Salinity changes are expected to be within 38 ppt, hence impact of salinity and temperature on the marine biota is expected to be minimal.
ii. However, it is recommended that good practices be implemented for inlet and outfall management in order to protect the marine environment.

Ballast, Leaks and Spills

In terms of ballast water, it will only be released in accordance with international and Jamaican standards.

Only LNG spills apply to the LNG Re-Gas Facility at the platform. In the event of a spill, the LNG will immediately begin to vaporize. Any LNG that ends up in the sea will eventually vaporize to methane gas. LNG will not contaminate the sea water as it will de-gas and end up in the atmosphere. In the process of evaporation, the LNG will cool surrounding sea water.

Impacts related to leaks or accidental spillage to the terrestrial and marine environment from tanks, pipes, hoses and pumps at land installations and in the marine environment during storage, transfer and transportation are as follows:

NATURAL GAS

Natural gas leak potential impacts (terrestrial and marine) from fires include dead vegetation, and asphyxia in confined spaces in the proximity of the leak.

DIESEL

Automotive Diesel Oil leak has potential environmental impacts in terms of a spill into the marine environment. ADO is considered a "light" oil. Light oils are very volatile (they evaporate relatively quickly), so they have a short retention time in the aquatic or marine environment (usually no longer than a few days). If they spread out on the water, as they do when they are accidentally spilled, they will evaporate relatively quickly. Light oils present two significant hazards. First, some can ignite or explode. Second, diesel is considered to be toxic. It can kill animals or plants that they touch, and they also are dangerous to humans who breathe their fumes or get them on their skin.

Diesel is moderately volatile and will leave residue (up to one-third of spill amount) after a few days. In the marine environment, diesel contains moderate concentrations of toxic (soluble) compounds. Diesel can “oil” intertidal resources with long-term contamination potential. However, diesel cleanup can be very effective in managing these risks. With respect to a terrestrial spill, diesel can cause ecological impacts from runoff in to surface water, contamination of terrestrial habitats, and vapor intrusion to indoor air. Human health effects of a spill can include impacts to human Health with respect to drinking water, direct exposure, and produce uptake as well as other contamination of agricultural uses, industrial uses, and gross contamination from taste, odors, and related mechanisms. In order to manage these risks of the ADO, the ADO tanks will be inside a berm for containment. Finally, since ADO is presently supplied to the JPS plant, the threat of an ADO spill already exists at the site and has been successfully managed in the past.

According to the National Oceanic and Atmospheric Administration (NOAA), diesel oil has a very low viscosity and is readily dispersed into the water column with moderate winds (5 -7 knots) or with breaking waves. Diesel oil is much lighter than water and it is not possible for this oil to sink and accumulate on the seafloor as pooled or free oil unless adsorption occurs with sediment. However, it is possible for the diesel oil that is dispersed by wave action to form droplets that are small enough be kept in suspension and moved by the currents. Because it is a light, refined petroleum product, small diesel spills will usually evaporate and disperse naturally within a few days.

Oil dispersed in the water column can adhere to fine-grained suspended sediments (adsorption) which then settle out and get deposited on the seafloor. This process is more likely to occur near river mouths, in this case the Bowers Gully, where fine-grained sediments are carried by rivers. It is less likely to occur in open marine settings, such as closer to the offshore FSU platform.

The NOAA states that, in terms of toxicity to water-column organisms, diesel is considered to be one of the most acutely toxic oil types. Fish, invertebrates, and seaweed that come in direct contact with a diesel spill may be killed. However, small spills in open water are so rapidly diluted that fish kills have never been reported. Fish kills have been reported for small spills in confined, shallow water.

Shellfish can be killed from large spills or tainted from small diesel spills in shallow, nearshore areas. These organisms bioaccumulate the oil but will also depurate (filter out) the oil, usually over a period of several weeks after exposure. Small diesel spills can affect marine birds by direct contact, though the number of birds affected is usually small because of the short time the oil is on the water surface. Mortality is caused by ingestion during preening.

RECOMMENDED MITIGATION

Pressure in the subsea ADO pipeline will be continuously monitored and recorded at the onshore pipeline facility. When a vessel is delivering ADO to the tanks, JPS, or both, the flow rate and pressure will be monitored both onshore and on the ship located at the offshore single point mooring (SPM). In the event of a sudden drop in flow rate or pressure, the vessel will be immediately contacted to stop delivering ADO into the pipeline and all isolation valves will be closed.

An automated block valve in the proximity of the beach will be located onshore and will be used for isolation and emergency shutdown purposes. Automated block valves will be located at the inlet of the meter skid and at each inlet to each regulator skid and the tanks. In the event of a pipeline leak, the automated block valves will close to stop transportation of ADO to the onshore storage tanks and/or to the power plant and isolate the pipeline.

The ADO storage tanks on land will each be located inside containment bunds sufficient to hold 110% of the volume of one tank. Each tank will have instrumentation to automatically shut down to prevent overfilling.

In the event of a storm/hurricane, the pipeline will be shut down and the isolation valves will be closed.

Sediment Transport and Coastal Dynamics

There will be no structures built along the shoreline/coastline so no changes in the nearshore sediment transport (erosion and accretion) or wave patterns are anticipated. The offshore facility will be comprised of pilings, a floating platform and the FSU. Therefore no changes in wave or current patterns are anticipated.

7.2.1.3 Air Impacts

Introduction

An air dispersion modelling analysis was undertaken to determine the impact of the air pollutants from the proposed facility on ambient air quality. A determination was also made whether a significant air quality impact will be created based on the incremental contribution of the proposed facility to the cumulative air quality impact. According to the Natural Resources Conservation Authority (Air Quality) Regulations, 2006, a "significant air quality impact", means:

(a) the increment in the predicted average concentration of sulphur dioxide (SO_2), total suspended particulates (TSP), particulate matter less than ten microns (PM_{10}) or nitrogen dioxide (NO_2) is greater than an annual average of 20 µg/m^3 or a 24-hour average concentration of 80 µg/m^3; or

(b) the increment in the predicted average concentration of CO is greater than 500 µg/m^3 as a 8-hour average or 2000 µg/m^3 as a 1-hour average

This section describes the air dispersion modeling analysis for SO_2, PM_{10}, NO_2 and CO and various priority air pollutants from the proposed facility only and the consequent comparison with the Jamaican National Ambient Air Quality Standards, as well as a determination whether the proposed facility's air emissions will create a significant air quality impact. It should be observed that the existing JPS 190 MW power plant at Old Harbour will be retired as soon as the proposed 190 MW power plant has been fully commissioned, and this scenario was considered in the modelling analyses.

Modeling Approach

The assessment methodology for the air dispersion modeling exercise follows the guidance specified in the Natural Resources Conservation Authority (NRCA) Ambient Air Quality Guideline Document of 2006. The detailed model recommended in the Ambient Air Quality Guideline Document is AERMOD. The model of selection was the commercially available AERMOD View dispersion model (version 9.1), developed by Lakes Environmental. This model is used extensively to assess pollution concentration and deposition from a wide variety of sources. AERMOD View is a true, native Microsoft Windows application and runs in Windows applications. The AMS/EPA Regulatory Model (AERMOD) was specially designed to support the EPA's regulatory modeling programs. AERMOD is a regulatory steady-state plume modeling system with three separate components: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD Terrain Preprocessor), and AERMET (AERMOD Meteorological Preprocessor). The AERMOD model includes a wide range of options for modeling air quality impacts of pollution sources, making it a popular choice among the modeling community for a variety of applications. Some of the modeling capabilities of AERMOD include the following:

- The model may be used to analyze primary pollutants and continuous releases of toxic and hazardous waste pollutants.
- Source emission rates can be treated as constant or may be varied by month, season, hour-of-day, or other optional periods of variation. These variable emission rate factors may be specified for a single source or for a group of sources. For this project all emission rates were treated as constant.
- The model can account for the effects of aerodynamic downwash due to buildings that are nearby point source emissions.
- Receptor locations can be specified as gridded and/or discrete receptors in a Cartesian or polar coordinate system.
- For applications involving elevated terrain, the U.S. EPA AERMAP terrain preprocessing program is incorporated into the model to generate hill height scales as well as terrain elevations for all receptor locations.
- The model contains algorithms for modeling the effects of settling and removal (through dry and wet deposition) of large particulates and for modeling the effects of precipitation scavenging for gases or particulates.
- AERMOD requires two types of meteorological data files, a file containing surface scalar parameters and a file containing vertical profiles. These two files are provided by the U.S. EPA AERMET meteorological preprocessor programme.

Model Inputs

SOURCE EMISSIONS

A critical step for conducting air dispersion modeling is to quantify the emissions from the various sources at the facility. The emission rates from the sources identified were estimated in accordance with the recommendation outlined in the Ambient Air Quality Guideline Document. According to Davis & Associates (2006), emission rates should be estimated in the following order of preference:

- Continuous emissions monitoring data
- Stack Emission Testing data
- Manufacturer's emission data
- Mass balance calculations
- Emission factors
- Engineering calculations

Table 7-26 shows the source information data determined for the LNG Terminal, while Table 7-27 displays the emission rates for criteria and priority air pollutants that were calculated based on USEPA emission factors and project data. Source information and air pollutant data for the other air pollution sources in the air shed – namely the BDFM, JPS existing and proposed power plant, the JEP power plant facilities and the alumina handling activities at Port Esquivel are shown in Table 7-29 to Table 7-33. These data were obtained from the Air Dispersion Modeling Report for the LNG-Fired 190 MW Power Plant dated October 2014, the 2015 Annual Air Emissions Summary Report for BDFM and the 2015 Emission Test Report for JEP. The source locations are identified in Figure 7-5.

Table 7-26 Source Information Data for the Proposed LNG Terminal

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height, m	Diameter, m	Exit Velocity, m/s	Exit Temperature, K
GEN1	POINT	Generator Set 1	276222	1975648	0	29	0.81	28	716
GEN2	POINT	Generator Set 2	276222	1975678	0	29	0.81	28	716
DG	POINT	Standby Diesel Generator	276205	1975660	0	35.3	0.4	1.063	678
FLARE	POINT	Flare	276200	1975684	0	33.7	1.8	6.1	1270
FWP	POINT	Fire Water Pump Engine	276234	1975636	0	29.8	0.2	43.7	685
UNLD1	POINT	Ship Unloading	276216	1975784	0	37	0.4	9.1	573
UNLD2	POINT	Ship Unloading	276216	1975546	0	37	0.4	9.1	573

Table 7-27 Air Pollutant Emission Rates for LNG Terminal

Pollutant, g/s	Generator Set (x2)	Standby Generator	Flare – Pilot Gas	Emergency Flare	Firewater Pump	Ship Unloading Auxiliary Engines (x2)
PM_{10}	8.8E-03	7.45E-03	6.71E-05	0.23	0.131	0.19
SO_2	5.5E-04	6.94E-03	1.78E-02	1.78E-02	0.122	0.39
NO_X	2.0	0.105	6.13E-04	2.06	1.84	7.83
CO	3.4	0.023	3.33E-03	11.2	0.396	0.86
Acetaldehyde	2.6E-03	1.82E-05			3.19E-04	
Acrolein	2.4E-03	2.19E-06			3.84E-05	
Arsenic			1.77E-09	5.93E-06		
Benzene	1.5E-03	2.21E-05	1.86E-08	6.23E-05	3.88E-04	
Benzo(a)pyrene		4.43E-09	9.72E-12	3.26E-08	7.77E-08	
Beryllium			9.72E-11	3.26E-07		
1,3 Butadiene	6.1E-04	9.24E-07			1.62E-05	
Cadmium			9.72E-09	3.26E-05		
Carbon Tetrachloride	1.6E-05					
Chromium			1.24E-08	4.15E-05		
Chloroform	1.3E-05					
Cobalt			7.42E-10	2.49E-06		
Copper			7.51E-09	2.52E-05		
Ethylene Dibromide	2.0E-05					
Formaldehyde	1.9E-02	2.8E-05	6.63E-07	2.23E-03	4.9E-04	
Lead			4.42E-09	1.48E-05		
Manganese			3.36E-09	1.13E-05		

Pollutant, g/s	Generator Set (x2)	Standby Generator	Flare – Pilot Gas	Emergency Flare	Firewater Pump	Ship Unloading Auxiliary Engines (x2)
Mercury			2.30E-09	7.71E-06		
Methylene Chloride	3.8E-05					
Nickel			1.86E-08	6.23E-05		
Selenium			2.03E-10	6.82E-07		
Styrene	1.1E-05					
Vinyl Chloride	6.7E-06					
Xylenes	1.35E-04	6.76E-06			1.18E-04	
Zinc			2.56E-07	8.6E-04		

Table 7-28 Source Information Data for the Proposed LNG-Fired 190 MW Power Plant

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height, m	Diameter, m	Exit Velocity, m/s	Exit Temperature, K
MS1	POINT	Main Stack 1	276701	1980416	3.0	45	3.9	11.6	370.5
MS2	POINT	Main Stack 2	276647	1980363	2.4	45	3.9	11.6	370.5
MS3	POINT	Main Stack 3	276618	1980335	2.1	45	3.9	11.6	370.5

Source: Air Dispersion Modeling Report for LNG-Fired 190 MW Power Plant, St. Catherine, Jamaica, 2014

Table 7-29 Air Pollutant Emission Rates for the Proposed LNG-Fired 190 MW Power Plant

Source ID	PM, g/s	SO2, g/s	NOx, g/s	CO, g/s	Acetaldehyde, g/s	Acrolein, g/s	Benzene, g/s	Formaldehyde, g/s	Xylenes, g/s
MS1	1.09	0.562	21.5	4.96	6.61E-03	1.06E-03	1.98E-03	0.117	1.06E-02
MS2	1.09	0.562	21.5	4.96	6.61E-03	1.06E-03	1.98E-03	0.117	1.06E-02
MS3	1.09	0.562	21.5	4.96	6.61E-03	1.06E-03	1.98E-03	0.117	1.06E-02

Source: Air Dispersion Modeling Report for LNG-Fired 190 MW Power Plant, St. Catherine, Jamaica, 2014

Table 7-30 Source Information Data for JEP, JPS and BDFM

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height, m	Diameter, m	Exit Velocity, m/s	Exit Temperature, K
JEP2	POINT	JEP2 Generators	276706	1980109	0.2	35	2.42	36.38	649.15
JEP1_6	POINT	JEP1 DG1-6 Generators	276813	1979972	3.9	30	2.66	43.01	602.15
JEP1_7	POINT	JEP Existing Barge - DG7	276772	1980003	3.97	30	1.08	43.01	602.15
JEP1_8	POINT	JEP Existing Barge - DG8	276772	1980003	3.97	30	1.08	43.01	602.15

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height, m	Diameter, m	Exit Velocity, m/s	Exit Temperature, K
JPS2	POINT	JPS Unit 2	276895	1980346	2	45.72	2.84	15.04	438.15
JPS3	POINT	JPS Unit 3	276866	1980334	2	45.72	2.93	21.61	431.15
JPS4	POINT	JPS Unit 4	276849	1980310	2	45.72	2.93	21.61	431.15
FEEDE	POINT	Feed Mill Engine	273410	1982465	15.44	2.4	0.35	10	550
FEEDB1	POINT	Feed Mill Boiler 1	273412	1982445	15.27	9.14	0.46	15.3	449.5
FEEDB2	POINT	Feed Mill Boiler 2	273413	1982442	15.23	6.1	0.35	15.3	494.2
FEEDGR	POINT	Feed Mill Grain Receiving	273473	1982496	15.2	15.24	0.21	15	330
MILL	POINT	Feed Mill	273478	1982481	14.72	10.36	0.2	15	330

Source: Air Dispersion Modeling Report for LNG-Fired 190 MW Power Plant, St. Catherine, Jamaica, 2014

Table 7-31 Source Information Data for Alumina Handling at Port Esquivel

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Release Height, m	Length X, m	Length Y, m	Initial Lateral Dimension, m	Initial Vertical Dimension, m
HDRSTRUL	AREA	Unloading of Hydrate to storage	274006.4	1979786	3	4.572	65.98	60.99		
HDRSTRLD	AREA	Loading of Hydrate to storage	274006.4	1979786	3	4.572	65.98	60.99		
HDRSTR2	AREA	Hydrate Storage	274035.2	1979775	3	15.24	34.25	35.54		
RLCRUNL	VOLUME	Unloading of alumina from railcars	274001.7	1979713	3	31.5	20.66		4.80465	3.4186
TRNSF1	VOLUME	Transfer station	274070.9	1979608	3	31.5	2.5		0.5814	7.3256
TSL05	VOLUME	Storage Silo #5	274010.8	1979573	3	52	33.8		7.86047	7.3256
TSL01	VOLUME	Silo #1	274092.1	1979580	3	52	17.53		4.07674	7.3256
TSL02	VOLUME	Silo #2	274105.9	1979559	3	52	17.53		4.07674	7.3256
TSL03	VOLUME	Silo #3	274119.1	1979538	2.41	52	17.53		4.07674	7.3256
TSL04	VOLUME	Silo #4	274135.9	1979514	2	52	17.53		4.07674	7.3256
SHPLDR	VOLUME	Ship Loader	274240.8	1979345	0	11.1	24.41		5.67674	4.6512
TRHSE	VOLUME	Transfer House	274178.8	1979465	2	47.7	20.66		4.80465	4.186

Source: Air Dispersion Modeling Report for LNG-Fired 190 MW Power Plant, St. Catherine, Jamaica, 2014

Table 7-32 Criteria Emission Rates for other nearby Existing Facilities

Source ID	Description	PM (g/s)	SO_2 (g/s)	NOx (g/s)	CO (g/s)
JEP2	JEP2 Generators	4.9	21.8	175.3	3.5
JEP1_6	JEP Existing Barge - 6 Generators	4.76	18.5	206.9	4.9
JEP1_7	JEP Existing Barge - DG7	0.74	3.0	36.8	0.54
JEP1_8	JEP Existing Barge - DG8	0.79	3.0	33.9	0.52
JPS2	JPS Unit 2	13.11	287.99	21.29	4.59
JPS3	JPS Unit 3	15.13	267.25	53.03	38.34
JPS4	JPS Unit 4	10.58	277.52	33.08	267.2
FEEDE	BDFM Diesel Engine	0.04016	0.405	2.591	0.6882
FEEDB1	BDFM Boiler 1	0.04846	2.447	0.498	0.003
FEEDB2	BDFM Boiler 2	0.00542	0.24	0.166	0.012
GRAIN	BDFM Grain Receiving	0.0833	0	0	0
MILL	BDFM Mills	0.8404	0	0	0
	Port Esquivel Sources	**PM (g/s)**			
HDRSTRUL	Unloading of Hydrate to storage	0.00377			
HDRSTRLD	Loading of Hydrate to storage	0.00377			
HDRSTR2	Hydrate Storage	0.1244			
RLCRUNL	Unloading of alumina from railcars	0.186			
TRNSF1	Transfer station	0.03067			
TSL05	Storage Silo #5	0.03067			
TSL01	Silo #1	0.03067			
TSL02	Silo #2	0.03067			
TSL03	Silo #3	0.03067			
TSL04	Silo #4	0.03067			
SHPLDR	Ship Loader	0.186			
TRHSE	Transfer House	0.186			

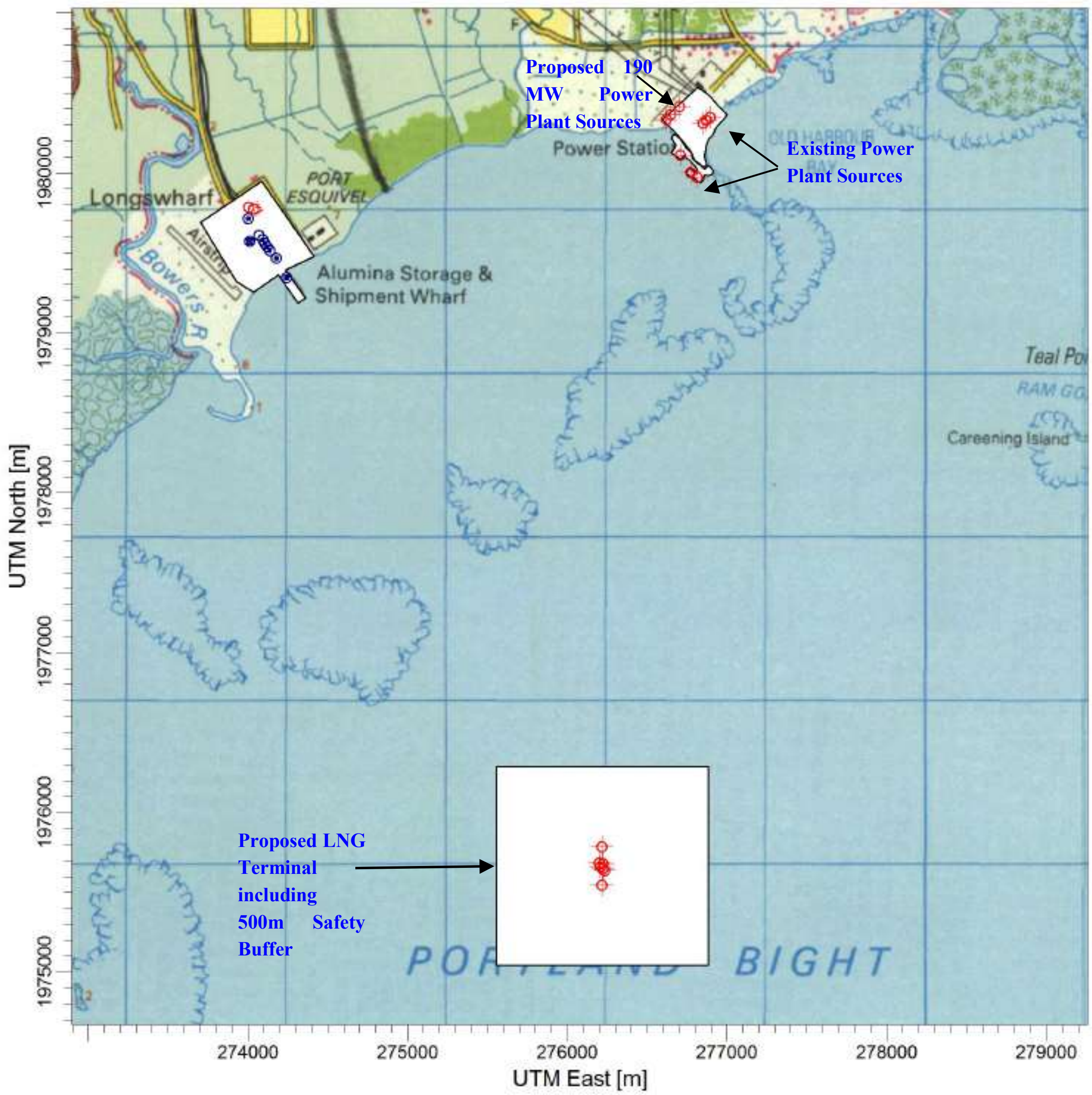
Source: Air Dispersion Modeling Report for 190 MW Power Plant, St. Catherine, Jamaica, 2014, Annual Air Emissions Report for BDFM and Emission Test Report for JEP, 2016

Table 7-33 Available Priority Air Pollutant Emission Rates for nearby Sources

Pollutants, g/s	FEEDE	FEEDB1	FEEDB2
Acetaldehyde	2.04E-05		
Acrolein	6.38E-06		
Benzene	6.28E-04	4.94E-07	5.1E-07
Benzo(a)pyrene	2.08E-07		
Formaldehyde	9.55E-04	7.62E-05	1.14E-04
Xylenes	1.56E-04		
Arsenic		3.05E-06	1.12E-06
Beryllium		6.42E-08	8.38E-07
Cadmium		9.19E-07	8.38E-07
Chromium		5.73E-07	8.38E-07
Copper		4.06E-06	1.68E-06
Lead		3.49E-06	2.52E-06
Mercury		2.61E-07	8.38E-07
Manganese		6.93E-06	1.68E-06
Nickel		1.95E-04	8.38E-07
Selenium		1.58E-06	4.19E-06
Zinc		6.72E-05	1.12E-06
Cobalt		1.39E-05	

PROJECT TITLE:

Modeled Sources



COMMENTS:	SOURCES:	COMPANY NAME:	
Point Sources Volume Sources Area Sources Plant Boundaries	35	AIR QUALITY CONSULTANTS LIMITED	
	RECEPTORS: 5169	MODELER: Stephen Haughton	AIR QUALITY CONSULTANTS LTD.
		SCALE: 1:40,000 (0 — 1 km)	
			PROJECT NO.:

Figure 7-5 Map showing Modeled Air Pollutant Sources

Comparison of Proposed Emission Rates with Emission Standards

The air pollutant sources associated with the LNG Terminal include standby generators, diesel engine firewater pump, a flare and gas generators with a capacity of 2,150 kW each. There are no stipulated air emission standards for the liquid fuel diesel engines less than 2 MW in capacity, and there is no specific standard for gas-fired generators. Additionally, there are no emission standards for gas-fired fuel combustion sources with less than 2.9 MW capacity.

Building Downwash Effects

Buildings located close to point sources may significantly affect the dispersion of the pollutants from the source. If the point source is relatively low, the air pollutants released may be trapped in the wake zone of nearby obstructions (structures or terrain features) and may be brought down to ground level in the immediate vicinity of the release point (down-wash). It is therefore necessary to determine if such effects are present for each point source.

The "Good Engineering Practice" (GEP) height is defined as the height necessary to ensure that point source emissions do not result in excessive pollutant concentrations in the immediate vicinity of the source. These excessive concentrations may be the result of atmospheric downwash, eddies, or wakes that may be created by the source itself, nearby structures, or nearby terrain obstacles. If a point source is below the GEP height, then the plume entrainment must be taken into account by modifying certain dispersion parameters used in the dispersion model. However, if the point source height meets GEP, then entrainment within the wake of nearby obstructions is unlikely and need not be considered in the modeling.

The GEP height formula is: $Hg = H + 1.5*L$ where Hg is the GEP height measured from ground level elevation at the base of the point source, H is the height of nearby structure(s) measured from the ground level elevation at the base of the point source, and L is the lesser dimension, height or projected width, of the nearby structure(s).

A building or structure is considered sufficiently close to a point source to cause wake effects when the minimum distance between the point source and the building is less than or equal to five times the lesser of the height or projected width of the building (5L). This distance is commonly referred to as the building's "region of influence." If the source is located near to more than one building, each building and point source configuration would have to be assessed separately. If a building's projected width is used to determine 5L, then the apparent width of the building must be determined. The apparent width is the width as seen from the source looking toward either the wind direction or the direction of interest. For example, for short-term modeling, the AERMOD model requires the apparent building widths (and also heights) for every 10 degrees of azimuth around each source. The AERMOD model also contains algorithms for determining the impact of downwash on ambient concentration and was used for determining predicted maximum estimates.

There are a number of buildings nearby the point sources that were identified in the modeling project and these are sufficiently close to cause wake effects for the plumes. The dimensions of the various buildings as well as the parameters for the various point sources were inputted into the Building Profile Input Program (BPIP) to generate the necessary building heights and widths.

The USEPA BPIP was designed to incorporate the concepts and procedures expressed in the GEP technical support document (EPA, 1985), the Building Downwash guidance (Tikvart 1988, Tikvart 1989, and Lee 1993), and other related documents into a program that correctly calculates building heights (BHs) and projected building widths (PBWs). The BPIP model is divided into two parts.

Part one (based on the GEP technical support document) is designed to determine whether or not a stack is subject to wake effects from a structure or structures. Values are calculated for GEP stack height and GEP-related BHs and PBWs. Indication is given to which stacks are being affected by which structure wake effect. Part two calculates building downwash BHs and PBWs values based on references Tikvart, 1988, Tikvart 1989, and Lee 1993, which can be different from those calculated in part one. Part two only performs the calculations if structure wake effects are influencing a particular stack.

Table 7-34 shows the calculated GEP stack heights for the proposed power plant facility. It was observed that the recommended stack heights were equal or above the calculated GEP stack heights and hence, the unmodified algorithms for building downwash were used by the model to generate the building heights and projected building widths that were calculated using part two of the BPIP program. Hence, it is expected that point source emissions would not result in excessive pollutant concentrations in the immediate vicinity of the source, but rather significantly beyond the facility's fenceline.

Table 7-34 Calculated GEP Stack Heights

PRELIMINARY* GEP STACK HEIGHT RESULTS TABLE
(Output Units: meters)

Stack Name	Stack Height	Stack-Building Base Elevation Differences	GEP** EQN1	Preliminary* GEP Stack Height Value
GEN1	29.00	0.0	64.0	65.00
GEN2	29.00	0.0	64.0	65.00
FWP	29.80	0.0	64.0	65.00
DG	35.30	0.0	64.0	65.00
FLARE	33.70	0.0	64.0	65.00
FLARE_E	33.70	0.0	64.0	65.00
UNLD1	37.00	0.0	64.0	65.00
UNLD2	37.00	0.0	64.0	65.00

* Results are based on Determinants 1 & 2 on pages 1 & 2 of the GEP Technical Support Document. Determinant 3 may be investigated for additional stack height credit. Final values result after Determinant 3 has been taken into consideration.

** Results were derived from Equation 1 on page 6 of GEP Technical Support Document. Values have been adjusted for any stack-building base elevation differences.

METEOROLOGICAL DATA

The AERMOD model requires hourly surface data values for wind speed, wind direction, temperature, rainfall, relative humidity, pressure, cloud cover and ceiling height and solar radiation, as well as upper air data. These data were obtained as a MM5 modeled data set for years 2011 through 2015 with its centre at UTM coordinates 276690 in the east and 1975653 in the north.

Both data files were then used to generate the meteorological input files required by the AERMOD dispersion model using the AERMET meteorological preprocessor programme. This AERMET programme has three stages to process the data. The first stage extracts meteorological data and assesses data quality through a series of quality assessment checks. The second stage merges all data available for 24-hour periods and writes these data together in a single intermediate file. The third and final stage reads the merged meteorological data and estimates the necessary boundary layer parameters for dispersion calculations by AERMOD.

The land use within a 3 km radius around the proposed LNG Terminal was water and hence the surface parameters applied to the AERMET processor were 0.14 (Albedo), 0.45 (Bowen Ratio) and 0.0001 (Surface Roughness).

The 2011-2015 meteorological preprocessed data was used to determine its corresponding Wind Rose plot (Figure 7-6) and it shows that the most predominant wind direction blows from the east, with the secondary wind direction being from the east-southeast. This means that the emissions plume will be dispersed mainly in the western direction, and secondarily in the west-northwesterly direction from the proposed facility. The average wind speed for the five years was obtained as 6.16 m/s.

MODEL DOMAIN, RECEPTOR NETWORK AND TERRAIN CONSIDERATIONS

The selected model domain was 20 km in both the east-west and north-south directions, with the centre of the domain being at the middle of the proposed LNG Terminal platform with coordinates 276,220 m UTME and 1,975,665 m UTMN. Figure 7-7 shows the model domain that was utilized in the project, including the receptor grid and plant boundaries. The model domain is overlain on a Jamaica Metric Grid 1:50,000 topographic map.

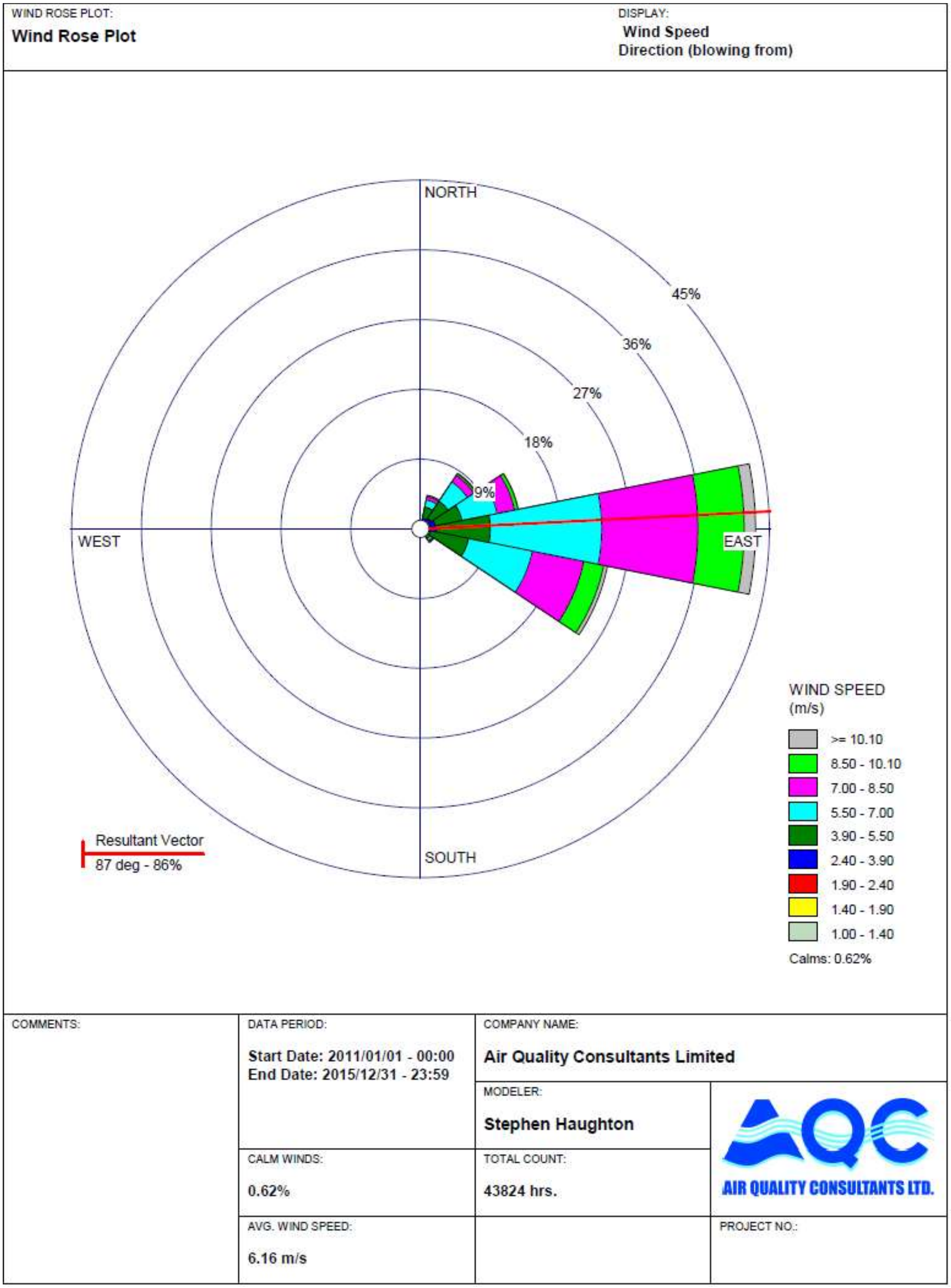
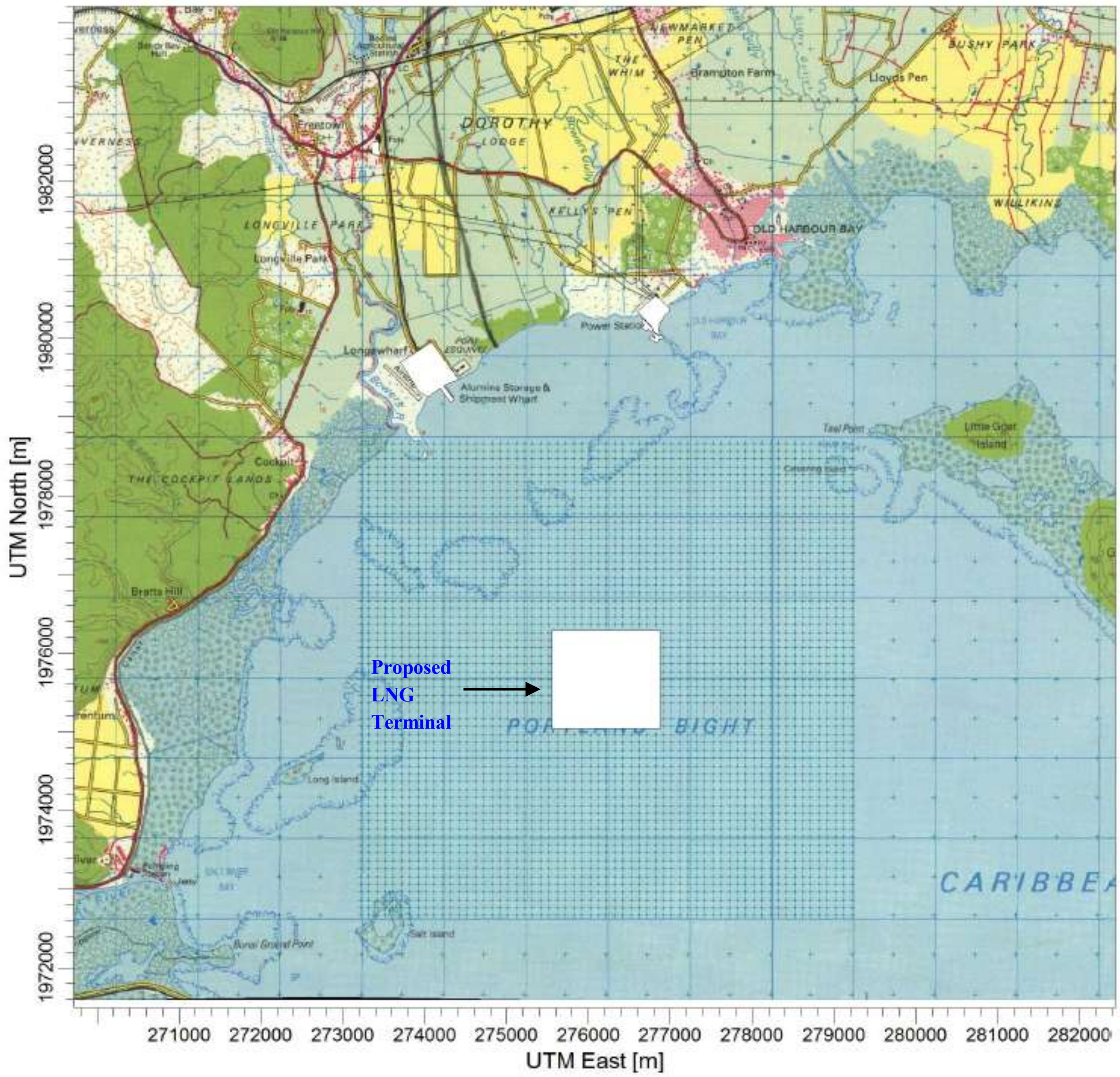


Figure 7-6 Wind Rose Plot - (2011-2015) Preprocessed Met Data

PROJECT TITLE:

Model Domain



COMMENTS:	SOURCES:	COMPANY NAME:	
Plant Boundaries ———	35	**AIR QUALITY CONSULTANTS LIMITED**	
Receptors ✦	RECEPTORS: 5169	MODELER: **Stephen Haughton**	AIR QUALITY CONSULTANTS LTD.
		SCALE: 1:80,000 (0 – 3 km)	
			PROJECT NO.:

Figure 7-7 Model Domain showing the Receptor Grid

Receptor Network

The selection and location of the receptor network are important in determining the maximum impact from a source and the area where there is significant air quality impact. Impacts were assessed at locations beyond the fence line. Consequently, the receptor locations were selected as a multi-tier grid that is defined by discrete cartesian receptors, square in shape, and with origin at the centre of the LNG Terminal platform. Certain special receptor locations were also defined, including schools, churches, a police station, a post office, a tax office, a health center, a market and two air quality monitoring stations, were included as part of receptor network.

The entire receptor network locations include the following:

- A 100-meter spaced grid within 3 km from the subject source; and
- A 500-meter spaced grid between 3 and 10 km from the subject source; and,
- A total of 26 special receptors that include schools, churches, a police station, a post office, a tax office, a health center, a market and two air quality monitoring stations (see Table 3-10).

A total of 5,169 receptors were considered, and some of these are depicted in Figure 7-7.

Terrain Considerations

The classification of the land use in the vicinity of the proposed power plant is needed because dispersion rates differ between urban and rural areas. In general, urban areas cause greater rates of dispersion because of increased turbulent and buoyancy-induced mixing. This is due to the combination of greater surface roughness caused by more buildings and structures and greater amounts of heat released from concrete and similar surfaces. The USEPA guidance provides two procedures to determine whether the character of an area is predominantly urban or rural. One procedure is based on land-use type, and the other is based on population density. Both procedures require an evaluation of characteristics within a 3-km radius from the subject source, but the land-use methodology is considered more accurate. Hence, this method was applied and it was determined that the rural dispersion coefficient be selected for this modeling project.

According to the land-use type methodology, a 3 km radius circle was circumscribed about the centre of the proposed power plant boundary. Then using the Auer land use types, less than 1% of the 3 km radius area around the project site matches the urban zones of I1, I2, C1, and R2 (Figure 7-8). The majority of the area was water, and hence the rural option was selected.

Table 7-35 Special Receptors

Description	X Coordinate, m	Y Coordinate, m	Elevation, m
Holy Mt. Zion Int'l Worship Centre	272439	1982438	23.05
Miracle Tabernacle Church of God	272452	1982427	22.31
Freetown Baptist Church	272370	1982510	27.67
Freetown Primary School	272726	1982485	13.1
Freetown SDA Church	272830	1982543	14.53
St. Michael's & George's Anglican Church	272674	1982404	18.35
New Testament Church Convention Centre	275522	1984642	30.47

Description	X Coordinate, m	Y Coordinate, m	Elevation, m
Green Park Health Centre	269678	1984465	40.34
Green Park Church	269919	1984552	43.59
Green Park Primary & Junior High School	269956	1984693	42.77
Green Park Church	269861	1985136	54.17
Lancasters Church	267755	1985199	75.88
Old Harbour SDA Church	276666	1984674	27
Sacred Heart Catholic Church	275666	1984910	33.07
St. Dorothy's Anglican Church	278712	1985006	20.39
Assembly Hall of Jehovah's Witnesses	277262	1986052	39.5
Mosque	280042	1985440	21
Old Harbour Tax Office	276264	1984620	32
Old Harbour Post Office	276424	1984659	29.91
Old Harbour Police Station	276222	1984690	31.07
Hebron Gospel Hall	276286	1984553	30.34
Old Harbour High School	276448	1984236	25.33
Marlie Mount Primary School	277884	1985326	43.91
Longville Park Air Quality Station	270754	1981594	76.6
Lauderwood Air Quality Station	272090	1986029	134.59
Old Harbour Bay Fish Market	278188	1980936	1.13

Table 7-36 Land Use Categories

Auer Land Use Categories I1, I2, C1, & R2 (Auer 1978)

Type	Use and Structure	Vegetation
I1	Heavy Industrial	Grass and tree growth extremely rare; <5% vegetation
	Major chemical, steel and fabrication industries; generally 3-5 story buildings, flat roofs	
I2	Light-moderate industrial	Very limited grass, trees almost totally absent; <5% vegetation
	Rail yards, truck depots, warehouse, industrial parks, minor fabrications; generally 1-3 story buildings, flat roofs	
C1	Commercial	Limited grass and trees; <15% vegetation
	Office and apartment buildings, hotels; >10 story heights, flat roofs	
R2	Compact Residential	
	Single, some multiple, family dwelling with close spacing; generally <2 story, pitched roof structures; garages (via alley), no driveways	Limited lawn sizes and shade trees; <30% vegetation

Source: Auer, A. H. 1978. Correlation of Land Use and Cover with Meteorological Anomalies, Journal of Applied Meteorology, 17:636-643

Additionally, the topography in the region of the proposed power plant is defined as either simple terrain (terrain lying below the stack top elevation) or complex terrain (terrain above the top of the stack). Measurements of the terrain in the area surrounding the proposed facility were obtained using world Shuttle Radar Topography Mission terrain data files with 30m resolution. It was determined that the topography from the east through south western directions of the proposed facility, up to 10 km, have terrain elevations less than 20 m and include the marine environment (Figure 7-8). Also, the areas from southwest through to the northern direction had elevations greater than 30 m and up to

400 m. Therefore, since terrain elevations extend above the proposed facility's highest top stack elevation, complex terrain algorithms were included as part of the dispersion modeling analysis.

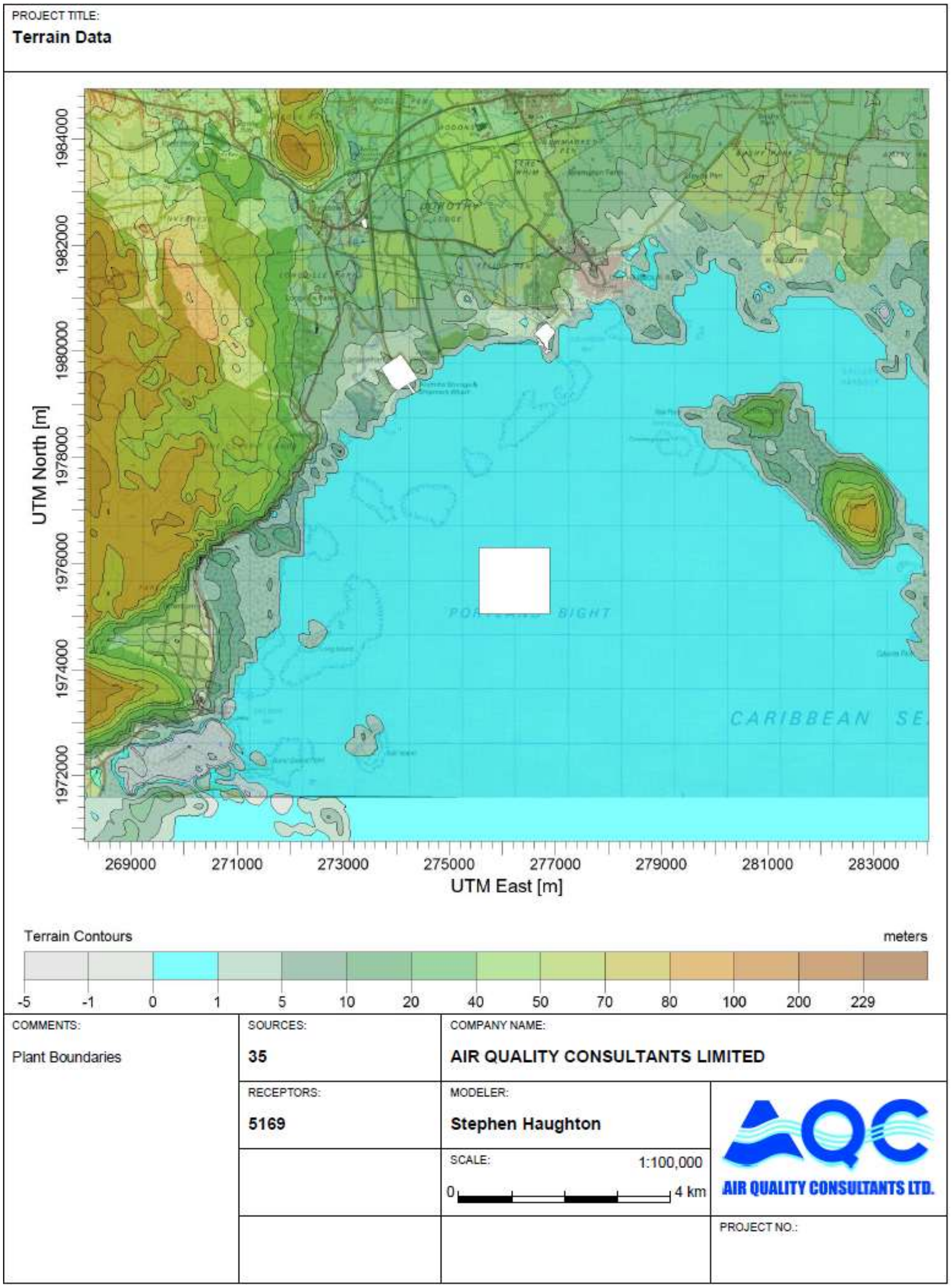


Figure 7-8 Terrain Data for the project area

Model Results

With the various sources identified, a model domain established of 20 km in the east-west direction and 20 km in the north-south direction and centred at the middle of the proposed LNG Terminal platform, and the necessary input files created, model predictions were made for the pollutants SO_2, NO_x, PM_{10}, CO and various priority air pollutants for averaging periods for which there are Jamaican National Ambient Air Quality Standards or Guideline Concentrations. Model runs were conducted for the proposed LNG Terminal air pollutant sources alone, as well as the future cumulative air quality impact in combination with the other defined sources in the vicinity of the proposed facility. As part of the future scenario with the new LNG Terminal and the proposed LNG-fired 190 MW power plant being in full operation, the existing oil-fired JPS 190 MW will be retired, and hence those air pollution sources will be removed from the future scenario.

