Environmental Impact Assessment

PROPOSED OLD HARBOUR PLANT RE-POWERING PROJECT (190 MW), OLD HARBOUR BAY, ST. CATHERINE, JAMAICA

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ENVIRONMENTAL IMPACT ASSESSMENT FOR PROPOSED OLD HARBOUR PLANT RE-POWERING PROJECT (190 MW), OLD HARBOUR BAY, ST. CATHERINE, JAMAICA

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LIST OF ACRONYMS

A	amsl	Above mean sea level
C	C	Celsius
	CBD	Convention on Biological Diversity
	CDMP	Caribbean Disaster Mitigation Project
	CN	Curve number
D	DAFOR	Dominant, Abundant, Frequent, Occasional, Rare
	dBA	A-weighted sound level (decibel)
	DBH	Diameter at breast height
	DEM	Digital elevation model
	DO	Dissolved oxygen
E	E	East/ Easting
	EIA	Environmental Impact Assessment
	EMP	Environmental Monitoring Programme
	ESRI	Environmental Systems Research Institute
	FOG	Fats Oil and Grease
F	ft	Feet
G	g/l	Grams per litre
	GIS	Geographic information system
	GOJ	Government of Jamaica
	GPS	Global Positioning System
H	HA	Hectares
	hr	Hour
	Hz	Hertz
I	IPCC	Intergovernmental Panel on Climate Change
	IUCN	International Union for Conservation of Nature
J	JAD 2001	Jamaica Grid 2001
	JNHT	Jamaica National Heritage Trust
K	km	Kilometre
L	LDUC	Land Development and Utilization Commission
	Leq	Time-average sound level
	Lj	jth sound level
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
	mm/24 hr	Millimetres per 24 hour period
	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
	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	PEL	Hearing Conservation and Permissible Exposure Limit
	PIF	Project Information Form
	PM10	Particulate matter smaller than 10 microns in diameter, respirable particulate matter
	PM2.5	Particulate matter smaller than 2.5 microns in diameter, 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
	SO_2	Sulfur Dioxide, sulfite
	SO_4	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
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 (JPS), the sole distributor of electricity in Jamaica, is planning to construct a 190 MW nominal combined cycle power plant, adjacent to JPS' existing Old Harbour facility, which currently has 220 MW of generation. Specifically, it is intended that liquefied natural gas (LNG) will be used to fuel the proposed power plant.

Impacts from the construction and operation of the proposed facility will potentially arise and it is considered 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) have been executed by the contracted entity, CL Environmental Co. Ltd., and this report serves to compile and present the findings of the EIA. It should be noted that the fuelling of the proposed power plant with LNG is considered a separate project, for which an additional EIA will be required.

COMPREHENSIVE DESCRIPTION OF PROJECT

Project Concept and Description

JPS negotiated over the past year though a licence amendment that was gazetted, the right to replace its own generation. The Plan to build a 190 MW new gas-fired plant was endorsed by the ESET on Feb 4 2015. This represents base load generation to replace existing oil fired units of equal capacity. The target capacity was determined through various resource scenarios which optimize use of existing contract generation and renewables. The plant is a combined cycle 3x1 configuration designed to have maximum flexibility and to integrate renewables.

This 190 MW Nominal combined cycle development will be undertaken from Q1 2016 to Q1 2018. This new capacity will be base-loaded and is intended to replace the heavy fuel oil burning aged steam unit plants. Jamaica Public Service Company Limited (JPS) was awarded the right to go forward with the project.

Proposed Project Location and Siting

The Old Harbour 190 MW Nominal combined cycle power plant is to be located approximately 75.6 kilometres (47 miles) from the city of Kingston near the community of Old Harbour on the south coast. The proposed is adjacent to JPS' existing 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 community of Old Harbour Bay, located on the south-western coast of Jamaica in the parish of St. Catherine, was estimated to have a total population of 8,537 in 2009. Located approximately 5km 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 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 proposed site is largely flat area with clay type soils with site elevation varying from approximately 1.5 meters to 3.0 meters above mean sea level.