During the NO_x model runs, the OLM was applied to convert NOx to NO_2 using the default in-stack NO_2/NOx ratio of 0.1 and an ozone concentration of 12 ug/m^3 which was the annual average ozone concentration as reported by NEPA for the year 2012.

Table 7-37 and Table 7-38 summarize the maximum predicted concentrations for the proposed LNG Terminal sources, as well as their comparison with the Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations. The results revealed that the maximum predicted ground level concentrations did not exceed any of the Significant Impact Concentrations (SICs). Additionally, the maximum predicted ground level concentrations plus the background concentrations (as recommended in the Air Quality Guideline Document) were all less than the JNAAQS and Guideline Concentrations.

Table 7-37 Model Results – Proposed LNG Terminal

Pollutant	Avg. Period	Background (µg/m^3)	Significant Impact Concentration (µg/m^3)	Jamaican NAAQS or GC (µg/m^3)	Proposed LNG Terminal		
					Max Conc (µg/m^3)	UTME (m)	UTMN (m)
PM_{10}	24-hr	9	80	150	0.145	268220	1974165
	Annual	20	20	60	0.028	275520	1975765
NO_2	1-hr	0	N/A	400	86.7	270220	1977165
	24-hr	0	80	N/A	11.7	268720	1973165
	Annual	0	20	100	2.5	275520	1975765
SO_2	1-hr	0	N/A	700	1.6	270720	1977165
	24-hr	0	80	280	0.18	268220	1974165
	Annual	0	20	60	0.024	275520	1975765
CO	1-hr	0	2000	40000	199.3	270220	1977165
	8-hr	0	500	10000	74.0	268720	1973165
1,3 Butadiene	1-hr	0	N/A	0.04	0.03556	270220	1977165
Acetaldehyde	1-hr	0	N/A	1250	0.1516	270220	1977165
	24-hr	0	N/A	500	0.0188	268720	1973165
Acrolein	1-hr	0	N/A	58.75	0.14	270220	1977165
	24-hr	0	N/A	23.5	0.01734	268720	1973165

Pollutant	Avg. Period	Background (µg/m³)	Significant Impact Concentration (µg/m³)	Jamaican NAAQS or GC (µg/m³)	Proposed LNG Terminal		
					Max Conc (µg/m³)	UTME (m)	UTMN (m)
Benzene	Annual	0	N/A	1	0.00182	275520	1975765
Benzo (a) pyrene	1-hr	0	N/A	0.00275	0	N/A	N/A
	24-hr	0	N/A	0.0011	0	N/A	N/A
Carbon Tetrachloride	1-hr	0	N/A	6	0.00093	270220	1977165
	24-hr	0	N/A	2.4	0.00012	268720	1973165
Chloroform	1-hr	0	N/A	1250	0.00076	270220	1977165
	24-hr	0	N/A	500	9×10^{-5}	268720	1973165
Ethylene Dibromide	1-hr	0	N/A	7.5	0.00117	270220	1977165
	24-hr	0	N/A	3	0.00014	268720	1973165
Formaldehyde	1-hr	0	N/A	162.5	1.1077	270220	1977165
	24-hr	0	N/A	65	0.1373	268720	1973165
Methylene Chloride	1-hr	0	N/A	550	0.0022	270220	1977165
	24-hr	0	N/A	220	0.00027	268720	1973165
Styrene	1-hr	0	N/A	2500	0.00064	270220	1977165
	24-hr	0	N/A	1000	8×10^{-5}	268720	1973165
Xylenes	1-hr	0	N/A	5750	0.01052	270220	1977165
	24-hr	0	N/A	2300	0.0013	268720	1973165
Vinyl Chloride	24-hr	0	N/A	1	5×10^{-5}	268720	1973165
	Annual	0	N/A	0.2	1×10^{-5}	N/A	N/A

Table 7-38 Model Results – Proposed LNG Terminal

Pollutant	Avg. Period	Background (µg/m³)	Significant Impact Concentration (µg/m³)	Jamaican NAAQS or GC (µg/m³)	Proposed LNG Terminal		
					Max Conc (µg/m³)	UTME (m)	UTMN (m)
Arsenic	1-hr	0	N/A	0.75	0	N/A	N/A
	24-hr	0	N/A	0.3	0	N/A	N/A
Beryllium	Annual	0	N/A	0.0013	0	N/A	N/A
Cadmium	1-hr	0	N/A	5	0	N/A	N/A
	24-hr	0	N/A	2	0	N/A	N/A
Chromium	1-hr	0	N/A	3.75	0	N/A	N/A
	24-hr	0	N/A	1.5	0	N/A	N/A
Cobalt	24-hr	0	N/A	0.12	0	N/A	N/A
Copper	1-hr	0	N/A	125	0	N/A	N/A
	24-hr	0	N/A	50	0	N/A	N/A
Lead	1-month	0	N/A	N/A	0	N/A	N/A
	3-month	0	N/A	2	N/A	N/A	N/A
Manganese	Annual	0	N/A	119	0	N/A	N/A
Mercury	1-hr	0	N/A	5	0	N/A	N/A
	24-hr	0	N/A	2	0	N/A	N/A
Nickel	1-hr	0	N/A	5	0	N/A	N/A

Pollutant	Avg. Period	Background (µg/m³)	Significant Impact Concentration (µg/m³)	Jamaican NAAQS or GC (µg/m³)	Proposed LNG Terminal		
					Max Conc (µg/m³)	UTME (m)	UTMN (m)
	24-hr	0	N/A	2	0	N/A	N/A
Selenium	24-hr	0	N/A	25	0	N/A	N/A
	Annual	0	N/A	10	0	N/A	N/A
Zinc	24-hr	0	N/A	12	1×10^{-5}	N/A	N/A

Figure 7-9 through Figure 7-18 show the pollutant contour plot-files for PM_{10}, NO_x, CO and SO_2 for the proposed LNG Terminal. The plot files show the most impacted areas based on the predicted pollutant concentrations generated by the model runs. The colour coded scale in the figures indicates the various impact concentrations obtained up to the predicted maximum concentrations achieved.

In conclusion, the model predictions for the LNG Terminal revealed compliance with the CO, PM_{10}, NO_2 and SO_2 ambient air quality standards and the priority air pollutant guideline concentrations for the applicable averaging periods. The incremental impact of the criteria air pollutants was also less than the established values that would have created a significant air quality impact.

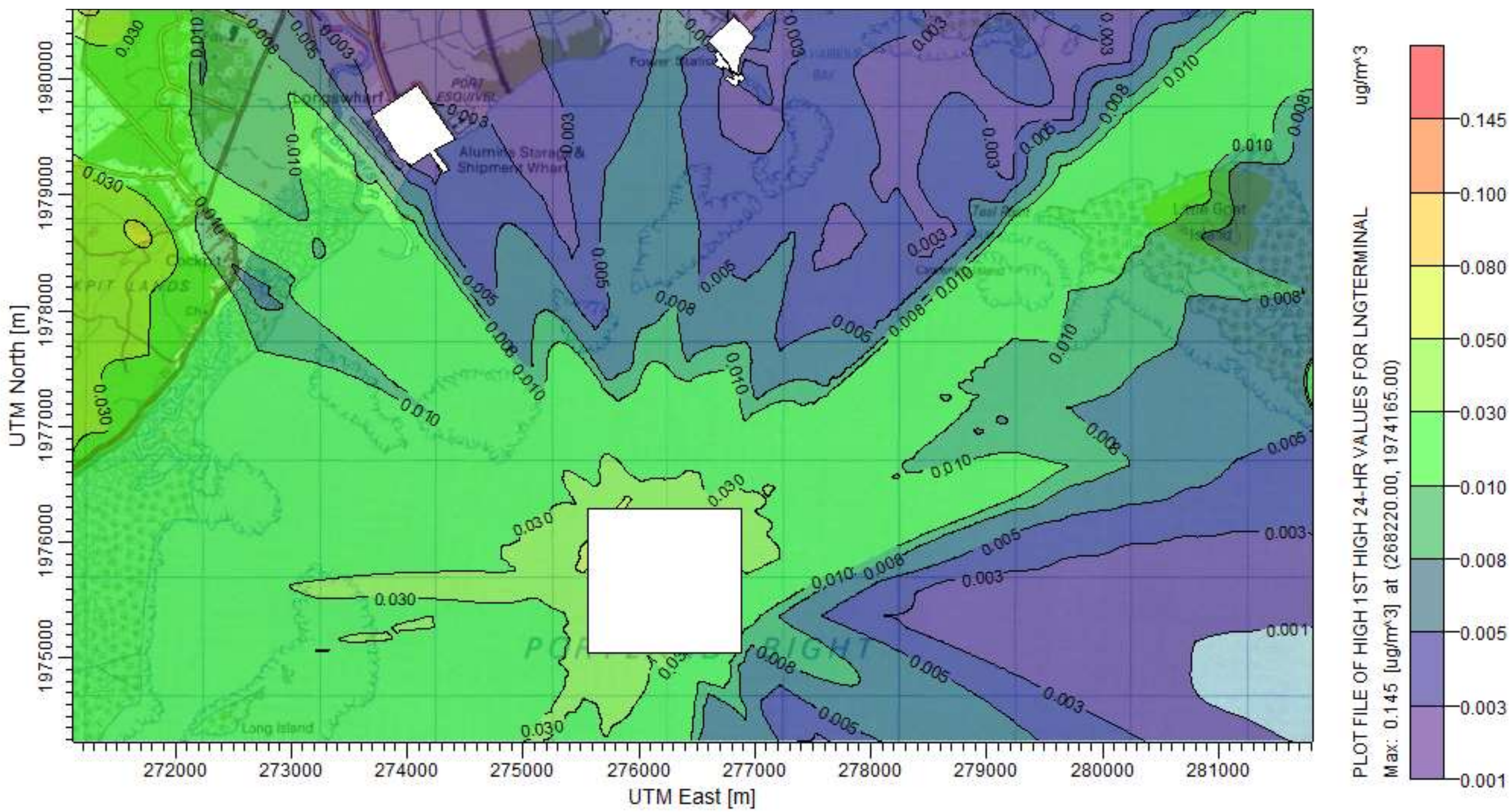


Figure 7-9 Predicted 24h PM10 Concentrations – Proposed LNG Terminal

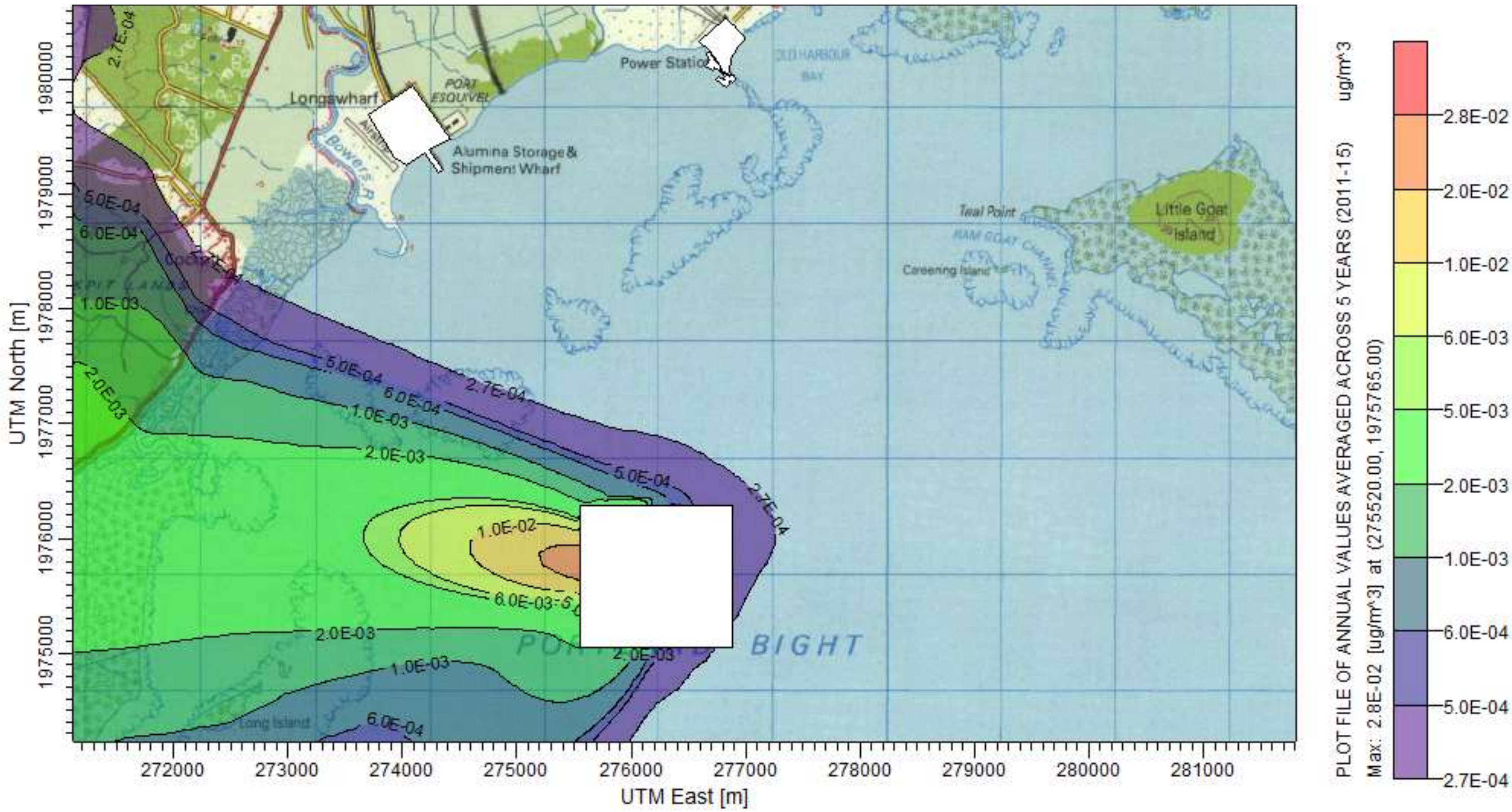


Figure 7-10 Predicted Annual PM10 Concentrations – Proposed LNG Terminal

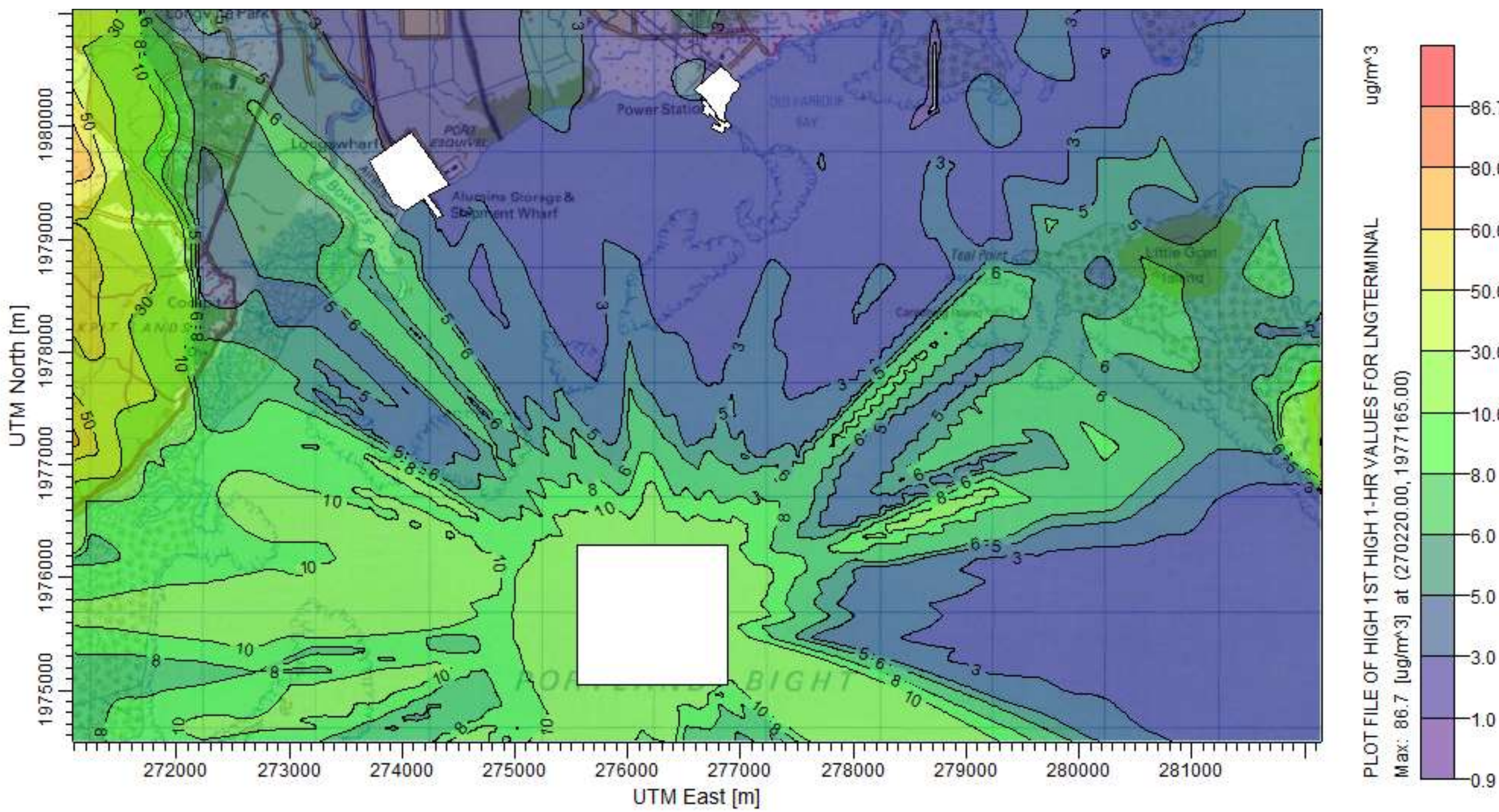


Figure 7-11 Predicted 1h NO2 Concentrations – Proposed LNG Terminal

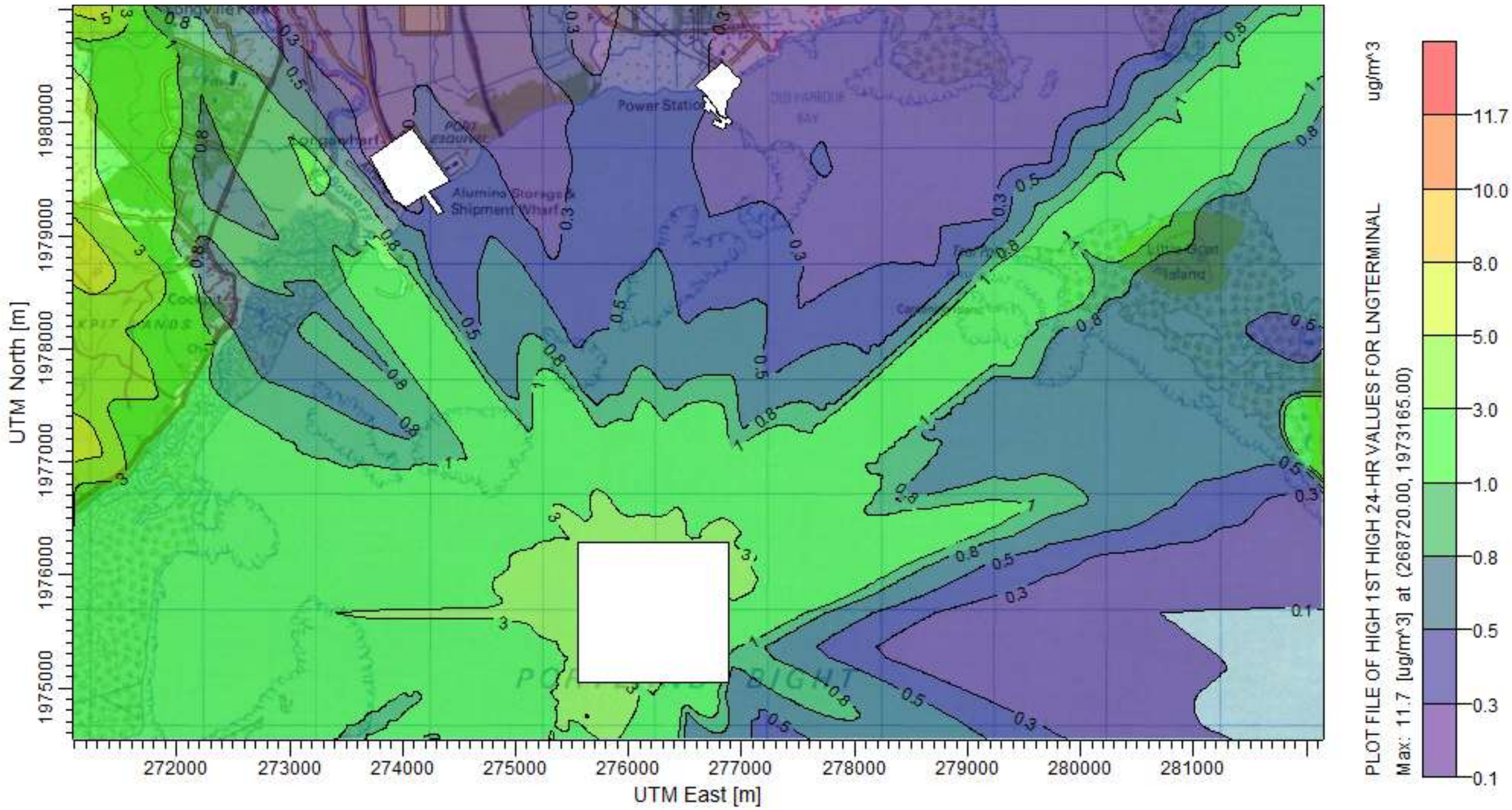


Figure 7-12 Predicted 24h NO2 Concentrations – Proposed LNG Terminal

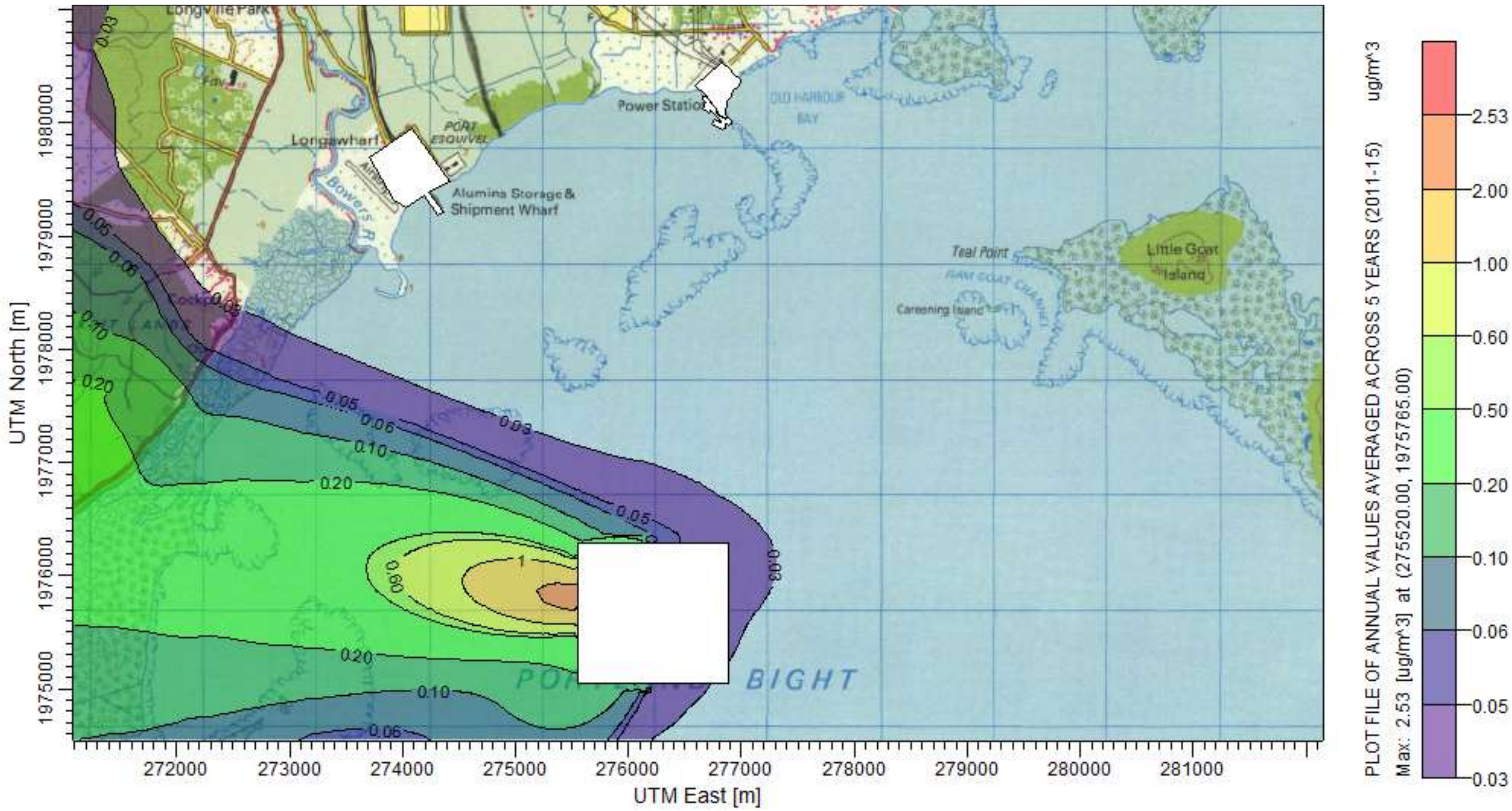


Figure 7-13 Predicted Annual NO2 Concentrations – Proposed LNG Terminal

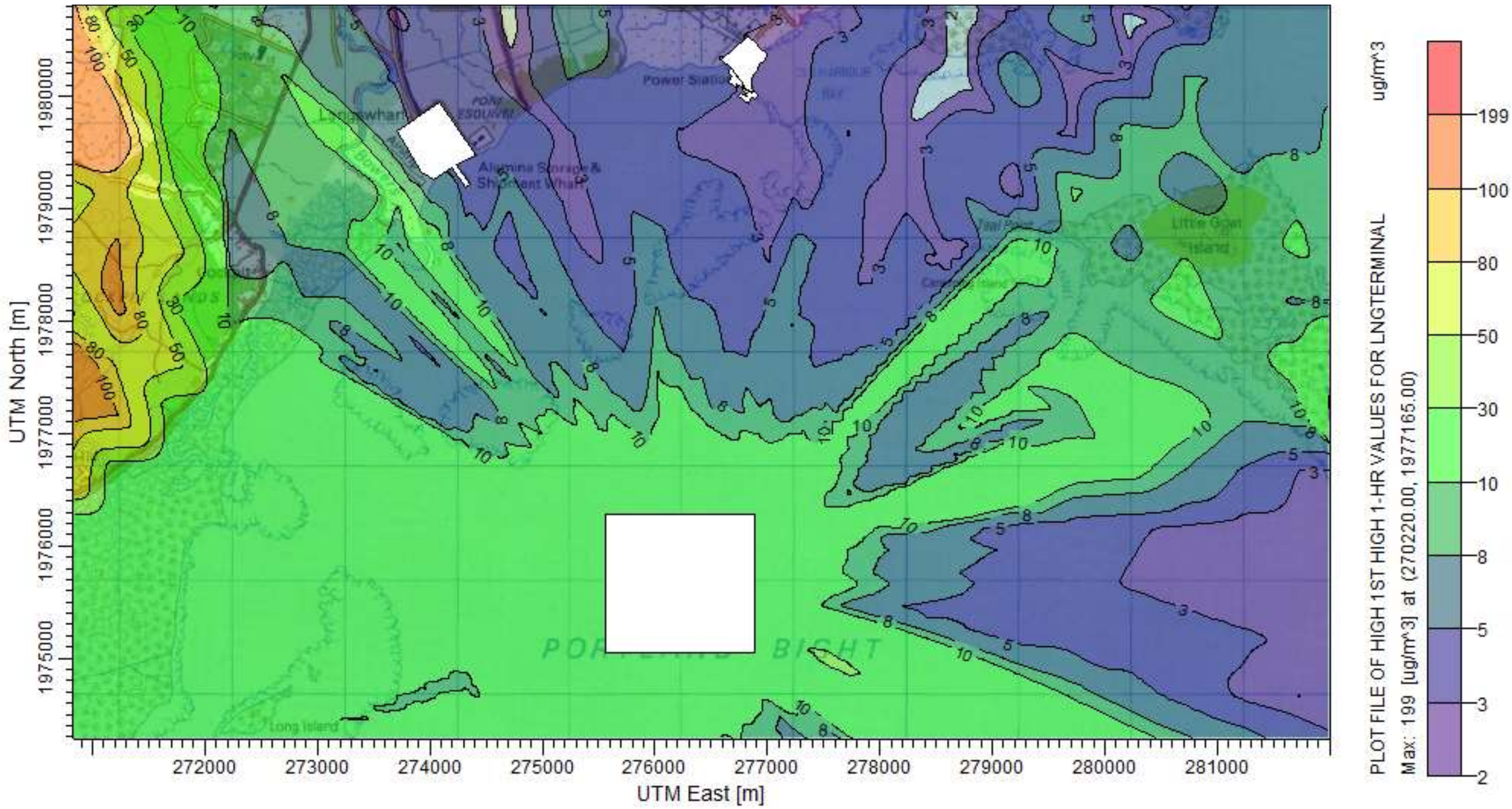


Figure 7-14 Predicted 1h CO Concentrations – Proposed LNG Terminal

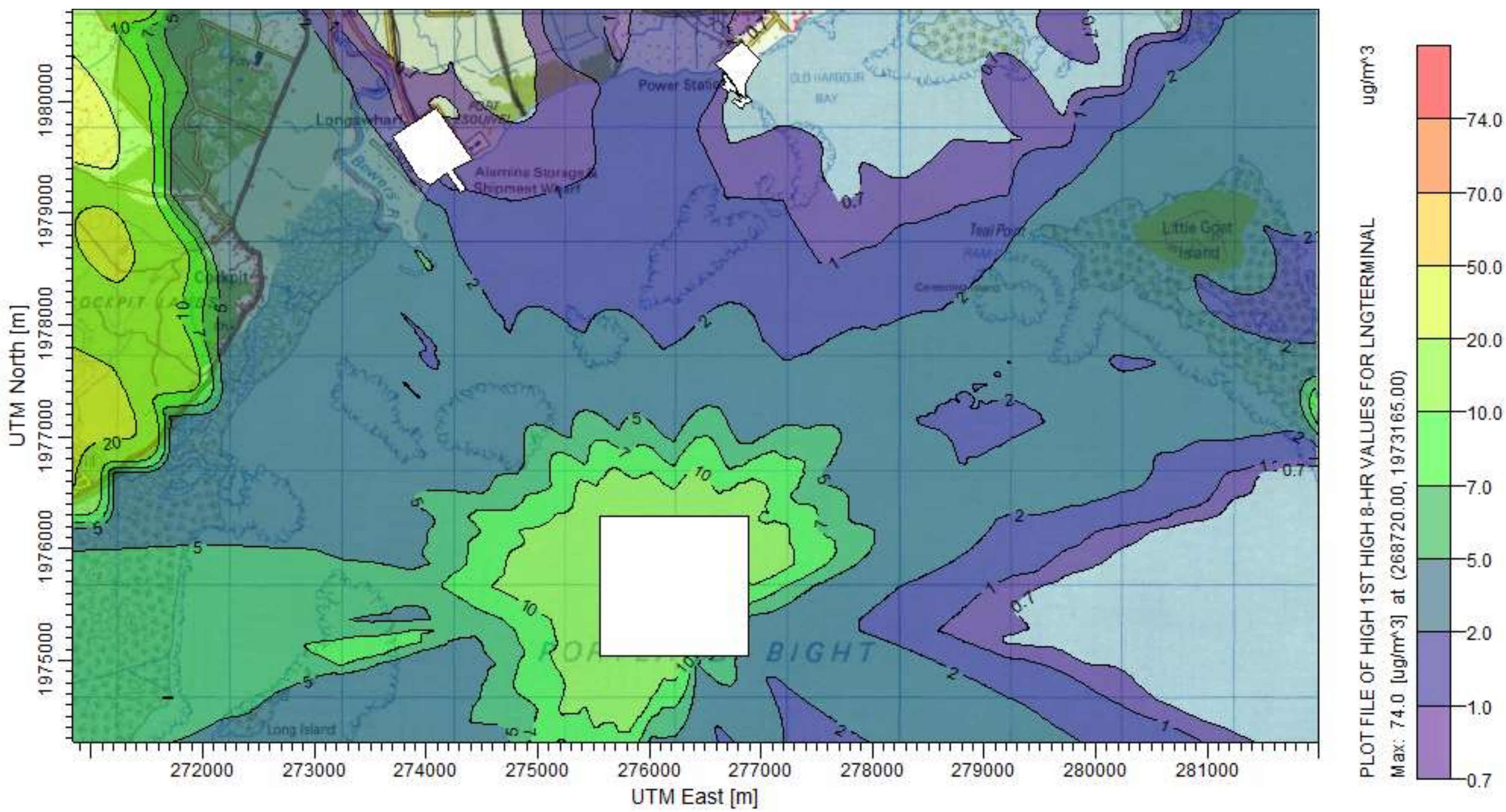


Figure 7-15 Predicted 8h CO Concentrations – Proposed LNG Terminal

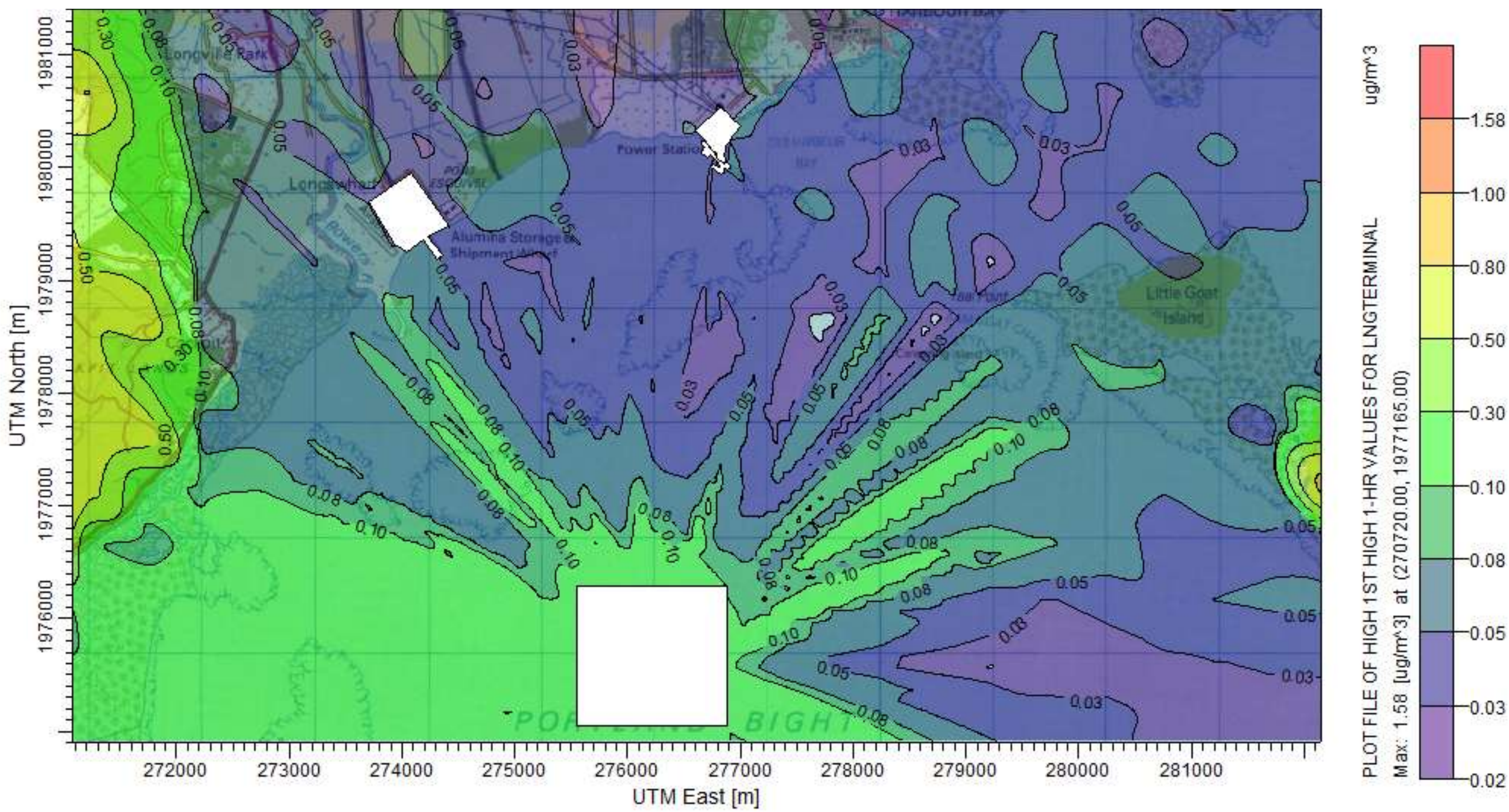


Figure 7-16 Predicted 1h SO2 Concentrations – Proposed LNG Terminal

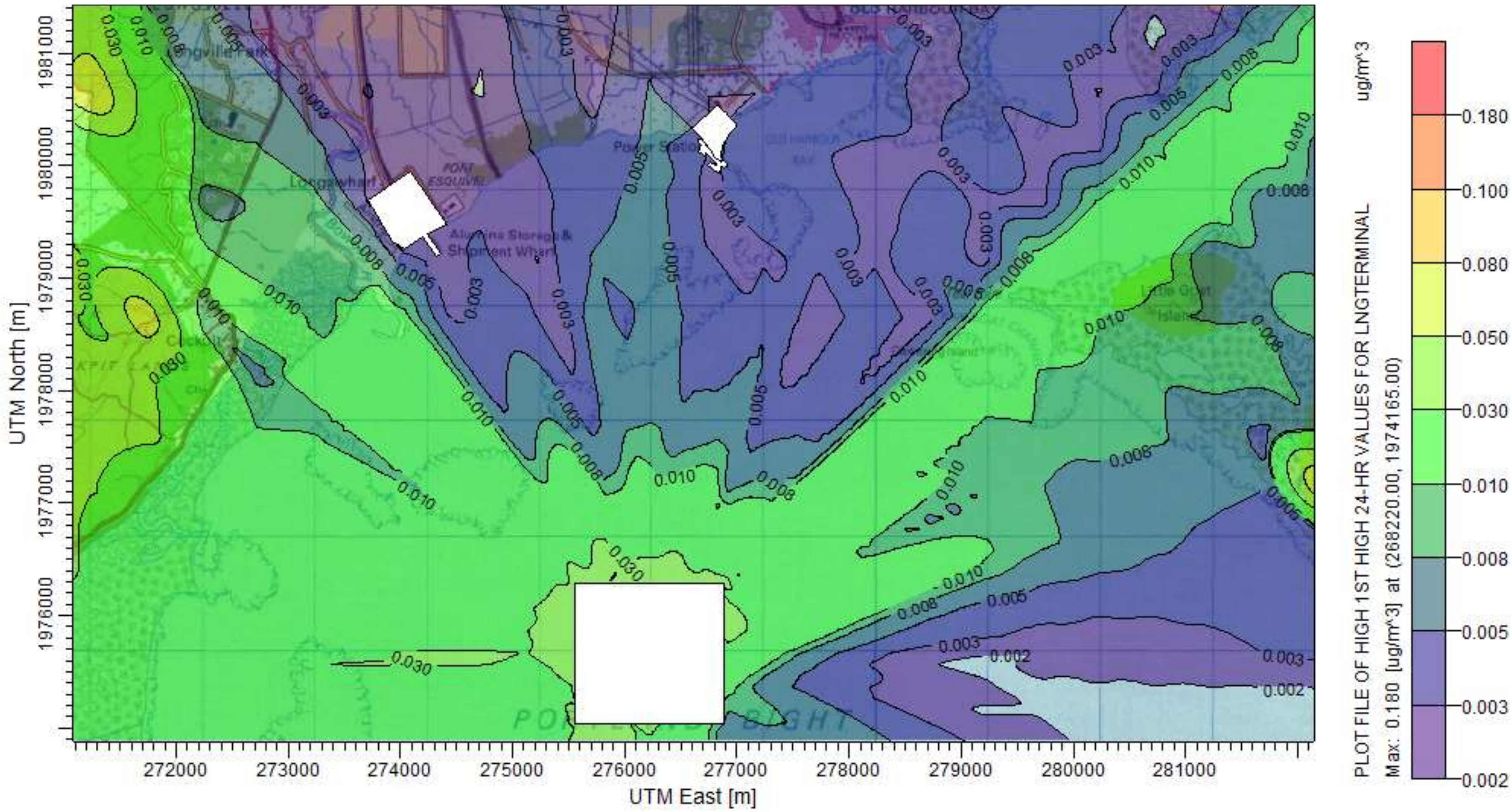


Figure 7-17 Predicted 24h SO2 Concentrations – Proposed LNG Terminal

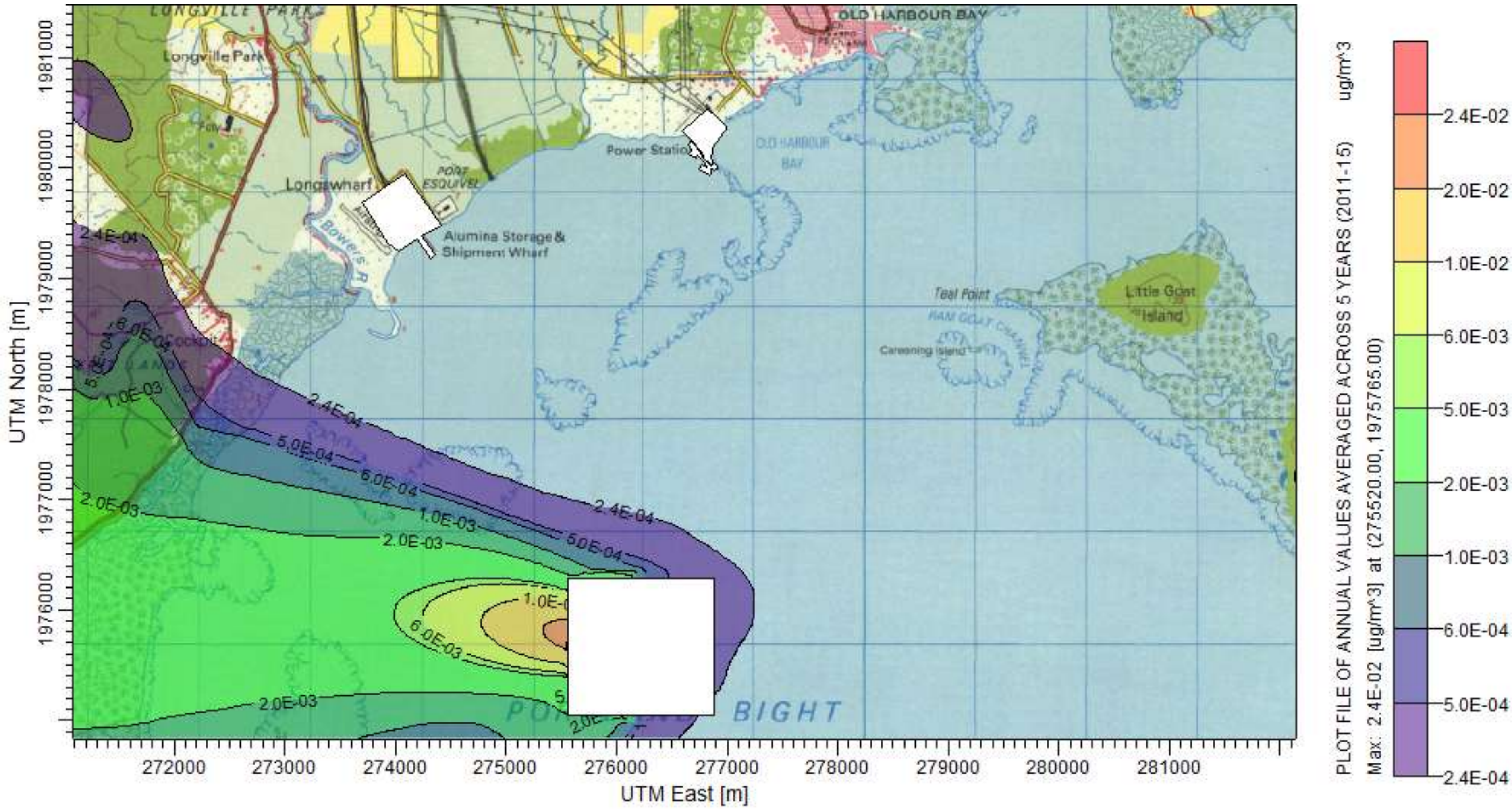


Figure 7-18 Predicted Annual SO2 Concentrations – Proposed LNG Terminal

7.2.2 Biological

7.2.2.1 Lighting

Lights will be placed on the platform as a security feature so as to prevent other marine vessels from collision during night time or low visibility situations. Some amount of lighting will also be present by the onshore metering facility. Lighting may have the potential to interfere with navigation of some marine species. These should be avoided where possible and lighting should be of low intensity.

Operational activities and associated noise on land and in the nearshore environment may disrupt or even prevent activities such as nesting. Although turtles have been known to historically utilize nearby beaches, the project area has had no document turtle nesting or activity in several years. Crocodiles have been document utilizing the coastal areas of the project for feeding, foraging and nesting.

RECOMMENDED MITIGATION

I. Lighting on the offshore platform should be minimal and only placed where necessary and should be of low intensity.
II. Fixtures should have low wattage (i.e. 450 lumens or less) "bug" type bulbs and non-reflective interior surfaces.
III. Fixtures mounted as low in elevation as possible through use of low-mounted wall fixtures, low bollards and ground level fixtures.
IV. For high intensity lighting applications such as providing security and similar applications shielded low-pressure sodium vapour lamps and fixtures shall be used.
V. No lights should be pointed out to sea or illuminate sections of the beach so as to cause confusion and disorientation of turtles or any other species that maybe affected by lunar activity.
VI. Floodlights, up-lights or spotlights for decorative and accent purposes that are directly visible from the beach or which indirectly or cumulatively illuminate the beach shall not be used.
VII. Staff will be sensitized about the sensitive species in the area. Special precautions will taken during turtle nesting season, this will include logging and reporting of all turtle sighings to the Agency.

7.2.2.2 Cooling Water System

Seawater cooling has been used in more than 50% of the LNG plants built since the 1960s (Birtwell, 2001). This is primarily attributed to the fact that use of seawater is more efficient, less expensive, and generates less noise than air cooling or other mechanical means of cooling.

LNG effluent discharges have been studied in a number of sites in British Columbia. In an LNG facility in Howe Sound near Squamish, BC, it was found that because of diffuser design and dissipation of heat as distance increases from the source, total volume of water with temperatures between 1-10 C around surrounding waters are expected to occur in an area less than 125 cubic meters (approximately 1/20th the volume of an Olympic sized swimming pool) (Woodfibre LNG Limited and Hemmeria Envirochem, Inc 2015). Intake velocities were less than 0.1 m/sec, which was less that the swimming speed of adult fish (Woodfibre LNG Limited and Hemmer Envirochem, Inc 2015). Within

10 m of the diffusers, water temperatures were found to be less than 1°C different than surrounding area temperatures, suggesting no impacts on local marine life.

Similar water quality studies were undertaken at an LNG facility at the Burrard Generator Station in Port Moody, BC. Studies suggest neglible effects from operations of the once-through cooling system on salmon, and inconsequential effects on phytoplankton (Birtwell, 2001) . Effects appears to be largely negated by tidal mixing. Although these studies were conducted in cold water environments, the information remains relevant to addressing thermal effects at the Old Harbour project.

The Old harbour benthic community may be minimal affected as a result of; The intake system and the discharge of water below ambient temperatures.

The intake system which may take in some amount of plankton(phytoplankton and zooplankton including fish eggs and larvae) and other organisms which are smaller than the intake filter mesh. The intake velocities are expected to be less than 0.1 m/sec, which was less that the swimming speed of adult fish (Environchem, 2015). Studies of other power plants have suggested that the loss of fish eggs and larvae as a result of both the intake system as well as the cooling system should be minimal on the fish stocks as these planktonic stages have a high natural mortality rate (Gasparini, 1983). The loss of plankton (the base of the fish food web) is also expected to be minimal and as a result have a minimal impact on the existing system.

The effluent discharged is expected to be of a lower temperature than the ambient surroundings and may also cause changes in wave action and currents resulting in the farfield dispersion of this thermal effluent. The model suggests that at the 100m extents, the temperature of the effluent will be less than 2°C below the ambient temperature of the sub-surface waters and as such the impacts on the benthic community is expected to be minimal. The model shows that cold water will mix and return to ambient temperatures before influencing any sensitive coral or seagrass community in the area. Fish may avoid cold water areas while some plankton loss may occur as a result of the cold water. The effect of the cold water on the fish and plnakon community is expected to be minimal.

RECOMMENDED MITIGATION

i. Once the effluent temperature adheres to the standards prescribed by the statutory authorities (NEPA, EPA, World Bank), no specific management measures will be required. Salinity changes are expected to be within 38 ppt, hence impact of salinity and temperature on the marine biota is expected to be minimal.
ii. However, it is recommended that good practices be implemented for inlet and outfall management in order to protect the marine environment.

7.2.3 Human/ Social

7.2.3.1 Maritime Operations

With the presence of marine vessels associated with offshore LNG platform as well as the LNG platform itself, exists the potential for accidents with other marine vessels in the area as well as interruption of fishing activity.

RECOMMENDED MITIGATION

There will be a marine security zone of 500 meters enforced around the off-shore mooring facility and clearly marked with buoys where boat access will be restricted and strictly controlled for safety reasons. In addition, there will be a hazard zone of 1000 meters from the platform where shipping will be restricted as clearly marked by additional buoys. The 500m security zone will be enforced using patrol and safety boats. When an LNCG is at the terminal the tug will additionally assist with the enforcement of the safety zone. The safety zone will be published and broadcast as a notice to mariners. No vessel will be permitted to enter the zone without authorization from the Terminal Operators.

Due to usage of the area by fishers and concerns expressed during stakeholder consultation, we are willing to reduce the 500m restricted/exclusion zone to 200m so as to accommodate the local fisherfolk only.

The terminal will be lighted per the Illuminating Engineer Society (IES) recommendations and applicable Occupational Safety and Health Administration (OSHA) standards. The platform lighting will utilize high efficiency LED lighting, minimizing power consumption. Design considerations will be taken to reduce the risk of light pollution such as unwanted spill lighting and sky glow.

7.2.3.2 Employment

Approximately 40 workers will be needed to permanently operate the facility (on-shore and off-shore). These positions will likely be a mix of off and on-island individuals. The staff needed to operate the facility will need to be highly trained in order to safely operate the facility but these positions will be available to on-island individuals after sufficient training. Therefore, the operation of the facility will provide an additional source of jobs and has the potential to be a significant positive impact.

RECOMMENDED MITIGATION

No mitigation required.

Solid Waste

It is expected that solid waste will be generated by the facility, at both the platform and on board the ships. The facility may periodically generate hazardous waste (typically less than 100 kilograms per month), including spent solvents, chemical cleaning wastes, and other wastes.

RECOMMENDED MITIGATION

Any domestic (non-hazardous) garbage from the ship will be collected and taken to shore for proper disposal. All food waste which is from locally obtained produce will also be collected and taken to shore for proper disposal. Hazardous waste will be managed according to applicable rules and regulations.

Wastewater

Sewage and wastewater loads will be minimal for the on-shore facility and offshore platform.

RECOMMENDED MITIGATION

Domestic wastewater from the on shore terminal control room will be collected in a septic tank and drain field to be constructed within the boundaries of the plant.

The facility will not result in the generation of process wastewater. The regasification process will utilize seawater which will result in the discharge of cooled water into the sea near the mooring facility using a mixing process to ensure that there is no more than 5^{o} C change in temperature. This effect will be carefully modelled and monitored to ensure that there are no negative effects on marine life in the vicinity.

There will be no effluent discharge from the FSU. Effluent is treated onboard in a three stage process and the effluent and waste will be collected by a waste handling company to discharge in accordance with MARPOL Requirements. The waste handling company is responsible for the handling and final disposal of the wastes and providing the Ship's Agent with a disposal certificate.

The following additional parameters will assist in avoiding pollution:

1. No oil or mixture containing oil shall be discharged or allowed to escape from a vessel while at the terminal.
2. No garbage or other materials, either liquid or solid, shall be discharged overboard from a vessel, but shall be retained in suitable receptacles on board for proper disposal on land.

7.2.4 Carrying Capacity

Carrying capacity refers to the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural, social, cultural and economic environment for present and future generations.

7.2.4.1 Social Environment

Currently, the use of fossil fuels has artificially increased the carrying capacity of the world by the use of stored sunlight, albeit at many other expenses. This proposed project plans to supply natural gas to the newly permitted JPS190 MW plant. This will lower the amount of greenhouse gases emitted compared with the existing JPSCo Old Harbour plant (to be decommissioned). The lowering of the emissions means that the contribution to global warming is reduced and therefore contributes to the reduction in the increase in sea level rise, thereby reducing the potential negative impact on the coastline of Jamaica and more specifically Old Harbour Bay and even more specific the site of the proposed plant.

Sewage and wastewater loads will be minimal for the on-shore facility. Domestic wastewater from the terminal control room will be collected in a septic tank and drain field to be constructed within the boundaries of the plant and therefore will not be dependent on existing systems within the SIA. Solid waste will be collected by private contractors and will be disposed of at an approved waste disposal facility. Any domestic (non-hazardous) garbage from the ship will be collected and taken to shore for proper disposal. This will not impact on solid waste collection or disposal in the SIA.

Traffic to and from the onshore metering facility will be minimal and there will be no net increase in vehicular traffic (possibly a decrease) as the existing JPSCo Old Harbour plant will be closed after the commissioning of the new 190 MW LNG plant and the vehicular traffic diverted to the new plant site.

The proposed power plant will have its own firefighting facility. It will be equipped with fire tanks, water pumps, hoses, extinguishers, etc. Firewater pumps will supply seawater from the ocean as the influent. Firewater monitors and hydrants will be located on the offshore facility as well as the onshore metering facility. Therefore, it will be able to deal with any eventualities as it relates to fires on the facility.

It is anticipated that proposed project will not negatively impact the social carrying capacity of the area.

7.2.4.2 Natural Environment

In ecological terms, the carrying capacity of an ecosystem is the size of the population that can be supported indefinitely upon the available resources and services of that ecosystem (Sustainable Measures, 2016).

The various ecosystems identified in the proposed project area heavily modified and continue to be shaped by going stresses both natural and anthropogenic. The terrestrial ecosystems potentially impacted area areas modified savannah lands where actual hard structures will be placed. The vegetation here is limited and the number of both resident and migratory animals seen in this area was also low. The proposed project should improve the quality of the airshed. Potential impact on species here should be minimal and as such not exceed the ability of the remaining terrestrial systems from providing sufficient ecological resources for both migrant and resident species.

The marine ecosystems in the proposed off shore project area are also heavily modified. Sensitive ecosystems such as coral reefs and seagrass beds are not expected to be influenced by the project. Loss of food some small fish and plankton into the cooling system is expected, as these have a naturally high mortality rate, the project is not expected to heavily impact on the carrying capacity of the existing marine environment. That is the anticipated species loss as a result of the project should have a minimal impact on existing carrying capacity. The introduction of hard structures (pilings and other features on the seafloor and in the water column) are also expected to increase the ecological volume in this area which has little to no relief. The off shore platform facility will act as a Fish Aggregation Devices (FAD) as well as provide substrate for colonization of benthic species. This may even act to provide additional resources and diversity to the ecosystem and as such increase the carry capacity in the proposed area.

7.3 LNG SPECIFIC IMPACTS AND MITIGATION

International standards and guidelines will be used primarily during both the construction and operational phases of the project. These standards and guidelines include identification of potential impacts and suggested mitigation for the biological and physical environment as well as general occupational health and safety. IFC Environmental Health and Safety (EHS) Guidelines are used for technical reference with general and industry-specific examples of Good International Industry Practice (GIIP). The EHS Guidelines contain the performance levels and measures that are normally acceptable to the IFC and that are generally considered to be achievable in new facilities at reasonable costs by existing technology.

IFC Environmental Health and Safety (EHS) Guidelines specific to this proposed project include:

1. **EHS Guidelines for Liquefied Natural Gas (LNG) Facilities** – include information relevant to LNG base load liquefaction plants, transport by sea, and regasification and peak shaving terminals. Coastal LNG facilities including harbours, jetties and in general coastal facilities (e.g. coastal terminals marine supply bases, loading / offloading terminals).
2. **EHS Guidelines for Gas Distribution Systems** – include information relevant to the distribution of low pressure natural gas from the city gate to residential, commercial, and industrial users.
3. **EHS Guidelines for Ports, Harbours and Terminals –** applicable to commercial ports, harbours and terminals for cargo and passenger transfer, as well as vessel maintenance.
4. **EHS Guidelines for Shipping –** include information relevant to the operation and maintenance of ships used for the transport of bulk cargo and goods.
5. **EHS Guidelines for Crude Oil and Petroleum Product Terminals** – include information relevant to land and shore-based petroleum storage terminals receiving and dispatching bulk shipments of crude oil, gasoline, middle distillates, aviation gas, lube oil, residual fuel oil, compressed natural gas (CNG), liquid petroleum gas (LPG), and specialty products from pipelines, tankers, railcars, and trucks for subsequent commercial distribution.
6. **EHS Guidelines for Electric Power Transmission and Distribution** – include information relevant to power transmission between a generation facility and a substation located within an electricity grid, in addition to power distribution from a substation to consumers located in residential, commercial, and industrial areas.
7. **EHS Guidelines for Thermal Power Plants** – includes information relevant to combustion processes fuelled by gaseous, liquid and solid fossil fuels and biomass and designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type (except for solid waste which is covered under a separate Guideline for Waste Management Facilities).

These industry sector EHS Guidelines listed above, are designed to be used together with the **IFC General EHS Guidelines** which provides guidance to users on common EHS issues potentially applicable to all industry sectors. Table 7-39 show how the General EHS Guidelines are organized.

Table 7-39 Organization of IFC General EHS Guidelines

1. Environmental
1.1 Air Emissions and Ambient Air Quality
1.2 Energy Conservation
1.3 Wastewater and Ambient Water Quality
1.4 Water Conservation
1.5 Hazardous Materials Management
1.6 Waste Management
1.7 Noise
1.8 Contaminated Land
2. Occupational Health and Safety
2.1 General Facility Design and Operation
2.2 Communication and Training
2.3 Physical Hazards
2.4 Chemical Hazards
2.5 Biological Hazards
2.6 Radiological Hazards
2.7 Personal Protective Equipment (PPE)
2.8 Special Hazard Environments
2.9 Monitoring
3. Community Health and Safety
3.1 Water Quality and Availability
3.2 Structural Safety of Project Infrastructure
3.3 Life and Fire Safety (L&FS)
3.4 Traffic Safety
3.5 Transport of Hazardous Materials
3.6 Disease Prevention
3.7 Emergency Preparedness and Response
4. Construction and Decommissioning
4.1 Environment
4.2 Occupational Health & Safety
4.3 Community Health & Safety

Potential environmental, health and safety issues associated with LNG facilities include the following and are discussed further in subsequent sections:

- Threats to the marine environment, shoreline and terrestrial habitats
- Hazardous material management
- Wastewater
- Air emissions
- Waste management
- Noise
- LNG transport

7.3.1 Marine Environment, Shoreline and Terrestrial Habitats

Potential impacts to the marine environment and shoreline during construction include; trenching for of pipelines and pile driving for the offshore facility. Direct impacts may include smothering of sensisitive species/systems; reduced water quality (suspended sediments and increased turbidity). The discharge of ballast water and sediment from ships during LNG terminal loading operations may result in the introduction of invasive species. Temporary habitat fragmentation or species displacement may occur during construction activities in both the marine and terrestrial environments.

7.3.1.1 Recommended Mitigation - International Guidelines

For LNG facilities located near the coast (e.g. coastal terminals marine supply bases, loading / offloading terminals), guidance for protecting marine and shoreline environments is provided in the IFC EHS Guidelines for Ports, Harbours, and Terminals, which includes the use of siltscreens. Ballast water from international ships should not be discharged in the neashroe environment. This should be monoitored by the facility as well as marine police and coast guard patrols. This should reduce the risk of a species introduction.

7.3.1.2 Recommended Mitigation - Overall Design Considerations

It is important to design an LNG facility that will protect the public from a credible, major release or incident. The following provides an outline of the design concepts and elements:

- Each landed storage tank is surrounded by a bund which is designed to contain at least 110% of the storage tank capacity (not applicable to floating storage.
- Areas outside the bund are provided with drainage and catch basins which will contain any LNG release from the process area.
- The LNG tanks have no penetrations above the maximum liquid levels such that the only way LNG can leave the tank is to be pumped out or to have a collapse of the tank integrity.
- There must be an extensive hazard detection system and continuous monitoring from the control room.
- There will be an emergency shutdown system which will secure the facility in case a hazardous event occurs.

7.3.2 Cryogenic Impacts in the Biological Environment

Negative long-term environmental impact from an LNG release is virtually non-existent. LNG is colourless, odourless, non-toxic and leaves no residue after evaporation. LNG and LNG vapour are not soluble in water, therefore ruling out water contamination. Potential damage to environmental and socio-economic components is limited to short-term hazards to flora, fauna and humans in the immediate vicinity of the release. For example, any fish in the immediate vicinity (a few hundred meters) of an LNG ship release would unlikely be frozen or otherwise harmed as any freezing of the water would be at the surface of the water. The ice will soon melt and the environment will return to normal with no residual trace of the incident. Likewise, any animals or birds within the vapour dispersion or thermal radiation range caused by a release could be immediately harmed or killed. Immediately after an LNG release, the area would be suitable for animals and humans to use again. Local population and property should sustain no long-term effects from an accidental LNG release.

7.3.2.1 Recommended Mitigation - Pipeline Placement

Pipelines should be placed in areas with little to no sensitive systems such as; seagrass beds, patch reefs, mangroves or other rare or endemic species, where possible. If pipelines must be placed through these ecosystems, then some sort of relocation or rehabilitation mitigation plan must be included.

7.3.3 Hazardous Material Management

LNG is a highly flammable material (due to its characteristic boil-off-gas-BOG) - as a result the storage, transport and transfer of LNG poses risks of fires and explosions. Storage, transport and transfer of LNG may result in leaks or accidental release from tanks, pipes, hoses, and pumps at land installations and on LNG transport vessels into the marine environment.

7.3.3.1 Recommended Mitigation - General Construction and Maintenance

- LNG storage tanks and components should meet international standards for structural design integrity and operational performance. Applicable international standards may include provisions for Overfill protection, Secondary containment, Metering and flow control,
- Fire protection (including flame arresting devices),
- Grounding (to prevent electrostatic charge).
- Storage tanks and components should undergo periodic inspection for corrosion and structural integrity and be subject to regular maintenance and replacement of equipment.
- A cathodic protection system should be installed to prevent or minimize corrosion, as necessary.
- Loading / unloading activities should be conducted by properly trained personnel according to pre-established formal procedures to prevent accidental releases and fire / explosion hazards. Procedures should include all aspects of the delivery or loading operation from arrival to departure, connection of grounding systems, verification of proper hose connection and disconnection.
- Adherence to no-smoking and no-naked light policies for personnel and visitors

7.3.3.2 Recommended Mitigation - Spills

A formal spill prevention and control plan should be developed in coordination with local regulatory agencies that addresses significant scenarios and magnitude of releases. The plan should be supported by the necessary resources and training. Spill response equipment should be conveniently available to address all types of spills, including small spills.

The facility should be equipped with a system for the early detection of gas releases, designed to identify the existence of a gas release and to help pinpoint its source so that operator-initiated ESDs can be rapidly activated, thereby minimizing the inventory of gas releases.

- An Emergency Shutdown and Detection (ESD/D) system should be available to initiate automatic transfer shutdown actions in case of a significant LNG leak;

- For unloading / loading activities involving marine vessels and terminals, preparing and implementing spill prevention procedures for tanker loading and off-loading according to applicable international standards and guidelines which specifically address advance communications and planning with the receiving terminal;
- Onshore storage tanks should be designed with adequate secondary containment. Facilities should provide grading, drainage, or impoundment able to contain the largest total quantity of flammable liquid that could be released from a single transfer in 10 minutes.
- Material selection for piping and equipment that can be exposed to cryogenic temperatures should follow international design standards;

7.3.4 External Fires

The possibility of an LNG release/fire caused by external events, such as a forest fires or adjacent oil storage fire is extremely remote because the facility is built from non-combustible materials, mostly steel and concrete. All components containing LNG are alloy/steel externally insulated. The safety zones also work to isolate the facility and prevent an external fire from threatening the facility. Storage tanks would be protected by the impoundment bund which would serve as a firebreak around the tank and process area. Furthermore, the facility should be equipped with an extensive firefighting system, which can be used to protect the facility from an external fire. The facility should also be designed to contain vapour dispersion and thermal radiation within its boundaries.

7.3.5 Flammable Vapour Dispersion

The primary hazard from the storage and handling of LNG is the possibility of a fire from the ignition of LNG vapours mixed with air. The two limiting conditions are an LNG release with and without immediate ignition. If the ignition is immediate or relatively soon after the start of the release, the fire size is determined by the LNG release rate which fuels the fire. If the ignition is delayed, an LNG vapour cloud will develop and disperse as it expands and/or moves downwind. For ignition to occur, the concentration of vapour in the atmosphere must be between 5 and 15% by volume. At concentrations above 15%, which is the Upper Flammable Limit (UFL), there is not enough air to sustain combustion. At concentrations below 5%, which is the Lower Flammable Limit (LFL), there is not enough fuel to sustain combustion. Since the vapour concentration tends to decrease as the cloud is dispersed by the wind and mixes with air, the maximum extent of the area at risk of ignition is represented by the footprint of the lower flammable limit (5%). Following the vapour cloud ignition, the fire will progressively spread through the flammable cloud and eventually will burn back to the source – either a pressurized jet or a liquid pool, depending on the source of the LNG release.

7.3.5.1 Flammable Vapour Dispersion Modelling

Dispersion modelling has been completed to determine the flammable vapour hazard footprint for a hypothetical accidental release from the proposed LNG facility. The most common LNG safety standards – NFPA 59A and EN 1473 – do not apply to offshore LNG facilities, therefore, there are no established regulatory requirements on credible LNG spill scenarios to be modeled for offshore facilities.

The most appropriate reference for offshore LNG facilities is the report published by Sandia National Laboratories in 2004 (Hightower et al., 2004): in this report, various accidental scenarios are considered and their consequences estimated for generic conditions. The most severe accidental scenario identified in the Sandia study consists of the collision of a large vessel with the LNG carrier, resulting in the waterline breach of an LNG tank with an effective spill area of 0.5-1 m^2. This scenario has been modeled for the proposed LNG facility in Old Harbour.

In addition to the LNG spill from the collision of a large vessel with the LNG carrier, the project also modeled the consequences of a failure of one of the LNG transfer arms during the offloading of LNG from the LNG carrier to the floating storage unit. In this case, the release was assumed to occur at full unloading flow (for one arm) for a full minute, after which the emergency shutdown valves would stop the flow of LNG.

Table 7-40 provides more details on the two accidental LNG release scenarios considered for this study.

Table 7-40 Details on the two accidental LNG release scenarios

	Large vessel collision	**Transfer arm failure**
Breach	1 m^2 hole	16" diameter hole (estimated)
Release rate	Variable (starting at approximately 4,700 kg/s, decreasing to 0)	21,000 gal/hr = 9.4 kg/s
Release duration	Approximately 64 minutes	1 minute

The ambient conditions used for the vapour cloud dispersion modelling are consistent with regulatory requirements for onshore facilities:

- Average ambient temperature for the site = 26.7°C;
- Relative humidity = 50%;
- Wind speed = 2 m/s
- Wind direction: several, directed from sea to shore.

The vapour dispersion modelling was performed using the computational fluid dynamics tool FLACS, which has been thoroughly validated against experimental data and is approved by the U.S. Department of Transportation as a tool to model LNG vapor dispersion.[10] Figure 7-19 and Figure 7-20 show the 3D geometry model of the LNG facility and of the surrounding areas, as used for the vapour dispersion modelling.

[10] http://www.regulations.gov/#!docketDetail;D=PHMSA-2011-0101

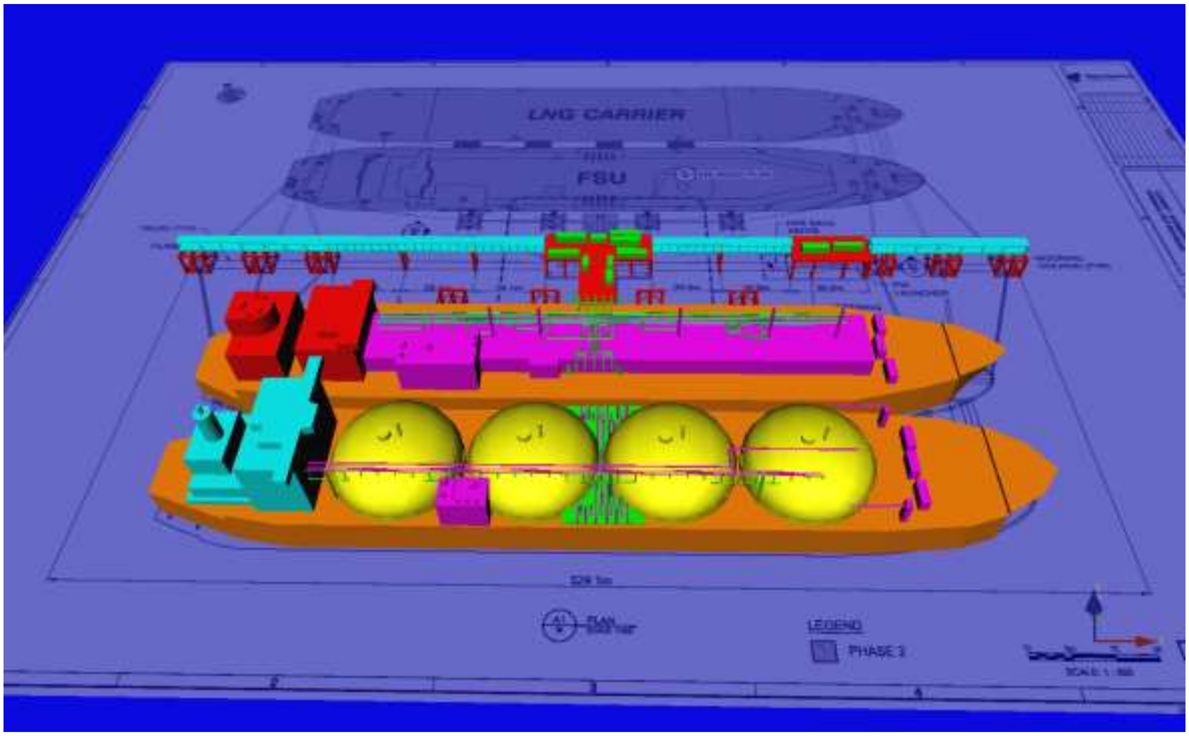


Figure 7-19 FLACS geometry model of the LNG facility.

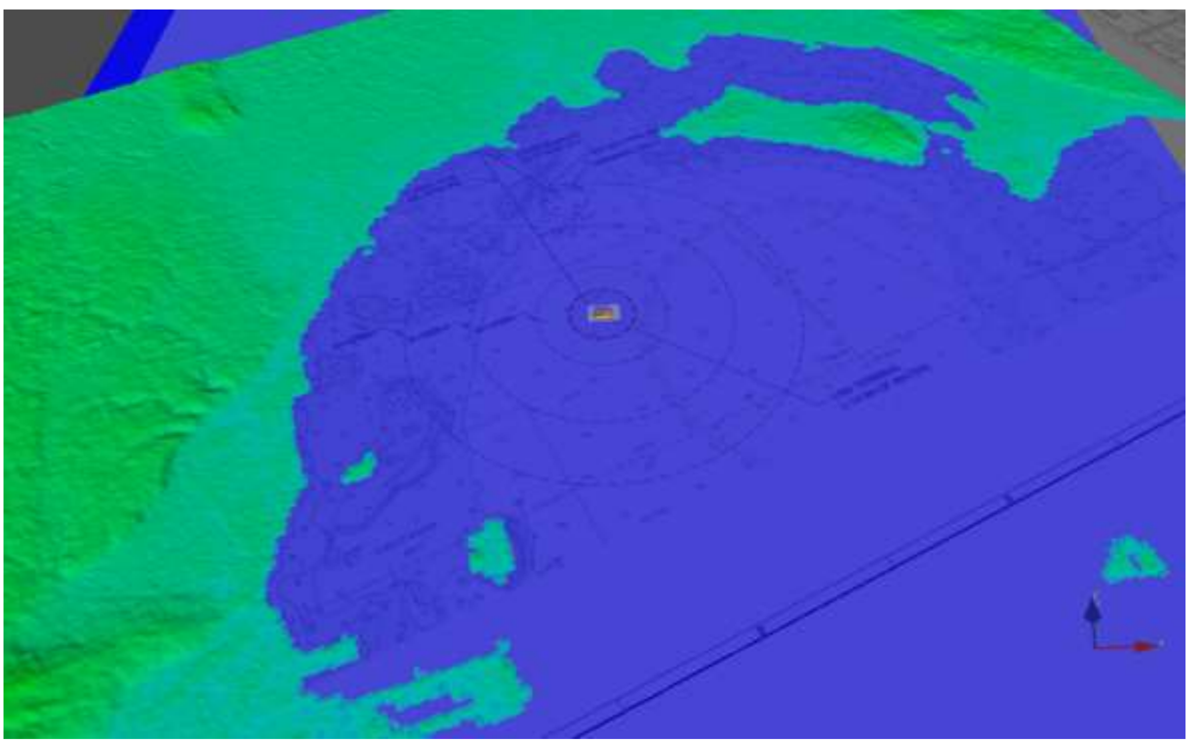


Figure 7-20 FLACS geometry model of the facility and surrounding areas.

7.3.5.2 Results

The results of the vapour dispersion modeling are shown in Figure 7-21 and Figure 7-22, respectively, for the LNG carrier breach and the unloading arm failure. The vapor cloud footprints show the maximum extent of the flammable cloud, at LFL (in yellow) and at 50%-LFL (in blue); even though the LFL is the physical limit below which ignition is not possible, the 50%-LFL threshold is typically considered for regulator purposes in order to allow for modeling uncertainties. The figures show that the flammable vapor cloud for both release scenarios dissipates below 50%-LFL before reaching the shoreline.

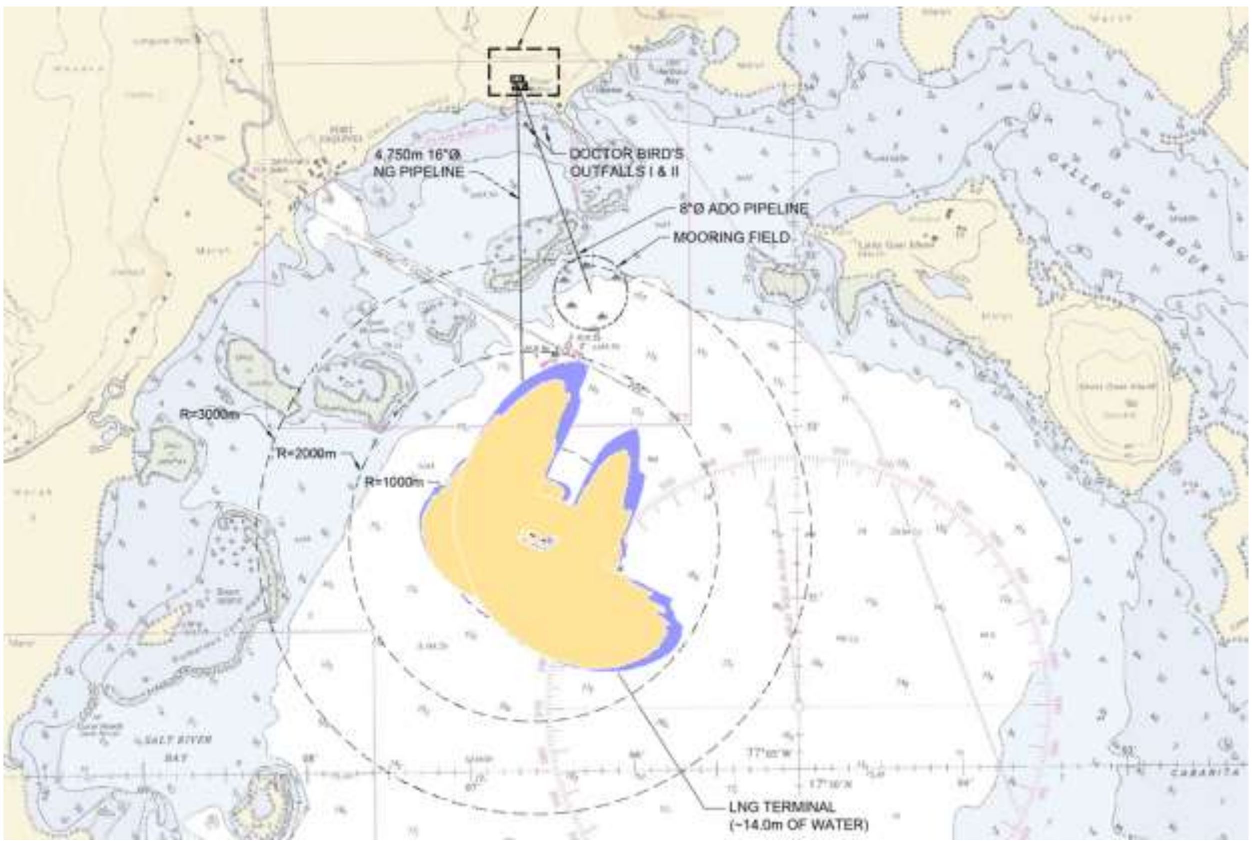


Figure 7-21 Vapour dispersion hazard footprint LFL (yellow) and 50%-LFL (blue) for LNG carrier breach scenario.

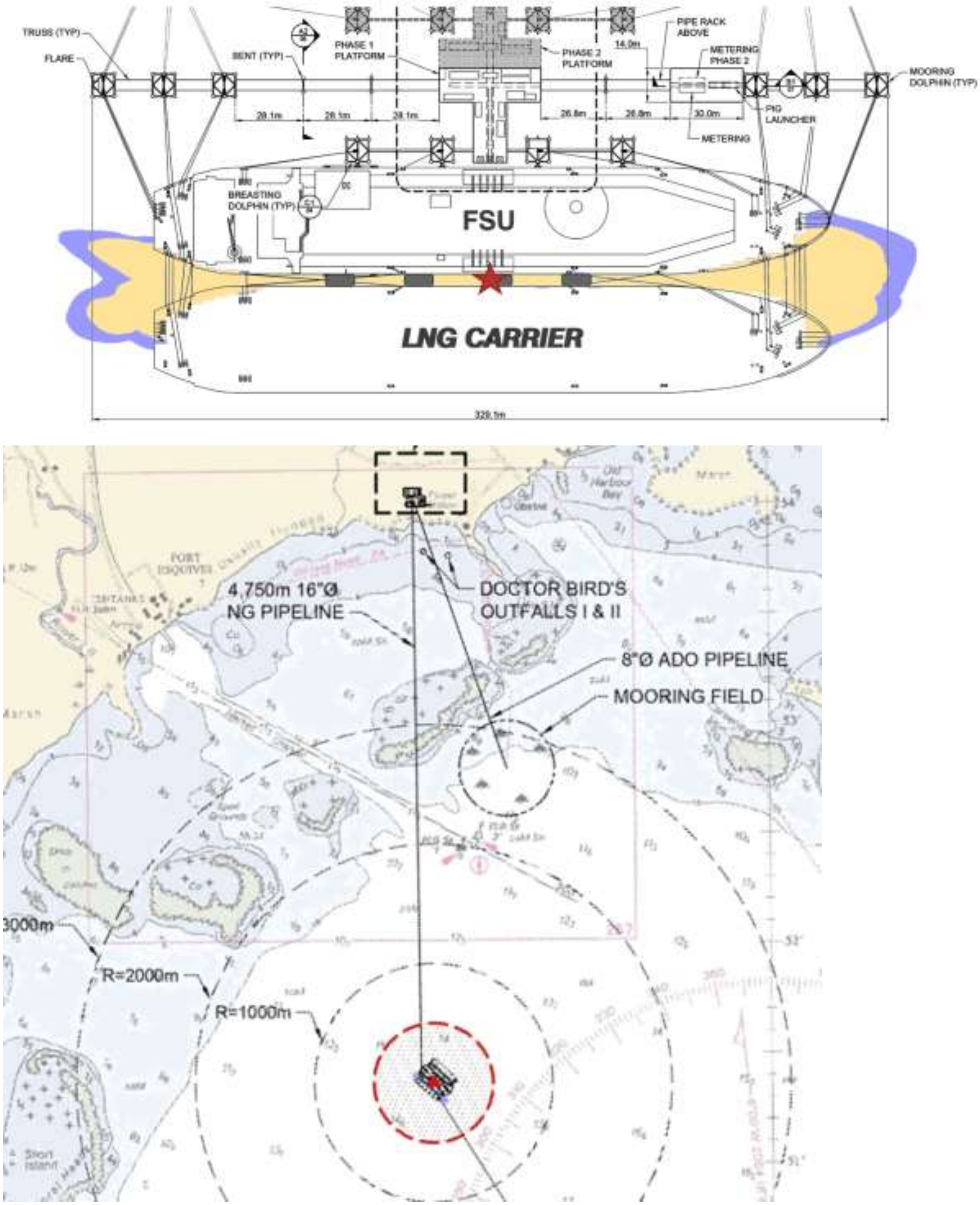


Figure 7-22 Vapour dispersion hazard footprint to LFL (yellow) and 50%-LFL (blue) for unloading arm failure scenario: close view (top) and view relative to the shoreline (bottom).

7.3.6 Thermal Radiation

If the vapours from an LNG spills such as described above are ignited close to the source, a pool fire will ensue on top of the liquid pool. Since an LNG pool over water is unconfined, its size will change over time and therefore the size of the fire (and the distance at which thermal radiation hazards can extend) also varies over time. For the purpose of this study, the thermal radiation hazards were calculated considering the largest size reached by the LNG pool during the spill scenario. This is a very conservative assumption, because: 1) it does not take into account the reduced fire size as the pool grows to and shrinks from its largest size; 2) it neglects the fact that the pool would not grow as large when ignited, because of the higher evaporation rate induced by the fire.

The ambient conditions for the thermal radiation calculations are estimatd as follows:

- Minimum temperature for the site = 21.1^{o}C;
- Relative humidity = 40%;
- Wind speed = 11.1 m/s (25 mph)

The hazard threshold for public exposure to a fire is set to 5 kW/m^2 in the most widely used LNG standards (e.g., NFPA 59A), therefore, the same threshold was used in this study. The thermal radiation hazard footprint was calculated using LNGFIRE3, which is the required model for pool fire calculations in NFPA 59A.

The thermal radiation distances to 5 kW/m^2 were calculated to be approximately 563.5 m and 50.9 m, respectively, for pool fires from the LNG carrier breach and the unloading arm failure. Figure 7-23 and Figure 7-24 show the results graphically, overlaid upon the facility plot plan; the figures show that the thermal radiation hazard area does not extend to the shoreline.

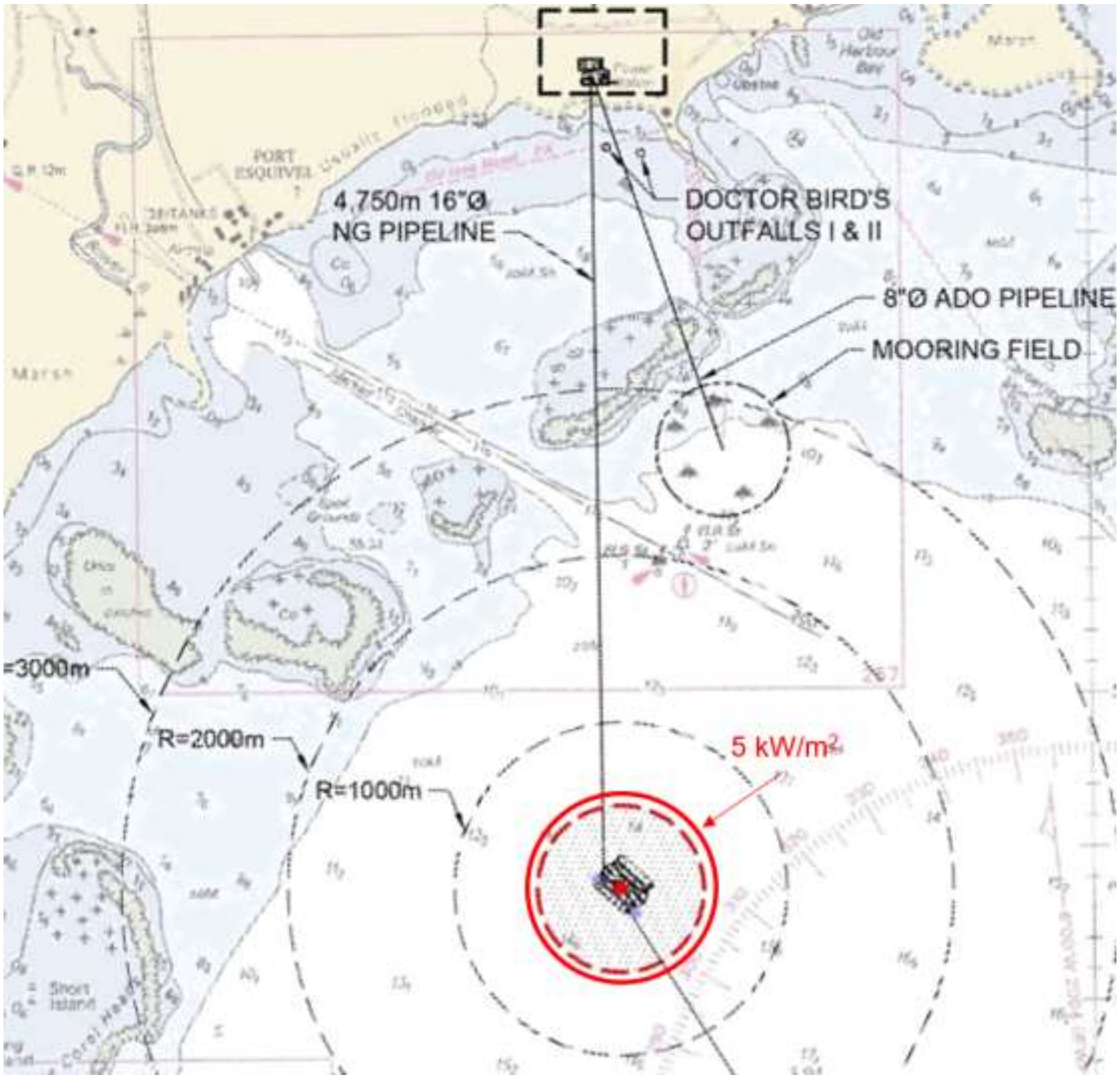


Figure 7-23 Thermal radiation hazard footprint for LNG carrier breach scenario.

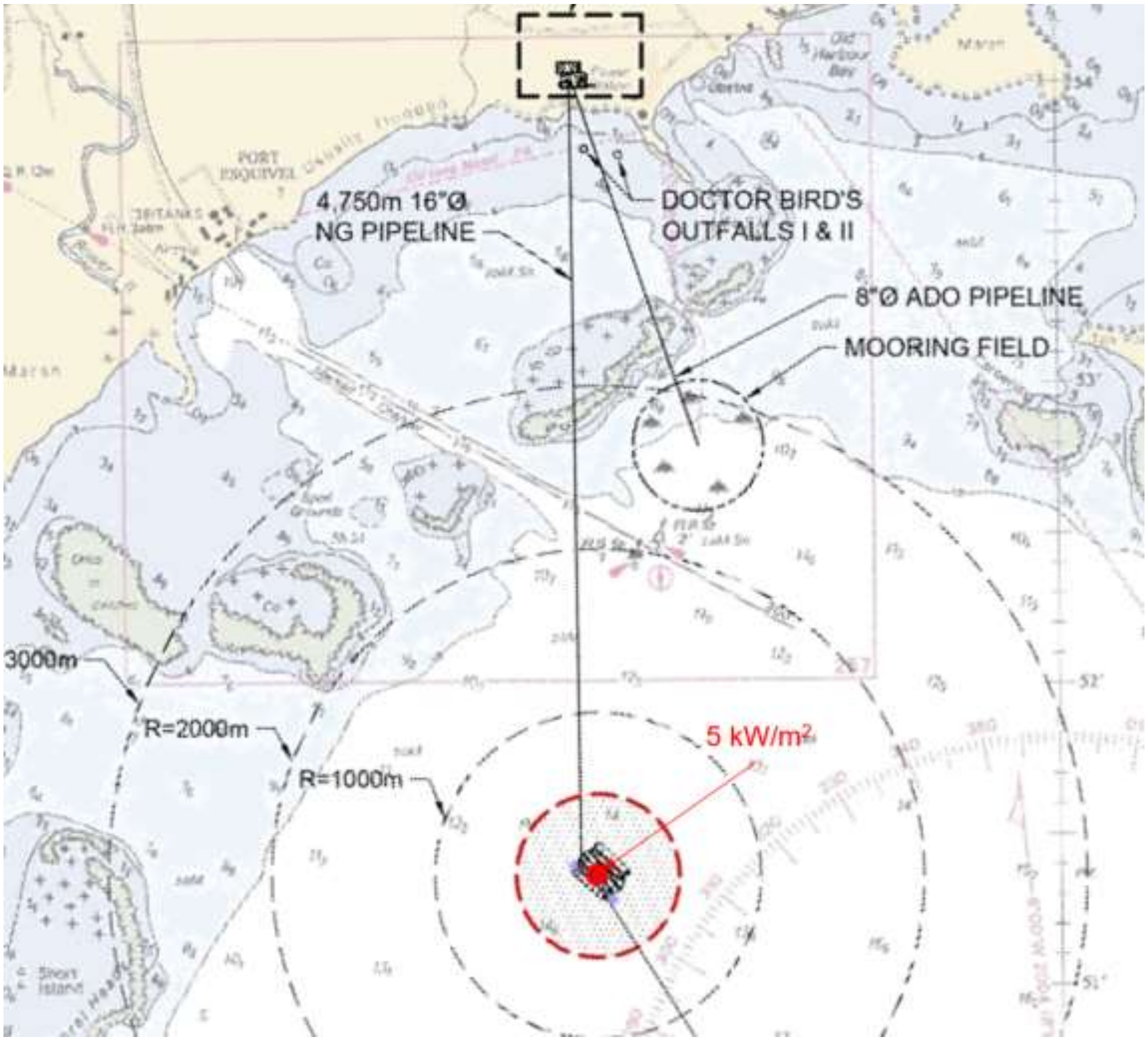


Figure 7-24 Thermal radiation hazard footprint for unloading arm failure scenario.

7.3.6.1 Recommended Mitigation - Exclusion Zones

Exclusion zones around terminal platform.

7.3.7 Vapour Dispersion

When a release occurs, the LNG will vapourise as it comes into contact with the relatively warm surfaces and atmosphere. The initial hazard following a release comes from the LNG spreading over the surface and vapourizing as it absorbs heat. The vapour generated will mix with air which begins the vapour dispersion process. One is able to calculate the theoretical distance the flammable concentration of a vapour cloud will travel. This distance is the Lower Flammable Limit (LFL) vapour dispersion isopleth. This distance is represented on a site plan as a ring of equal concentration, called an "isopleth".

7.3.7.1 Recommended Mitigation - Vapour Control

Canadian Standards Association (CSA Z-276-2007) requires that the isopleth (range or dispersion path)for a (Lower Flammable Limit)LFL vapour cloud must not go beyond the LNG facility boundaries or property that cannot or will not have occupancies and thus result in a distinct hazard to the public. The hazard is not the vapour itself, but the possibility that it could be ignited. If ignited, the vapour cloud will not expand any further, but instead, will burn back to the vapour source. The LNG fire will continue to burn until the fuel is consumed or the fire extinguished.

7.3.8 Frostbite

Low temperatures (frostbite) may occur, but only in the immediate area of the release and would be confined to the site. The heat transfer from LNG vapours is low such that exposures to cold vapours are not a hypothermia or frostbite hazard. Direct spills of liquid can cause injury but these are only a hazard to plant employees.

7.3.8.1 Recommended Mitigation - Frostbite

Employees of the facility must be trained and instructed as to a safe course of action to follow in the event of an emergency as required by the codes covering the facility.

7.3.9 Wastewater

Cooling water and cold water streams for revapourization heating at LNG receiving terminals may result in significant water use and discharge streams. Other wastewater streams generated at LNG facilities include; drainage, sewage water, tank bottom water (e.g. from condensation in LNG storage tanks), fire water, equipment and vehicle wash water, and general oily water.

The facility will not result in the generation of process wastewater. The regasification process will utilize seawater which will result in the discharge of cooled water into the sea near the mooring facility using a mixing process to ensure that there is no more than 5^{o} C change in temperature. This effect will be carefully modelled and monitored to ensure that there are no negative effects on marine life in the vicinity.

7.3.9.1 Recommended Mitigation - Wastewater

- Water conservation opportunities should be considered for LNG facility cooling systems. The proposed project will utilize a seawater cooling system and reduce the water demand. Other options include air cooled heat exchangers in place of water cooled heat exchangers and opportunities for the integration of cold water discharges with other proximate industrial or power plant facilities). The selection of the preferred system should balance environmental benefits and safety implications of the proposed choice.
- Cooling or cold water should be discharged to surface waters in a location that will allow maximum mixing and cooling of the thermal plume;
- There will be no effluent discharge from the FSU. Effluent is treated onboard in a three stage process and the effluent and waste will be collected by a waste handling company to discharge

in accordance with MARPOL Requirements. The waste handling company is responsible for the handling and final disposal of the wastes and providing the Ship's Agent with a disposal certificate.

The following additional parameters will assist in avoiding pollution:

- No oil or mixture containing oil shall be discharged or allowed to escape from a vessel while at the terminal.
- No garbage or other materials, either liquid or solid, shall be discharged overboard from a vessel, but shall be retained in suitable receptacles on board for proper disposal on land.

7.3.10 Air Emissions

Air emissions (continuous or non-continuous) from LNG facilities include combustion sources for power and heat generation (e.g. for dehydration and liquefaction activities at LNG regasification activities at LNG receiving terminals), in addition to the use of compressors, pumps, and reciprocating engines (e.g. boilers, turbines, and other engines). Emissions resulting from flaring and venting, as well as from fugitive sources, may result from activities at the regasification terminals. Principal gases from these sources typically include carbon monoxide (CO), and carbon dioxide (CO_2).

Sources of air emissions from the Regas unit include the electrical generator, emergency generator, flare and leaks from equipment/pipe flanges and connections containing LNG or natural gas. The electrical generator is sized to support continuous electrical load (Phase I) plus capacity to allow start-up of the largest electrical motor without affecting operations of other equipment. This results in an oversized capacity of about 50%. At full capacity the generator, depending on the final model selected, has the capacity of producing 3,000 kW to 3,500 kW. Normal continuous load will be 2,150 kW for Phase I. NOx emissions resulting from operation of the generator at reduced load are estimated at less than 1.0 g/bhp-hr. The electrical generator will be operated continuously except during times of maintenance. The emergency generator is sized to provide power for emergency lighting and the Uninterruptible Power Supply (UPS) which powers the control and shut-down system. Generator output is 20 kW. Diesel engine is CARB and EPA emission certified and are interim Tier IV compliant. The electrical generator has a flue gas rate of 283 cubic feet per minute at rated capacity and will be operated less than one week per year. The flare will be used only during plant emergency shutdown or during facility start-up. It's heat release is 260MMBtu/hr during release and it is estimated to operate less than 24 hrs. Finally, the equipment/pipe flanges and connections are another source of air emissions. Fugitive emissions from these components can be determined from the number of connections in hydrocarbon service. There approximately 500 to 510 connections with an average size of 6 inches in hydrocarbon service. Routine maintenance efforts will serve to minimize the emissions from these sources.