The proposed site of the new power plant is on the storage area for the existing Old Harbour 220 MW plant and is located near the Intermediate Acacia Forest (Thorn Savannah) ecosystem. This ecosystem is comprised mainly of Acacia sp. trees and stands. The Intermediate is distinguished from the Secondary Acacia Forest ecosystem 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). Typical bird species within this zone of vegetation are warblers.

The Intermediate Acacia Forest ecosystem is less significant/ecologically important than the Mangrove Ecosystem and Salina Ecosystem. Although the relative species diversity and abundance of avifauna tends to be average for this type of ecosystem, avifauna species tend to be more robust than their marine/salina counterparts and they, therefore, have more habitat options to migrate to, during development and construction within this vegetation zone. C.L. Environmental, 2007.

The proposed site for the power plant is on the existing JPSCo Old Harbour plant in an area used for storage, in addition to an area immediately west of the storage area to be purchased from the National Land Agency. The project site is located in the Portland Bight Protected Area.

Proposed Plant Technical Specifications

The new plant proposed herein will consist of one (1) power block of nominal 190MW combined cycle plant. The block's configuration consists of 3 combustion turbine generators x 3 heat recovery steam generators (HRSGs) x1 steam turbine generator. The combustion turbines will be dual fuel capable, however, the plant is designed for using natural gas fuel only. Each gas turbine unit is a 40 MW class, the steam turbine is a 75 MW class, providing nominal 190 MW block size in the 3 x 3 x 1 combined cycle duct fired configuration.

The exhaust gas from the gas turbine is led to the associated HRSG for generating the steam which in turn will be fed to a common steam turbine generator. The HRSGs will be dual pressure, non-reheat type, with duct burners, in order to obtain optimum exhaust gas energy utilization based on thermo-economic considerations.

The plant is designed for both base load and cycling duty (two shift operation) in order to be able to comply with all instructions from the system load dispatcher. The plant will operate with a 98% average annual equivalent availability factor (EAF) for the life time of the plant. This reliability is based on the inherent reliability of the Original Equipment Manufacturer (OEM) turbine packages, the unique features of the OEM gas turbines that allow for optimum maintenance schedules, a robust balance of plant (BOP) design, all coupled with a competent operations and maintenance staff that will be provided. In addition, the company intends to enter into a long term service agreement (LTSA) with the OEM for scheduled maintenance on the gas turbines. This will ensure that maintenance is done in accordance with OEM requirements, with genuine OEM parts and service, and in an expeditious manner.

A metering system is used in order to measure net energy output from the plant, and to monitor and co-ordinate operation of the facility. The location of the metering system will be in a 138 kV substation control building, and potential transformers for the metering system will be located on the 138 kV side of each generator transformer feeders in the 138 kV switchyard to measure net electrical energy outputs.

Continuous emissions monitoring (CEM) ports will be provided for the measurement of air emission levels in the exhaust stack of each HRSG.

Plant effluents will be treated to comply with the effluent discharge limit criteria (National Resources Conservation Authority's (NRCA) Jamaican National Trade Effluent Standards) and discharged to Old Harbour Bay through the existing cooling water discharge flume of the Old Harbour power plant. The Global Positioning System (GPS) location for the discharge point will be determined following the dispersion modelling exercise. The EIA will assess the suitability of the location for the discharge of plant liquid effluent.

The plant will be designed to meet the regulatory standards and is designed for an operating life of at least 25 years.

The design of the buildings will meet or exceed the requirements as established in the latest updates to the National Building Code and Caribbean Uniform Building Code. The civil structures for the project will be designed to meet the seismic requirement for ground acceleration of 0.4 g with a 10% probability of occurrence over a 50 years period and withstand maximum hurricane intensity wind speeds of 67.0m/s (241 km/h).

Project Construction

Schedule

Site preparation will commence by the first quarter 2016 and construction of the JPS power plant is scheduled to commence in by the second quarter of 2016. Commercial operation of Unit #1 is expected 22 months after the commencement of construction and the commercial operation of the other two units are slated one month after each other.

COST BENEFIT ANALYSIS

The UNIDO Approach for Social Cost Benefit Analysis as prescribed by United Nation Industrial Development Organization (UNIDO) was used to analyse the JPS natural gas power plant at Old Harbour, St. Catherine.