7.3.10.1 Exhaust Gases

Exhaust gas emissions produced by the combustion of natural gas or liquid hydrocarbons in turbines, boilers, compressors, pumps and other engines for power and heat generation, can be the most significant source of air emissions from LNG facilities.

7.3.10.2 Venting and Flaring

Flaring or venting is an important safety measure used at LNG facilities to ensure gas is safely disposed of in the event of an emergency, power or equipment failure, or other plant upset condition. A flare will be installed on the off shore platform in order to provide this safety measure.

7.3.10.3 Fugitive Emissions

Fugitive emissions at LNG facilities may be associated with cold vents, leaking pipes and tubing, valves, connections, flanges, packings, open-ended lines, pump seals, compressor seals, pressure relief valves, and general loading and unloading operations.

7.3.10.4 Recommended Mitigation - Air Emissions

- Air emission specifications should be considered during all equipment selection and procurement.
- The overall objective should be to reduce air emissions and evaluate cost-effective options for reducing emissions that are technically feasible. Significant (>100,000 tons CO_2 equivalent per year) greenhouse gas (GHG) emissions from all facilities and support activities should be quantified annually as aggregate emissions in accordance with internationally recognized methodologies and reporting procedures.
- Flaring or venting should be used only in emergency or plant upset conditions. Continuous venting or flaring of boil-off gas under normal operations is not considered good industry practice and should be avoided.
- BOG should be collected using an appropriate vapour recovery system (e.g. compressor systems). For LNG plants (excluding LNG carrier loading operations), the vapour should be returned to the process for liquefaction or used on-site as a fuel; on board LNG carriers BOG should be re-liquefied and returned to the storage tanks or used as a fuel; for regasification facilities (receiving terminals), the collected vapours should be returned to the process system to be used as a fuel on-site, compressed and placed into the sales stream/pipeline, or flared.
- Methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of facilities. The selection of appropriate valves, flanges, fittings, seals, and packings should be based on their capacity to reduce gas leaks and fugitive emissions. Additionally, leak detection and repair programs should be implemented.

7.3.11 Waste Management

Non-hazardous and hazardous wastes routinely generated at LNG facilities include general solid waste, 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. molecular sieves) and oily sludge from oil water separators, spent amine from acid gas removal units, scrap metals, and medical waste, among others.

7.3.11.1 Recommended Mitigation - Waste Management

Waste materials should be segregated into non-hazardous and hazardous wastes and considered for re-use /recycling prior to disposal. A waste management plan should be developed that contains a waste tracking mechanism from the originating location to the final waste reception location. Storage, handling and disposal of hazardous and non-hazardous waste should be conducted in a way consistent with good EHS practice for waste management.

7.3.12 Noise

The main noise emission sources in LNG facilities include pumps, compressors, generators and drivers, compressor suction / discharge, recycle piping, air dryers, heaters, vapourizers used during regasification, and general loading / unloading operations of LNG carriers / vessels.

7.3.12.1 Recommended Mitigation

Atmospheric conditions that may affect noise levels include humidity, wind direction, and wind speed. Vegetation, such as trees, and walls can reduce noise levels. Installation of acoustic insulating barriers can be implemented, where necessary on land. On the off shore platform, personal protective equipment will be made available to reduce worker exposure to unacceptable noise levels.

7.3.13 LNG Transport

Common environmental issues related to vessels and shipping include; hazardous materials management (risk of spills); wastewater and other effluents (ballast water and sewage); fires and explosions, contamination of marine waters and other water sources; air emission; solid waste generation of LNG tankers / carriers.

7.3.13.1 Recommended Mitigation

Recommendations for their management are covered in the EHS Guidelines for Shipping. Measures to Avoid, Minimize, or Mitigate Environmental Risk.

- LNG vessel design, construction and operations should comply with international standards and codes; relating to hull requirements (e.g. double hulls with separation distances between each layer), cargo containment ,pressure / temperature controls, ballast tanks, safety systems, fire protection, crew training,
- Guidelines include; International Maritime Organization's (IMO) International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, known as the International Gas Carrier Code (IGC Code).
- Further guidance is provided in the standards, codes of practices, principles and guidelines issued by the Society of International Gas Tanker and Terminal Operators (SIGTTO),

7.3.14 Shipping Hazards – Grounding and Collision

The risk and environmental impacts of LNG shipping are different compared to the receiving (off shore and on shore) facilities. In principle, the hazards are similar (fire from LNG release), however the potential causes of a release are different and the area potentially affected by the release will move along the route of a ship. This rules out the on shore approach of the impoundment and exclusion zones. The maritime approach is an evaluation of the suitability of the waterway/ship route. This includes potential navigational issues, other maritime vessels, existence of reefs and/or any other structure (shallow/sand bar), off shore island cays. When evaluating the possibility of a ship grounding at or near the terminal, two factors must be considered: the physical features of the navigable area and the speed and control of the LNG ship.

The hazards from grounding depend on the nature of the bottom and the speed of the ship, therefore, any grounding that might occur at low speed near the LNG terminal would not be of sufficient force to cause a cargo release. Instead, the greater hazard is the release of fuel oil from tanks in the vicinity of the engine room which will cause severe damage to the marine environment if released.

In the event of a severe grounding, direct exposure to the relatively warm seawater would cause LNG to evaporate, create large amounts of vapour and build pressure in the damaged cargo tank. Excess pressure would lift the safety valves and vapour would escape to the atmosphere. Without an ignition source, the vapour cloud would continue to form until the contents of the exposed tank had been vapourized. If the vapour cloud found an ignition source, it would burn back to the source and continue to burn until the cargo tank was empty or the fire extinguished. If unconfined, LNG does not explode; it simply burns. Danger to the surroundings would be a function of the LNG ship's location at the time of the grounding.

7.3.14.1 Recommended Mitigation

As the ship approaches the facility, it will be under control of a licensed pilot. The manoeuvring for berthing and turning of the ship will be assisted by tugboats. The tugboats will be able to control the movement of the ship and prevent grounding. The potential for damage in the event of grounding would be further mitigated by the ship's reduced speed as it approaches the offloading berth and its double hull. The energy required to cause a release of cargo during a grounding incident is very large and would require both high ship speed and a hard, penetrating bottom.

Maritime regulations should be set regarding clearance areas between ships and smaller vessels. Regardless of the very low probability of a collision, it is the general practice to establish a safety or security moving zone for the LNG carriers. This also serves to keep small boats clear of the hazards associated with getting too close to any large vessel.

7.3.15 LNG Release due to Equipment or System Failure

The most credible type of release is the result of equipment or system leakage, such as a leaking valve seal or flange gasket. This type of release is typically small and non-threatening. The probability of such a failure is greatest at flanges or joints where components, pipes, and valves are connected and undergo temperature changes. These small leaks are visible and easily repaired by facility personnel.

7.3.15.1 Recommended Mitigation

The LNG facility should be equipped with an extensive array of gas detection and flame detection equipment. Small leaks will be detected either visually, by trained personnel working in the facility, or by the detection equipment. Small leaks and/or fires should be easily handled by facility personnel, with assistance from the Fire Department if necessary.

Any release will be contained and directed to a sump, thus mitigating the extent of vapour dispersion. Should the vapour ignite, the thermal radiation will be mitigated by containment in the sump. The fire will continue until the fuel is consumed or the fire is extinguished. Damage will be confined to the terminal boundaries, including any controlled areas outside the property lines

7.3.16 Terrorism and Sabotage

A successful act of terrorism will require a high level of training and must be capable of being planned and initiated without detection. This limits the size of the weapon that can be used in the attack and therefore limits the credible threats to those using relatively small, easily accessible, and easily transported weapons. The most credible and practical threat will perhaps be from a small boat loaded with explosives. However, if this was to occur the possibility of cargo release would be small because the LNG ship's double hull plus separate cargo tanks would not be damaged to the extent of causing a release with these explosions at the waterline.

Should the explosives cause a release to occur, the result would be similar to that of a grounding except that there would be a high probability of ignition with a fire alongside the hull. The LNG would come in contact with seawater and may freeze as the heat from the seawater is absorbed to vapourize the LNG. Vapour dispersion would occur until either the vapour cloud reached a concentration below the LFL or the vapour cloud found an ignition source. If ignited, the vapour would burn back to the vapour source and continue to burn until the fuel was consumed or the fire extinguished.

The most accessible targets are the facility's storage tanks or the cargo tanks on the LNG ship at the dock. However, in each case, the access to the facility limits weapons to those that could be carried by hand. The access by vehicles limits approach to the point that the explosive would not be close enough to the structures to cause significant damage.

7.3.16.1 Recommended Mitigation

- Terminal and shipping personnel will be screened by the terminal before hiring.
- Ship crews and plant operators tend to be very stable as the jobs are considered to be monetarily attractive. There is very little turnover in terminal staffing and hence a low possibility for unscrupulous persons to work aboard the vessels.
- All authorized persons and vehicles will be subject to search before entering the facility. All unauthorized persons will be turned back.

- LNG facilities should be required by law to have significant security features built into the facility.
- LNG ship's double hull plus separate cargo tanks prevent significant damage which may cause a LNG release given a terrorist attack.
- The LNG ship's cargo tanks are surrounded by insulation within the double hull construction of the ship. The tops of the tanks have an outer cover above the main deck, called the weather dome. The weather dome should absorb most of the blast from any explosion and any damage to the cargo tank will be reduced.
- The credibility of the threat of a small boat with explosives is greatly reduced by the fact that the LNG ship will be located in restricted waters with security provisions in the berth area. The security provisions are normally for protection of the LNG vessel, other ships or a secondary benefit of the security craft as a deterrent of sabotage in the waterway.
- Terrorists are more interested in "high profile" targets with strong symbolic value, or targets that can cause mass casualties or severe economic damage. In general, LNG terminals are not attractive targets due to their "low political profile", difficulty of attack, and high level of security.

7.3.17 Natural Disasters

The possibility of a LNG release resulting from an act of nature such as hurricane, earthquake and tsunami is remote, as design standards should take seismic, wind and weather factors into account. Should an act of nature cause a release, the result will be the same or less than other scenarios previously stated. An LNG release on shore would be impounded by the bund and the resulting vapour dispersion or thermal radiation would be limited to the terminal site and not cause injury or damage to adjacent property.

Natural disasters involving a LNG delivery ship include hurricanes and other unfavourable weather systems. The LNG ship should not dock and, if docked, should undock and depart if the weather is predicted to exceed the design criteria.

During unpredicted natural events, such as earthquakes, the LNG ship could break its moorings during cargo discharge. In such a case, the unloading arms would exceed their operational range and the automatic disconnection system would activate. A small amount of LNG would be released. If the LNG ship broke all its moorings and propulsion was not available, the ship could drift and a grounding or allusion with the dock could occur.

7.3.17.1 Recommended Mitigation

The tanks should be designed to take into account the wind loads (both typical and maximum) for the region and must be able to withstand a Category 5 hurricane. Equipment and structures must also be designed to withstand the harshest recorded environment for the region.

It is also important to ensure that the ship's automatic disconnection system is maintained and functioning properly, in the event of unpredicted natural disasters.

8.0 CUMULATIVE ENVIRONMENTAL IMPACTS

8.1 TRAFFIC (VEHICULAR AND PEDESTRIAN) AND ROAD INFRASTRUCTURE

8.1.1 Potential Impacts

Traffic to and from the on shore facility will be minimal except during construction since LNG will be piped directly to the metering station on shore rather than using trucks. There will be some minimal traffic for on shore staffing at shift changes. Construction of the on shore facility will involve up to 20 people for land clearing and an additional 90 to 100 staff for construction of the on shore facility itself. Associated traffic will be short term and end after construction is complete (approximately four months). The JPS facility will have restricted access to the construction site through the JPS plant site in order to minimize traffic disruption to the nearby residential community.

The possibility exists that accidents involving pedestrians may occur at some stage during project construction or operation. This could be traffic-related, or other accidents.

In anticipation of the new 190MW power plant to be built, JPS has begun road widening and road rehabilitation/paving works of the Terminal Road which leads through the Old Harbour Bay community to the location of the power plant. With these improvements taking place, there should be no transportation problems or damage to road infrastructure from vehicles and equipment associated with construction and operation activities for the onshore LNG metering facility.

Boat traffic to the platform will also be minimal after construction is complete and will mainly consist of daily staffing changes which will be minimal since only a small number of staff are needed to conduct offshore operations. The staff to administer the FSU will live on board except for periodic shore leave. Therefore, two or three daily boat trips to and from the platform to Port Esquivel will probably be all the boat traffic required for operation of the off shore facilities. This additional boat traffic is minimal compared to the present level of boat traffic out of the Port.

During construction, there will be considerably more boat traffic during construction of the platform and laying of the pipelines since that effort will take considerable time (estimated at twelve months).

Therefore, the cumulative impact of traffic and site access will be minimal during operation of the facility. During construction (especially of the off-shore facility and laying of the pipeline), there will be a temporary increase in boat traffic.

8.1.2 Recommended Mitigation

i. Construction traffic entering or leaving Old harbour Bay may be scheduled for off peak hours to minimize additional congestion and or disruptions in the regular traffic flow.

ii. Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
iii. Adequate and appropriate road signs should be erected to warn road users and pedestrians of the construction activities. For example, signs which require reduced speed near the construction site. Signage stating speed limits of 15-30 km/h should be erected.
iv. The trucks should be parked within the proposed area unless they are in use.
v. Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
vi. The use of flagmen should be employed to regulate traffic flow.
vii. Efforts will be made with the Port Authority of Jamaica to coordinate this required work effort in order to minimize conflicts with normal port marine vessel traffic.

8.2 RAW MATERIALS AND EQUIPMENT

8.2.1 Potential Impacts

Some of the materials to construct the on-shore facility will be acquired locally but the materials and equipment for the off-shore platform and pipelines (as well as the equipment for the on-shore facility) will have to be acquired off island due to their specialized nature. The materials for the on-shore facility that can be acquired locally include crushed aggregate needed to stabilize the site. Given the small size and upland nature of the on-shore facility, only a small amount of aggregate will be needed from a local source to stabilize the on-shore facility. Since there are several sources of aggregate available from existing quarries, this additional amount should be easily accommodated and not require a new quarry or significant expansion of an existing quarry.

Any raw materials used in construction will be stored onsite (in the case of the onshore metering centre) and on barges (in the case of the offshore platform). There will be a potential for them to become air or waterborne. Stored fuels and the repair of construction equipment has the potential to leak hydraulic fuels, oils etc.

8.2.2 Recommended Mitigation

i. Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
ii. A central area should be designated for the storage of raw materials. This area should be lined or fenced in order to prevent the leakage of chemicals into the sediment/water.
iii. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental runoff.

8.3 STORAGE OF FUELS AND CHEMICALS

8.3.1 Potential Impacts

It is anticipated that refuelling and maintenance of large machinery will take place on the construction site. Except for the LNG stored on the FSU, there will be minimal storage of fuel and lubricants on the site. With the storage of fuels and maintenance of construction equipment, there is the potential of leakage of hydraulic fuels, oils etc. Spilled chemicals can contaminate soil, as well as pollute the surface water and marine environment.

8.3.2 Recommended Mitigation

i. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored.
ii. In addition, these containers should be placed on hard, impermeable surfaces and surrounded by bunds to contain the volume being stored in case of accidental spillage.
iii. LNG on the FSU will be carefully managed in order to ensure its safe delivery via pipeline to the on-shore facility and the JPS plant.
iv. Careful metering of the pipelines will ensure that any leaks are detected quickly and properly managed.

The cumulative impact of fuel and chemicals will be minimal from both the on-shore and off-shore facilities.

8.4 MARINE WATER QUALITY

8.4.1 Potential Impacts

Cumulative impacts on water quality from the facility will be from the small on-shore facility as well as the off-shore platform and associated FSU. With respect to the on-shore facility, there will be some stormwater runoff from the facility as well as runoff during construction. The off shore facility and associated FSU will have some potential water quality impacts mainly from stormwater runoff, discharge of water used to warm the LNG before it is discharged into the pipeline, and domestic wastewater from the platform and FSU from the staff required to maintain these facilities. Given the relatively small size of the platform and its remote location, the effect of runoff and cooling water discharge on water quality will be negligible

Heavy Fuel Oil is delivered weekly to JPS and JEP via tankers by the existing mooring field. With the new proposed ADO pipeline to be utilized by the existing mooring field, there exists the potential for marine water quality to be affected by residual spillage from ADO delivery.

8.4.2 Recommended Mitigation

i. Stormwater from the facility will be managed through on-site stormwater management and construction of Best Management Practices and use of capture strategies to avoid direct discharge into the bay.
ii. The discharge of heating water will be done in such a manner as to meet all NEPA water quality requirements.
iii. All domestic wastewater from the staff for the platform or FSU will be treated to meet all NEPA requirements before discharge.

iv. Care should be taken during connection and disconnection of pipeline ends to avoid or reduce the amount of residual spillage of fuel during delivery.

Overall, any cumulative impact on water quality from the on shore or off shore facilities will be minimal given the relatively small size of the facilities, their relatively remote locations and the commitment of the project to employ appropriate Best Management Practices for stormwater and appropriate treatment for the discharge of heating water and domestic wastewater.

8.5 NOISE

The cumulative noise impact takes into account all the existing background noise sources which include the existing Jamaica Public Service Old Harbour power plant, the Jamaica Energy Partners Doctor Bird I and II Barges, Jamaica Ethanol, Operations at Port Esquivel, Hi Pro Feed Mill, and other anthropogenic activities such as night noises. The predicted noise from the new noise source (the proposed LNG Terminal and Regassification Project) is then added to the existing noise levels to determine what, if any impact this new development would have on the surrounding community. This is considered a worst case scenario as the existing Jamaica Public Service Old Harbour power plant will be decommissioned once the new 190 MW plant becomes operational.

8.5.1 Potential Impacts

Sensitive receptors (schools, churches and clinics) within 6 km were mapped. Note that this list is not exhaustive. The noise attributed to the operation of the LNG Terminal and Regassification Project alone and in combination with Jamaica Energy Partners Doctor Birds I and II at the various receptors was predicted using both the General Prediction Model and the Concawe Model with wind blowing from the south (worst case scenario).

8.5.1.1 Noise Stations

The operation of the proposed LNG Terminal and Regassification Project will result in an increase in the existing noise level (cumulative) at some locations (Table 8-1 and Table 8-2).

Comparison with NEPA Standards

Only Station N7 (JPS 190 MW EIA) and Stations N7 to N9 (SJPC EIA) were non -compliant with the NEPA day time standard and Stations N5 to N7 JPS 190 MW EIA) and Stations N7 to N9 (SJPC EIA) were non – compliant with the night time standards when the cumulative noise levels are calculated. It is important to note, that at the Stations showing non – compliance, the NEPA standards were being exceeded at these locations prior to the addition of the proposed project whether during the day or night time.

Comparison with World Bank Guidelines

Station N7 (JPS 190 MW EIA) and Stations N7 to N9 (SJPC 360 MW EIA) exceeded the World Bank guidelines during the day time when the cumulative noise levels were calculated, however, they were compliant with the 3dBA rule, thus compliant with World Bank guidelines.

Stations N5 to N7 and N9 (JPS 190 MW EIA) and Stations N6 – N9 and N11 (SJPC 30 MW EIA) were non- compliant with the World Bank night time guidelines when the cumulative noise levels are calculated. They were however compliant when the 3 dbA rule was applied.

Of note, the baseline noise levels at all the non -compliant Stations exceeded the World Bank guidelines prior to the operation of the LNG Terminal and Regassification Project.

Table 8-1 Cumulative noise levels with the LNG Terminal and Regassification Project operational compared with the NEPA standards and World Bank guidelines (JPS 190 MW EIA)

STN. NO.	LOCATION	ZONE	BASELINE	PREDICTED NOISE FROM LNG TERMINAL & REGASSIFICATION PROJECT, JPS 190MW & DOCTOR BIRDS I & II (GP)	CUMULATIVE NOISE FROM LNG TERMINAL & REGASSIFICATION PROJECT, JPS 190MW & DOCTOR BIRDS I & II (GP)	NEPA STD.	WORLD BANK GUIDELINE	BASELINE	PREDICTED NOISE FROM LNG TERMINAL & REGASSIFICATION PROJECT, JPS 190MW & DOCTOR BIRDS I & II (GP)	CUMULATIVE NOISE FROM LNG TERMINAL & REGASSIFICATION PROJECT, JPS 190MW & DOCTOR BIRDS I & II (GP)	NEPA STD.	WORLD BANK GUIDELINE
N1	North-Western Property Boundary	Industrial	66.9	47.7	66.9	75	70	59.6	47.7	59.9	70	70
N2	South-Western Property Boundary	Industrial	62.4	36.9	62.4	75	70	56.5	36.9	56.5	70	70
N3	South-Eastern Property Boundary	Industrial	64.0	45.1	64.0	75	70	58.0	45.1	58.2	70	70
N4	North-Eastern Property Boundary	Industrial	62.9	47.8	62.9	75	70	59.8	47.8	60.1	70	70
N5	Informal Settlement Area	Residential	61.4[11]	42.2	61.4	55	55	59.9	42.2	**60.0**	50	45
N6	Blackwood Garden Housing Scheme	Residential	52.2[12]	36.0	52.2	55	55	46.9	36.0	**47.2**	50	45
N7	Old Harbour Bay Police Station	Residential	56.2[13]	25.3	**56.2**	55	55	52.7	25.3	**52.7**	50	45
N8	New Harbour Village Phase II Housing Scheme	Residential	43.1	23.3	43.1	55	55	41.9	23.3	41.9	50	45
N9	Longville Park Housing Scheme	Residential	51.7[14]	0.0	51.7	55	55	49.9	0.0	**49.9**	50	45

NB: Numbers that are bold and red indicate non-compliance with both NEPA standards and World Bank guidelines, bold green indicate non-compliance with NEPA Standard but compliance with World Bank guidelines when the 3 dBA rule is applied and bold purple indicate compliance with NEPA guidelines and compliance with World Bank guidelines when the 3 dBA rule is applied.

[11] Average of noise data from 2007 – 2012 (Campbell 2014), Jamaica Energy Partners Annual Noise Assessment (2013 and 2014) and current measurements
[12] Average of noise data from Jamaica Public Service Noise Assessments (2010, 2011 and 2013), South Jamaica Public Company EIA (2012) and current measurements
[13] Average of noise data from 2007 – 2012 (Campbell 2014), Jamaica Energy Partners Annual Noise Assessment (2013 and 2014), South Jamaica Public Company EIA (2012) and current measurements
[14] One of noise measurements conducted for the South Jamaica Public Company EIA (2012)

Table 8-2 Cumulative noise levels with the LNG Terminal and Regassification Project operational compared with the NEPA standards and World Bank guidelines (SJPC 360 MW EIA)

STN. NO.	LOCATION	ZONE	BASELINE	PREDICTED NOISE FROM LNG TERMINAL & REGASSIFICATION PROJECT, JPS 190MW & DOCTOR BIRDS I & II (GP)	CUMULATIVE NOISE FROM LNG TERMINAL & REGASSIFICATION PROJECT, JPS 190MW & DOCTOR BIRDS I & II (GP)	NEPA STD.	WORLD BANK GUIDELINE	BASELINE	PREDICTED NOISE FROM LNG TERMINAL & REGASSIFICATION PROJECT, JPS 190MW & DOCTOR BIRDS I & II (GP)	CUMULATIVE NOISE FROM LNG TERMINAL & REGASSIFICATION PROJECT, JPS 190MW & DOCTOR BIRDS I & II (GP)	NEPA STD.	WORLD BANK GUIDELINE
N1	Northern Property Boundary	Commercial	51.3	35.6	51.4	65	70	45.1	35.6	45.6	60	70
N2	Eastern Property Boundary	Commercial	53.1	43.5	53.6	65	70	51.1	43.5	51.8	60	70
N3	Southern Property Boundary	Commercial	58.7	47.1	59.0	65	70	56.4	47.1	56.9	60	70
N4	Western Property Boundary	Commercial	50.9	38.1	50.9	65	70	53.4	38.1	53.5	60	70
N5	JPS Guard House	Industrial	61.4[15]	35.3	61.4	75	70	54.9	35.3	54.9	70	70
N6	Blackwood Garden Housing Scheme	Residential	52.2[16]	36.0	52.2	55	55	46.9	36.0	**47.2**	50	45
N7	Old Harbour Bay Police Station	Residential	56.2[17]	25.3	**56.2**	55	55	52.7	25.3	**52.7**	50	45
N8	New Harbour Village – Phase 1	Residential	60.6[18]	16.7	**60.6**	55	55	56.3	16.7	**56.3**	50	45
N9	Church Pen	Residential	59.4	0.0	**59.4**	55	55	53.6	0.0	**53.6**	50	45
N10	Bodles	Commercial	53.5	9.9	53.5	65	70	50.6	9.9	50.6	60	70
N11	Longville Park Housing Scheme	Residential	51.7[19]	0.0	51.7	55	55	49.9	0.0	**49.9**	50	45

NB: Numbers that are bold and red indicate noncompliance with both NEPA standards and World Bank guidelines, bold green indicate noncompliance with NEPA Standard but compliance with World Bank guidelines when the 3 dBA rule is applied and bold purple indicate compliance with NEPA guidelines and compliance with World Bank guidelines when the 3 dBA rule is applied.

[15] One of noise measurements conducted for the South Jamaica Public Company EIA (2012)
[16] Average of noise datd from Jamaica Public Service Noise Assessments (2010, 2011 and 2013), South Jamaica Public Company EIA (2012) and current measurements
[17] Average of noise data from 2007 – 2012 (Campbell 2014), Jamaica Energy Partners Annual Noise Assessment (2013 and 2014), South Jamaica Public Company EIA (2012) and current measurements
[18] Average of noise data from 2007 – 2012 (Campbell 2014), Jamaica Energy Partners Annual Noise Assessment (2013 and 2014) and South Jamaica Public Company EIA (2012)
[19] One of noise measurements conducted for the South Jamaica Public Company EIA (2012)

8.5.1.2 Sensitive Receptors

Schools

When the predicted noise generated from the operation of the LNG Terminal and Regassification Project, JPS 190MW and the JEP Doctor Birds I and II were considered, the noise did not exhibit the inverse square law for both the General Prediction and Concawe models. The noise levels ranged from a low of 0.0 dBA (Old Harbour Early Childhood Institution and Old Harbour Primary) to a high of 42.2 dBA (Blackwood Gardens Basic School) (Table 8-3).

COMPARISON WITH LOCAL STANDARD AND INTERNATIONAL GUIDELINE

When the predicted noise levels from the operation of the LNG Terminal and Regassification Project, JPS 190MW and the JEP Doctor Birds I and II plants are operational, the noise levels at all school were compliant with both NEPA day time standard and World Bank guideline (Table 8-3).

Table 8-3 Schools listed in order of increasing distance (m) from the proposed JPS 190MW power plant with the predicted noise from JPS 190MW and the Doctor Birds I and II power plants

SCHOOLS	LNG TERMINAL AND REGASSIFICATION PROJECT (LAeq (16))	NEPA STD	WORLD BANK GUIDELINE
Blackwood Gardens Basic School	42.2	45	55
Children First Basic	41.0	45	55
Old Harbour Bay Primary	40.2	45	55
Baptist Early Childhood Centre	39.8	45	55
St. Wade Basic School	40.2	45	55
Old Harbour High School	31.4	45	55
Portmore Community College (Old Harbour)	30.8	45	55
Freetown Primary	30.0	45	55
Monsignor Colin Bryan Preparatory	29.2	45	55
Longville Park Early Childhood Centre	28.5	45	55
Old Harbour Early Childhood Institution	0.0	45	55
Old Harbour Primary	0.0	45	55

Churches

When the noise generated from the operation of the LNG Terminal and Regassification Project, JPS 190MW and the JEP Doctor Birds I and II were predicted the noise levels ranged from a low of 0.0 dBA (St Dorothy's Anglican Church and Old Harbour Baptist) to a high of 43.0 dBA (Mount Refuge Fire Baptize Holiness) (Table 8-4).

COMPARISON WITH LOCAL STANDARD AND INTERNATIONAL GUIDELINE

All predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guideline (Table 8-4).

Table 8-4 List of churches in order of increasing distances (m) from the proposed JPS 190 power plant with the predicted noise from JPS 190MW and Doctor Birds I and II power plants

CHURCHES	LNG TERMINAL AND REGASSIFICATION PROJECT (LAeq (16))	NEPA STD	WORLD BANK GUIDELINE
Mount Refuge Fire Baptize Holiness	43.0	55	55
Unnamed Church	40.8	55	55
St Phillips Anglican		55	55
Refuge Temple Old Harbour Bay	39.9	55	55
Old Harbour Bay Baptist	39.6	55	55
Old Harbour Bay SDA	38.9	55	55
Faith Bible Baptist Church	38.2	55	55
Old Harbour Evangelistic Centre	31.9	55	55
Church of Our Lord Apostolic Faith	31.5	55	55
Jehovah Witness	31.5	55	55
Hebron Gospel Hall	31.1	55	55
Old Harbour SDA	38.9	55	55
Holy Ghost Ministries Inc.	30.1	55	55
Church of the Holy Trinity	30.5	55	55
St. Michael & St. George Anglican	30.0	55	55
Longville Park Church	28.6	55	55
St Dorothy's Anglican Church	0.0	55	55
Old Harbour Baptist	0.0	55	55

Clinics

The noise levels at two clinics were examined when noise levels were predicted with LNG Terminal and Regassification Project, JPS 190MW and JEP Doctor Birds I and II are operational. The noise levels varied from 29.8 dBA (Old Harbour Health Centre) and 38.6 dBA (Bay View Medical Centre) (Table 8-5).

COMPARISON WITH LOCAL STANDARD AND INTERNATIONAL GUIDELINE

All predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guideline (Table 8-5).

Table 8-5 Noise levels at clinics in order of increasing distance (m) from the proposed JPS 190 MW power plant with the predicted noise from JPS 190MW and Doctor Birds I and II power plants

CLINICS	LNG TERMINAL AND REGASSIFICATION PROJECT (LAeq (16))	NEPA STD	WORLD BANK GUIDELINE
Bay View Medical Centre	38.6	55	55
Old Harbour Health Centre	29.8	55	55

8.5.2 Recommended Mitigation

No mitigation is required.

8.6 AIR QUALITY

8.6.1 Potential Impacts

Particulate sampling (both PM2.5 and PM10) conducted during the 2014 JPS 190 MW EIA and the 2012 SJPC 360MW EIA indicated that all sampling stations in and around the currently proposed LNG facility were compliant with 24-hour US EPA standards (35 $\mu g/m^3$ for PM2.5 and 150 $\mu g/m^3$ for PM10). In addition, sampling for Total Suspended Particulates (TSPs) were also in compliance with 24-hour NEPA standards (150 $\mu g/m^3$).

As previously noted, air emissions (continuous or non-continuous) from LNG facilities include combustion sources for power and heat generation. Emissions resulting from flaring and venting, as well as from fugitive sources, may result from activities at the regasification terminals. Principal gases from these sources typically include nitrogen oxides (NOX), carbon monoxide (CO), carbon dioxide (CO_2), and, in case of sour gases, sulphur dioxide (SO_2). Offshore sources of air emissions from the Regas unit include the electrical generator, emergency generator, flare and leaks from equipment/pipe flanges and connections containing LNG or natural gas. NOx emissions resulting from operation of the generator at reduced load are estimated at less than 1.0 g/bhp-hr. Exhaust gas emissions produced by the combustion of natural gas or liquid hydrocarbons in turbines, boilers, compressors, pumps and other engines for power and heat generation, can be the most significant source of air emissions from LNG facilities. The diesel engine is CARB and EPA emission certified and are interim Tier IV compliant. Routine maintenance efforts will serve to minimize the emissions from these sources.

As part of the air dispersion modeling analyses, a determination of the impact of the existing sources on the ambient air quality was made, as well as the cumulative impact with the addition of the air pollutant sources associated with the proposed 190 MW power plant and the consequent retirement of the existing oil-fired 190 MW JPS facility, as well as the sources of the proposed LNG Terminal.

Table 8-6 shows the model results for the existing operating sources and the future sources category for criteria pollutants. The results for the existing sources revealed predicted highest concentrations that exceed the respective ambient air quality standards for NO_2 (1h and annual averaging periods), and all averaging periods for SO_2. When the future sources were modeled, the results revealed similar exceedences except for 24h and annual SO_2. From these results it can be concluded that the replacement of the implementation of the LNG Terminal and the associated combustion of LNG at a new 190 MW power plant to replace the existing JPS oil-fired power plant will significantly improve the prevailing SO_2 ambient air quality concentration within the air shed.

Table 8-6 Cumulative Impacts (with Proposed LNG Terminal)

Pollutant	Avg. Period	Background (µg/m^3)	NAAQS (µg/m^3)	Existing Sources			Future Sources		
				Max Conc (µg/m^3)	UTME (m)	UTMN (m)	Max Conc (µg/m^3)	UTME (m)	UTMN (m)
PM_{10}	24-hr	14	150	99.7	273350.51	1982416.59	99.4	273350.51	1982416.59
	Annual	20	60	44.4	273350.51	1982416.59	44.0	273350.51	1982416.59
NO_2	1-h	0	400	2274.2	267720	1973165	2127.7	272220	1983665
	Annual	0	100	216.8	273298.33	1982394.39	216.4	273298.33	1982394.39
SO_2	1-hr	0	700	8930.2	267720	1973165	1035.2	273220	1982165
	24-hr	0	280	1210.2	272220	1985665	257.7	273220	1982165
	Annual	0	60	130.0	275720	1980665	43.5	273298.33	1982394..39
CO	1-hr	0	40000	3707.4	272220	1985665	892.1	273361.97	1982349.81
	8-hr	0	10000	1433.3	268220	1977165	808.3	273361.97	1982349.81

Bold type indicate exceedences above the respective standard

8.7 EMPLOYMENT

8.7.1 Potential Impacts

About 20 workers will be needed for the site preparation work for the project for the on-shore facility, 225 to 250 workers for construction of the on-shore and off-shore facilities as well as construction of the pipelines, and about 40 workers to permanently operate the facility (on-shore and off-shore). These positions will likely be a mix of off and on-island individuals with much of the construction being done by locally contracted individuals. The staff needed to operate the facility will need to be highly trained in order to safely operate the facility but these positions will be available to on-island individuals after sufficient training. Therefore, the construction and operation of the facility will provide an additional source of jobs in the immediate area.

Since the JPS plant is basically converting to natural gas from diesel, there will be construction-related positions but only a minor increase (if any) in permanent positions at the JPS plant. Similarly, if existing local industries convert to natural gas from other existing sources of energy, there may be an increase in temporary construction jobs but little net gain in new positions.

However, it is possible that new industries may locate in the area based on the new availability of natural gas which would result in a net increase in employment. In addition, existing industries may convert to the use of natural gas but unless that results in an expansion of the industry, any additional employment would likely be minimal.

Overall, the project is expected to increase employment in the area both directly (temporarily from construction and permanently from operation of the facility) as well as cumulatively as new industries locate or existing industries expand based on the availability of natural gas.

8.7.2 Recommended Mitigation

It is anticipated that persons from the community will be employed directly with other persons benefiting indirectly. This has the potential to be a significant positive impact. No mitigation is required.

9.0 RESIDUAL IMPACTS

Section 7.0 (Identification and Assessment of Potential Direct and Indirect Impacts and Recommended Mitigation) described the potential impacts that would occur as a result of different phases of the project and how the proposed mitigation measures would contribute to minimising or eliminating the impacts. Not all impacts can be fully mitigated and therefore residual impacts will be experienced by the environmental and social receptors affected by the project. These are discussed below.

9.1 SITE PREPARATION AND CONSTRUCTION

9.1.1 Noise

The proposed project has the potential to be a noise nuisance during the construction phase and may be a nuisance to surrounding residential communities.

9.1.2 Air Quality

Fugitive dust has the potential to affect the health of construction workers, the resident population and any surrounding vegetation. Both types of impacts will be of low intensity and of relatively short duration.

9.2 OPERATION

9.2.1 Socio-Economic

9.2.1.1 Unmet Employment Expectations

Because of the high unemployment rate in the area and in the island in general, residents in directly affected communities who are unsuccessful in their job application are likely to become frustrated when they do not gain employment on the proposed project. This could create resentment and possibly hostility towards those who are successful in getting jobs, and even towards NFE South Holdings Ltd. The possibility also exists that there will be resentment towards NFE South Holdings Ltd arising from perceptions of bias in the recruitment process.

9.2.1.2 Accidents involving community members

The possibility exists that accidents involving community members may occur at some stage during project construction or operation. This could be traffic-related, or other accidents. A residual impact is created in terms of diminishing the standard of living for a person, negatively impacting his or her household.

10.0 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

The discussion and analysis of alternatives in Environmental Impact Assessments should consider other practicable strategies that will promote the elimination of negative environmental impacts identified. This section is a requirement of the National and Environment and Planning Agency (NEPA), and is critical in consideration of the ideal development with minimal environmental disturbance.

This report has identified the major environmental impacts, both adverse and beneficial noted by scientific experts. The project team and the consulting scientists worked together, utilizing findings of these impacts to analyze possible options for the final development. In addition to examining the advantages and disadvantages of potential project alternatives over that which is proposed, the ability to meet project objectives and the feasibility (for example in terms of available technologies, budget constraints and logistics) of each were additional evaluation criteria.

The alternatives listed below are discussed in detail in subsequent subsections:

- The “No-Action” Alternative
- The Proposed Development as described in the EIA
- Project Site and Layout Alternatives
    - Construct an Off Shore Platform and Associated Pipelines Near Goat Island
    - Construct the Off Shore Platform at the Location in the Preferred Alternative but Install LNG and ADO Pipelines on the Sea Floor Between the Two Existing Reefs
    - Different Locations for LNG Import Terminal based on Varying Ship Sizes
    - Land Based Storage, Regasification and Metering Systems
- Different Delivery Options
    - Marine Trestle
    - Cryopipeline
    - LNG Trucked to Site
- Alternatives to other Project Features
    - Flaring
    - Use of Seawater in the Regasification Process

It should be mentioned that two main design alternatives were considered and evaluated for this project in addition to the no action alternative. The first design alternative involved installation of the off shore platform and associated pipelines near Goat Island (Section 10.3.1). The second design alternative considered alternative locations for the LNG (and new ADO) pipelines between the two reefs by laying them on the ocean floor, with the off shore platform located as proposed in the preferred alternative (Section 10.3.2).

10.1 NO ACTION ALTERNATIVE

The "no action" alternative is required to ensure the consideration of the original environment without any development. This is necessary for the decision-makers in considering all possibilities.

This alternative would involve no construction of an off shore platform or associated LNG and ADO pipelines to carry LNG to the JPS plant. This alternative was rejected since the JPS plant is presently being converted to operate on LNG for reasons outlined in this EIA. Without a source of LNG, the JPS plant under construction could not operate thereby throwing into jeopardy electricity for the entire area served by the JPS plant. Alternatively, the current on-going investment in upgrading the JPS plant to LNG would be wasted and the plant might continue to operate on diesel fuel with none of the anticipated local improvements in air and water quality as well as cost of electricity. This alternative fails to meet the purpose and need for the project.

10.2 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA

This project proposes to construct a marine terminal facility comprised of a vessel berth and off-shore offloading and regasification platform at the general location approved by the Port Authority of Jamaica in the Portland Bight area of Jamaica. This facility will accommodate a Floating Storage Unit (FSU) vessel for LNG storage and a LNG carrier delivering LNG to the FSU. The FSU is a LNG carrier refitted for use as a storage vessel. LNG will be delivered by ship from various potential locations in the United States or other locations. The platform would contain equipment to regasify LNG as well as related process and safety equipment. The liquid gas from the FSU which is stored at pressure close to atmosphere would be carefully regasified and the gas would then be released into an undersea pipeline which be directionally drilled in basically a straight line from the platform to the vicinity of the JPS plant. This submerged line will minimize environmental impacts since it will be directionally drilled in a relatively straight line. The gas pipeline would then be directionally drilled on shore to a small receiving facility on shore near the proposed gas power plant that JPS is constructing where it can be metered and then sent to the power plant. In addition, the project will construct a new, or refurbish an existing ADO line to storage tanks at the renovated power plant in order to enhance the reliability of the facility in case of LNG delivery interruptions.

The Project as proposed would include the following advantages:

- Fits in with the National Energy Policy which seeks to develop a modern, efficient, diversified and environmentally sustainable energy sector providing affordable and accessible energy supplies, with long-term energy.
- Forms the basis of providing a more diversified and environmentally friendly fuel source that has the potential to reduce the cost of electricity to the country and improve electricity supply reliability.

- Provide the Jamaica Public Service Company's Old Harbour Plant with a cleaner and more cost effective fuel in furtherance of the goals of the National Energy Policy.

The Project as proposed would include the following disadvantages:

- Clearance of coastal vegetation to construct onshore facilities
- Deterioration of marine water quality during pipeline deployment
- Potential LNG-related risks and hazards

Alternative 2 is the preferred alternative as it fits in with the National Energy Policy which seeks to develop a modern, efficient, diversified and environmentally sustainable energy sector providing affordable and accessible energy supplies, with long-term energy.

10.3 PROJECT SITE AND LAYOUT ALTERNATIVES

10.3.1 Construct an Off Shore Platform and Associated Pipelines Near Goat Island

This alternative locates the off shore platform near Goat Island in order to avoid any possible conflict with the shipping channel into Port Esquivel (Figure 10-1). This alternative would also allow for a shorter, more direct alignment of the LNG and ADO pipelines to the JPS plant through a gap in the reef where the existing ADO lines from the mooring field are currently located. The platform would be located in somewhat shallower water as compared to the preferred location (12.5 to 13 m of water versus 14 m at the preferred location).

Although this alternative would result in shorter and less expensive pipeline routes, it would bring the industrial effects (principally noise, air emissions, and light as well as potential spills from the FSU) closer to the sensitive environmental resources in and near Goat Island. Since the water at this location is significantly shallower, it is likely that dredging would be needed to construct an access channel to the platform. In addition, the pipelines would be installed on the seabed with resulting disturbances to aquatic life. For these reasons, this location for the off shore platform and alignment for the pipelines was rejected in favour of the preferred alternative which would have less environmental impact.

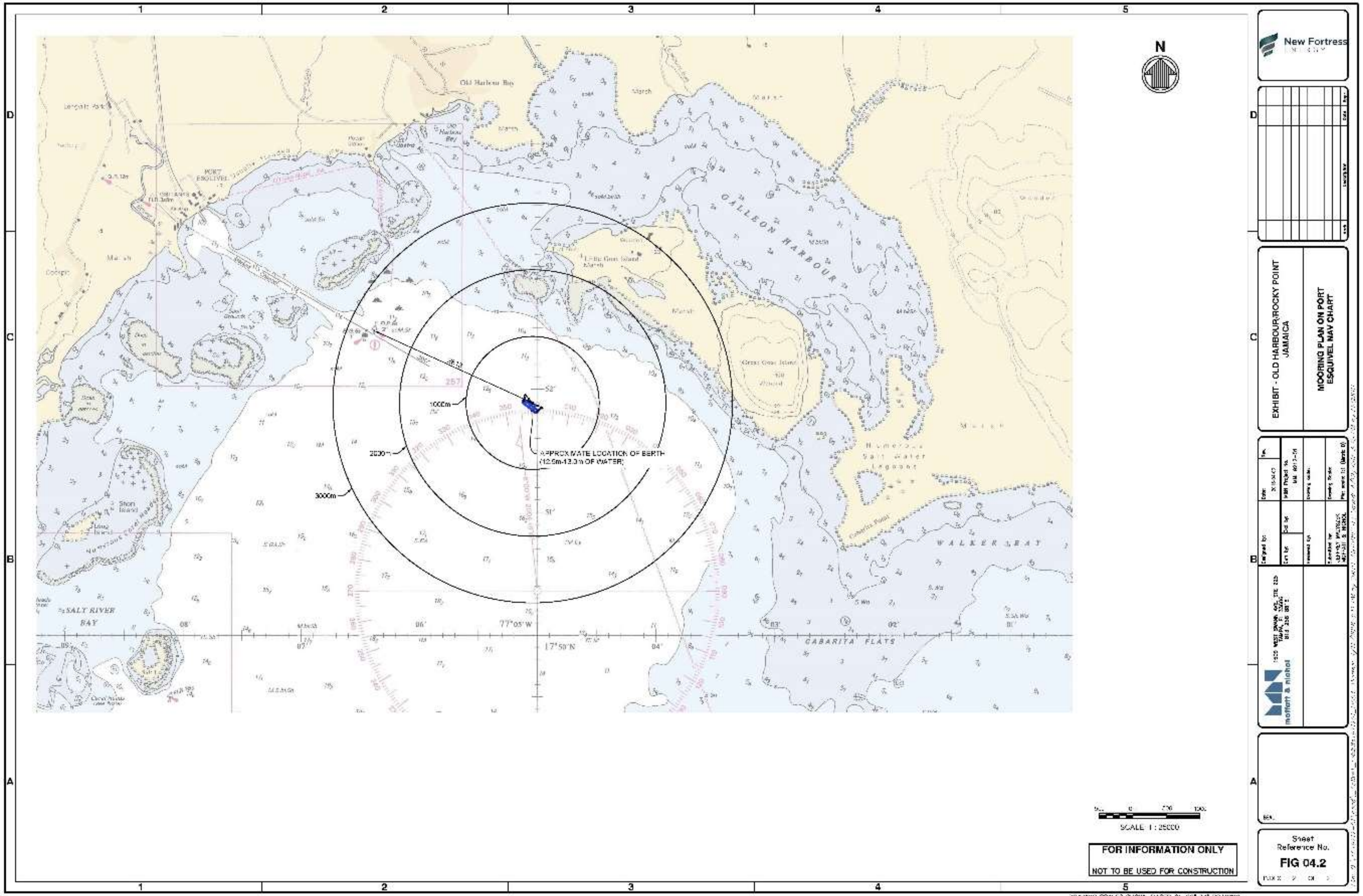


Figure 10-1 Alternative A near Goat Island

10.3.2 Construct the Off Shore Platform at the Location in the Preferred Alternative but Install LNG and ADO Pipelines on the Sea Floor Between the Two Existing Reefs

This alternative relies on an off shore platform located at the same location as the platform in the preferred alternative (Figure 3-1). This location for the offshore terminal was encouraged by the Port Authority of Jamaica in order to reduce the potential for impacts on commercial shipping into Port Esquivel. This alternative would still involve a new NG pipeline from the planned off shore platform and a new ADO pipeline from the mooring field. These pipelines would be placed parallel to the existing ADO lines that run to the JPS plant between two sections of the reef (Figure 10-2). These lines would generally be laid on the sea floor except close to shore where the lines would be buried through directionally drilling allowing for connection with to the on shore facility. Offshore, these lines would be located to run between the two remnant coral reefs situated between the existing mooring facility and the JPS plant and JEP Doctor Bird Barges. The lines would follow the general location of the existing ADO lines that run from the mooring facility to the JPS plant.

This alternative was rejected since these alternative locations for the LNG and ADO lines are longer in length (and therefore with higher expense) as well as environmental impacts associated with placing these lines on the sea bottom with resulting disruption of the seabed life. Instead, a direct route with a longer directional drill is proposed for both lines which will result in no disturbance of the seabed near or in the reef area. This approach will clearly have less impact on the seabed environment at the site.

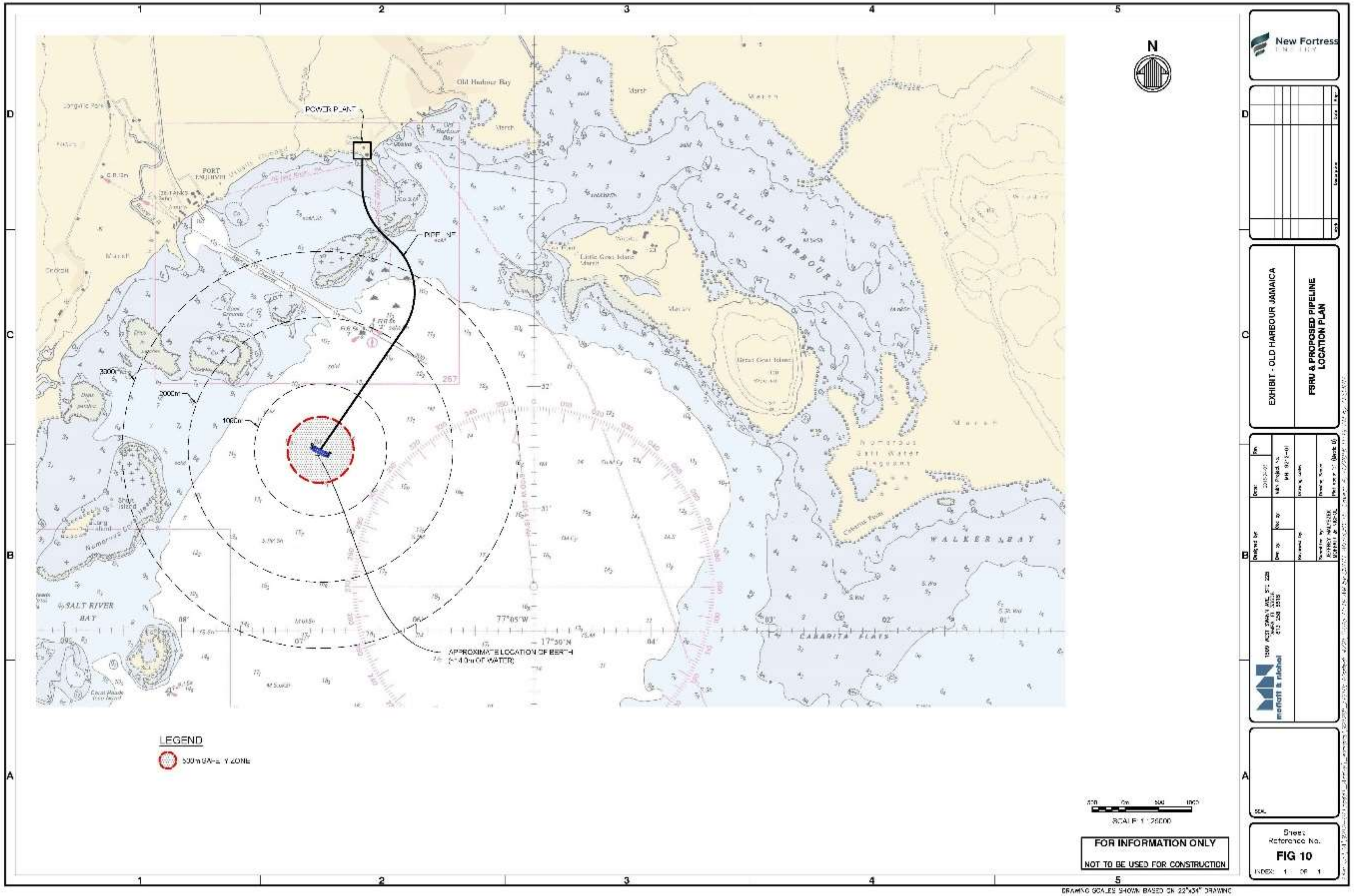


Figure 10-2 Alternative B with pipelines aligned with gap in reef

10.3.3 Different Locations for LNG Import Terminal based on Varying Ship Sizes

Three locations for LNG Terminals using either trestles or cryogenic pipes were investigated. Additionally, the size of the LNG carriers were also assessed at these locations (Figure 10-3 to Figure 10-9).

The mid-bay and nearshore location alternatives will require marine dredging in order to accommodate the design LNG vessels at the new marine facility. The offshore location alternatives will not require any dredging as the location of the new LNG marine facility has been conceptually established in sufficiently deep water to accommodate the design vessels.

For all of the new work dredging associated with both locations the dredged depth for the primary design vessel is taken to be 11 meters while the dredged depth for the secondary design vessel is taken to be 13 meters.

For both the mid-bay and nearshore location alternatives the existing dredged channel for the Port Esquivel facility is utilized. The existing dredged channel is 120 meters wide and 12.2 meters deep. However, while the nautical chart supports this channel width the soundings indicate that the water depth is potentially less than 12.2 meters. Therefore, the existing dredged channel is conservatively estimated to be 120 meters wide and 11.5 meters deep for this dredging analysis. Based on the minimum channel requirements, the existing channel is wide enough for both the primary and secondary design vessels and it is deep enough for the primary design vessel. However, the existing channel is not deep enough for the secondary design vessel so additional new work dredging of the existing channel will be required to accommodate it.

In addition to the new work dredging and channel improvement dredging associated with the mid-bay and nearshore locations, long term maintenance dredging will be needed to maintain safe navigation for LNG vessels. The ship sizes, volumes that need to be dredged (preliminary and annually) and marine trestle length are listed in Table 10-1.

The costs involve for the preliminary and maintenance dredging makes these options not as attractive due to the increase costs that would incur on the proposed project. Therefore, these options were rejected.

Table 10-1 Summary of marine facility alternatives

Location	Design Vessel	Preliminary Marine Trestle / Subsea Pipeline Length	Preliminary New Work Dredging Requirements	Preliminary Annual Maintenance Dredging Requirements	Preliminary Unloading Platform & Marine Trestle Deck Elevation
Offshore	Primary Design Vessel (30,000 m^3 cargo cap.)	2,500 meters	0 cubic meters	0 cubic meters	+ 10.5 meters
	Secondary Design Vessel (150,000 m^3 cargo cap.)	4,000 meters	0 cubic meters	0 cubic meters	+12.0 meters
Mid-Bay	Primary Design Vessel (30,000 m^3 cargo cap.)	900 meters	1,220,000 cubic meters	27,400 cubic meters	+8.5 meters
	Secondary Design Vessel (150,000 m^3 cargo cap.)	900 meters	3,345,000 cubic meters	43,700 cubic meters	+8.5 meters
Nearshore	Primary Design Vessel (30,000 m^3 cargo cap.)	1,550 meters	1,190,000 cubic meters	43,000 cubic meters	+8.0 meters
	Secondary Design Vessel (150,000 m^3 cargo cap.)	1,550 meters	2,940,000 cubic meters	44,400 cubic meters	+8.0 meters
Nearshore (Alternate)	Primary Design Vessel (30,000 m^3 cargo cap.)	400 meters	1,190,000 cubic meters	43,000 cubic meters	+8.0 meters
	Secondary Design Vessel (150,000 m^3 cargo cap.)	400 meters	2,940,000 cubic meters	44,400 cubic meters	+8.0 meters

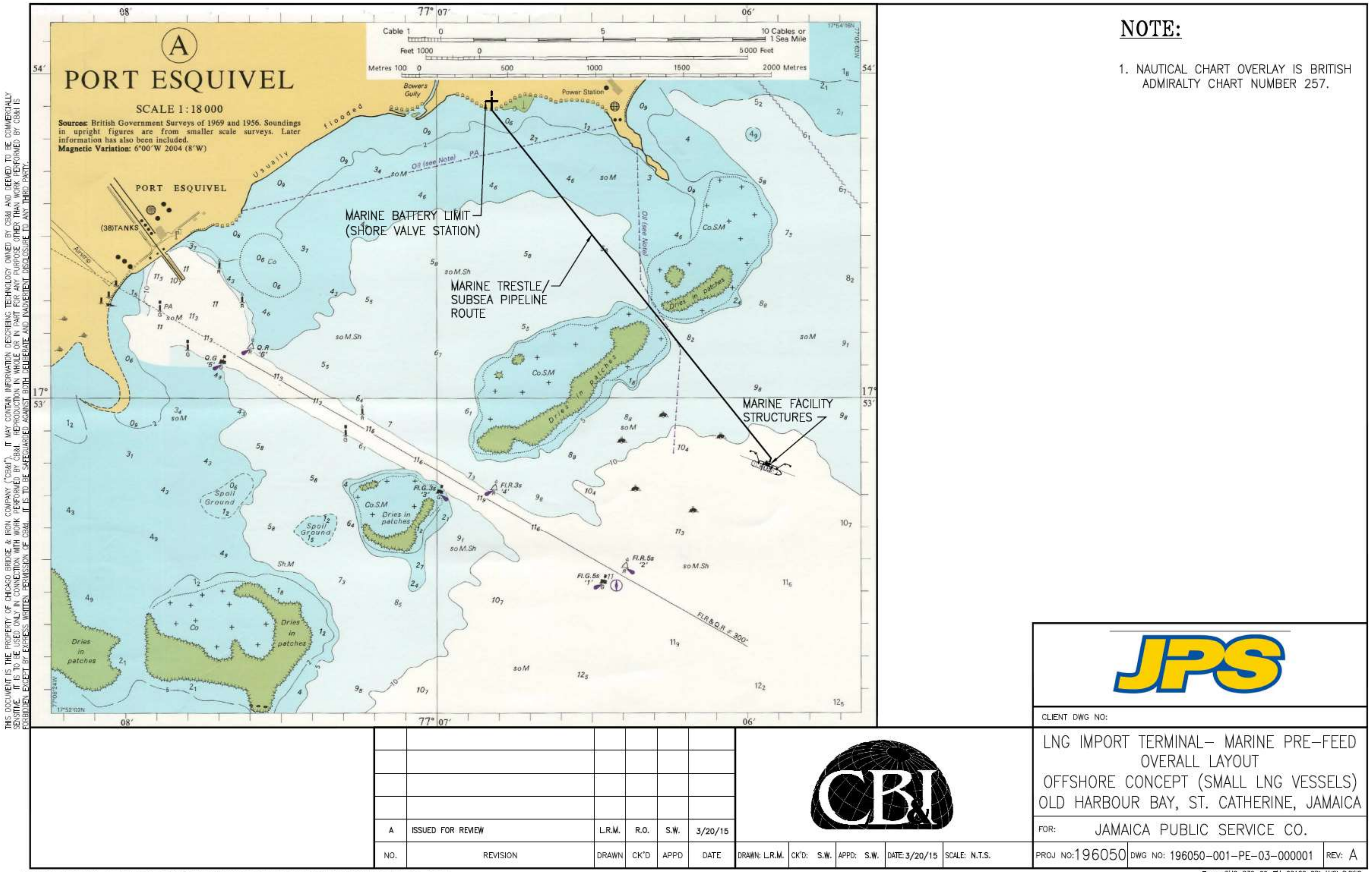


Figure 10-3 LNG Terminal offshore concept (small LNG vessels)

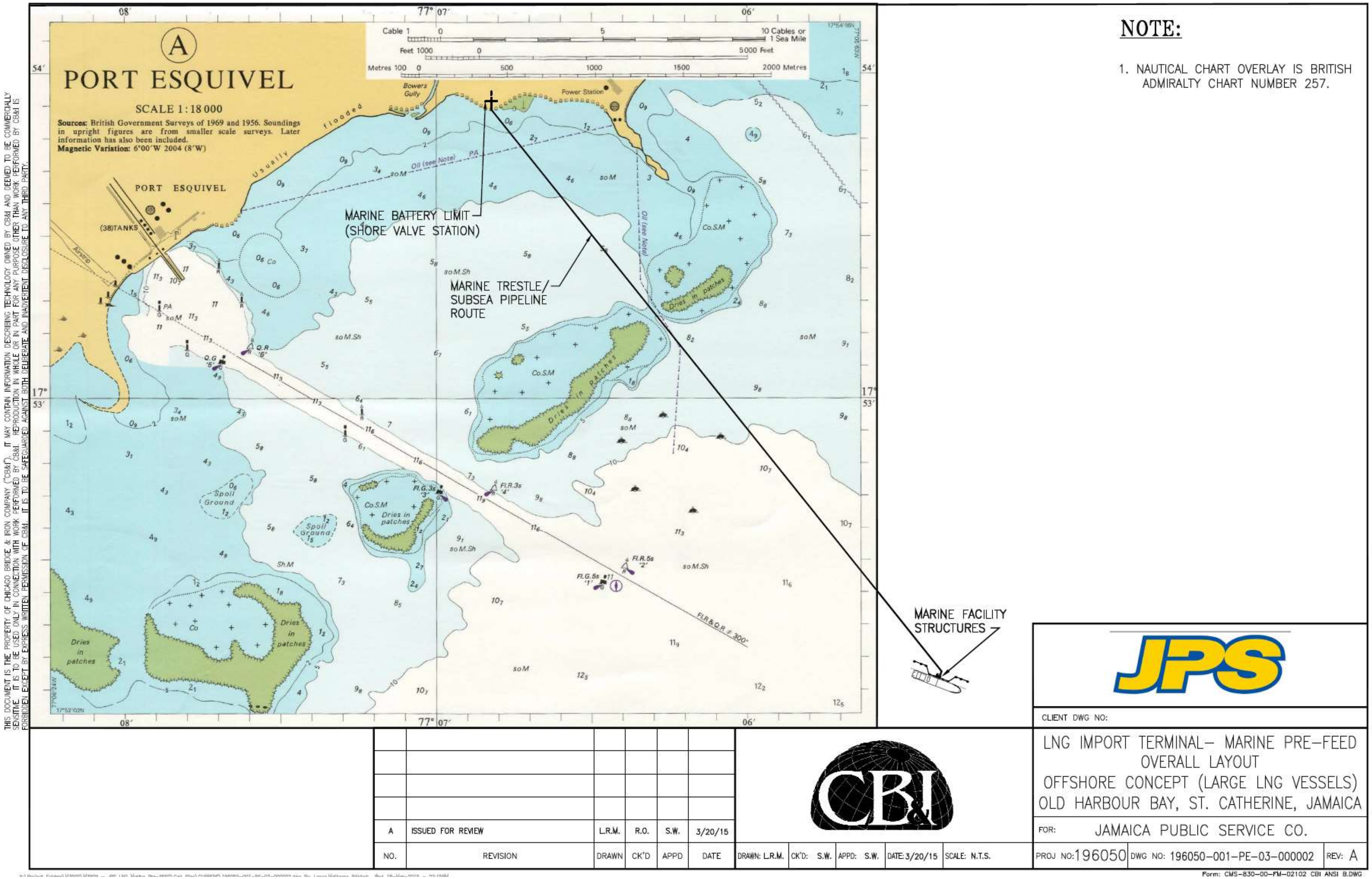


Figure 10-4 LNG Terminal offshore concept (large LNG vessels)

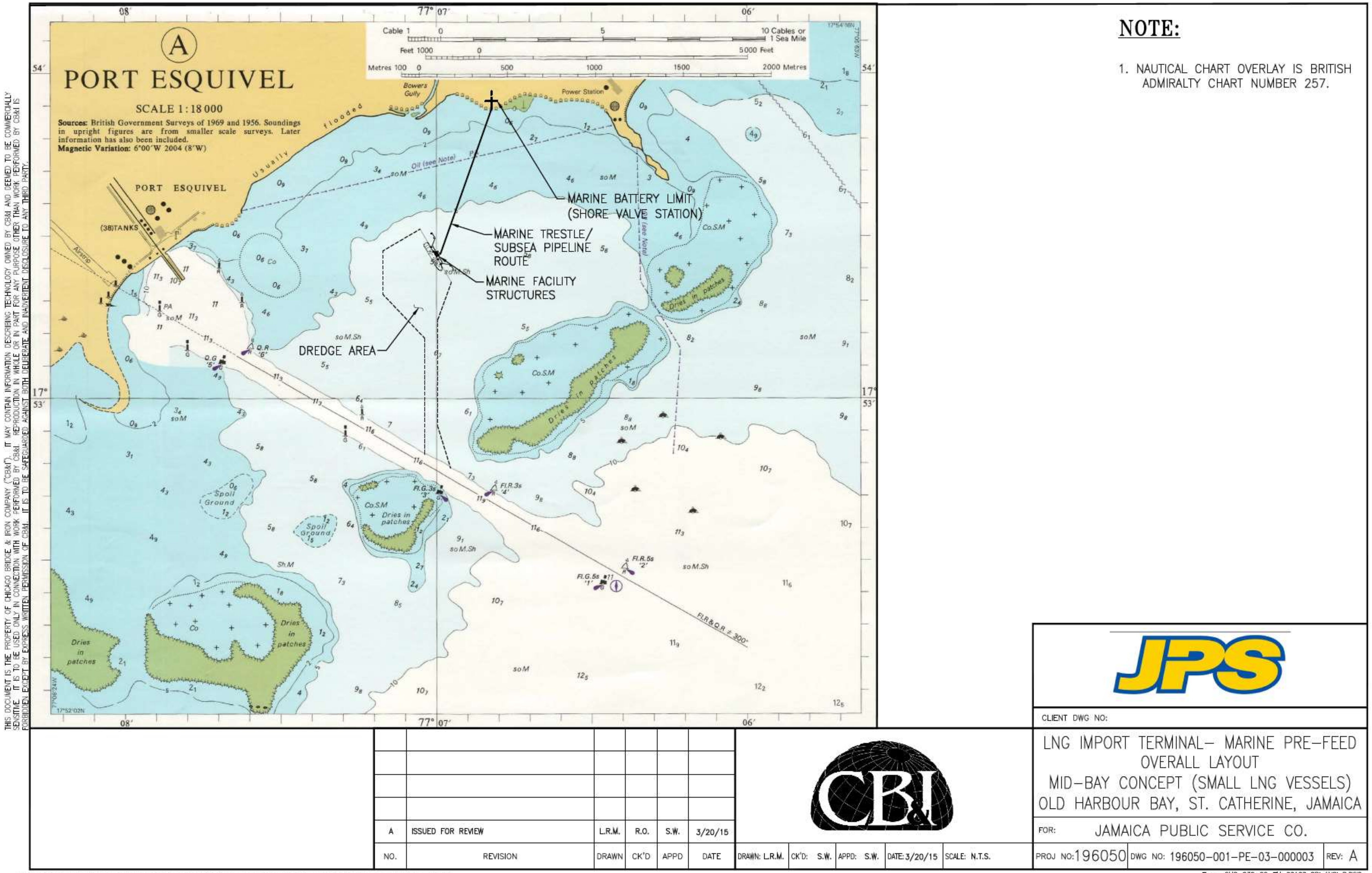
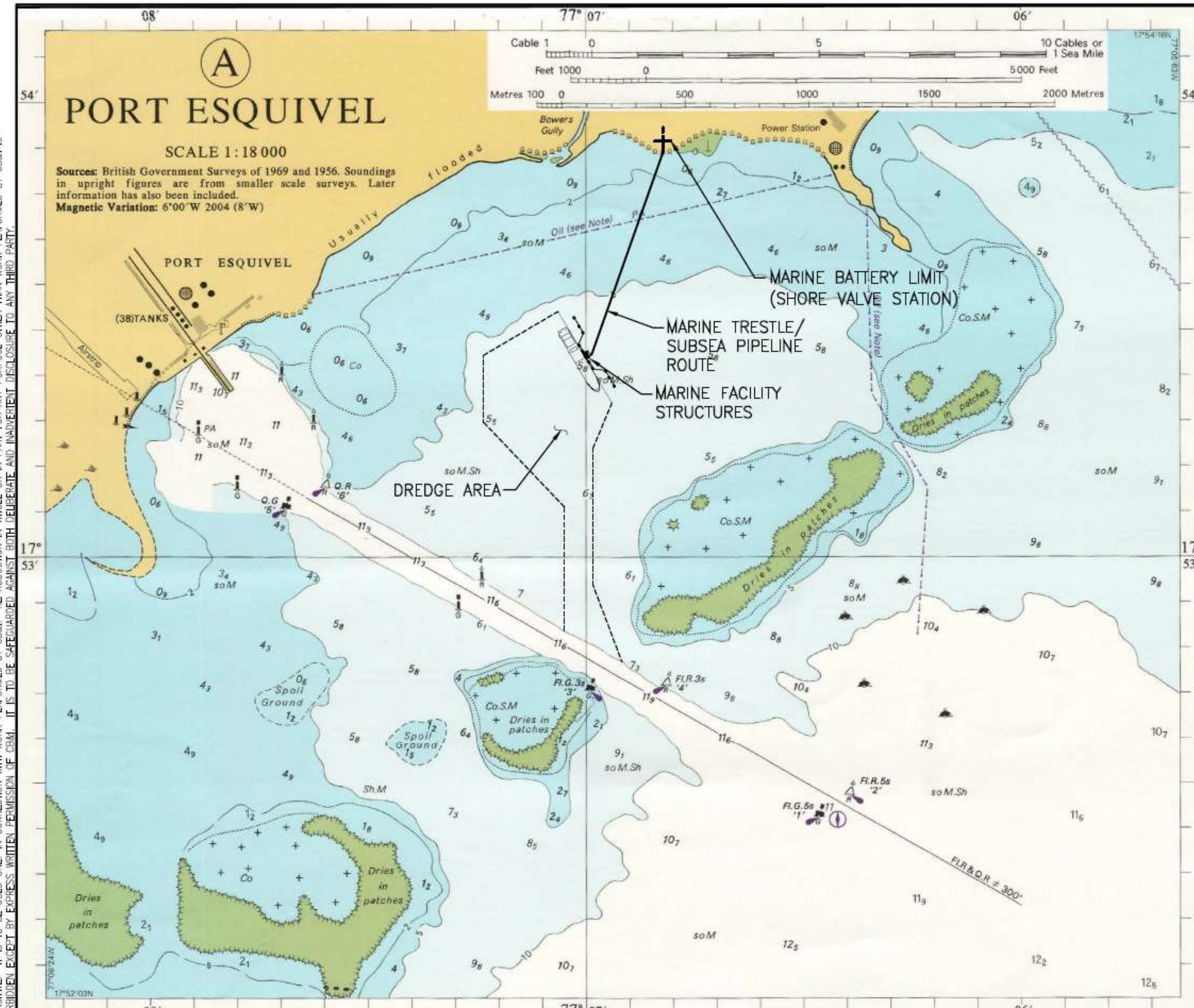


Figure 10-5 LNG Terminal mid-bay concept (small LNG vessels)



NOTE:

1. NAUTICAL CHART OVERLAY IS BRITISH ADMIRALTY CHART NUMBER 257.

JPS

CLIENT DWG NO:

NO.	REVISION	DRAWN	CK'D	APPD	DATE
A	ISSUED FOR REVIEW	L.R.M.	R.O.	S.W.	3/20/15

CB&I

DRAWN: L.R.M. CK'D: S.W. APPD: S.W. DATE: 3/20/15 SCALE: N.T.S.

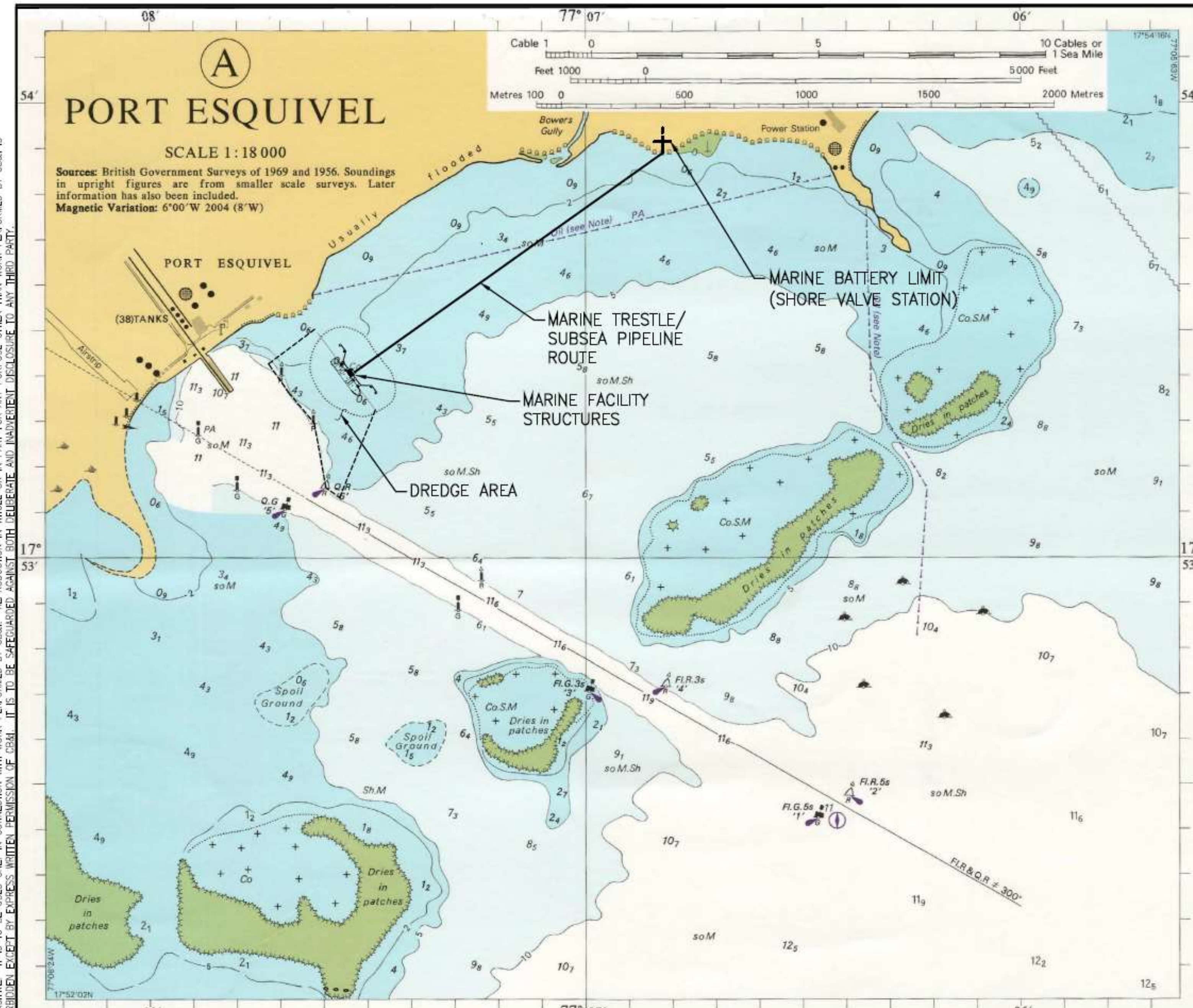
LNG IMPORT TERMINAL– MARINE PRE-FEED OVERALL LAYOUT
MID-BAY CONCEPT (LARGE LNG VESSELS)
OLD HARBOUR BAY, ST. CATHERINE, JAMAICA

FOR: JAMAICA PUBLIC SERVICE CO.

PROJ NO: 196050 DWG NO: 196050-001-PE-03-000004 REV: A

Form: CMS-830-00-FM-02102 CBI ANSI B.DWG

Figure 10-6 LNG Terminal mid-bay concept (large LNG vessels)



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CLIENT DWG NO:

LNG IMPORT TERMINAL– MARINE PRE–FEED OVERALL LAYOUT
NEARSHORE CONCEPT (SMALL LNG VESSELS)
OLD HARBOUR BAY, ST. CATHERINE, JAMAICA

FOR: JAMAICA PUBLIC SERVICE CO.

NO.	REVISION	DRAWN	CK'D	APPD	DATE
A	ISSUED FOR REVIEW	L.R.M.	R.O.	S.W.	3/20/15

DRAWN: L.R.M. CK'D: S.W. APPD: S.W. DATE: 3/20/15 SCALE: N.T.S.

PROJ NO: 196050 DWG NO: 196050–001–PE–03–000005 REV: A

Form: CMS–830–00–FM–02102 CBI ANSI B.DWG

Figure 10-7 LNG Terminal nearshore concept (small LNG vessels)

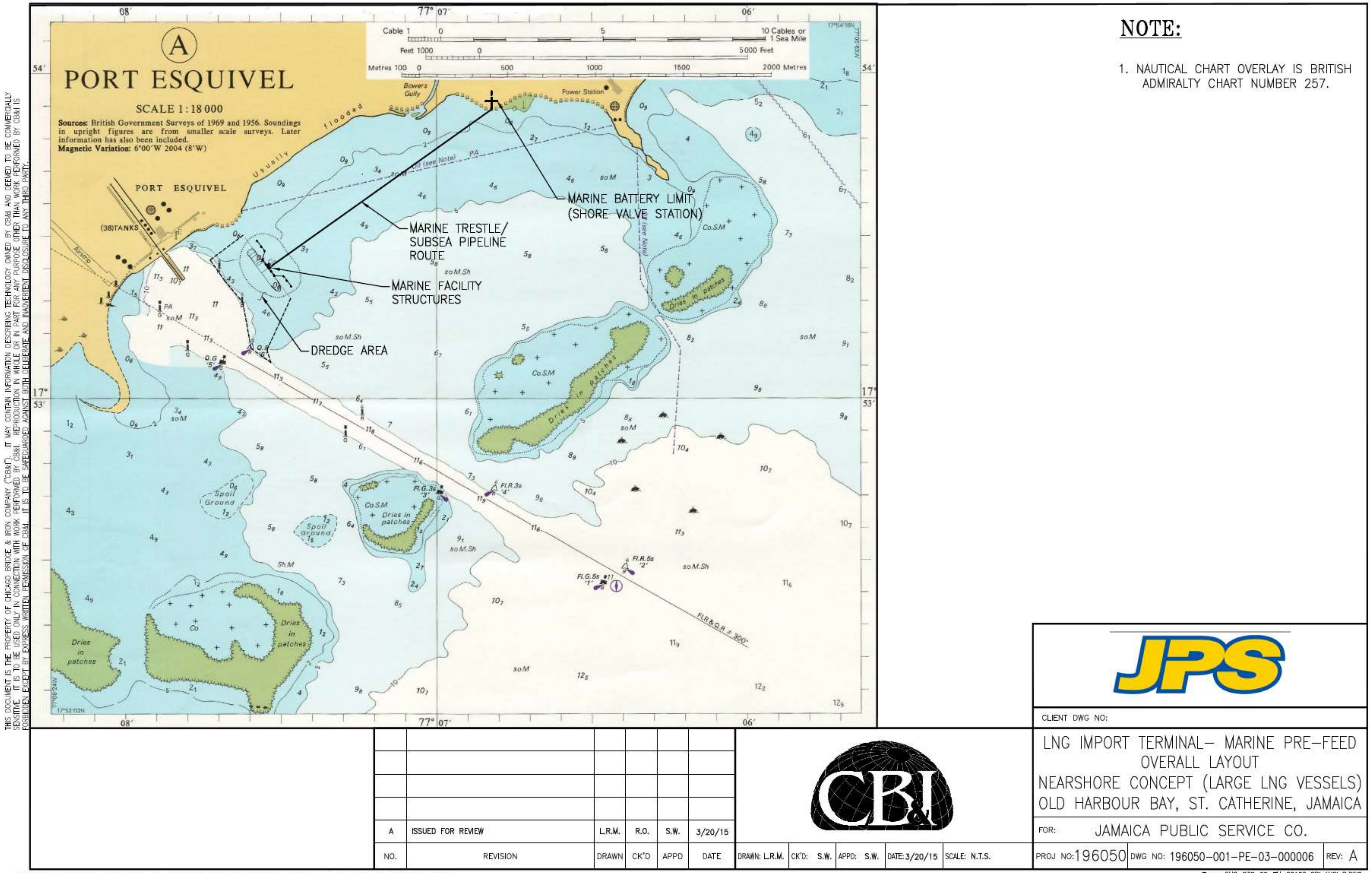


Figure 10-8 LNG Terminal nearshore concept (large LNG vessels)

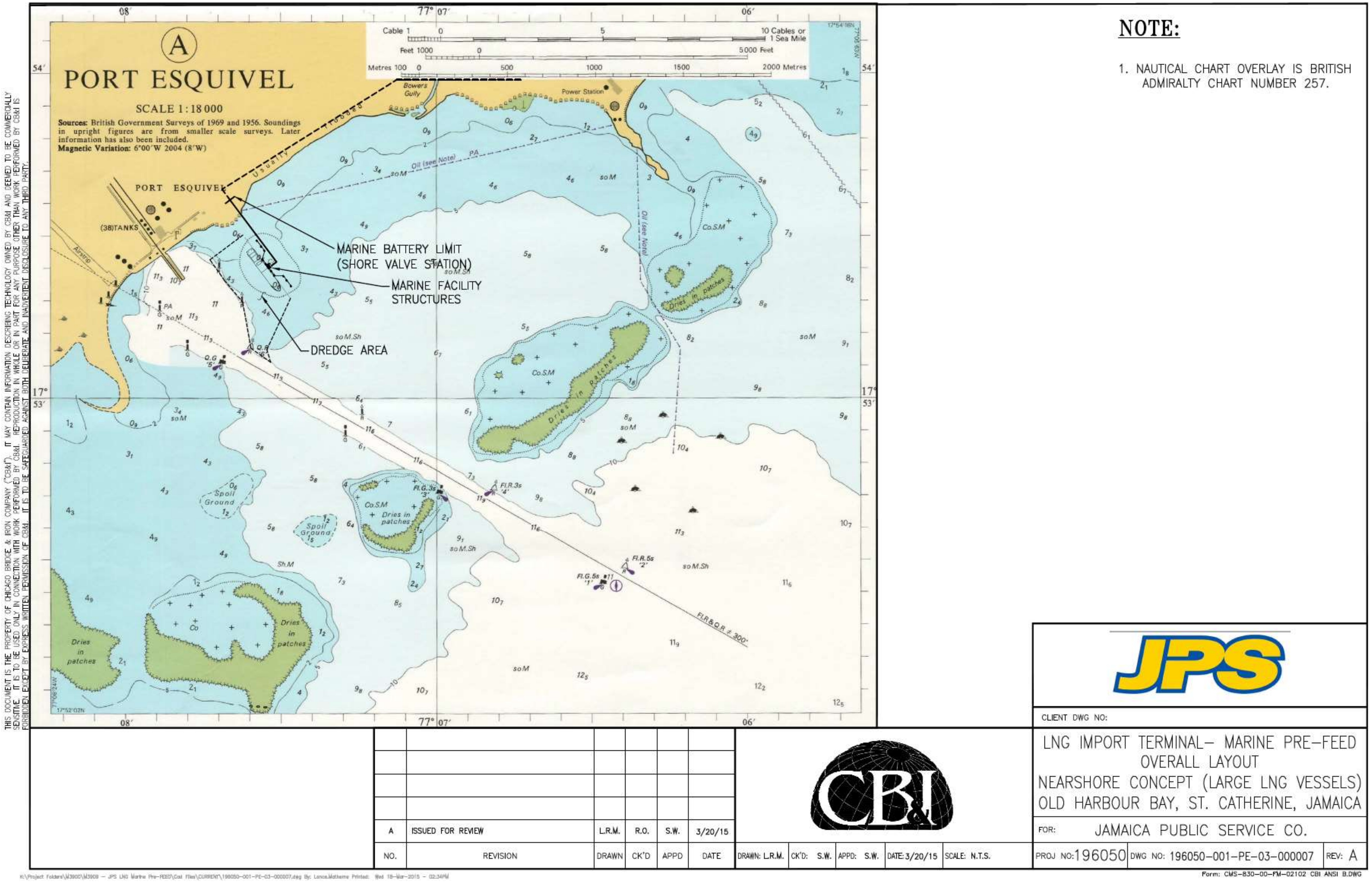


Figure 10-9 LNG Terminal nearshore concept B (large LNG vessels)

10.3.4 Land Based Storage, Regasification and Metering Systems

This alternative explores the possibility of putting the entire system on land with the exception of the LNG delivery system from the LNG carrier (Figure 10-10). LNG would be offloaded offshore from the LNG carrier and piped to a cryogenic single containment double wall structure LNG storage tank on land (Figure 10-11). The infrastructure would include a flare to handle Boil Off Gas (BOG). The LNG would then be regasified to NG using either Shell and Tube Vaporizers (STV) with a WEG system or Open Rack Vaporizers (ORV) with Seawater and the NG pumped to the JPS 190 MW plant through a metering system.

The major potential positive for this alternative is that the major infrastructure would be less susceptible to hurricane waves and surges. However, the potential negatives of being closer to the human centres in the event of an accident, increase potential for negative impacts on the residents (such as thermal radiation).

The potential negatives outweighs the potential positives therefore, this alternative was rejected.

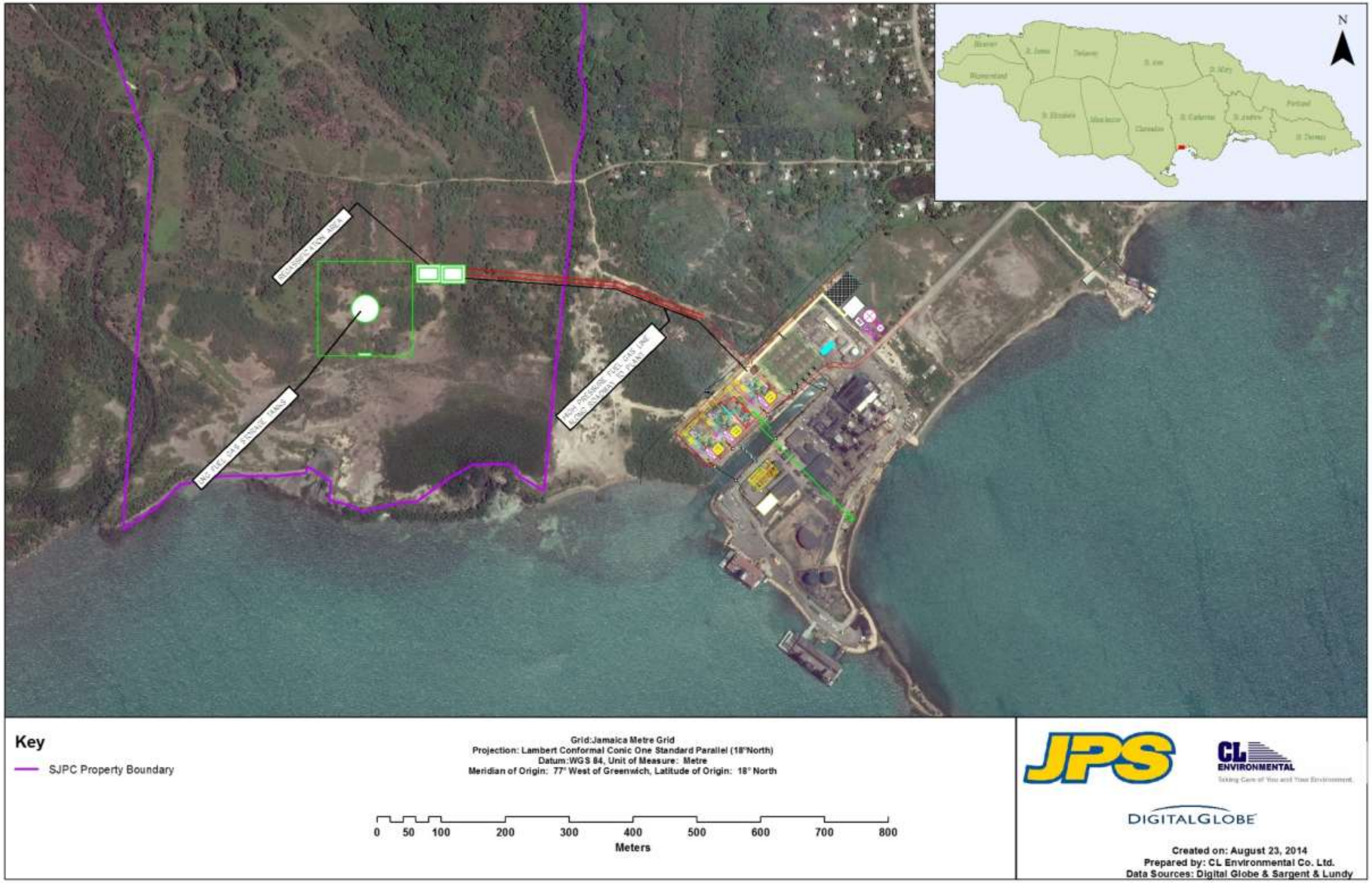
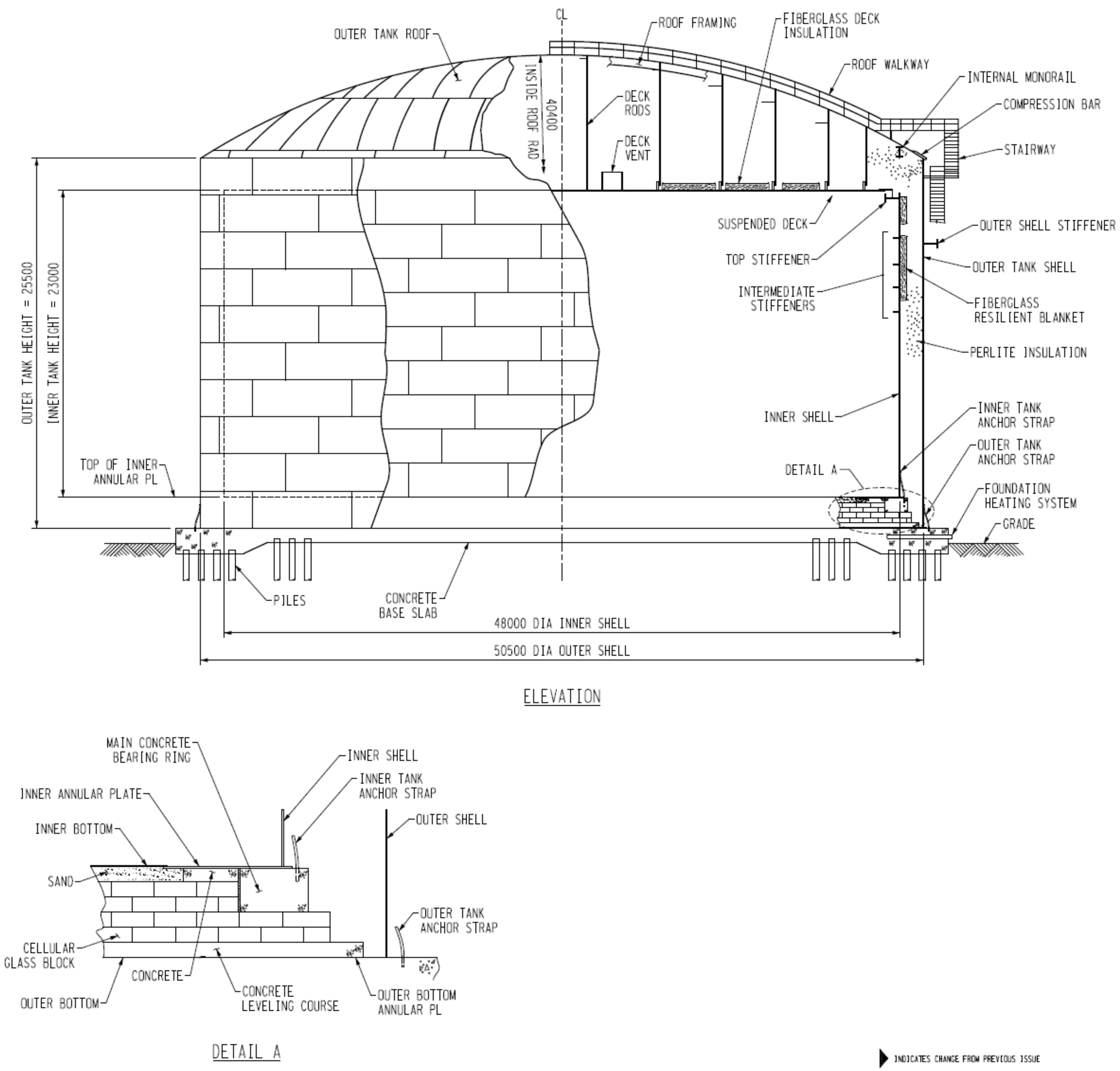


Figure 10-10 General layout of the proposed JPS 190MW Combined Cycle Power Regasification Plant



DESCRIPTION	INNER TANK	OUTER TANK
SERVICE PRODUCT	LNG	-
NET CAPACITY	40000 M3	-
MAXIMUM NORMAL OPERATING LEVEL	22250 mm	-
PRODUCT DESIGN DENSITY	470 KG/m3	-
DESIGN TEMPERATURE	-168° C	-
CORROSION ALLOWANCE	-	-
DESIGN STANDARD	API 620 APP Q, 12th ED	
TANK DESIGN PRESSURE - MAX.	13.79 kPa (2 PSIG)	
TANK DESIGN PRESSURE - MIN.	-0.5 kPa	
SEISMIC DESIGN - STD/CODE	-	
ALLOWABLE BOILOFF PER DAY	0.15% GROSS CAPACITY	
FOUNDATION	BASE SLAB FOUNDATION W/ PILES	

MATERIAL SPECIFICATION		
ITEM	MATERIAL-INNER TANK	MATERIAL-OUTER TANK
SHELL	A553 TYPE 1	A516-70
BOTTOM	A553 TYPE 1	A36
ANNULAR PLATE	A553 TYPE 1	A516-70
SUSPENDED DECK	B209 5083-0	-
SUSPENDED DECK RODS	304 SS / A36	-
SHELL STIFFENERS	A553 TYPE 1	A36 / A516-70
COMPRESSION BAR	-	A516-70
ROOF	-	A516-70
ROOF STRUCTURAL	-	A36
ANCHOR STRAP	-	304 SS

NOTES:

1. NORMAL MAXIMUM OPERATING LEVEL IS USED IN COMBINATION WITH ANY ABNORMAL EVENT.
2. BOIL-OFF IS BASED ON VOLUME TO DESIGN LIQUID LEVEL.

ISSUED FOR INFORMATION — JFJ — EAW — 1
REV'D FOUNDATION TO SLAB ON PILES ISSUED FOR INFORMATION — JFJ — EAW — JEK — 06MAR15 — 0

BY | CHKD | DATE | REVISIONS | REMARKS

GENERAL ARRANGEMENT
40,000 M3 LNG TANK
JAMAICA PUBLIC SERVICE LIMITED
JAMAICA

BY EAW CHKD JEK DATE 06MAR15
JOHN BLACK
ENGINEERING ASSIGNED
DOC NO. 196050-000-SP-01-010101
CONTRACT NO 196050
DWG NO 101 SHT NO 01 REV 1

▶ INDICATES CHANGE FROM PREVIOUS ISSUE

Figure 10-11 Section of the LNG tank

10.4 DIFFERENT DELIVERY OPTIONS

Two concepts are considered for the routing of the process and utility piping from the shoreline to the LNG unloading platform. The first concept considered is the marine trestle concept and the second is the subsea pipeline concept. Each of these two concepts are analyzed for each conceptual location of the marine facility in order to compare the two potential approaches and support a decision with respect to how the piping will be routed to the LNG unloading platform.

10.4.1 Marine Trestle

The marine trestle concept is widely used for providing pipeline routing and vehicular/pedestrian access to marine loading and unloading platforms located offshore. This concept offers the benefit of having all of the piping located in an area where it can be accessed for inspection and maintenance purposes. Moreover, this concept offers the benefit of providing vehicular and pedestrian access to the unloading platform, thereby eliminating the requirement for marine vessel access to the unloading platform and providing a means for inspections and maintenance of the topside equipment without the need for waterborne equipment.

The preliminary marine trestle structure developed for the Marine Pre-FEED effort includes pile bents spaced at 24 meter intervals. Each pile bent features multiple driven piles with a reinforced concrete cap. The width of the reinforced concrete cap is 10 meters at the typical pile bents. Wider pile bents are provided every 192 meters to accommodate pipe loops to allow for expansion and contraction of the topside piping; these pile bents are 18 meters in width. Additionally, one larger pile bent is provided between each pipe loop to accommodate additional piles for the support of the anchor point in the piping. Above the pile caps the bridge spans will be supported with reinforced concrete bridge girders. These bridge girders support a reinforced concrete vehicular bridge that is approximately 5 meters wide to provide for one-way vehicular access between the shore and the LNG unloading platform as well as reinforced concrete pipe support beams that are each 4 meters long to support the product and utility piping. The preliminary marine trestle structure is illustrated (Figure 10-12 and Figure 10-13). With the above configuration, the vapour return line could be used for LNG transfer if necessary, thus providing a certain limited redundancy.

The overall length of the marine trestle is based on each location concept described above. The typical 192 meter span is simply repeated as many times as necessary to connect the various unloading platform locations to the shoreline.

The potential negative impact s of this alternative is that it would present a physical barrier for the fishers using the area, be prone to hurricane and seismic activities. It would also potentially have a negative visual impact.

This alternative was rejected.

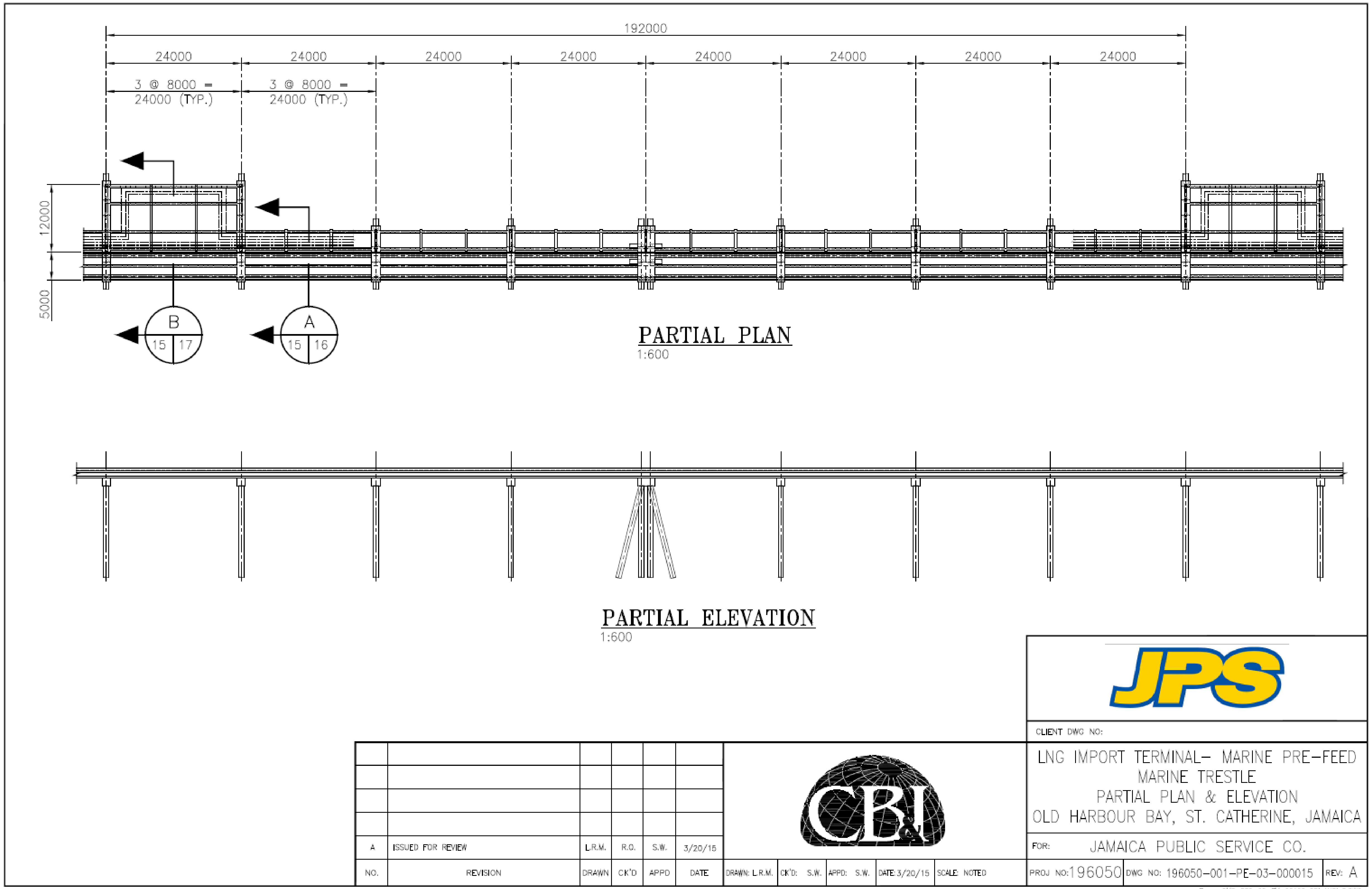


Figure 10-12 Partial plan view of the marine trestle

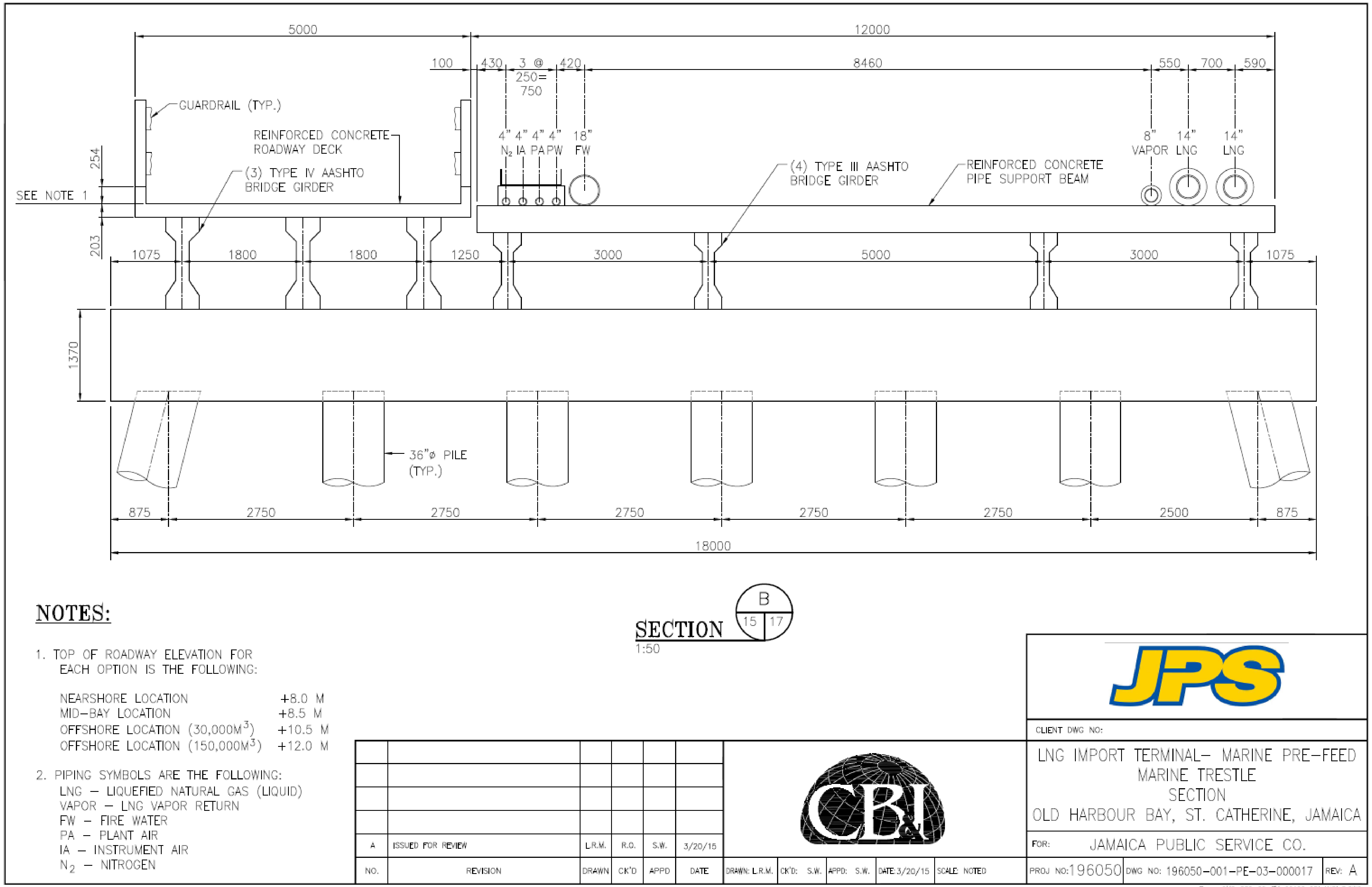


Figure 10-13 Marine trestle section

10.4.2 Cryopipeline

As an alternative to the marine trestle, a cryogenic subsea pipe can be used for the transfer of the LNG and vapour return. For this duty, a fully qualified system is provided. The subsea pipe has the advantage of not interfering with marine traffic and placing the pipelines out of harms way. There is lesser environmental impact and a more favourable response to seismic activities by avoiding interactions with other structures.

The ITP LNG pipe in pipe in pipe (PIPIP) system comprises a 36% Ni-Fe alloy (Invar) inner pipe for LNG transport, an intermediate low temperature carbon steel (LTCS) pipe for secondary containment and a carbon steel outer pipe for mechanical and corrosion protection. The inner pipe is wrapped with Izoflex insulation panels; inserted into the intermediate pipe, and the annulus has a reduced pressure to reduce heat loss and provide for leak detection, with the outer annulus filled with an inert gas (nitrogen) at a pressure slightly above local ambient to prevent flooding in the event of an outer pipe leak.

The coefficient of thermal expansion of 36% Ni-Fe is approximately 10 times less than stainless steel and as such internal bellows and expansion loops are not required. The elimination of expansion loops reduces the overall pipeline line length, which may allow for sizing optimization for the same hydraulic design.

The insulation material, Izoflex, is a microporous insulation consisting of Silica Dioxide, Titanium Dioxide and glass fibre mix that can withstand temperatures from –200°C to + 900°C and has a thermal conductivity of 0.005 W/m-K at LNG temperatures (0.0029 BTU/ft hr ºF) as applied at reduced pressures.

The LNG PIPIP system consists of the following elements:

- 14” LNG, Inner 36% Ni/Fe pipe,
- 20” LNG, LTCS Intermediate pipe, and
- 24” LNG, Carbon Steel Outer pipe.

The Vapour Return system consists of the following elements:

- 8” Vapour return, 36% Ni/Fe inner pipe,
- 15” Vapour return, LTCS Outer pipe.

The LNG, vapour return and utilities lines would be grouped together in a bundle and laid on the sea bed in a straight line from the onshore battery limit to the selected mooring platform.

The subsea pipe is illustrated with the landfall zone, the bend at the loading berth, and the vertical riser (Figure 10-14). A test section of the ITP PIPIP system (28” / 34” / 38”) is illustrated in Plate 10-1.

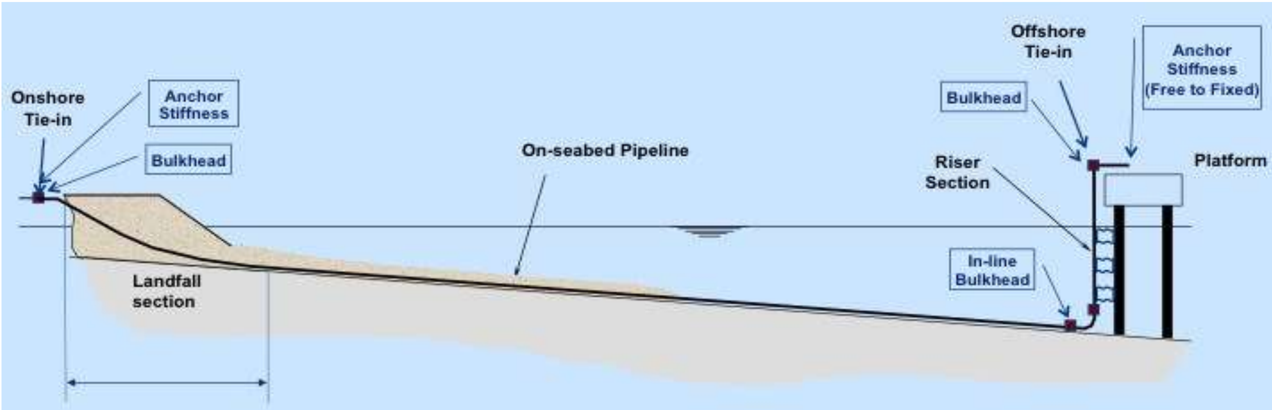


Figure 10-14 Schematic of subsea pipeline

Plate 10-1 Test section of ITP PIPIP system (28" / 34" / 38")

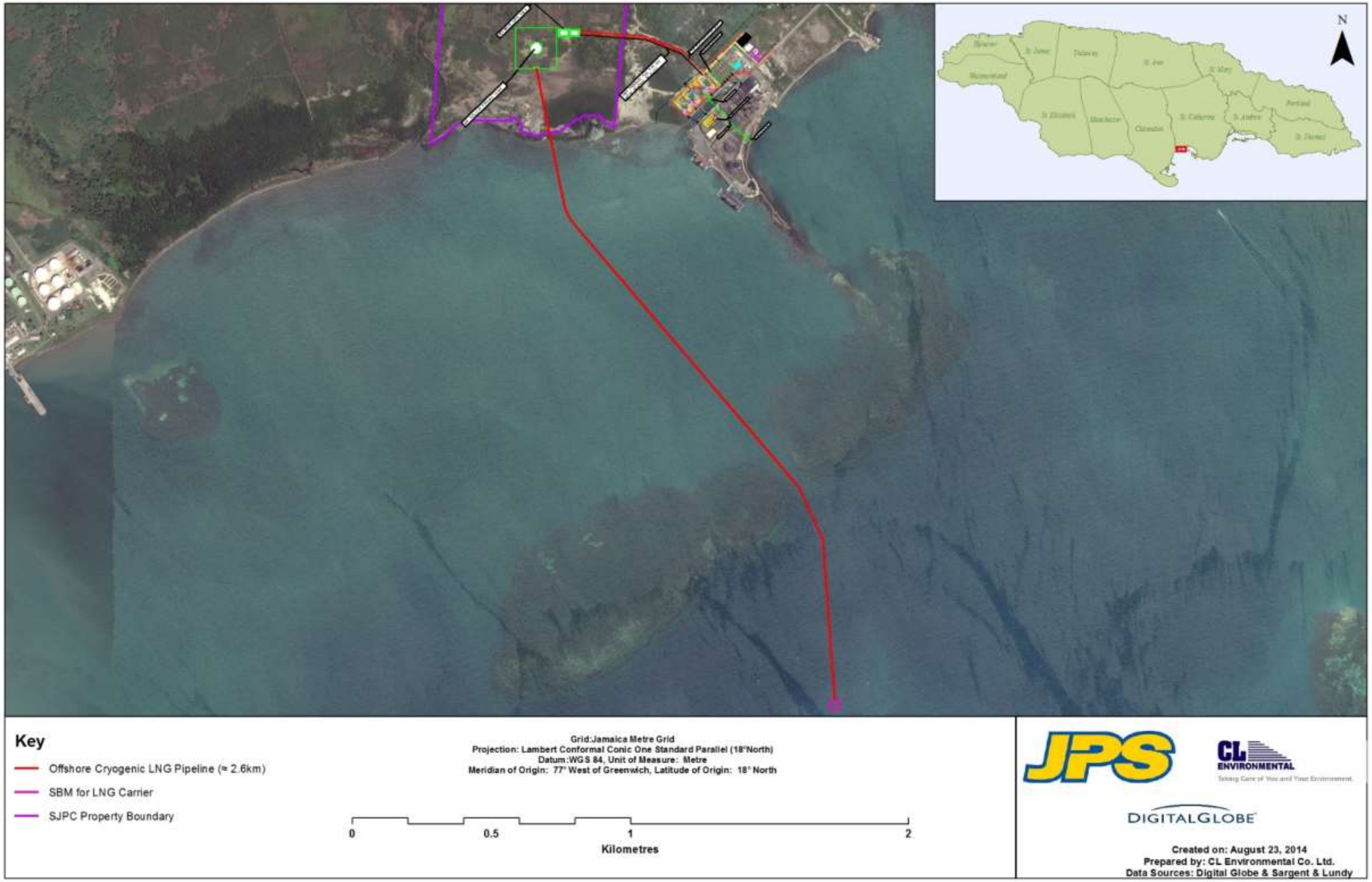


Figure 10-15 JPS 190MW Combined Cycle Power Regasification Plant LNG fuel supply layout

10.4.3 LNG Trucked to Site

Another alternative is to truck ISO Containers of NG to the JPS 190 MW plant. The fuel consumption of the 190 MW plant would require approximately 52 ISO Containers of NG gas per day.

This volume would potentially result in negative impacts for transportation along roadways (traffic and increased potential for accidents) and also for the marine delivery of the containers. Port Esquivel is the closest port but it is not equipped with cranes for loading and offloading cargo. Therefore a new pier would have to be built to facilitate the marine delivery of these containers in the Old Harbour Bay area. If they were to enter through the port in Kingston, it would result in a logistic nightmare.

Due to these factors this alternative was not considered and was rejected.

10.5 ALTERNATIVES TO OTHER PROJECT FEATURES

10.5.1 Flaring

The alternative to flaring would be venting the gas directly to the atmosphere, which is possible but not as environmentally friendly, with regard to air emissions, as flaring. Flaring or venting is an important safety measure used at LNG facilities to ensure gas is safely disposed of in the event of an emergency, power or equipment failure, or other plant upset condition.

10.5.2 Use of Seawater in the Regasification Process

The alternative to seawater in the regasification process is an ambient air vapourizer system which is not optimal given the operational requirements of the facility and would require a significantly larger platform to account for a much larger footprint for the equipment.

A Gas Combustion Unit (GCU) can be installed on the FSU, with capacity sufficient to deal with all excess boil off gas (BOG) generated at maximum designed boil off rate (i.e. 0.15%) with engines stopped (as per standard LNG carrier design requirements). If the FSU is installed with closed loop capability as an alternative to seawater vaporizers, the regasification steam boilers will function as a GCU if needed by dumping steam.

10.6 OVERVIEW OF ALTERNATIVE ANALYSIS

Based on the above, the development as proposed in the EIA is the most economical option that will result in the provision of the needed fuel type and capacity with reduced potential impacts which can be mitigated.

11.0 COST BENEFIT ANALYSIS

11.1 METHODOLOGY

The United Nation Industrial Development Organization (UNIDO) and the Centre for Organization of Economic Cooperation and Development (COECD) have come with useful publications dealing with the problem of measuring social costs and social benefits. It may be noted, in this context, that the actual cost or revenues from the goods and/or services to the organization do not necessarily reflect the monetary measurement of the cost ant or benefit to the society. This is because these figures are grossly distorted on account of restriction and controls imposed by the government. Hence a different yardstick has to be used for evaluating a particular in terms of cost and sacrifice on the part of the society. Such payments are easily valued at opportunity cost or shadow prices to judge their real impact in terms of cost to society for the purpose of social cost benefit evaluation.

The approach for this analysis uses a five stage methodology:

1) Calculation of financial profitability measured at market prices.
2) Obtaining the net benefit of the project measured in terms of economic prices.
3) Adjustment for the impact of the project on savings and investment.
4) Adjustment for the impact of the project on income distribution.
5) Adjustment for the impact of the project on merit goods and demerit goods

11.1.1 Calculation of Financial Profitability Measured at Market Prices

A good technical and financial analysis must be done before a meaningful economic evaluation can be made. For this reason, financial profitability is a prerequisite in all cases.

Financial profitability produces an estimate of the project s financial pro t or the net present value of the project when all inputs and outputs are measured at market prices. The first step in stage one is to complete standard tables of income statement, balance-sheet and cash-flow. The financial income statement is the central table in this analysis as it is used to record the inputs and outputs of the project. Cash ow statement is also important here as the financial income statement only shows the annual pro t and disguise investment. The net cash ow is derived from the financial income statement by standard accounting procedures and is equal to the gross cash ow (operating pro t before interest and taxes plus allowances for depreciation) minus capital investments.

11.1.2 Obtaining the Net Benefit of the Project Measured in Terms of Economic Prices

Stage two of the UNIDO approach is concerned with the determination of the net bene t of the project in terms of economic prices, also referred to as shadow prices. Market prices represent shadow prices only under conditions of perfect markets which are almost invariably not fulfilled in developing countries. Hence, there is a need for developing shadow prices and measuring net economic bene t in terms of these prices.

11.1.3 Adjustment for the Impact of the Project on Savings and Investment

Most of the developing countries face scarcity of capital. Hence, the governments of these countries are concerned about the impact of a project on savings and its value thereof. Stage three of the UNIDO method, concerned with this, seeks to answer the following questions:

- Given the income distribution impact of the project what would be its effects on savings?
- What is the value of such savings to the society?

The saving impact of a project is equal to

$$\sum_i \triangle Y_i \times MPS_i$$

Where $4Y_i$ is the change in income of group i as a result of the project, and MPS_i is the marginal propensity to save of group i.

11.1.4 Adjustment for the Impact of the Project on Income Distribution

Many governments regard redistribution in favour of economically weaker sections or economically backward regions as a socially desirable objective. Due to practical difficulties in pursuing the objective of redistribution entirely through the tax, subsidy, and transfer measures of the government, investment projects are also considered as investments for income redistribution and their contribution toward this goal is considered in their evaluation this calls for suitably weighing the net gain or loss by each group, measured earlier, to reflect the relative value of income for different groups and summing them.

If there are only two groups in a society, poor and rich, the determination of weight is just an iterative process between the analysts (at the bottom) and the planners (at the top). This is called bottom-up approach. When more than two groups are involved, weights are calculated by the elasticity of marginal utility of income. The marginal utility of income is the weight attached to an income is

$$w_i = (b{=}c_i)n$$

Where,
W_i = weight of income at c_i level
c_i = level of income of group
b = base level of income that has a weight of 1.00
n = elasticity of the marginal utility of income

11.1.5 Adjustment for the Impact of the Project on Merit Goods and Demerit Goods

The steps of adjustment procedure are:

- Estimating the present economic value
- Calculating the adjustment factor
- Multiplying the economic value by the adjustment factor to obtain the adjusted value
- Adding or subtracting the adjusted value to or from the net present value of the project as calculated in stage four.

11.2 THE PROPOSED PROJECT BASED ON THE OPPORTUNITY COST

Here we apply the methodology outlined above to the proposed project.

11.2.1 Calculation of Financial Profitability Measured at Market Prices

Table 11-1 presents the estimates of revenue collected by the project during its lifetime. There are two ways for natural gas to be traded between countries that have a lot of natural gas to those that don't. The first is building natural gas pipeline. The second is to build facilities to liquefy natural gas or to make LNG. Jamaica is going with the second option.

LNG has some fixed costs above and beyond the cost of the raw natural gas. These costs are typically amortized over 20 years. The most significant of those fixed costs are: a) Liquification plant $1.1 per Mcf +/- $0.20. b) Shipping costs (LNG tankers and operating costs) $0.70 per Mcf +/- $0.30 depending on distance. c) Cost for regasification $0.35 per Mcf. Therefore 2.65 per MCF is the marginal cost of producing LNG over and above the price of natural gas.

The price of natural gas used in the projections is the average over the period from January 1997 to June 2016. Figure 11-1 displays the Henry Hub natural gas spot price over that period.

The Maximum daily consumption of LNG for the 190 MW Combined Cycle Plant at Natural Gas is 35 MM SCFD (MM SCFD- Million Standard Cubic Feet per day) thus the Maximum yearly consumption would be 12775 MM SCF/year (365 x 35 MM SCFD), which is 12,775,000 MM BTU-British thermal unit. Assuming a 50 per markup in the sales to the JPS, Table 11-1 presents the estimates of the guaranteed financial cash ow from the project.

The NPV is the difference between the present value of the annual total fixed costs, total variable operating and maintenance, and fuel and transportation cost; the capital expenditure for capital and construction and the present value of projected revenue. The calculation of NPV at market prices for the project turned out to be US$ 318,510,000 therefore as per financial evaluation the project should be under taken.

Table 11-1 Estimates of financial flows of revenue earned by the project during its lifetime (Measured is Millions of USD)

Year	Revenue	Year	Revenue
2017	88.11	2030	88.11
2018	88.11	2031	88.11
2019	88.11	2032	88.11
2020	88.11	2033	88.11
2021	88.11	2034	88.11
2022	88.11	2035	88.11
2023	88.11	2036	88.11
2024	88.11	2037	88.11
2025	88.11	2038	88.11
2026	88.11	2039	88.11
2027	88.11	2040	88.11
2028	88.11	2040	88.11
2029	88.11	PV	537.21
Annual Fixed O& M Cost			19.00
Present value of O & M Cost			115.84
Construction Cost			103.00
Net Present Value			318.51

** Cost is measured in millions of US$ Dollars. This uses a discount rate of 16%. Assuming that the exchange rate remain stable and oil prices are the same as 2016*

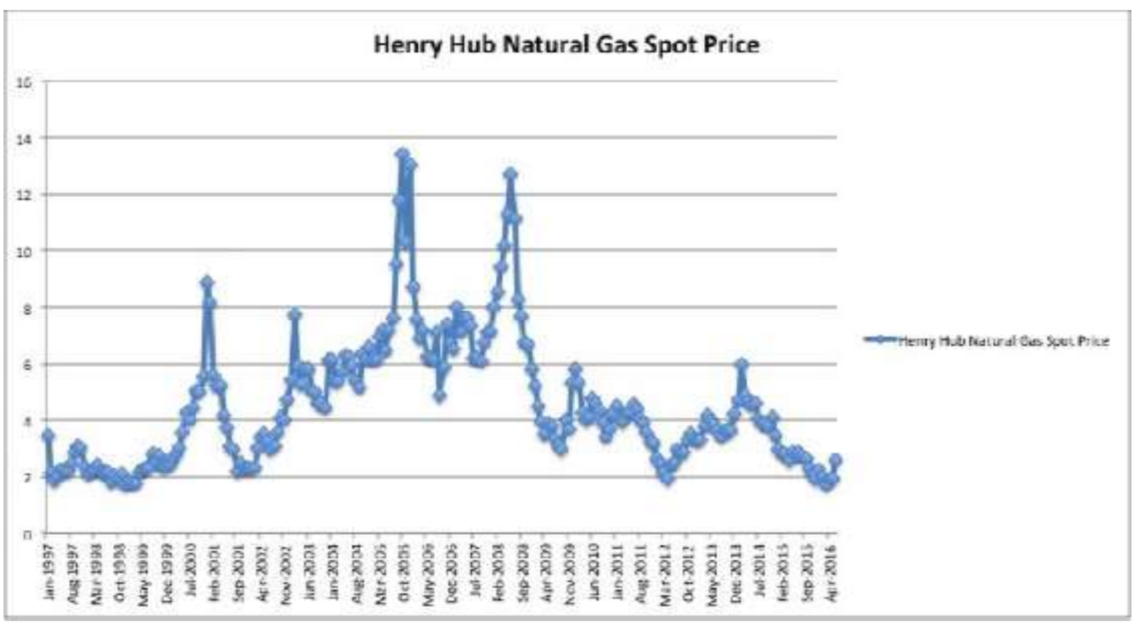


Figure 11-1 Henry Hub natural gas spot price

11.2.2 Obtaining the Net Benefit of the Project Measured in Terms of Economic Prices

11.2.2.1 Identification of Economic (Social) Benefits and Costs

Social benefits/costs are as follows:

- The major benefit of190 MW Old Harbour power plant and building the marine terminal and pipeline would be the manufacturing sector which will bene t from the lower cost of electricity and the establishment of the more reliable power supply. This will lead to more possibility of manufacturing that will lead to creation of employment opportunities for unskilled and skilled workers. This is hard to quantify and hence the number are not adjusted for it. Which means that the social bene t stayed below is a lower bound.
- The use of natural gas instead of oil will lead the reduction of the import oil bill and save foreign exchange. Leading to less pressure on the exchange rate which could lead less inflation of about 1 percentage point. (These number from a simple regression of the net international reserve on the JA$/US$ exchange rate.)
- Using natural gas would lead to greenhouse gas hence lead to reduction of environmental cost.
- There is the potential for increased employment during the pre-clearance and construction phases. It is anticipated that approximately 15 persons will be employed directly during the site clearance and an average of 75 persons to a maximum of 150-300 persons at the peak during construction. Approximately 80% of the work force will be obtained from local labour. In addition, it is anticipated that approximately 200 and 600 indirect and induced jobs are expected to be created during the site clearance and construction phases respectively; thus further benefitting the community. This represents a significant level of employment within the study area and has the potential to be a significant positive impact. This labour will be otherwise unemployed or under employed in the Jamaican economy.
- Revenue earned by the government in the form of taxes from the increase earnings employment provided by the project.
- The decrease in pollutants and hence the reduction in the environment cost from switching from Oil power plant to a Natural Gas plant.
- Decrease costs of power to end consumers due to rising fuel and coal costs.

Table 11-2 shows the Operation and Maintenance (O&M) cost of the project in terms of shadow (economic) prices.

Table 11-2 Estimates of financial flows of operation and maintenance (O&M) expenditures in terms of shadow prices (during its life time)

Year	Spare Parts	Labor Cost	Other expenses	Shadow Price of Pare Parts	Shadow Price of Labor cost	Shadow Price of Other Cost
2017	8.55	3.8	6.65	9.41	3.04	6.65
2018	8.55	3.8	6.65	9.41	3.04	6.65
2019	8.55	3.8	6.65	9.41	3.04	6.65
2020	8.55	3.8	6.65	9.41	3.04	6.65
2021	8.55	3.8	6.65	9.41	3.04	6.65
2022	8.55	3.8	6.65	9.41	3.04	6.65
2023	8.55	3.8	6.65	9.41	3.04	6.65
2024	8.55	3.8	6.65	9.41	3.04	6.65
2025	8.55	3.8	6.65	9.41	3.04	6.65
2026	8.55	3.8	6.65	9.41	3.04	6.65
2027	8.55	3.8	6.65	9.41	3.04	6.65
2028	8.55	3.8	6.65	9.41	3.04	6.65
2029	8.55	3.8	6.65	9.41	3.04	6.65
2030	8.55	3.8	6.65	9.41	3.04	6.65
2031	8.55	3.8	6.65	9.41	3.04	6.65
2032	8.55	3.8	6.65	9.41	3.04	6.65
2033	8.55	3.8	6.65	9.41	3.04	6.65
2034	8.55	3.8	6.65	9.41	3.04	6.65
2035	8.55	3.8	6.65	9.41	3.04	6.65
2036	8.55	3.8	6.65	9.41	3.04	6.65
2037	8.55	3.8	6.65	9.41	3.04	6.65
2038	8.55	3.8	6.65	9.41	3.04	6.65
2039	8.55	3.8	6.65	9.41	3.04	6.65
2037	8.55	3.8	6.65	9.41	3.04	6.65
2038	8.55	3.8	6.65	9.41	3.04	6.65
Shadow Present Value				$60.83	$19.65	$42.99
Total Discounted shadow Value						$123.47

The NPV calculation was done after doing below mentioned adjustments for social costs and social benefits:

- The O&M cost components i.e. spares, salaries and other expenses were multiplied by factor of 1.1, 0.8 and 1 to convert into corresponding components in shadow prices. Labour cost makes up 25% of O&M cost.
- The exchange rate effect is used to reduce the discount rate from 16% to 15%.

11.2.2.2 Environment Impact Caparison

Greenhouse Gas (GHG) Emissions for The Existing JPS Facility

Using USEPA* greenhouse gas emission factors for Oil-Fired Utility Boilers and a total oil consumption of 306,099,807 L/y, the following emission rates were calculated (Table 11-3).

Table 11-3 Greenhouse gas emission rates for oil-fired utility boilers facility

Facility	Pollutant	Emission	Emission	Facility Emission
		Factor, lb/103 gal	Factor, kg/L	Rate, tonne/y
Oil-Fired s	CO2	24,400	2.928	896,260.2
Utility Boiler	N2O	0.53	0.0000636	19.5
	CH4	0.28	0.0000336	10.3

**United States Environmental Protection Agency. May 2010. Emission Factor Documentation for AP-42: External Combustion Sources, Tables 1.3-3, 1.3-8 and 1.3-12. Office of Air Quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle, North Carolina.*

Greenhouse Gas (GHG) Emissions for LNG Facility

Using USEPA* greenhouse gas emission factors for LNG-Fired Stationary Gas Turbines and the heat consumption rate of 1.383 x 109 kJ/h for the LNG to be used, the following emission rates were calculated (Table 11-4):

Table 11-4 Greenhouse Gas Emission rates for LNG Facility

Facility	Pollutant	Emission	Facility Emission
		Factor, lb/MMBtu	Rate, tonne/y
NG-Fired	CO2	110	573,000
Combustion Turbine	N2O	0.003	15.6
	CH4	0.0086	44.8

**United States Environmental Protection Agency. July 1998. Emission Factor Documentation for AP-42: Stationary Gas Turbines. Office of Air Quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle, North Carolina.*

Table 11-5 Greenhouse Gas Emission rates for LNG Terminal

Unit	Pollutant	Facility Emission
tonnes/yr	CO2	141
tonnes/yr	N2O	3.50E-05
tonnes/yr	CH4	0.0511

Table 11-6 Combined Greenhouse Gas Emission rates for LNG Terminal and power plant

Unit	Pollutant	Facility Emission
tonnes/yr	CO2	573,141
tonnes/yr	N2O	15.6003
tonnes/yr	CH4	44.8511

The difference in pollutant is for CO2, N2O, and CH4 are 223,120, 3.9, -34.31 tonne/y respectively. Using a social of US$40 for CO2, US$29,000 for N2O and US$ 2,000 for CH4. See Marten, Alex L., and Stephen C. Newbold (2012) for calculations. Therefore, the difference in Greenhouse Gas is valued at US$8.969 million. The present value over 25 years is US$ 57.98 million.

According to the United States Environmental Protection Agency, the Central Value (3% discount rate) of the social cost of CO2 emissions in the year 2020 is $47 per metric ton, rising to 51 per metric ton in the year 2025. However, it should be noted that we are using US $40 per tonne per year as the estimate of the cost of CO2 (See Marten, Alex L., and Stephen C. Newbold (2012) for calculations). The cost is in current value terms while the US47 in 2020 is the future value (i.e. after taking into account the discount rate). Therefore, given our discounts rate we are using a higher value then the central Value reported by the United States Environmental Protection Agency social cost of CO2 emissions in both 2020 and 2025. Hence, using our value we are valuing the environmental cost of CO2 at higher price.

11.2.2.3 Social Benefit from Employment

There is the potential for increased employment during the pre-clearance and construction phases. It is anticipated that approximately 15 persons will be employed directly during the site clearance and an average of 75 persons to a maximum of 150-300 persons at the peak during construction. Approximately 80% of the work force will be obtained from local labour. In addition, it is anticipated that approximately 200 and 600 indirect and induced jobs are expected to be created during the site clearance and construction phases respectively; thus further benefitting the community. This represents a significant level of employment within the study area and has the potential to be a significant positive impact. This labour will be otherwise unemployed or under employed in the Jamaican economy. Using the standard 1.6 multiplier for job creation the value of the employment effect US$32,960,000. Note that 25% of the construction is labour cost and 80% of the labour will be local labour.

11.2.2.4 Benefit from Lower Electric Cost

There is annual fuel savings of US$ 74,200,000 which is 38% reducing in cost assuming a 75% pass through to the consumer and a 25% mixed of the generating capacity of the JPS then this result in a 7% reduction is consumer prices.

Table 11-7 Electricity consumption by income/consumption distribution

Consumption Percentile	Electricity Bill (JA$)	EX Rate (JA$ to US$)	Electricity Bill (US$)	Savings /household (US$)	Total Savings(US$)
0-20th Percentile	35,069	88.75	395	27.65	431,340
21-40th Percentile	44.799	88.75	505	35.35	551,460
41-60th Percentile	54,143	88.75	610	42.7	666,120
61-80th Percentile	67,067	88.75	756	52.92	825,552
81-100th Percentile	97,113	88.75	1094	76.58	1,194,648
Total					3,669,120
NPV					23,720,000

** The JPS have 78000 paying households*

11.2.2.5 The Net Social Present Value of the Project

NPV of the project after Stage 2 turns out to be US$ 425,420,000. This shows that after taking into account the net social benefits and costs, it is worthwhile to take up the project as NPV is positive even after including the environmental impact.

Table 11-8 Net Social Present Value of the project

Components	NPV (Millions US$)
Financial benefit	537.21
(O&M) cost economic prices.	-123.46
Construction cost	-103.00
Green House Gas	57.98
Employment effect	32.96
Electricity cost	23.72
Total NSPV	425.42

11.2.3 Adjustment for the Impact of the Project on Savings and Investment

Following are the groups which will be benefited by the project:

- Government
- JPS/New Fortress
- Labour
- Consumers/producers

Table 11-9 gives the calculation of saving impact on the above mentioned stakeholders. The Net Savings Impact turns out to be US$ 198,690,000.

Table 11-9 Calculation of Saving Impact on stakeholders

Stake holders	Net Benefit	MPS	Savings Impact
JPS/New Fortress	318.51	0.55	174.9
Workers	32.96	0.29	9.56
Consumers/producers	23.72	0.60	14.23
			198.69

Social value or shadow price of savings is calculated as follows:

$$I = r(1 - a)=(k - ar)$$

Where,
I is the social value of US$ of savings (investment)
r is the marginal productivity of capital
a is the reinvestment rate on additional income arising from investment
k is the social discount rate

The value of I used in this study is 1.55, which is taken from the study done by Murty (1980) in which he has explored the problems related to the evaluation of income distributional effects of public investment projects.

Therefore, net saving impact in terms of shadow prices is:

= *Total savings * I*
= 198;690;0000 * 1:55
= 307;970;000

Table 11-10 gives the calculation of NPV at Stage 3.

Table 11-10 Calculation of NPV at Stage 3

NPV From stage two	425.42
Net saving Impact	307.97
NPV at Stage 3	733.39

Thus, the NPV after taking into account the savings impact turns out to be US$733,390,000.

11.2.4 Adjustment for the Impact of the Project on Income Distribution

Given that the consumer and workers will benefits the impact on the income distribution is neutral. Thus, the NPV after Income Distribution Impact turns out to be US$733,390,00.

11.2.5 Adjustment for the Impact of the Project on Merit Goods and Demerit Goods

The adjustment factor turns out to be 1.3. This shows that social value of the project exceeds its economic value by 130%.

11.2.6 Calculation of Adjustment Factor and Adjusted NPV

Table 11-11 gives the Calculation of NPV at Stage 5.

Table 11-11 Calculation of NPV at Stage 5

Adjustment Factor	Unit	1.3
NPV at Stage 4	733.39	
New NPV after Stage 5		953.41

Thus, the final NPV of the project after application of Social Cost Benefit Analysis turns out to be US $953,410,000. Hence, the project should be undertaken as it has multiple social benefits which are reflected in the final positive NPV of the project.

11.3 THE PROPOSED PROJECT BASED ZERO GREENHOUSE GAS ALTERNATIVE

From a technical point of view, it is just not feasible within reasonable parameters to meet all of Jamaica's energy need from wind or solar alone. In fact, to ensure that generation technologies facilitate integration of renewable generation while minimizing cost of energy and maximizing efficiency of fuel conversion there is a need to replace the current Old Harbour plant with a system that maximizes flexible synchronous generation with fast response and reserve for active power and frequency control. Therefore, the need to the use the LNG plants. The social cost is based on opportunity cost, which uses the next best alternative, which is what the EIA did.

However, the terms of reference called for an evaluation based on zero greenhouse gas alternative. Below we conduct such an analysis.

11.3.1 Obtaining the Net Benefit

11.3.1.1 Environment Impact Caparison

The difference in pollutant of the LNG facility and zero greenhouse gas facility for CO2, N2O, and CH4 are -573,141, -15.6003, -44.8511 tonne/y respectively. Using a social cost of US$40 for CO2, US$29,000 for N2O and US$ 2,000 for CH4. See Marten, Alex L., and Stephen C. Newbold (2012) for calculations. Therefore, the difference in Greenhouse Gas is valued at a cost of US$23.47 million. The present value over 25 years is US$ 151.71 million.

11.3.1.2 The Net Social Present Value of the Project

NPV of the project after Stage 2 under the zero greenhouse gas alternative turns out to be US$ 215,730,000. This shows that after taking into account the net social benefits and costs, it is worthwhile to take up the project as NPV is positive even after including the environmental impact.

Table 11-12 Net Social Present Value of the project under Zero greenhouse gas alternative

Components	NPV (Millions US$)
Financial benefit	537.21
(O&M) cost economic prices.	-123.46
Construction cost	-103.00
Green House Gas	-151.71
Employment effect	32.96
Electricity cost	23.72
Total NSPV	215.73

Table 13 gives the calculation of NPV at Stage 3 under the zero greenhouse gas alternative. Thus, the NPV after taking into account the savings impact turns out to be US$523,700,000.

Table 11-13 Calculation of NPV at Stage 3 under zero greenhouse gas alternative

NPV From stage two	215.73
Net saving Impact	307.97
NPV at Stage 3	523.7

11.3.2 Adjustment for the Impact of the Project on Income Distribution

Given that the consumer and workers will benefits the impact on the income distribution is neutral. Thus, the NPV after Income Distribution Impact turns out to be US$523,700,000

11.3.3 Adjustment for the Impact of the Project on Merit Goods and Demerit Goods

The adjustment factor turns out to be 0.63 under the zero greenhouse gas alternative. This shows that social value of the project exceeds its economic value by 64%.

11.3.4 Calculation of Adjustment Factor and Adjusted NPV

Table 11-14 gives the Calculation of NPV at Stage 5 under the zero greenhouse gas alternative.

Table 11-14 Calculation of NPV at Stage 5 under the zero Greenhouse gas alternative

Adjustment Factor	Unit	0.64
NPV at Stage 4	523.7	
New NPV after Stage 5		335.17

Thus, the final NPV of the project after application of Social Cost Benefit Analysis turns out to be US $335,170,000. Hence, the project should be undertaken as it has multiple social benefits which are reflected in the final positive NPV of the project even when compare to the zero greenhouse gas alternative

11.4 THE PROPOSED PROJECT INCORPORATING MANGROVE ANALYSIS

The environment impact survey found a mangroves forest in the int project zone. Although the current project would not add signi.cant reduction in that forest any development prevents these forest from reverting to the orginal state and as such CBA include an assessment of these cost.

Occurring at the intersection of land and sea within 30 degrees of the Equator, mangrove forests thrive in coastal zones characterized by desiccating heat, choking mud, and salt levels that would kill most plants. Nevertheless, mangrove ecosystems are among the most productive and biologically complex ecosystems on the planet and provide us with a myriad of essential ecosystem services. Mangroves provide pivotal support to commercial fisheries acting as nursery, breeding, spawning and hatching habitats for offshore fisheries and exporting organic matter to the marine environment, producing nutrients for fauna in both the mangroves themselves and in adjacent marine and estuarine ecosystems. Mangroves also play a crucial role in shoreline protection, where they serve as natural barriers, dissipating the destructive energy of waves and reducing the impact of hurricanes, cyclones, tsunamis and storm surges. Several studies have documented that regions with intact mangroves were exposed to significantly lower levels of devastation from cyclones than those with degraded or converted mangroves. Mangroves play a significant role in stabilizing fine sediments, contributing to shore stabilization and erosion control. Additionally, mangrove forests are often a rich source of timber, fuel wood, honey, medicinal plants and other raw materials. Finally, they attract ecotourists, fishers, hunters, hikers and birdwatchers providing a valuable realized or potential source of national income.

11.4.1 Evaluation of the Mangrove Forest

Previous studies include surveys conducted in 2012 (CL Environmental Co. Ltd., 2012) and 2014 (CL Environmental Co. Ltd., 2015) and described the area as having 3 distinct communities, which were severely disturbed secondary-succession vegetation types: Mangrove (degraded wetland near the coast); Salina and Thorn savannah. These types were also reported during the survey for this project, with approximate survey zoned areas as follows:

- Mangrove forest:
- Black mangrove zone = 24,776.4 m^2 or 0.025 km^2
- Disturbed mixed mangrove/pastoral zone = 30,831.9 m^2 or 0.031 km^2
- Red mangrove zone = 3,143.3 m^2 or 0.003 km^2
- Salt marsh/salina zone = 17,761.60 m^2 or 0.003 km^2

11.4.2 Environmental Impact Caparison

Methods for valuing ecosystem services vary depending on the nature of the service. For ecosystem functions that produce marketable goods and services, prices are used in several alternative methods. The first is the production function approach (PF), which is based on the notion that the ecological function is an input to the production process and its value is measured by its effect on the productivity of marketed outputs . PF measures the value as the change in consumer surplus (CS) and producer surplus (PS) that result from the change in the quantity or quality of the environmental good . The net factor income approach (NFI) measures the value of the environmental service as the change in PS by subtracting the cost of other production inputs from total revenue of the marketable good. The market prices (MP) method assigns the total revenue derived from the marketable goods and services as the value of the ecosystem service that generated them. However, MP estimates are often upward biased since the cost of other production inputs are neglected. Below we used the NFI approach.

11.4.3 Net Social Present Value of Proposed Project

Table 11-15 shows the net present social value of project under zero greenhouse gas alternative and ecosystem.

Table 11-15 Net present social value of project under zero greenhouse gas alternative and ecosystem cost

Components	NPV (Millions US$)
Financial benefit	537.21
(O&M) cost economic prices.	-123.46
Construction cost	-103.00
Green House Gas	-151.71
Ecosystem cost	-102.0
Employment effect	32.96
Electricity cost	23.72
Total NSPV	113.7

NPV of the project after Stage 2 under the zero greenhouse gas alternative and accounting for the Ecosytem impact on the Mangroaves turns out to be US$ 112,700,000.00. This shows that after taking into account the net social bene.ts and costs, it is worthwhile to take up the project as NPV is positive even after including the environmental impact.

Table 11-16 shows the NPV calculation at Stage 3 under zero greenhouse gas alternative and ecosystem cost.

Table 11-16 Calculation of NPV at Stage 3 under zero green house gas alternative and Ecosystem cost

NPV From stage two	113.7
Net saving Impact	307.97
NPV at Stage 3	420.7

Thus, the NPV after taking into account the savings impact turns out to be US$420,700,000.00.

11.4.4 Adjustment for Project Impact on Income Distribution

Given that the consumer and workers will bene.ts the impact on the income distribution is neutral. Thus, the NPV after Income Distribution Impact turns out to be US$420,700,000.00.

11.4.5 Adjustment for Project Impact on Merit Goods and Demerit Goods

The adjustment factor turns out to be 0.63 under the zero green house gas alternative. This shows that social value of the project exceeds its economic value by 64%.

11.4.6 Calculation of Adjustment Factor and Adjusted NPV

Table 11-17 gives the calculation of NPV at Stage 5 under the zero green house gas alternative and Ecosystem cost.

Table 11-17 Calculation of NPV at Stage 5 under zero greenhouse gas alternative and Ecosystem

Cost

Adjustment Factor	Unit	0.64
NPV at Stage 4	420.7	
New NPV after Stage 5		269.25

Thus, the final NPV of the project after application of Social Cost Benefit Analysis turns out to be US $269,250,000.00. Hence, the project should be undertaken as it has multiple social benefits which are reflected in the final positive NPV of the project even when compare to the zero green house gas alternative and taking into accoun the economic value of the ecosystem.

11.5 CONCLUSION

The cost benefit shows that the project has a positive NPV using all recommended methodologies.

12.0 ENVIRONMENT HEALTH AND SAFETY (EHS) MANAGEMENT AND MONITORING PLAN

12.1 FSU AND REGAS FACILITY, UNDERWATER PIPELINE, AND ONSHORE PIPELINE

12.1.1 Monitoring During Site Preparation and Construction

The following measures will be taken with respect to monitoring during site preparation and construction to ensure that environmental impacts are minimized.

- Daily inspection of the construction to ensure it is following the proposed plan and to ensure that site drainage systems are not impacting the coastal environment. Check and balance can be provided by NEPA and the St. Catherine Parish Council
  Person(s) appointed by NFE South Holdings Ltd. may perform this exercise.
- Undertake monthly water quality monitoring to ensure that the construction works are not negatively impacting the aquatic environment quality. The parameters that should be monitored are temperature, salinity, dissolved oxygen, pH, turbidity, TDS, BOD, COD, nitrate, phosphate, total suspended solids and faecal coliform. This is estimated to cost approximately **J$170,000** per sampling event. NEPA will determine the frequency of sampling. Turbidity monitoring should be conducted more frequently during directional drilling exercises for pipeline deployment.
  Any organization with the capability to conduct monitoring of the listed parameters should be used to perform this exercise. It is recommended that a report should be given to NEPA at the end of each monitoring exercise with an annual summary of all results.
- Monthly noise surveys should be undertaken to determine worker's exposure and construction equipment noise emission.
  Any organization with the capability to conduct monitoring of the listed parameters should be used to perform this exercise. It is recommended that a report should be given to NEPA at the end of the monitoring exercise. The estimated cost for this exercise is **J $300,000** per noise survey.
- Daily monitoring to ensure that fugitive dust from cleared areas and raw materials are not being entrained in the wind and creating a dust nuisance.
  Person(s) appointed by NFE South Holdings Ltd may perform this exercise.
- Undertake daily inspections of trucks carrying raw material to ensure that they are not over laden as this will damage the public thoroughfares.
  Person(s) appointed by NFE South Holdings Ltd may perform this exercise.

- Undertake daily assessment of the quantity of solid waste generated and keep records of its ultimate disposal. Additionally, solid waste generation at the construction site should also be monitored.
  Person(s) appointed by NFE South Holdings Ltd may perform this exercise.
- Weekly assessment to determine that there are adequate numbers of portable toilets and that they are in proper working order. This will ensure that sewage disposal will be adequately treated.
  Person(s) appointed by NFE South Holdings Ltd may perform this exercise.
- Monitor and approve the suppliers and sources of local materials. Inspection of the quarry should be conducted to ensure that they are legal. Copies of these licences should be kept on file.
  Person(s) appointed by NFE South Holdings Ltd may perform this exercise.
- Daily monitoring of vehicle refuelling and repair should be undertaken to ensure that these exercises are carried out on hardstands. This is to reduce the potential of soil contamination from spills. Spot checks should be conducted by NEPA.
  Person(s) appointed by NFE South Holdings Ltd may perform this exercise.
  No additional cost is anticipated for this exercise.
- Where possible, construction crews should be sourced from within the study area. This will ensure that the local community will benefit from the investment.

12.1.2 Monitoring During the Operational Phase

- Standard operating procedures will encompass employee training programs, periodic mechanical inspections and maintenance, and periodic emergency and safety drills. All procedures, protocol, training, and maintenance/inspections will be tracked by a computerized management system.
- Annual noise assessments should be conducted. This should be contracted out to a third party company or individual that specializes in performing such tests. The contracted party shall have a proven experience in noise monitoring. All monitoring should be conducted according to generally accepted industry standards and the plant shall conform to the World Bank Ambient Noise Levels and the National Environment and Planning Agency Standards.
  The annual noise assessment is estimated to cost approximately J$375,000 per assessment.
- Undertake monthly inspection of drainage and wastewater systems to ensure that they are in proper working order to negate potential detrimental environmental impacts from malfunctioning infrastructure.
  Person(s) appointed by NFE South Holdings Ltd. may perform this exercise.

12.2 REPORTING REQUIREMENTS

12.2.1 Noise Assessment

A report shall be prepared by the Contracted Party. This report shall include the following data:

i. Dates, times and places of test.
ii. Test Method used.
iii. Copies of instrument calibration certificates.
iv. Noise level measurements in decibels measured on the A scale (dBA) and wind direction.
v. Noise levels measured in low, mid and high frequency bands (dBL)
vi. A defined map of each location with distance clearly outlined in metric
vii. Assessment done according to varying loads of the facility
viii. Any other relevant operating information (such as unusual local noise source)
ix. Evaluation of data, discussions and statement giving a professional opinion of the noise impact of the facility.

- The report shall be submitted to Plant Manager or his designate within two weeks after completion of testing.
- The Plant Management shall distribute the report within forty five (45) days of testing being completed.
- In the event that emissions do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted.
- Reports will be maintained on file at the plant for a minimum of three years.

12.2.2 Water Quality Assessment

A report shall be prepared by the Contacted party. It shall include the following data:

i. Dates, times and places of test.
ii. Weather condition.
iii. A defined map of each location with distance clearly outlined in metric.
iv. Test Method used.
v. Parameters measured
vi. Results
vii. Conclusions

- The report will be submitted to the Plant Manager or his designate within two weeks of the monitoring being completed.

- Plant management shall distribute the report to NEPA within forty five (45) days of testing being completed.
- In the event that parameters do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted.
- An annual summary report should be prepared and submitted to NEPA.
- Reports will be maintained on file at the plant for a minimum of three years.

13.0 EMERGENCY PREPAREDNESS AND RESPONSE

13.1 OFFSHORE LOADING FACILITY

The Regas Facility is designed with safety features in accordance with NFPA 59A and general good engineering practices. The process design takes into consideration all possible scenarios that may result in situations where the equipment design parameters may be exceeded. These situations are addressed via a combination of process control, operator intervention and/or additional safety features such as shut-off valves, vent valves, relief valves, instrumentation, alarms and changes in design conditions. When operating parameters approach design conditions, a PLC based shut-down system will initiate a pre-determined sequence of operations resulting in area or complete system shut-down. A dedicated fire and gas detection system will continually monitor for the presence of combustible gas, fire/flame and low temperatures that could signify an LNG or natural gas leak resulting in area or complete system shut-down. Separate smoke detection is monitored in all enclosed spaces such as MCC, control room and operator quarters. The shut-down system is designed to carry out its instruction even in the event of total power loss via the use of a UPS with back-up emergency power. Equipment layout will take into consideration OSHA minimum requirements and designed route for emergency egress of operating and maintenance personnel. Finally, the system configuration/equipment layout, safety features, operating/shut-down procedures and trained operators form the basis for the facility risk assessment and evacuation plans.

13.2 NATURAL GAS (NG) PIPELINE

13.2.1 Pressure Monitoring & Response

Flow rate and pressure in the subsea pipeline will be continuously monitored and recorded at the onshore pipeline facility and at the offshore platform. The natural gas pipeline will have a leak detection system which will detect a break or leak in the subsea pipeline. The system will send a signal to the automated block valves to close and a signal will be sent to the platform to stop delivering natural gas into the pipeline. Coordination with JPS will take place immediately as well.

13.2.2 Block Valves

An automated block valve will be located at the launcher and receiver and will be used for isolation and emergency shutdown purposes. The launcher block valve will be located on the platform and the receiver valve will be onshore in the proximity of the beach

Automated block valves will be located at the inlet of the meter skid and at the inlet to each regulator skid.

In the event of a pipeline leak, the automated block valves will close to stop transportation of natural gas to the power plant and isolate the pipeline. The location of the leak will be determined by utilizing an active acoustic wave analysis monitoring system.

In the event of a fire at the power plant, the automated block valves will close and a signal will be sent to the platform to stop delivering natural gas into the pipeline.

13.2.3 Subsea Block Valve

The need for an automated subsea block valve will be evaluated during the detailed design process.

If needed, the automated subsea block valve will be located on the subsea pipeline approximately 60 to 150 meters (200 to 500 feet) away from the offshore platform and will be used for isolation and emergency shutdown purposes. The subsea valve will prevent a fire on the offshore platform from being fed by the natural gas in the subsea pipeline.

During construction, the subsea pipeline will include a pipe spool piece of exactly the same length as the valve skid. After the subsea pipeline is installed, the pipe spool will be replaced with the valve skid.

13.2.4 Hurricanes and Tropical Storms

The pipeline operation will follow the operation of the offshore platform in the event of a storm.

13.3 8-INCH (20.32 CM) AUTOMOTIVE DIESEL OIL (ADO) PIPELINE

13.3.1 Pressure Monitoring & Response

Pressure in the subsea pipeline will be continuously monitored and recorded at the onshore pipeline facility. When a vessel is delivering ADO to the tanks, JPS, or both, the flow rate and pressure will be monitored both onshore and on the ship located at the offshore single point mooring (SPM). In the event of a sudden drop in flow rate or pressure, the vessel will be immediately contacted to stop delivering ADO into the pipeline and all isolation valves will be closed. Coordination with JPS will take place immediately as well.

13.3.2 Block Valves

A boarding valve will be located on the SPM buoy. The boarding valve will be an 8-inch (20.32 cm) ball valve. The vessel offloading ADO will control this valve and will shut down the system in case of emergency. Control of the boarding valve is not dependent on any onshore coordination and would enhance safety considerations.

Depending on the type of SPM buoy, an automated subsea shutdown valve may be located on the Pipeline End Termination (PLET) skid for isolation and emergency shutdown purposes. Hydraulic Power Units and Hydraulic Swivels placed on the SPM buoy will provide hydraulic power to control this valve. Loading hose connect and disconnect should ensure that no that no inventory is released during such operations.

An automated block valve in the proximity of the beach will be located onshore and will be used for isolation and emergency shutdown purposes. Automated block valves will be located at the inlet of the meter skid and at each inlet to each regulator skid and the tanks. In the event of a pipeline leak, the automated block valves will close to stop transportation of ADO to the onshore storage tanks and/or to the power plant and isolate the pipeline. In the event of a fire at the power plant while delivering ADO to the power plant, the pumps will shut down and the automated block valves will close. If a vessel is delivering ADO to either the tanks or JPS, the flow will be stopped until such time it is deemed safe to resume delivery to the tanks only.

13.3.3 Tanks

The ADO tanks will each be located inside containment sufficient to hold 110% of the volume of one tank. Each tank will have instrumentation to automatically shut down to prevent overfilling.

13.3.4 Hurricanes and Tropical Storms

The pipeline will be shut down and the isolation valves will be closed in the event of a storm.

13.4 ONSHORE FACILITY

There are onshore facilities for both the natural gas pipeline and ADO pipeline.

13.4.1 Natural Gas (NG)

The natural gas pipeline system will have a receiver, filter, meter/regulator skid, and control building. Flow rate and pressure in the subsea pipeline will be continuously monitored and recorded at the onshore pipeline facility.

The meter/regulator skid utilizes a monitor/worker setup. There are two control valves in series. One valve regulates the pressure into JPS and the other monitors the pressure. In the event, the worker regulator fails, the monitor regulator will take over pressure regulation. In the event of a leak or break, the leak detection system will send a signal to the automated block valves to close and a signal will be sent to the platform to stop delivering natural gas into the pipeline. Coordination with JPS will take place immediately as well.

13.4.2 Automotive Diesel Oil (ADO)

The ADO pipeline system will have a receiver, two (2) meter/regulator skids, a pump skid, storage tanks, and control building. Pressure in the subsea pipeline will be continuously monitored and recorded at the onshore pipeline facility. When a vessel is delivering ADO to the tanks, JPS, or both, the flow rate and pressure will be monitored onshore. In the event of a sudden drop in flow rate or pressure, the vessel will be immediately contacted to stop delivering ADO into the pipeline and all isolation valves will be closed. Coordination with JPS will take place immediately as well.

13.4.3 Block Valves

An automated block valve in the proximity of the beach will be located onshore and will be used for isolation and emergency shutdown purposes. Automated block valves will be located at the inlet of the meter skid and at each inlet to each regulator skid and the tanks. In the event of a pipeline leak, the automated block valves will close to stop transportation of ADO to the onshore storage tanks and/or to the power plant and isolate the pipeline. In the event of a fire at the power plant while delivering ADO to the power plant, the pumps will shut down and the automated block valves will close. If a vessel is delivering ADO to either the tanks or JPS, the flow will be stopped until such time it is deemed safe to resume delivery to the tanks only.

13.4.4 Tanks

The ADO tanks will be located inside containment sufficient to hold 110% of the volume of one tank. Each tank will have instrumentation to automatically shut down to prevent overfilling.

14.0 RISK ASSESSMENT

The following narrative analyzes the key risks to human health and ecosystems associated with the proposed project from both human activities and natural phenomenon.

14.1 HISTORY

Liquefaction, storage and regasification is an old technology with the first patent for LNG handling/shipping dating to 1914. Commercial LNG shipments began in 1959 with the transport of LNG from Lake Charles, LA USA to Canvey Island, UK, and the industry has since expanded globally using LNG vessels without any serious incidents or loss of cargo. Over the past 55 years, more than 100,000 LNG sea voyages were completed without major accidents, safety problems, hazardous incidents or public fatalities and injuries, both in port and at sea. The LNG world fleet presently has approximately 450 vessels and 170 on order. All these vessels are built with double hulls with additional containments between the hull and the LNG. These vessels operate between 19 exporting countries and 34 importing countries.

The outstanding modern day safety record across the LNG value chain is driven by strict industry regulations, standards, and controlled mitigation and preventative measures in place at LNG facilities. Therefore, there has only been a handful of serious incidents that resulted in one or more fatalities involving LNG facilities since the start of commercial operations and the casualties have been restricted to facility operators and workers: Skikda, Algeria, 2004 (export terminal), Bontang, Indonesia, 1983 (export terminal), Cove Point Maryland, 1979 (import terminal) and Arzew, Algeria, 1977 (export terminal).

The LNG offloading facility and associated infrastructure will be built to international standards consistent with modern industry practice.

14.2 LNG OFFLOADING FACILITY

The proposed LNG offloading facility will consist of four breasting dolphins and six mooring dolphins with steel pipe piles with a steel frame and steel superstructure topped with a concrete deck. Following pile installation, pre-fabricated steel frames will be lowered onto the piles and welded in place to form the substructure of the platform. The process equipment will be installed with pre-fabricated skids configured in a modular design. LNG proposes the following risks to personnel working on site and during a spill involving LNG.

14.2.1 Cryogenic Hazards

Direct contact with LNG will cause freezing of objects it contacts. Long-term exposure can cause degradation of Personal Protective Equipment (PPE) resulting in injury. The proposed LNG offloading facility will consist of a floating storage unit complete with containment systems and other protections designed to prevent leaks and spills. To minimize any exposure concern, operating personnel will wear the appropriate protective outerwear and, in the event of a spill, Self-Contained Breathing Apparatus (SCBAs) when entering areas known to contain spilled LNG or vapor. The platform facility will be outfitted with a resistive low temperature detector that will send an alarm signal to the control room and the operator console. In the event that an upset condition exists, the operators will be alerted and will execute emergency protocols. During spills, vapor releases, or fire related emergencies related to the LNG offloading facility, there are specific hazards that could pose a threat to terminal personnel (e.g., burns to exposed skin and soft tissue areas (i.e., eyes) and respiratory issues caused due to displacement of O_2 by LNG vapors. To mitigate these hazards, the minimum protective measures will include (a) eye/face protection such as splash goggles that meet or exceed ANSI Z.87.1 will be worn where there is a potential for liquid to contact the eye (a face shield may also be necessary depending on the possible conditions of use), (b) skin/hand protection such as thermal insulating gloves, flame retardant clothing, and properly rated protective equipment, and (c) respiratory protection such as a self-contained breathing apparatus (in situations of oxygen deficiency). In addition, regular safety training will be a requirement for staff that work on the platform and FSU.

Probability of incident is low. The fact that cryogenic hazards are restricted to operational procedures at the LNG facility indicates that such hazards affecting the general public are minimal to non-existent and no environmental impacts are expected.

14.2.2 Fire Hazards

In the event of a leak or catastrophic release of LNG, and during the period of LNG vaporization, a fire may occur from a source of ignition. Although there are a number of safety features and processes in place to prevent catastrophic events from occurring, there are a number of fire risks surrounding normal operations with the LNG unloading facility resulting from a catastrophic release of LNG. The most common types of fire events that are most likely to occur within the LNG unloading facility are (a) flash fire caused by the ignition of LNG vapor dispersed in air, (b) a jet fire following a release and ignition, and (c) a pool fire following a release and ignition. The locations with the LNG unloading facility that have a higher probability of a fire event occurring are within the (1) vaporization area and (2) ship to platform transfer area.

Within the LNG unloading facility, there are a number of systems dedicated to fire, gas, and leak detection, which will trigger an audio and visual alarm with the LNG unloading facility. The LNG unloading systems uses the following types of systems to reduce the overall risk to employees working within the LNG unloading terminal: shutdown and isolation, process control monitoring systems, leak detection / gas detection systems, low temperature detection systems, and fire detection system.

An integral part of the fire prevention and protection system at the LNG unloading facility is early warning gas detection. These devices are designed to alert operators in the event of a LNG/NG release. Such an alert allows operators to initiate a shutdown and/or isolate a system so hazards can be minimized or avoided, until the leak is repaired. In the event a detector activates, an alarm signal is sent to the operator console for further investigation. In addition, the LNG unloading facility will be equipped with flame detectors strategically placed in areas where a fire could occur due to a series of catastrophic events at the FSU interface and vaporization area.

Since LNG is lighter than water, any environmental impact from a spill is likely to be minimal and localized. Lowered water temperatures would likely be short-lived and restricted to the immediate area of the platform. Similarly, any environmental impact of a fire would also be localized and end once the LNG supply is removed. Secondary impacts to the surrounding communities are not anticipated as all systems are designed to contain fires within the LNG facility.

Probability of incident is low.

14.2.3 Severe Weather

The proposed area for the LNG unloading facility is an area protected from severe weather as fully described in earlier sections. In the event of severe weather event, the operating procedures implemented will minimize the potential loss of life, injury, and damage to the environment / property. Terminal personnel will monitor on a daily basis the possibility of inclement weather, which could affect the terminal. An operator will also monitor the National Oceanic Atmospheric Administration (NOAA) weather alert radio to ensure that it is operational and being monitored during operating hours. The NOAA radio will be located in the main control room. In addition, the terminal manager and the site environmental health and safety representative will ensure a severe weather kit is stored on site. If the terminal is forced to shut down all operations resulting from severe weather shut-down and start-up will be done with the terminal's start-up procedures. Due to its geographic location, the likelihood of the terminal being impacted by a hurricane or tropical storm is possible. The terminal will follow the steps and requirements as prescribed within its disaster preparedness plan. A tropical storm is defined as being a closed, low-pressure circulation at the surface with wind speeds ranging from 39 to 73 mph. A hurricane is defined as being a violent, tropical, cyclonic storm having wind speeds of or in excess of 74 miles per hour (32 m/sec). Hurricanes have been given a scale of Category 1 – Category 5 ranging from lowest to greatest of risk and hazard. A hurricane watch is issued when a hurricane reaches a position, which constitutes an appreciable threat to a specific area. Upon issuance of the watch, the terminal will begin taking all of the necessary precautions as defined in the disaster preparedness plan. In addition, there will be a plan to relocate the FSU to a safe location in case of a severe hurricane. This plan will be included in the final EAP for the project.

Probability of incident is moderate.

14.2.4 Power Outage

The terminal may experience a power outage with or without severe weather in the area. Whenever a loss of power occurs, the emergency lighting units will be activated. The terminal is equipped with back-up power sized to allow continued operation of the main control room. A power outage will have no effect on LNG transfers or releases that could negatively impact the surrounding natural environment or local communities in the area.

Probability of incident is low.

14.2.5 Marine Operations

The approach to the terminal will include (a) Leading marks to establish the width of navigable channels and turning basin will be appropriately placed; (b) Electronic navigational aids to support navigation under adverse weather conditions and allow for ship movements at nights; (c) Berth monitoring system for weather, mooring tension, berthing speed and angle measurement; (d) Jetty safety zones should be effectively patrolled while the LNGC and FSU are alongside thus providing control over local vessels.

14.2.6 LNG Unloading to Storage System

The unloading system will include (a) Emergency release couplings to shut the flow of LNG in the event of an incomplete connection or premature separation; (b) Methane detection system to alert operators and the control room of methane release beyond the design limits; and (c) Pressure, temperature, flowrate interlocks. The BOG management system will control surplus BOG during holding or unloading operation either for BOG recovery back to FSU or send out with BOG Compressors to subsea pipeline.

14.2.7 Storage

The FSU storage tanks will: (a) Be equipped with a Safety Instrumented System (SIS) to provide a comprehensive coverage to monitor all potential hazards, leaks within the FSU/LNGC and automatically initiate appropriate shutdown and containment measures, (b) Have provisions to alert the operators upon detection of high level alarms in the affected tank so as to isolate the tank from overfilling when LNG is being loaded to the storage tanks

The FSU storage tanks shall be designed to have sufficient strength to withstand dynamic sloshing loads at any fill level when: (a) FSU is moored to the jetty and sending LNG, and; (b) During emergency departure of the FSU from the jetty due to severe weather conditions.

14.2.8 Vaporization Process

The vaporization system will include: (a) Methane detection system to alert operators and the control room of methane release beyond the design limits; (b) Operator inspection procedures; and (c) pressure, temperature, and flowrate interlocks.

14.2.9 Measurement and Odourization Process

Measurement system will include: (a) Acoustic leak detection system to alert operators and the control room of potential leaks; (b) Control system pressure settings to alert operators and the control room of drops in pressure which may be caused by leaks; and (c) Mass flow meters that will detect differentials between the custody skids. Similar to other systems on the island, we do not intend to odourize the gas that will be transmitted.

14.2.10 Natural Gas discharge to floating units to onshore facilities

Transmission system will include: (a) Acoustic leak detection system to alert operators and the control room of potential leaks, (b) Control system pressure settings to alert operators and the control room of drops in pressure which may be caused by leaks; and (c) Mass flow meters that will detect differentials between the custody skids.

14.3 NATURAL GAS PIPELINE

The natural gas pipeline will be mostly directionally drilled using a horizontal directional drill from the planned metering facility at the JPS plant to the offshore platform for a distance of approximately 5,410 meters. Once installed, the key risk to the pipeline will be an intentional or unintentional intrusion that causes a leak. Because the pipeline is buried underwater, the risk of injury to people or property is minimal. However, the location of the pipeline will be clearly marked on all nautical charts and notices to mariners. In addition, a leak detection system will be installed and active so once a leak is discovered the pipeline can be shut down and emergency procedures activated. In the case of a leak, it is most likely that the NG will come to the surface since it is lighter than water and then rapidly dissipate since it is unlikely that there will be an ignition source in the remote location of the pipeline.

Probability of incident is low.

14.4 ADO PIPELINE

The ADO pipeline will be directionally drilled from the existing mooring field to the on-shore facility for a distance of approximately 2,012 meters with an additional 100 meters from the mooring location to the seabed and 800 meters trenched on land. In case of a leak, measures will be in place on shore to contain and remove any fuel from the environment.

Probability of incident is low.

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16.0 APPENDICES

Appendix 1 – Terms of Reference

TERMS OF REFERENCE
For An
ENVIRONMENTAL IMPACT ASSESSMENT

For A
Proposed Floating Storage Unit and Regasification Unit
At
Old Harbour, St. Catherine

By
NFE South Holdings Limited

15 July 2016

Submitted by:
Date
Prepared by: ‹Include Name of Consultant›

TABLE OF CONTENTS

Background

This project proposes to construct a marine import facility comprising of a vessel berth and off-shore offloading and regasification platform at the general location approved by the Port Authority of Jamaica (PAJ) in the Portland Bight Protected Area of Jamaica. This facility will accommodate a Floating Storage Unit (FSU) vessel for LNG storage and a liquefied natural gas (LNG) carrier delivering LNG to the FSU. The FSU is a LNG carrier refitted for use as a storage vessel. LNG will be delivered by ship from various potential locations in the United States of America or other locations. The Regasification platform would contain equipment to regasify LNG as well as related process and safety equipment. The liquid gas from the FSU would be carefully regasified and the gas would then be pumped into an undersea pipeline, which will be directionally drilled using a Horizontal Directional Drill (HDD) to the Jamaica Public Service Company's (JPS) plant in Old Harbour, St. Catherine. The gas pipeline would continue to be directionally drilled on-shore to a small receiving facility on-shore near the proposed gas power plant that JPS is constructing where it will be metered and then sent to the power plant. In addition, the project will construct an off-shore mooring facility with a new ADO line to storage tanks at the renovated power plant in order to provide a back-up power source in case of LNG delivery interruptions.

The purpose of this document is therefore to establish the Terms of Reference (TOR) for the EIA.

The EIA report must be produced in accordance with the approved TOR.

Where the need arises to modify the TOR, the required amendments/modifications are to be made and submitted to the Agency. Approval for the TOR must be obtained from the Agency, in writing, prior to the commencement of the EIA study.

The Terms of Reference to conduct the Environmental Impact Assessment are as follows:

The National Environment and Planning Agency and the Natural Resources Conservation Authority reserves the right to reproduce, transfer and disclose any and all contents contained in the submitted environmental impact assessment report without the written consent of the proponent, consultants and/or its agents.

1. Executive Summary

Provide a brief statement on the content of the EIA report. The executive summary should provide a comprehensive overview and objectives for the project proposal, natural resources, justification for the project, etc. In addition, it should include relevant background information and provide a summary of the main findings, including but not limited to main impacts and mitigation measures, analyses and conclusions in the report.

2. Introduction

Provide the context of the project and the EIA, the delineation and justification of the boundary of the study area, general methodology, assumptions and constraints of the study.

The study area shall include at least the area within 1 km radius of the boundaries of the proposed site.

3. Legislation and Regulatory Consideration

Outline the pertinent regulations and standards governing environmental quality, safety and health, cultural significant finds, protection of sensitive areas, protection of endangered species, protected areas, siting and land use control at the national and local levels. The examination of the legislation should include at a minimum, legislation such as the NRCA Act, the Public Health Act, the Town and Country Planning Act, Beach Control Act, Harbours Act, Port Authority Act, Maritime Authority Act, National Solid Waste Management Authority Act, Office of Utilities Regulation Act, and the appropriate international convention/protocol/treaty where applicable.

This section should also examine the Government National Energy Policy, renewable projects, and discuss briefly the Montego Bay Micro LNG Receiving Terminal in relation to the National Energy Policy.

4. Project Description

Provide a comprehensive description of the project including any information necessary to identify and assess the potential environmental impacts of the project. This should include:

- An overall master plan of the site, including current, proposed and future use of the lands;
- Objectives and information on, rationale for the project;
- Project Background, the nature, location/existing setting, timing, duration, frequency, general layout, as well as the impact on the carbon footprint of the energy sector are to be discussed;

- Pre-construction activities;
- Construction methods, works and duration;
- Post construction plans;
- Project schedule;
- The nature, location/existing setting, timing, duration, frequency, general layout including construction of the facility including pipelines, metering stations, tanks, etc. and their impacts on the surroundings communities, as well as the impact of the Project on the power supply and carbon footprint of the energy sector are to also be discussed;
- A description of raw material inputs (including source of raw material for any proposed land reclamation), technology and processes to be used as well as products and by-products generated, should be provided;
- Hazardous material management;
- The LNG gas supply by ship, storage and regasification area, including description of the route the pipeline will take and all right-of-ways and supporting infrastructure that will be required;
- Details of all physical features included as part of the project to prevent the release of LNG from marine transfer pipelines, storage tanks, regasification facilities, etc.;
- The Automotive Diesel Oil (ADO) supply by ship and storage area, including description of the route the pipeline will take and all right-of-ways and supporting infrastructure that will be required;
- Details of all physical features included as part of the project to prevent the release of ADO from marine transfer pipelines, storage tanks, etc.;
- Details for each type of LNG installation with minimum details as follows:
    - Reception [Location (i.e. onshore/offshore), connection to coastline, capacity to unload (m^3/h), number of loading arms, arm diameter, unloading pressure (bar), vapour arm, natural gas composition, expected shipping frequency, details of tug support operations];
    - Storage [Location (i.e. onshore/offshore), Loading Capacity (m^3/h), Capacity (m^3), number of tanks, type of tank, type of technology, storage temperature (°C), storage pressure (bar), isolation system, boil off gas management system (if proposed), Number of Vaporizers, Unloading Capacity (m^3/h), Vaporizer material, Outlet pressure (bar), Outlet temperature (bar), Cold detection system: (Yes / No), Metering system, Odorisation system: (Yes / No), Odorisation substance, Capacity of odorisation tank (m^3), Remote Control: (Yes / No)];
    - Processing [Number of vaporizers, capacity (m^3/h), operating pressure (bar), outlet temperature (°C), boil off gas management system (if proposed), materials, details of odorisation system, odorisation substance, capacity of odorisation tank(s) (m^3), location of odorisation tank(s), MSDS of odorisation substance];
    - Transportation Network [operating pressure (bar), design pressure, length of pipeline, depth of pipeline, number of vertex, pipe diameter, materials, thickness of pipeline, type of cathodic protection system, monitoring system, disposal of waste including hydrostatic test water and discharge points];
    - Regulating and Metering Station [Inlet pressure (bar), Outlet pressure (bar), Number of regulating lines, Capacity per line (m^3/h), Remote control (Yes / No), Type of volume meter]

  - Vehicle for Distribution [cistern capacity (m^3), transport temperature (°C), transport pressure (bar), isolation system, distribution route, end user];
  - Final Consumer [Supply pressure (bar), Minimum supply pressure (bar), Operation pressure (bar), Regulating and metering equipment: (Yes / No), Type of installation to supply: (Turbine, engines, boilers, burner, dryers)]
- Outline of areas to be reserved for construction and areas to be preserved in their existing state as well as activities and features which will introduce risks or generate impact (negative and positive) on the environment
- Buffer zones/Setbacks/Easements and Exclusion Zones. This includes any existing and proposed right of ways/easements for power lines, cell towers, telecommunication conduits, road reservations, water pipelines and other terrestrial and marine pipelines, canals or any other conveyance through the site. Setbacks will also be indicated.
- Storage of Chemicals: Information on the storage and or use of any chemicals inclusive of other hydrocarbon fuels on the site during the construction and operational phases.
- Coordinates of on-shore and off-shore pipeline routing
- Details of the marine facility including but not limited to:
  - A description of all off shore activities including the location (geo-reference coordinates), the size of the area to be developed;
  - Description of the zone of influence;
  - Jetty and wharf facilities
  - Ship loading and unloading equipment
  - Details of area to be dredged and dredge spoil disposal areas
  - Details of capital and maintenance dredging equipment and methods
  - The type of material and methods of construction for the coastal/marine works, including pipe unloading methodology and proposed landing sites.
- Details of all physical features included as part of the project to prevent the release of LNG from terrestrial and marine transfer pipelines, storage tanks, regasification facilities, etc.
- Safety features including identification and notification of leaks
- Source of potable water
- Information on sewage and wastewater treatment and disposal
- Details on solid waste management and disposal
- Details on the fire suppression system

The information presented in this section should be supported by maps and drawings and should include where applicable a general site layout plan, pipeline route maps, restriction area plan, process diagrams, trench depth drawing, trench fill reference drawing, metallic posts, identification plates, cathodic protection sets and architectural and engineering drawing.

5. Description of the Environment

This section should include a detailed description of the proposed sites (marine and terrestrial) and surrounding environment. Baseline data should be generated in order to give an overall evaluation of the existing environmental conditions, including a historical meteorological evaluation to include, but not be limited to, wind characteristics and analysis, values and functions of the area, as follows:

i. Physical environment
ii. Biological environment
iii. Socio-economic and cultural constraints

The methodologies employed to obtain baseline and other data should be clearly detailed in the EIA. Baseline data will include:

5.1 Physical Environment

- Topography, soils, climate, drainage (including gullies), geology (including but not limited to seismicity and faults), geomorphology of the site and hazard vulnerability including impacts on current landscape, aesthetic appeal and hydrology should be examined. Special emphasis should be placed on storm water runoff, drainage patterns. Geotechnical study should also be conducted within the proposed terrestrial study area.
- **Water quality** for any riverine environment, marine body and surface water feature including wells and streams in the vicinity of the development. Quality Indicators should include but not be limited to Nitrate, Phosphate, Faecal Coliform, and Total Suspended Solids.
- **Climatic conditions and air quality** in the area of influence including particulates. Base line data of ambient air parameters must be included for the area extending at least 5 km from the project boundary by observation at a number of locations. Specific importance should be attached to areas in close proximity of the project site, particularly those areas in within 1 km of the project site. Data is to be analyzed for one wet and one dry season with at least one station in the up-wind/ non-impact/ non-polluting area (control site). The parameters should include but not be limited to:
  - nitrogen dioxide
  - sulphur dioxide

  All possible sources of air pollution within the area of influence shall be identified and quantified and ranked as major, significant or insignificant in accordance with the NRCA (Air Quality) Regulations, 2006 and presented in the emissions inventory. Data collected should include: nitrogen dioxide, sulphur dioxide, and other harmful air pollutants. Factors such as historical wind speed and direction, precipitation, relative humidity and ambient temperature data shall be assessed pre development.
- Noise levels of undeveloped site and the ambient noise in the area of influence.
- Sources of pollution existing and extent of contamination.
- Availability of solid waste management facilities.

5.2 Carrying capacity

- The ecological carrying capacity of the site should be assessed.

5.3 Natural Hazards and Disaster Risk Reduction for Climate Change

Risk assessment of the development in relation to hurricanes, tropical storm, flooding and earthquakes must be undertaken. A seismic hazard analysis of the site and surrounding areas shall be done to determine the peak horizontal ground motion and site spectral response for short and long period waves of 0.2 seconds and 1 second respectively using probabilistic ground motion models.

5.4 *Biological Environment*

Description of terrestrial habitats, existing vegetation type, flora and fauna surveys inclusive of a species list; commentary on the biodiversity, ecological health, function and value in the project area, threats and conservation significance. This should include:

- A detailed qualitative and quantitative assessment of terrestrial habitats in and around the proposed project sites and the areas of impact. This must also include flora and fauna surveys and should include species lists and their status.
- Special emphasis should be placed on rare, endemic, protected or endangered species. Migratory species should also be considered. There may be the need to incorporate micro-organisms to obtain an accurate baseline assessment. Generally, species dependence, habitats/niche specificity, community structure and diversity ought to be considered.

The field data collected should include, but not be limited to:

- Species lists for each community
- A habitat map of the area

5.5 *Heritage*

- An assessment of artifacts, archaeological, geological and paleontological features.

5.6 *Socio-economic Environment*

Demography, regional setting, location assessment and current and potential land-use patterns (of neighboring properties); description of existing infrastructure such as transportation, electricity, water and telecommunications, and public health and safety; cultural peculiarities, aspirations and attitudes should be explored; and other material assets of the area should also be examined. A socio-economic survey to determine public perceptions of the project (both negative and positive) should also be completed and this should include but not be limited to potential impacts on social, aesthetic and historical/cultural values.

6. Public Participation

Describe the public participation methods, timing, type of information provided and collected from public and stakeholder target groups meetings. The sampling methodology employed must be appropriate for the population size and distribution and must be weighted towards the communities in closest proximity to the proposed development. The instrument used to collect the information must be included in the appendix and should be submitted to the Agency, for approval, prior to its administration. Stakeholder meetings should also be held to inform the public of the proposed development and the possible impacts, and will also gauge the feeling/response of the public toward the development.

The issues identified during the public participation process should be summarized and public input that has been incorporated or addressed in the EIA should be outlined.

Public Meetings should be held in accordance with the Guidelines for Conducting Public Presentation at a time and location signed off by the National Environment and Planning Agency (NEPA). A public meeting will be held to present the findings of the EIA once the EIA is completed and submitted for consideration. All relevant documents are required to be made available to the public. In addition, any material change to the design of the project will require a further public meeting to be undertaken by the developer and all changes made to the document should be clearly outlined to the public.

7. Identification and Assessment/Analysis of Potential Impacts

A detailed analysis of the project components should be done in order to: identify the major potential environmental, health and safety impacts of the project; distinguish between levels of impact, significance of impact (a ranking from major to minor/significant to insignificant should be developed), positive and negative impacts, duration of impacts (long term or short term or immediate), direct and indirect and impacts, reversible or irreversible, long term and immediate impacts and identify avoidable impacts.

Cumulative impacts should also be evaluated taking into account previous developments and any proposed development immediately adjacent to the subject development within the area. The identified impacts should be profiled to assess the magnitude of the impacts. The major concerns surrounding environmental, health, and safety issues should be noted and their relative importance to the design of the project and the intended activities indicated. The extent and quality of the available data should be characterized, explaining significant information deficiencies and any uncertainties associated with the predictions of impacts.
An environmental issue is determined to be major, after an examination of the impact (positive and negative) is done and the negative impact significantly outweighs the positive.

It is also determined by the number and magnitude of mitigation strategies which need to be employed to reduce the risk(s) introduced to the environment. Project activities and impacts should then be ranked as major, moderate and minor and presented in separate matrices for all the phases of the project (i.e., preconstruction, construction, operational and decommissioning/closure). The potential impacts may be subdivided into Physical Impacts, Biological Impacts and Socio-economic and Cultural Impacts. All impacts should be listed, ranked and assessed and any residual negative impacts that potentially have no solution for mitigation should be identified.

Identify potential impacts as they relate to (but are not restricted by) the following:

7.1 Physical and Biological

- Change in drainage patterns and potential for flooding
- Landscape impacts of excavation, land reclamation and construction
- Loss of biodiversity and natural features
- Habitat loss and/or fragmentation (Terrestrial and Marine). Emphasis should be placed on any rare, endangered, and endemic species found.

- Impact of noise and vibration especially on terrestrial and marine mammals and reptiles should be examined as well as the impact of light pollution.
- Loss of ecosystem functions including wetlands and marine ecosystems such as seagrass beds and coral reefs
- Air quality
- Socio-economic and cultural impacts including increased traffic, demand on existing infrastructure and resources
- Noise and vibration
- Solid waste disposal
- Soil pollution
- Change in land use
- Visual impacts – aesthetics
- Impacts on aircrafts in the area
- Water pollution including the marine environment and potable, surface and ground water
- Pollution and disturbance of the marine environment as result of incidents with equipment or vessels, oils spills, etc.; increased turbidity; release of latent pollutants in the sediments and contamination of disposal, reclamation and storage sites
- Possible changes in the sediment transport and wave patterns, and coastline dynamics – including erosion and accretion
- Sewage and trade effluent treatment systems and discharge
- Discharge of cooling and/or cold water
- Risk of explosion, fire and thermal radiation supported by the results from appropriate models and analyses
- Risk to the plant, the environment and the surrounding population associated with the impacts of natural hazards such floods, hurricanes, tropical storms, earthquakes, etc., supported by the results from appropriate models and analyses and considering climate change. This should also include risks associated with LNG/ADO supply/transport, storage and regasification.
- Potential impact of high voltage transmission lines (sphere of influence)
- Impacts in relation to the discharge of ballast water and sediment air emissions (including but not limited to soot blowing) from ships during LNG and ADO unloading operations)
- Impacts related to leaks or accidental spillage of ADO, LNG or NG to the terrestrial and marine environment from tanks, pipes, hoses and pumps at land installations and in the marine environment during storage, transfer and transportation.
- Odorizing substances such as mercaptans are flammable and are toxic to humans. Under sufficient pressure, they are explosion hazards and should be managed with the same risk reduction strategies as natural gas. Impacts related to leaks, accidental spill and explosions should be examined.

7.2 Natural Hazard

Impact of Natural Hazards: Hurricanes, Earthquakes, Landslides and Flooding

7.3 Heritage

Loss of and damage to: artifacts, archaeological, geological and paleontological features

7.4 Human/Social/Cultural

Effects on socio-economic status such as changes to public access and recreational use, impacts on existing and potential economic activities, public perception, contribution of development to national economy and development of surrounding communities. Cultural and socio-economic impacts to include land use/resource effects should be assessed. In particular, impacts on the existing users of the water column should be examine (e.g., fisher-folk).

7.5 Public Health Issues of Concern

The impact of the proposed development on soil and air should be examined.

7.6 Risk Assessment

Analyze the risks to human health and ecosystems associated with the development from both human activities, such as blasting, and natural phenomenon. This should include: 1) Identifying the hazards 2) Assessing the potential consequences 3) Assessing the probability of the consequences and 4) Characterizing the risk and uncertainty. The monetary costs of the risks, the costs of emergency response and/or avoidance of risks should also be considered.

The physical, biological and sociological status will provide the framework in which to assess the impacts of the proposed project.

8. Impact Mitigation

The mitigation measures should endeavour to avoid, reduce and remedy the potential negative impacts while at the same time enhancing the positive impacts projected. Mitigation and abatement measures should be developed for each potential negative impact identified. Full details of the methods proposed to be employed in the implementation of these measures should be provided, including details on the scheduling/timelines, source of materials, location and responsible parties where appropriate. Where appropriate, maps and diagrams should also be used to illustrate areas where mitigation measures are proposed to be implemented.

Where suitable mitigation measures cannot be identified for an identified major potential impact, alternatives to the activity resulting in the impact or a justification for the lack of alternatives or mitigation measures **must** be provided.

The EIA should also indicate the emergency preparedness and response plans for dealing with risks and hazards identified.

9. Analysis of Alternatives

This should include the no action alternative and project design alternatives. These should be assessed according to the physical, ecological and socio-economic parameters of the site. The examination of project alternatives should incorporate the use history of the overall area in which the site is located and previous uses of the site itself. A rationale for the selection of any project alternative should be provided.

Conduct a Cost Benefit analysis of the Project. The Cost Benefit Analysis should include the use-change as per the proposed project and the existing state and a comparison of the annual value of the lost welfare associated with impacts of the project with the net social gain from the project.

10. Environmental, Health and Safety Management and Monitoring Plan

Environmental, Health and Safety Management and Monitoring plans should be developed which will detail the requirements for the various phases of the project. This should include, but not be limited to recommendations to ensure the implementation of mitigation measures and long term minimization of negative impacts.

A draft environmental, health and safety monitoring programme should be included in the EIA, and a detailed version submitted to NEPA for approval after the granting of the permit and prior to the commencement of the development.

At the minimum the monitoring programme should outline:

- the locations/sites selected for monitoring
- the parameters which will be monitored for each activity and proposed mitigation measure
- the proposed methodology to be employed for the monitoring of the various parameters
- the frequency of the monitoring
- the proposed format that the monitoring reports will take
- tables and graphs are to be used where appropriate
- the frequency of the submission of the monitoring reports
- the responsible parties for the monitoring

11. List of References

12. Appendices

The appendices should include but not be limited to the following documents:

12.1 Reference documents
12.2 Photographs/ maps
12.3 Data Tables
12.4 Glossary of Technical Terms used
12.5 Final Terms of Reference
12.6 Composition of the consulting team, team that undertook the study/assessment including name, qualification and roles of team members
12.7 Notes of Public Consultation sessions
12.8 Instruments used in community surveys

13. Activities

In order to effectively and efficiently conduct the Environmental Impact Assessment it will be necessary to carry out various activities which include:

13.1 Documentation Review

All documentation pertaining to the development will need to be reviewed. These should include, but not limited to, the project profile, site plan, drainage plan, vegetation clearance plan, applications made for financing or planning approval, and any technical and engineering studies that have been done.

13.2 Analysis of Alternatives

Alternatives to the site location, project design and operation conditions will be analyzed including the "no-action" alternative. These alternatives will be assessed based on the physical, ecological and socio-economic parameters of the site identified. The consultant should provide justification for the selection of the chosen alternative(s). The physical, biological and sociological settings will provide the framework in which to assess the different project alternatives.

Note

All findings must be presented in the EIA report and **must reflect** the headings in the body of the TORs, as well as references. GIS references should be provided where applicable. Fifteen hard copies and an electronic copy of the report should be submitted. One copy of the document should be perfect bound.

The report should include an appendix with items such as maps, site plans, the study team, photographs, and other relevant information.

Appendix 2 – Study Team

- **CL Environmental Co. Ltd.:**
  - Carlton Campbell, Ph.D., CIEC (Noise, Noise modelling, Air Quality and Socio-economics)
  - Matthew Lee, M.Sc. (Water Quality, Marine Benthic Survey and Air Quality)
  - Rachel D'Silva, B.Sc. (Water Quality, Marine Benthic Survey)
  - Karen McIntyre, M.Sc. (Legislation, Socioeconomics and GIS)
  - Kimani Kitson-Walters, M. Phil (Vegetation Survey, Water Quality)
  - Achsah Mitchell, M. Phil (Vegetation Survey, Water Quality)
  - Errol Harrison (Field Technician – Air Quality and Noise)
  - Glen Patrick (Field Technician – Air Quality and Noise)

- **CEAC Solutions Ltd.:**
  - Christopher Burgess M.Sc. Eng., PE (Hydrodynamics Modelling,, Waves and Storm Surge Modelling)
  - Carlnenus Johnson, B.Sc Eng. (Hydrodynamics Modelling,, Waves and Storm Surge Modelling)
  - Kristifer Freeman, B Sc, Eng. (Oceanography, Shoreline Vulnerability)
  - Marc Henry (Drafting and Design)

- **Moffatt & Nichol (Raleigh, NC):**
  - John R. Dorney, Senior Environmental Scientist (Overall general editing, Cumulative Impacts, Executive Summary, Alternatives)
  - Jerry McCrain, Senior Environmental Scientist (General editing, Cumulative Impacts)

- **Moffatt & Nichol (Tampa, FL):**
  - Deborah MacPhearson, Lead Project Manager/Marine Structural Engineer (Project Schedule; Project Infrastructure, Effluent and Emissions; Project Operations and Maintenance; Physical Environment; Emergency Preparedness and Response).
  - Michael Frenier, P.E., Assistant Project Manager (Project Schedule; Project Infrastructure, Effluent and Emissions; Project Operations and Maintenance; Physical Environment; Emergency Preparedness and Response).

- **OnQuest (San Dimas, CA):**
  - Rey Rodriquez, Senior Project Manager and Ed Rodriguez (Vice President, Process Operations (Executive summary, Project Infrastructure, Effluent and Emissions, Associated Facilities and Environmental Issues, Project Construction, Project Operations and Maintenance, Engineering and Design Details for the Old Harbour Project, Emergency Preparedness and Response for Off-Shore Loading Facility.)

- Universal Pegasus International – UPI, (Houston, TX):
  - James Watson, Vice President (Executive Summary, Project Concept and Description, Project Schedule, Project Infrastructure, Effluent, and Emissions, Associated Facilities and Environmental Issues, Project Construction, Project Operations and Maintenance, Emergency Preparedness and Response, Natural Gas Pipeline, 8-inch Automotive Diesel Oil (ADO) Pipeline)

- New Fortress Energy – New York, NY.
  - Brannen McElmurray – Risk Assessment, General editing.

- Associate Consultants:
  - Eric Garraway, Ph.D. (Faunal Survey)
  - Catherine Murphy, Ph.D. (Faunal Survey)
  - Philip Rose, Ph.D. (Vegetation Survey)
  - Camilo Trench, MSc (Vegetation Survey)
  - Marc Rammelaere, M.Sc. (Geology)
  - Sacha Todd, Ph.D. (Freshwater Survey)
  - Stephen Haughton, M Phil (Air Quality Dispersion Modelling)
  - Jannette Manning, M Sc (Perception Survey)

Appendix 3 – NEPA Guidelines for Public Participation

SECTION 2

PUBLIC CONSULTATIONS GUIDELINES
FOR
ENVIRONMENTAL IMPACT ASSESSMENTS

SECTION 2 - TABLE OF CONTENTS

Chapter 1: GENERAL GUIDELINES

Chapter 2 : SPECIFIC GUIDELINES FOR PUBLIC CONSULTATIONS

Chapter 3: CONDUCTING SUBSEQUENT PUBLIC CONSULTATIONS

APPENDICES

CHAPTER 1: GENERAL GUIDELINES

1.0 Introduction

There are two levels of public consultation involved in the Environmental Impact Assessment (EIA) process. The first is direct involvement of the affected public or community in public consultations during the EIA study. These consultations allow the developer to provide information to the public about the project and to determine what issues the public wishes to see addressed. The extent and results of these consultations are included in the documented EIA report.

The second level of involvement takes place after the EIA report is prepared in the form of a public meeting and the submission and review of comments on the EIA report. This occurs after the applicant has provided the information needed for adequate review by the public.

1.1 Purpose

These guidelines are prepared in relation to the second level of consultation outlined above for the use of the applicant and the public.

CHAPTER 2: SPECIFIC GUIDELINES FOR PUBLIC MEETING FOR ENVIRONMENTAL IMPACT ASSESSMENTS (EIAS)

2.1 Requirements

Arrangements for the public consultation, in particular the public meeting, must be made in discussion with NEPA in respect of date, time, venue, chairperson, specially invited participants and length of time for the submission of comments.

A permanent record of the meeting is required hence, the applicant must submit to NEPA a copy of the verbatim report of the public meeting within seven (7) days of the date of the meeting.

2.2 Public Notification

The public must be notified at least three (3) weeks before the date of the public meeting. The applicant must seek to ensure that in addition to specific invitation letters, at least **three (3)** notices are placed in the most widely circulated newspapers advertising the event; one (1) notice per week. A copy of the notice shall be forwarded to NEPA for approval prior to publication in the newspapers. The NEPA will also post a copy of the Notice on its Website once it has been approved. To ensure that the Notice is distributed as widely as possible, at least two (2) other methods of notification such as community notice boards, flyers, town criers etc. shall be utilized. In addition, specific notice to relevant local NGOs and community groups should be made by the applicants. Evidence of the two (2) additional methods of notification and specific notices must be submitted to the NEPA.

The notices should indicate that:-

-the EIA has been submitted to NEPA;
- the purpose of the meeting;
- how to access the EIA report for review;
- the date, time and venue of the public presentation;
- contact information (NEPA/NRCA/TCPA and the APPLICANT).

The public meeting should be conducted no less than 3 weeks after the EIA has been accepted for posting and has been made available to the public and no less than 3 weeks after the first notice announcing public meeting has been published by the applicant. ***(A typical notice is in***

Appendix 1).

2. 3 Responsibility of Applicant

The applicant is responsible for distribution of copies of the EIA Report to make them available to the public at least three (3) weeks before the public meeting. Copies should be placed in the Local Parish Library and the Parish Council Office as well as the NEPA Documentation Centre, NEPA Regional Office nearest to the project site and other community locations as agreed upon. A summary of the project components and the findings of the EIA in non-technical language should also be prepared for distribution at the public meeting.

2.4 Conduct of the Meeting

With respect to the conduct of the meeting, the chairperson should be independently selected so as to ensure his/her neutrality. NEPA should be consulted regarding the selection of a chairperson. The role and responsibilities of the chairperson are outlined in ***Appendix 3***.

2.5 The Presentation

The technical presentation by the applicant should be simple, concise and comprehensive. The main findings of the EIA including adverse and beneficial impacts identified and analyzed should be presented. **(A typical agenda for a meeting is given in Appendix 2)**

Mitigation measures and costs associated with these measures should be presented. The meeting should inform the public on how they will get access to monitoring results during the construction and operational phases of the project, as it seeks to facilitate their participation in the monitoring and enforcement of the conditions under which approvals may being granted. Graphic and pictorial representations should support the technical presentation.

Presenters are advised to keep the technical presentation simple and within a time limit of 20-30 minutes depending on the complexity of the project and to allow a minimum of 30 minutes for questions. ***(A typical outline of a Project presentation is given in Appendix 4)***

2.6 Submission of Verbatim Report

The applicant will submit to NEPA a copy of the verbatim report of the public meeting within seven (7) days of the date of the meeting.

2.7 Submission of Public Comments

Please note that the public will be given a period of twenty-one (21) days after the public meeting to submit written comments to NEPA.

APPENDICES

APPENDIX 1

NOTIFICATION OF PUBLIC MEETING

THERE WILL BE A PUBLIC CONSULTATION ON THE ENVIRONMENT IMPACT ASSESSMENT REPORT

OF:

VENUE:

DATE:

TIME:

THE PUBLIC IS INVITED TO PARTICIPATE IN THE CONSULTATION BY WAY OF ASKING QUESTIONS RELATING TO THE PROPOSED PROJECT.

A COPY OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT MAY BE CONSULTED AT THE

____________________ PARISH LIBRARY

____________________ PARISH COUNCIL OFFICE

NEPA'S Documentation Centre at 11 Caledonia Avenue, Kingston 5

____________________ NEPA Website: www.nepa.gov.jm

For further information contact:

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APPENDIX 2

AGENDA

1. WELCOME AND INTRODUCTION
2. STATEMENT BY THE NATIONAL ENVIRONMENT & PLANNING AGENCY
3. PRESENTATION OF EIA FINDINGS AND MEASURES TO MINIMIZE IMPACTS
4. QUESTION AND ANSWER SESSION
5. CLOSING REMARKS

APPENDIX 3

ROLE AND RESPONSIBLITIES OF THE CHAIRPERSON

The chairperson has the main role of guiding the conduct of the meeting and seeing to it that the concerns of the public are adequately aired and addressed by the proponent/consultants.

The responsibilities of the chairperson include explaining the NEPA approval process, that is, the steps involved and the role of the NEPA at these public presentations. In other words, the chairperson should explain the context within which the meeting is taking place.

The chairperson should ensure that adequate time is allowed for questions and answers, and must understand clearly and communicate the purpose of the meeting to the audience. The chairperson is responsible for introducing the presenters.

The chairperson should contribute to but not monopolize the meeting.

APPENDIX 4

STRUCTURE OF PRESENTATION

1. DETAILED DESCRIPTION OF PROJECT PROPOSAL

2. DETAILS OF IMPACTS IDENTIFIED

3. DESCRIPTION OF PROPOSED MITIGATION MEASURES

4. RESPONSE TO ANY ISSUES RAISED PRIOR TO PUBLIC CONSULTATION (MEDIA, WRITTEN QUERY ETC.)

Appendix 4 - Hydrolab DS-5 Calibration Certificate

OTT Hydromet

Certificate of Instrument Performance

Company Name: CL ENVIRONMENTAL Certification for Job#: 4802458

Part/Model Number: DATASONDE - 5 Serial Number: 48757

RECEIVED CONDITION: (One must be checked)	☑	Within Tolerance
	☐	Within Tolerance but Limited (*see service report)
	☐	Out of Tolerance (*see service report)

RETURNED CONDITION: (One must be checked)	☑	Within Tolerance
	☐	Within Tolerance but Limited (*see service report)

Test Equipment Used, (ID#): N.I.S.T. - traceable glass thermometer (H-B Thermometer, Serial **2Z9208)** and a Cole-Parmer "*PolyStat*" Constant Temperature Circulator

Environmental Conditions:

Actual Temperature:	Instrument Reading:	Error
10 °C	10.00°C	0.00°C
20 °C	20.00°C	0.00°C
30 °C	29.98°C	0.02°C

OTT Hydromet does hereby certify that the above listed equipment meets or exceeds all Manufacturers' Service Specifications (unless limited conditions apply). Test equipment used for performance verification are calibrated using standards traceable to the National Institute of Standards and Technology (NIST). Where such standards do not exist, the basis for calibration is documented. The proper operation of the above instrument was established at the time of certificate issuance. To insure continued performance, user must adhere to all requirements listed in the instrument manual.

Certified by: Chad Fletcher

Title: Certified Instrument Service Technician

Certification Date: 7/28/2015

5600 Lindbergh Drive • Loveland, CO 80538
(800) 949-3766 / FAX (970) 461-3921

ADCON TELEMETRY OTT HYDROLAB

Appendix 5 – Noise Calibration Certificate

3M Oconomowoc
Personal Safety Division

3M Detection Solutions
1060 Corporate Center Drive
Oconomowoc, WI 53066-4828
www.3M.com/detection
262 567 9157 800 245 0779
262 567 4047 Fax

Page 1 of 2

3M

Certificate of Calibration

Certificate No: 5510375QII050083

Submitted By: CL ENVIRONMENTAL COMPANY LIMITED
22 FORT GEORGE HEIGHTS
KINGSTON 9, JAMAICA

Serial Number:	QII050083	Date Received:	4/2/2015
Customer ID:		Date Issued:	4/3/2015
Model:	QC-10 CALIBRATOR	Valid Until:	4/3/2016
Test Conditions:		**Model Conditions:**	
Temperature:	18°C to 29°C	As Found:	IN TOLERANCE
Humidity:	20% to 80%	As Left:	IN TOLERANCE
Barometric Pressure:	890 mbar to 1050 mbar		

SubAssemblies:

Description: **Serial Number:**

Calibration Procedure: 56V981

Reference Standard(s):

I.D. Number	Device	Last Calibration Date	Calibration Due
ET0000556	B&K ENSEMBLE	6/19/2014	6/19/2015
T00230	FLUKE 45 MULTIMETER	2/14/2014	2/14/2016

Measurement Uncertainty:

+/- 1.1% ACOUSTIC (0.1DB) +/- 1.4% VAC +/- 0.012% HZ
Estimated at 95% Confidence Level (k=2)

Calibrated By: Paul M. Wegmann — PAUL WEGMANN, **Service Technician** 4/3/2015

Reviewed/Approved By: **Technical Manager/Deputy** 4/3/2015

This report certifies that all calibration equipment used in the test is traceable to NIST or other NMI, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of 3M Detection Solutions.

098-393 Rev. B

An ISO 9001 Registered Company
ISO 17025 Accredited Calibration Laboratory

ACCREDITED

3M Oconomowoc
Personal Safety Division

3M Detection Solutions
1060 Corporate Center Drive
Oconomowoc, WI 53066-4828
www.3M.com/detection
262 567 9157 800 245 0779
262 567 4047 Fax

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3M

Certificate of Calibration

Certificate No: 5510375QII050083

(A) indicates out of tolerance condition

Test Type	Nominal	Tolerance-	Tolerance+	As Found	As Left	Unit
AC OUT/1kHz	1.000	0.950	1.050	0.994	1.002	VAC
Calibration	114.0	113.7	114.3	113.9	114.0	dB
Frequency	1000	980	1020	996	996	Hz

* indicates non accredited

098-393 Rev. B

An ISO 9001 Registered Company
ISO 17025 Accredited Calibration Laboratory

ACCREDITED

Appendix 6 – Floral Species List

SPECIES ENCOUNTERED ON SJPC LANDS

Source: CL Environmental, 2012

Scientific name	Common name	Growth form	DAFOR Ranking
Abrus precatorius	Crab Eyes	Climbers/Twiners	R
Antigonon leptopus	Coralita		R
Cissus sicyoides	Soldier Withe, Snake Withe, Pudding Withe		F-A
Cryptostegia grandiflora	Indian Rubber Vine		O
Ipomoea sp.			F
Ipomoea triloba			O
Mikania micrantha	Guaco		O
Momordica balsamina	Cerasee		R
Passiflora ?triflora			R
Passiflora maliformis	Sweet Cup		O
Phaseolus vulgaris	Red Peas		R
Pithecoctenium echinatum	Monkey Comb		O-F
Selenicereus grandiflorus	Queen-of-the-Night		O
Trichostigma octandra	Basket Withe		F
Urechites lutea	Nightshade, Nightsage		O-F
Achyranthes indica	Devil's Horse-whip	Herbs	A
Adropogon sp.			F-A
Asclepias curassavica	Red Top, Redhead		R
Batis maritima	Jamaican Sapphire		O
Bidens pilosa	Spanish Needle		O
Bromelia penguin	Pingwing		R
Commelina diffusa	Water Grass		R
Cynodon dactylon	Bermuda Grass, Bahama Grass		F
Cyperus sp.			O
Eleocharis sp.			O
Emilia javanica	Cupid's Shaving Brush		O
Gomphrena sp.			O
Heliotropium angiospermum	Dog's Tail		R
Leonotis nepetifolia	Christmas Candlestick		R
Mimosa pudica	Shame-o-lady		O
Musa sapientum	Banana		R
Oeceoclades maculata	Monk Orchid/Ground Orchid		O
Panicum maximum	Guinea Grass		A
Paspalum sp.			O
Rhynchospora nervosa	Star Grass		F
Rivina humilis	Bloodberry		F
Sesuvium portulacastrum	Seaside Purslane		O
Sporobolus indica			F-A
Sporobolus jacquemontii			A
Sporobolus virginicus			R
Stemodia maritima			R
Talinum traingulare			R
Typha domingensis	Reedmace		O
Vernonia cinerea			O
Allamanda cathartica	Yellow Allamanda	Shrubs	O
Allamanda violacea	Purple Allamanda		O

Scientific name	Common name	Growth form	DAFOR Ranking
Capparis baducca			R
Chromalaena (Eupatorium) odoratum	Christmas Bush		R
Lantana camara	White Sage, Wild Sage		R
Malpighia sp.			R
Pisonia aculeata	Cockspur		O
Pithecellobium unguis-cati	Privet		R
Pluchea carolinensis	Wild Tobacco		R
Plumbago sp.			R
Randia aculeata	Box Briar, Indigo Berry, Ink Berry		R
Ricinus communis	Castor Oil Plant, Oil Nut		R
Sida acuta	Broomweed		A
Stenocereus hystrix	Dildo Pear		R
Harrisia gracilis	Torchwood Dildo	Shrubby Herbs	R
Urena lobata	Ballard Bush, Bur Mallow		F
Acacia tortuosa	Wild Poponax	Trees	A
Avicennia germinans	Black Mangrove		R
Rhizphora mangle	Red Mangrove		O
Caesalpinia bonduc	Grey Nickal/Grey Nicker		R
Cassia emarginata	Senna Tree, Yellow Candle Wood		R
Cocus nucifera	Coconut		R
Comocladia pinnatifolia	Maiden Plum		R
Cordia sp.			R
Guazuma ulmifolia	Bastard Cedar		A
Haematoxylum campechianum	Logwood		O
Nectandra sp.			R
Samanea saman	Guango		F
Tecoma stans			O

Appendix 7 – Avifauna Species List

WETLAND BIRDS ENCOUNTERED

Source: CL Environmental, 2015

Groupings	Proper Name	Scientific Name	Status	DAFOR	Habitat Type
Frigate birds	Magnificent Frigatebird	*Fregata magnificens*	Resident	O	Coastal
Gulls	Laughing Gull	*Leucophaeus atricilla*	Resident	O	Coastal
Herons and egrets	Black-Crowned Night Heron	*Nycticorax nycticorax*	Resident	R	Mudflat/ Salina
Herons and egrets	Cattle Egret	*Bubulcus ibis*	Resident	D	Mudflat/ Salina
Herons and egrets	Great Blue Heron	*Ardea herodias*	Resident / Migrant t	R	Mudflat/ Salina
Herons and egrets	Great Egret	*Casmerodius albus*	Resident / Migrant	R	Mudflat/ Salina
Herons and egrets	Green Heron	*Butorides virescens*	Resident	O	Mudflat/ Salina
Herons and egrets	Little Blue Heron	*Egretta careulea*	Resident	R	Mudflat/ Salina
Herons and egrets	Yellow-Crowned Night Heron	*Nycticorax violaceus*	Resident	O	Mudflat/ Salina
Ibeses	Glossy Ibis	*Plegadis falcinellus*	Resident	R	Mudflat/ Salina
Ibeses	White Ibis	*Eudocimus albus*	Resident	R	Mudflat/ Salina
Pelican	Brown Pelican	*Pelecanus occidentalis*	Resident	O	Coastal
Plover	Black-Bellied Plover	*Pluvialis squatarola*	Resident / Migrant	R	Mudflat/ Salina
Plover	Piping Plover	*Charadrius melodus*	Resident / Migrant	R	Mudflat/ Salina
Plover	Ruddy Turnstone	*Arenaria interpres*	Resident	O	Mudflat/ Salina
Plover	Sanderling	*Calidris alba*	Resident	R	Mudflat/ Salina
Plover	Semipalmated Plover	*Charadrius semipalmatus*	Resident / Migrant	R	Mudflat/ Salina
Plover	Wilson's Plover	*Charadrius wilsonia*	Resident	O	Mudflat/ Salina
Plover	Kildeer	*Charadrius vociferus*	Resident	O	Mudflat/ Salina
Sandpipers	Least Sandpiper	*Calidris minutilla*	Resident	O	Mudflat/ Salina
Sandpipers	Long-billed Curlew	*Numenius americanus*	Resident / Migrant	R	Mudflat/ Salina
Sandpipers	Solitary Sandpiper	*Tringa solitaria*	Resident / Migrant	R	Mudflat/ Salina
Sandpipers	Spotted Sandpiper	*Actitis macularius*	Resident / Migrant	O	Mudflat/ Salina
Stilts	Back-necked Stilt	*Himantopus mexicanus*	Resident	O	Mudflat/ Salina
Warbler	Yellow Warbler	Dendroica petechia	Resident	R	Terrestrial

Nb: DAFOR scale used to categorize the birds identified in the study; Dominant (n ≥ 20), Abundant (n= 15 – 19); Frequent (n=10 – 14); Odd (n= 5- 9); Rare (n< 4).

TERRESTRIAL BIRDS ENCOUNTERED:

Source: CL Environmental, 2015

Proper Name	Code Used	Scientific Name	Status	DAFOR
American Redstart	AMRE	Setophaga ruticilla	Migrant	R
Antillean Palm Swift	APSW	Tachornis phoenicobia	Resident	F
Bananaquit	BANA	Coereba flaveola	Resident	O
Black-Whiskered Vireo	BWVI	Vireo altiloquus	(Summer) Migrant	O
Common Ground Dove	COGD	Columbina passerina	Resident	O
Greater Antillean Bullfinch	GABU	Loxigilla violacea	Resident	R
Greater Antillean Elaenia	GAEL	*Elaenia fallax*	Resident	R
Jamaica Tody	**JATO**	**Todus todus**	**Endemic**	**O**
Jamaican Euphonia	**JAEU**	**Euphonia Jamaica**	**Endemic**	**R**
Jamaican Lizard-cuckoo	**JALC**	**Saurothera vetula**	**Endemic**	**R**
Jamaican Mango	**JAMH**	**Anthracothorax mango**	**Endemic**	**O**
Jamaican Oriole	**JAOR**	**Icterus leucopteryx**	**Endemic**	**O**
Jamaican Pewee	**JAPE**	**Contopus pallidus**	**Endemic**	**R**
Jamaican Vireo	**JAVI**	**Vireo modestus**	**Endemic**	**O**
Jamaican Woodpecker	**JAWO**	**Melanerpes radiolatus**	**Endemic**	**O**
Loggerhead Kingbird	LOKI	Tyrannus caudifasciatus	Resident	F
Northern Mockingbird	NOMO	Mimus polyglottos	Resident	F
Jamican Parakeet	**JAPA**	**Aratinga nana**	**Endemic**	**F**
Red-billed Streamertail	**RBST**	**Trochilus polytmus**	**Endemic**	**O**
Sad Flycatcher	**SAFL**	**Myiarchus barbirostris**	**Endemic**	**R**
Smooth-Billed Ani	SBAN	Crotophaga ani	Resident	F
Stolid Flycatcher	**STFL**	**Myiarchus stolidus**	**Endemic**	**R**
Turkey Vulture	TUVU	Carthartes aura	Resident	O
Vervain Hummingbird	VEHU	Mellisuga minima	Resident	O
White Crowned Pigeon	WCPI	Columba leucocephala	Resident	F
White-Collared Swift	WCSW	Streptoprocene zonaris	Resident	O
White-Winged Dove	WWDO	Zenaida asiatica	Resident	D
Yellow Warbler	YEWA	Dendroica petechia	Resident	R
Yellow-faced Grassquit	YEFC	Tiaris olivacea	Resident	F
Zenaida Dove	ZEDO	Zenaida aurita	Resident	O

JAMAICAN WINTER MIGRANT BIRDS NOT OBSERVED DURING THIS STUDY (BIRDLIFE INTERNATIONAL, 2016)

Source: Jamaica Broilers Ethanol Plant EIA, 2006, Environmental Solutions Limited (ESL, 2006b)

Scientific name	Proper Name	Category (IUCN red list status)
Nomonyx dominicus	Masked Duck	LC
Mareca americana	American Wigeon	LC
Spatula discors	Blue-winged Teal	LC
Calidris minutilla	Least Sandpiper	LC
Ictinia mississippiensis	Mississippi Kite	LC
Catharus minimus	Grey-cheeked Thrush	LC
Vermivora chrysoptera	Golden-winged Warbler	NT
Parula americana	Northern Parula	LC
Dendroica magnolia	Magnolia Warbler	LC
Dendroica tigrina	Cape May Warbler	LC
Dendroica caerulescens	Black-throated Blue Warbler	LC
Dendroica coronata	Yellow-rumped Warbler	LC
Dendroica virens	Black-throated Green Warbler	LC
Dendroica fusca	Blackburnian Warbler	LC
Dendroica discolor	Prairie Warbler	LC
Dendroica palmarum	Palm Warbler	LC
Dendroica cerulea	Cerulean Warbler	VU
Protonotaria citrea	Prothonotary Warbler	LC
Helmitheros vermivorum	Worm-eating Warbler	LC
Limnothlypis swainsonii	Swainson's Warbler	LC
Seiurus aurocapilla	Ovenbird	LC
Parkesia noveboracensis	Northern Waterthrush	LC
Parkesia motacilla	Louisiana Waterthrush	LC
Geothlypis trichas	Common Yellowthroat	LC
Catharus bicknelli	Bicknell's Thrush	VU
Vireo gilvus	Warbling Vireo	LC
Dendroica dominica	Yellow-throated Warbler	LC
Charadrius nivosus	Snowy Plover	NT
Puffinus lherminieri	Audubon's Shearwater	LC
Gallinula galeata	Common Gallinule	LC
Rallus crepitans	Clapper Rail	LC
Fulica americana	American Coot	LC
Numenius phaeopus*	**Whimbrel**	-
Calidris alpine*	**Dunlin**	-
Limnodromus griseus*	**Short-billed Dowitcher**	-

Category:

LC – Least Concern

NT – Near Threatened   *VU - Vulnerable*

BIRD LIST TAKEN FROM JAMAICA BROILERS ETHANOL PLANT EIA (ESL, 2006B)

Family Groups	Family	Common Name	Scientific Name	Status	DAFOR
Pelecans	Pelecanidae	Brown Pelican	*Pelecanus occidentalis*	b	F
Frigatebirds	Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	b	F
Bitterns and Herons	Ardeidae	Great Egret	*Ardea alba*	b	O
Bitterns and Herons	Ardeidae	Cattle Egret	*Bulbicus ibis*	b	F
Bitterns and Herons	Ardeidae	Green Heron	*Butorides virescens*	b	O
Bitterns and Herons	Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*	b	O
New World Vultures	Cathartidae	Turkey Vulture	*Cathartes aura*	b	O
Falcons & Caracaras	Falconidae	American Kestrel	*Falco sparverius*	b	O
Plovers and Lapwings	Charadriidae	Black-bellied Plover	*Pluvialis squatarola*	m	O
Sandpipers and Allies	Scolopacidae	Spotted Sandpiper	*Actitis macularia*	m	O
Gulls and Terns	Laridae	Royal Tern	*Sterna maxima*	b	O
Pigeons & Doves	Columbidae	Rock Dove	*Columba livia*	b	A
Pigeons & Doves	Columbidae	White-crowned Pigeon	*Columba leucocephala*	b	R
Pigeons & Doves	Columbidae	Mourning Dove	*Zenaida macroura*	b	R
Pigeons & Doves	Columbidae	Zenaida Dove	*Zenaida aurita*	b	R
Pigeons & Doves	Columbidae	White-winged Dove	*Zenaida asiatica*	b	R
Pigeons & Doves	Columbidae	Common Ground-Dove	*Columbina passerina jamaicensis*	bes	A
Parrots, Macaws & Allies	Psittacidae	Olive-throated Parakeet	*Aratinga nana nana*	bes	O
Cuckoos and Anis	Cuculidae	Smooth-billed Ani	*Crotophaga ani*	b	O
Nightjars & Allies	Caprimulgidae	Antillean Nighthawk	*Chordeiles gundlachii*	bs	R
Hummingbirds	Trochilidae	Vervain Hummingbird	*Mellisuga minima minima*	bes	R
Woodpeckers & Allies	Picidae	Jamaican Woodpecker	*Melanerpes radiolatus*	be	O
Tyrant Flycatchers	Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*	bs	D
Tyrant Flycatchers	Tyrannidae	Loggerhead Kingbird	*Tyrannus caudifasciatus jamaicensis*	bes	O
Swallows	Hirundinidae	Caribbean Martin	*Progne dominicensis*	bs	F
Swallows	Hirundinidae	Cave Swallow	*Pterochelidon fulva*	b	F
Swallows	Hirundinidae	Barn Swallow	*Hirundo rustica*	m	O
Mockingbirds & Thrashers	Mimidae	Northern Mockingbird	*Mimus polyglottos*	b	F
Vireos & Allies	Vireonidae	Jamaican Vireo	*Vireo modestus*	be	O
Vireos & Allies	Vireonidae	Black-whiskered Vireo	*Vireo altiloquus*	bs	F

Family Groups	Family	Common Name	Scientific Name	Status	DAFOR
Wood Warblers	**Emberizidae**	Yellow Warbler	*Dendroica petechia*	b	O
Bananaquits	**Emberizidae**	Bananaquit	*Coereba flaveola faveola*	bes	O
Grassquits	**Emberizidae**	Yellow-faced Grassquit	*Tiaris olivacea*	b	F
Finches	**Emberizidae**	Saffron Finch	*Sicalis flaveola*	b	O
Emberizids	**Emberizidae**	Greater Antillean Grackle	*Quiscalus niger*	bes	O

Classification based on H. Raffaelle "Birds of the West Indies."
Status according to Downer and Sutton "Birds of Jamaica."
Abundance determined by numbers of individuals during survey period

Key
b=breeding resident species bes=Jamaican endemic sub-species
be=jamaican endemic species bs=summers and breeds m=non-breeding migrant

Appendix 8 – JNHT Non-Technical Summary of Archaelogical Impact Assessment for 360MW Power Plant

NON-TECHNICAL SUMMARY

S.1 The Jamaica National Heritage Trust (JNHT) has concluded an Archaeological Impact Assessment (AIA) on the site of the proposed Jamaica Public Service Company (JPSCO) 360MW Power Plant located in Old Harbour Bay. The field survey was conducted in 2 days, May 16 and 17, 2012.

S.2 This Archaeological Impact Assessment was carried out in response to a request made by CL Environmental Ltd.

S.3 The research objectives of the assessment are to ascertain the presence of historical and archaeological resources and describe the status of these resources, along with any other socio-economic attributes and appraise their worth in context of the proposed development, legislative and regulatory considerations. In addition, to identify and predict any potential positive, negative, reversible, irreversible, short and long term impact and to indicate possible mitigation to negative impacts, as well as recommendations to enhance positive impacts, also to outline possible alternatives to the project and/or aspects of it. Where necessary indicate suitable management and monitoring plan for the earth breaking stage of the project.

S.4 There are a number of pertinent policies, legislation, regulations and environmental standards of the Government of Jamaica (GOJ) relating to environmental protection that are applicable to any development and that a developer will need to consider when embarking on a particular scale and type of development. There are several government agencies mandated with the authority to control certain types of development that may have potential negative impact on the natural and cultural environment. These are Natural Resources Conservation Authority, National Environment and Planning Agency, Parish Council, The National Solid Waste Management Authority, National Land Authority, Ministry of Health and the Jamaica National Heritage Trust (JNHT).
The Jamaica National Heritage Trust Act of 1985 established the JNHT. The Trust's functions outlined in Section 4 include the following responsibilities:

- To promote the preservation of National Monuments and anything designated as Protected National Heritage for the benefit of the Island;

- To carry out such development as it considers necessary for the preservation of any National Monument or anything designated as Protected National Heritage;
- To record any precious objects or works of art to be preserved and to identify and record any species of botanical or animal life to be protected. Section 17 further states that it is an offence for any individual to:
    - Wilfully deface, damage or destroy any national monument or protected national heritage or to deface, damage, destroy, conceal or remove any mark affixed to a national monument or protected national heritage;
    - Alter any national monument or mark without the written permission of the Trust;
    - Remove or cause to be removed any national monument or protected national heritage to a place outside of Jamaica.

S.5 Historically, the area contains historic and archaeological sites dating back to Jamaica's first known inhabitants (The Taino) and later those who came the Spanish, the Africans and the British. The area has seen various land uses over the past centuries. Cattle rearing were the main activity in the area during pre and post emancipation periods. It should be noted that all the plantations, pens and estates in the area had plantation houses and enslaved villages. In the more recent past aquaculture was done on some areas of the property.

S.6 The survey techniques employed in this project were dictated by the nature of the topography, vegetation cover, accessibility and time allowed for the survey. It is believed that these techniques will provide us with the best possible coverage and accuracy of the results. The background information on the site was derived from primary documentary sources supported by secondary narratives.

S.7 For easy reference, the proposed development area was divided into two zones based on topography and vegetation cover. A map was generated that highlights the features found and recommendations made. A table of contents guides the reader. The study is complete with photographs of these historical remains, current usage of the site and artefacts as well as modern structures that now occupy the site.

S.8 Currently the section slated for development is in ruinate with charcoal burning occurring. No pre-historical or historical cultural material or feature was observed in the area designated for the construction of the plant. It is worth noting, however, that survey of the area was restricted by the dense vegetation cover. Pre historical cultural material in the form of pottery sherds, both Spanish and English bricks and concrete troughs associated with cattle rearing were found to the immediate east and west of the site. This means that when the vegetation cover is removed from the core area the probability of finding pre historic and historic cultural material is very high. Thus it is necessary that watching briefs be carried out by the JNHT during clearing and excavation stages.

S.9 Based on the archaeological evidence available to us at this time, the value of the artefact assemblages observed are not significant to the point that will hamper the development of the area. **The JNHT has no objection against the proposed development; providing that an archaeological watching brief is conducted during the initial phase of construction. The JNHT also requests that prior to clearing and excavation a schedule of activities be sent so that a team can be dispatched to conduct aforementioned watching brief in a timely manner.**

Appendix 9 – Perception Survey Questionnaire

Questionnaire ID: ____________ Date: __________
Time started: ____________
Time finished: ____________
Name of Interviewer: ____________
Community: ____________

OBJECTIVES:

- To determine the extent to which fishermen are dependent on the Old Harbour area for their livelihood as well as subsistence
- To determine the extent to which fishermen in OLD Harbour use depend on the area in the immediate vicinity of the project site for subsistence
- To determine whether the community is aware of the proposed project and whether there are any a priori concerns with the project (including potential environmental impacts)

My name is .... I am part of an environmental team from CL Environmental conducting a survey of fisherfolk/community members in the the Old Harbour Bay area for the proposed NFE South Holdings Ltd (NFE) Old Harbour Floating Storage Unit and Pipeline Project.

The project involves construction of a marine import facility comprised of a vessel berth and off-shore offloading and regasification platform at the general location approved by the Port Authority of Jamaica in the Portland Bight area of Jamaica. This facility will accommodate a Floating Storage Unit (FSU) vessel for LNG storage and a LNG carrier delivering LNG to the FSU. In short, LNG will be delivered by ship from various possible locations in the United States or elsewhere. The platform would contain equipment to regasify LNG as well as related process and safety equipment. The liquid gas would then be pumped into an undersea pipeline which follows the general route of an existing Automotive Diesel Oil (ADO) line which runs from the existing mooring facility to the JPS plant in Old Harbour. The gas pipeline would then be directionally drilled on shore to a small receiving facility on shore near the proposed gas power plant that JPS is constructing where it can be metered and then sent to the power plant. In addition, the project will construct an off-shore mooring facility with a new ADO line to storage tanks at the renovated power plant in order to provide a back-up fuel source in case of LNG delivery interruptions.

This facility will be constructed off-shore in the western side of Portland Bight at a distance about 200 meters from the shipping channel to Port Esquivel in about 14 meters of water deep. This is a permanent facility made of steel and designed to resist both potential seismic and hurricane/tropical storms in the area. This facility will contain mooring provisions for LNG ships to dock at the facility on seven to ten day intervals depending on demand for the gas. The ships will then off-load the LNG which will be stored in the FSU and regasified on the facility constructed on the platform and sent to shoreside distribution facilities. The facility will be designed so it can be readily expanded as demand for LNG grows in the region.

You were randomly selected to take part in this survey and your participation in this interview is voluntary. You do not have to answer any questions that you are not comfortable with and you can stop me at any time during our discussion to seek clarification. There are no right or wrong answers. I can assure you of full confidentiality in this survey. Your identity and responses will be kept confidential and your privacy will be protected. I will not use your name, only a code number, to identify your information in my formal analysis and reports.

Do you have any questions?	Yes / No
May we proceed with our survey?	Yes / No

1

Questionnaire ID: ______________ Date: __________
Time started: ______________
Time finished: ______________
Name of Interviewer: ______________
Community: __________________

SECTION 1: Reliance on the environment for livelihood

1. What is your primary occupation? Fisherman Full Time ☐ Fisherman Part time ☐ Other

2. Do you rely on the immediate Old Harbour Bay for your fishing? Yes/No If no, Do you source fish from any other areas? Yes/No. If yes please state.......................
3. Have you noticed any changes to your fishing catch in the past 10 years? Yes/No If yes please state
   i. ______________________________
   ii. ______________________________
   iii. ______________________________

4. What do you think has caused these changes?
   i. ______________________________
   ii. ______________________________
   iii. ______________________________

5. What percentage of your income do you derive directly from fishing

   ☐ >75% ☐ 51 – 75% ☐ 25 – 50% ☐ <25%

6. Has the income which you derive from fishing changed over the past ten years?

   ☐ Increase ☐ Decrease ☐ No Change

7. If so, by how much?

   ☐>50% ☐31 – 50% ☐11 – 30% ☐<10%

8. What would you say is the main reason for your change in income?

   ____
   ____
   ____

Questionnaire ID: ____________ Date: ________
Time started: ____________
Time finished: ____________
Name of Interviewer: ____________
Community: ____________

9. Do you have any other source of income (apart from fishing and included skills). Yes/No… please state
   1. ____________
   2. ____________
   3. ____________

10. Would you be willing to state your monthly income?

☐ Yes ☐ No

SECTION II: Perception of Project impact on the environment

1. Have you ever heard of a company called NFE South Holdings Limited (NFE) (New Fortress Energy)?
   ☐ Yes ☐ No

2. Did you know that NFE is proposing to build an LNG Floating Storage Unit, Regasification facility and Pipelines to deliver the LNG to the JPS Power Station? ☐ Yes ☐ No

   If yes, how were you made aware? (i) Newspaper (ii) Television (iii) Radio (iv) Community meeting (v) Word of mouth (vi) Other ----------------------------

3. Do you think the project could affect your fish catch during construction or operation? Yes/No ….. how/why

   If yes/No please specify ____________

4. Do you think the locations of the proposed Floating Storage Unit, Regasification facility, pipelines and metering facility is suitable? ☐ Yes ☐ No

   If no, where would be more suitable in your opinion? ____________

5. Are you aware of any Protected areas / sites in your community or nearby?
   ☐Yes ____________ ☐No

   If yes, what do you know about the site? ____________

6. Are you aware of any nature reserves in your community or nearby? ☐ Yes ☐ No

   If yes, where is the site?
   ____

7. Do you have any concerns about the proposed Project? ☐ Yes ☐ No

If yes, please specify ____________
____
____

3

Questionnaire ID: _____________ Date: __________
Time started: _____________
Time finished: _____________
Name of Interviewer: _____________
Community: ____________________

SECTION III: Background

1. Age: ☐ >25 ☐ 26-40 ☐ 41-60 ☐ >60
2. Gender: ☐ Male ☐ Female
3. Highest level of education:
   ☐ Primary ☐ Secondary ☐ Tertiary ☐ Tech Voc
4. Do you own your own home? ☐ Yes ☐ No
5. Do you rent? ☐ Yes ☐ No
6. Do you own any land? ☐ Yes ☐ No
7. How long have you lived in the Old Harbour Bay area?
   ☐ <1 year ☐ 1 – 10 years ☐ 11 – 20 years ☐ > 20 years
8. What is your average total household income per week? (This is in JMD)
   ☐ $2000 - $3000 ☐ $ 3001 - $4000 ☐ $4001- $5000 ☐ $5001 - 6000 ☐ $6001 – 7000 ☐ >$8000

ANY OTHER COMMENTS

____

____

THANK YOU FOR YOUR TIME TODAY. I APPRECIATE YOUR PARTICIPATION IN THIS SURVEY.

4

Appendix 10 – Letter from the Ministry of Industry, Commerce, Agriculture & Fisheries (Fisheries Division), September 2016

MINISTRY OF INDUSTRY, COMMERCE, AGRICULTURE & FISHERIES

AGRICULTURE AND FISHERIES PORTFOLIO | HOPE GARDENS, KINGSTON 6, JAMAICA
TELEPHONE: (876) 927-1731-50 • (876) 619-1731 | FAX: (876) 960-7422 | WEBSITE: HTTP://WWW.MOA.GOV.JM
INDUSTRY AND COMMERCE PORTFOLIO | 4 ST. LUCIA AVENUE, KINGSTON 5, JAMAICA
TELEPHONE: (876) 968-7116 • (876) 618-0691 | FAX: (876) 960-7422 | WEBSITE: HTTP://WWW.MIIC.GOV.JM

ANY REPLY OR SUBSEQUENT REFERENCE TO THIS COMMUNICATION SHOULD BE ADDRESSED TO THE PERMANENT SECRETARY AND THE FOLLOWING REFERENCE QUOTED:

REF.

September 2, 2016

Dr. Carlton Campbell
Managing Director
C. L. Environmental Company Ltd.
P.O Box 2919
Constant Spring P.O.
Kingston 8

Dear Dr. Campbell,

Re: Environmental Impact Assessment for the New Fortress Energy Marine Terminal and Pipeline Project, Old Harbour, St. Catherine

This serves to acknowledge receipt of your subjected missive dated August 24, 2016. Please find the Fisheries Division's response with respect to the under-mentioned:

1. **The location of the proposed Project** - We offer no objection to the proposed locations for the Marine Terminal and Floating Storage Unit(s). The area leading to Salt River is traversed by only a few fishers who may fish just outside the Salt River Special Fishery Conservation Area (Sanctuary), and further South towards the Bluff. The fishers from the Old Harbour Bay Fishing Beach tend to exit the Bay in a South Easterly direction, away from the proposed Floating Storage Unit (FSU).

2. **The potential impact it might have on fishers** - Pursuant to the aforementioned, the potential impact on the majority of fishers and fishing activities should be minimal. However, there are some fishers, particularly those who use smaller non-mechanized vessels with oars, who fish in the area for small demersal and pelagic fish species using nets and hand lines who will be adversely impacted. These fishers may be somewhat displaced, particularly if there is a large sterile zone around the proposed FSU. We note in perusing your submitted documents, that a Safety Zone of five hundred (500) metres from the wharf was mentioned. We are mindful of your company's safety concerns regarding Liquefied Natural Gas (LNG) and the interest of the fishers; consequently, we suggest that in order to minimize the possible displacement of those fishers, that the proposed safety/sterile zone around the FSU be no more than two hundred (200) metres. With respect to the legislation regarding Safety/Security Zone within the Jamaican jurisdiction around a wharf/vessel, your attention is drawn to the Harbours Act, Harbour Rules, 1971, Section 10, 2 (a), which currently allows only a mandatory one hundred (100) metres from any wharf or vessel.

-2-

Dr. Carlton Campbell
September 2, 2016
Re: **Environmental Impact Assessment for the New Fortress Energy Marine Terminal and Pipeline Project, Old Harbour, St. Catherine**

3. **The Caribbean Coastal Area Management Foundation (C-CAM) has noted that the proposed terminal site is a Red Snapper feeding ground. Comments from the Fisheries Division are sought on this statement including potential impact from the operation of the Terminal -** The proposed site for the FSU is a feeding ground not just for the Red Snapper, but for several other demersal species, coastal pelagics and invertebrates such as Sea Cucumbers. Given our knowledge of the ecology of the area and our experiences with similar installations, our expectation is that the installation and operation of the proposed FSU should have minimal medium to long term negative impacts on the ecology of the proposed site. This expectation is given on the basis that effluents, noise, vibrations and other pollutants are kept within standards or eliminated where possible around the proposed FSU facility during installation and longer term operations.

Thank you for providing excerpts of the Draft Report regarding the proposed project to construct the marine LNG terminal facility in the Portland Bight area of Jamaica. Do invite the Fisheries Division to future consultative meetings planned with the fishers regarding this project, and should you have any further queries or require further clarifications, do not hesitate to contact us.

Respectfully,

Lt. Cdr. (Ret'd) Paul Wright, JP
Chief Executive Officer

Copy to: Mr. Dermon Spence, Chief Technical Director - MICAF
Mr. Andre Kong, Director of Fisheries - MICAF
Mr. Peter Knight, JP, Chief Executive Officer - NEPA

Appendix 11 – Draft Mangrove Rehabilitation/Replanting Plan Outline

Site Preparation

- Possible grading of site so as to create the hydrological regime suitable for mangrove growth.
- The deployment and maintenance of suitably placed and sized silt curtains prior to sand placement and grading (if needed). The silt curtains will be removed after the required sand movements and sedimentation rate as determined by NEPA/NWA.
- Mangrove seedlings/saplings will be obtained from the University of the West Indies Port Royal Marine Laboratory. The seedlings will be acclimatized (grown in similar water salinity) and hardened before being transported to the replanting site. The proposed replanting site map can be seen below.

Planting

- Age 18 – 36 month old, hardened and acclimated mangrove saplings will be planted at the replanting site.
- Saplings will be planted with random 1 metre spacing.
- Fencing/screening off of the area to prevent animals such as goats and cows from feeding on the seedlings will be conducted after planting exercises.

Monitoring and Reporting

- Weekly inspection for the first six to eight weeks to assess any adverse impacts on the seedlings from wind, wave action, debris flows etc. If so, corrective action will be taken, for example relocating seedlings to higher ground or constructing baffles seawards of the seedlings.
- Data collection on mangrove seedlings will be conducted on a representative number of plants. This will include but not be limited to: plant height, number of nodes/leaves, number of prop roots and pneumatophores (if applicable).
- Seedling failure and external stressors will be recorded.
- Measurements of water quality data will be collected to determine if the water quality that the mangroves are being exposed to are suitable for sustained growth. The basic parameters to be measured are temperature, salinity, pH, dissolved oxygen, nitrate and phosphate.
- A total of 12 mangrove monitoring events and subsequent reports to NEPA will be conducted and submitted with the following schedule:
    - Time Zero (One month after completion of replanting exercise).
    - Year 1- Every 4 months: Month 4, Month 8 and Month 12
    - Year 2-5, every six(6) months:
        - Month 18
        - Month 24
        - Month 30

- Month 36
- Month 42
- Month 48
- Month 54
- Month 60-Final Report

The proposed replanting site map can be seen below.

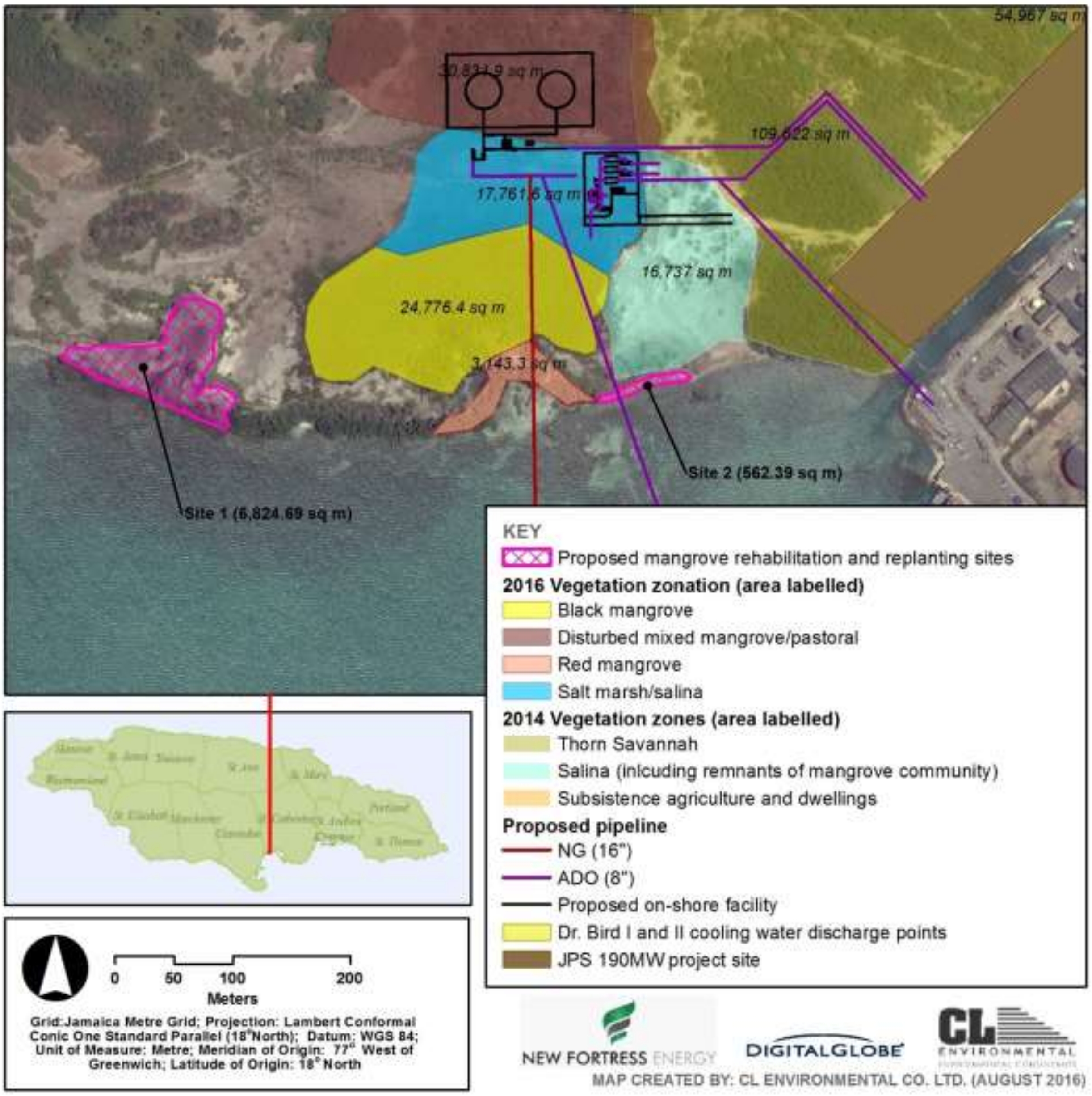

Figure 16-1 Proposed mangrove rehabilitation and replanting sites

Appendix 12– NEPA Draft Mangrove Monitoring Specifications

MONITORING SPECIFICATIONS

Mangroves

Monitoring report should include

a. The name (s) of the persons responsible for monitoring

b. Dated photographs evidence of all works (photographs should be taken from the same angle at the same location)

c. Time and date of monitoring and analysis

d. An estimate of the timeline for completion of activity

e. Water quality (Salinity, temperature, pH,)

f. Record the depth constructed or remediated the tidal channels along their length and overall condition of the channels (open, closed, partially visible, etc)

g. Remedial planting conducted and the locations using georeferenced maps *if any*

h. Details on the following

   i. Percentage cover and species composition of planted and volunteers mangroves over time

   ii. Height and number of leaves (greater than 25 leaves is represented as >25) of at least 10 mangrove seedlings occurring in each stratified random quadrat

   iii. Number of prop roots and pnematophores

   iv. Degree of thinning (average number of planted seedlings that are experiencing leaf loss), remedial planting

   v. Record level of seedling failure if any and provide scientific explanation (pests, predation, hydrology, etc)

   vi. Impact of any external stress such as storm events following the exercise.

   vii. Comments and Observations

MANGROVE

Restoration Summary Form

Weekly Log of Restoration Activity

Persons Conducting Restoration:	**GPS Location of Restoration Site/s:** *(State format)*:	**Date of Restoration:**
		Week No:
	Site no:	
Authorized by:		

Brief summary of weekly restoration activities as implemented:		
No. of Tidal Channels Constructed or Remediated:	**Grids Planted per week** *(This should be accompanied by gridded map of the restoration site)*:	
Average Depth of Tidal Channels:	**No. of Grids**	**GPS Location of Grids**

Total No of Seedlings Planted: ( ) **Source:** *Nursery ( )* *Wild Stock ( )* **Species:** *Red: ( ) Black : ( ) White: ( ) Button: ( )*		
Comments and Observation:		

Monitoring Summary Form (Routine)

Persons Conducting Monitoring : **Authorized by:**	**GPS Location of Planting Site/s** *(State format)*:	**Date of Monitoring:** **Growth and Survival Trend Graph:**

Monitoring Period: *( ) Time Zero ( ) Time Zero Plus 60 days ( ) Time Zero Plus 180 days ( ) Time Zero Plus 365 days*

( ) Year 1 Plus 180 days ( ) Year 1 Plus 365 days ( ) Year 2 Plus 180days ( ) Year 2 Plus 365days

( ) Year 3 Plus 180 days ( ) Year 3 Plus 365days ( ) Year 4 Plus180 days ( ) Year 4 Plus 365days

Percentage Survival of Planted Seedlings: *Red ( ) Black ( )* *White( ) Button( )*	**Average No. of Seedlings:** *Live ( ) Dead ( )*	**Average Height of Planted Seedlings:** *Red ( ) Black( )* *White ( ) Button ( )*
Average No. of Volunteer Seedlings: *Red ( ) Black( )* *White ( ) Button ( )*	**Species Composition of Planted Seedlings** *(Percentage)* *Red ( ) Black ( ) White( ) Button( )*	

Average No. of Leaves of Planted Seedlings:	**Average No. of pnematophores:**	**Average No. of prop roots:**
Water Quality: *Temperature:* *Salinity:* *pH:*		
Date and Extent of Remedial Planting *if any(details should be outlined on the remediation monitoring form):*		
Comments, Observation and Ecological Trend:		