The cost benefit shows that the project has a positive net present value (NPV) using all recommended methodologies.

IDENTIFICATION AND ASSESSMENT OF POTENTIAL DIRECT AND INDIRECT IMPACTS AND RECOMMENDED MITIGATION

Site Preparation and Construction

<u>Noise Pollution</u>

Heavy Equipment

Site clearance for the proposed development necessitates the use of heavy equipment to carry out the job. Equipment to be used include bulldozers, backhoes etc. They possess the potential to have 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. The 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.

Access Road

During the site clearance and construction phases of the Proposed Project, an access road will be built to the site which will facilitate the movement of heavy vehicles and equipment. It is anticipated that during the site filling phase is when the highest daily volume of vehicular traffic will occur. It is anticipated that during this phase approximately 70 truck trips per day to carry fill material to the site. SoundPlan 7.3 model was used to determine the potential noise impact to the community for this activity (worst case scenario). A speed limit of 30 km/h for the trucks was used in the model.

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 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.

The avifauna will be marginally affected by changes in the noise environment; the community dynamics and population have already been shaped by elevated noise levels in the project area and zone of influence. Therefore, no mitigation is required.

Vibration

Construction activities often generate vibration complaints. This may be as a result of interfering with persons 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. Comparing these level with the British Standard from a human standpoint, most equipment used would result in no vibration being perceived except with pile driving which might just be perceptible. From a building standpoint, the vibration levels predicted will have no effect residential buildings within proximity of the JPS 190MW Power Plant project.

Recommended Mitigation

a. Sequence of operations:
   i. Phase demolition, earth-moving and ground-impacting operations so as not to occur in the same time period. Unlike noise, the total vibration level produced could be significantly less when each vibration source operates separately.
   ii. Avoid night time activities. People are more aware of vibration in their homes during the night time hours.
b. Alternative construction methods:
   i. Avoid impact pile-driving where possible in vibration-sensitive areas. Drilled piles or the use of a sonic or vibratory pile driver causes lower vibration levels where the geological conditions permit their use.
   ii. Select demolition methods not involving impact, where possible.

iii. Avoid vibratory rollers near sensitive areas.

c. Have regular meetings or devise a communication strategy to inform the residents of construction activities.

Storage of Raw Material and Equipment

Any raw materials used in construction 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

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.

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

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 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.

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.

Air Quality

Site preparation 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.

Recommended Mitigation

i. Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and 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.

Habitat Fragmentation

The effects of habitat fragmentation are expected to be minimal negative since the study site and surrounding areas were already degraded and the species composition limited by current land use practices (e.g. logging, burning and livestock grazing). Although planned access roads and fencing may limit the movement of animal vectors, the grasses and some of the common herbs present are wind propagated. The marine environment also appears to be heavily degraded and may also experience some habitat fragmentation as a result of the lying of various pipelines. However the impacts of these activities is expected to be minimal.

Recommended Mitigation

i. Limit rights-of-passage to areas already showing noticeable signs of habitat degradation. For example areas with open fields and pastureland.
ii. Develop thorough procedures for the proper disposal of solid waste as well as hazardous and flammable materials. Restrict their disposal into surrounding locales.

Accidental or Intentional Removal of Important Plant Species or Communities

Over 52 plant species were encountered. This moderate species richness is possibly due to the mixture of vegetation types present and the then prevailing drought. Although none were endemic, endangered, threatened or rare, the diversity of the area is important. Therefore, minimising the negative impact on the flora during the construction phase of the development is also important.

Recommended Mitigation

i. The removal of vegetation should be strictly limited to the development site.
ii. Altering the orientation or placement of the development's footprint should be considered in more densely vegetated or otherwise sensitive communities mentioned above are not or minimally disturbed.
iii. A proper plan should be developed concerning transportation routes and storage for equipment and material.
iv. The proposed post construction or operation road network should be kept simple as well as be used throughout the preparation and construction phases of the project.
v. Proper planning regarding access points to the construction site should be established.
vi. A buffer area should be established and maintained between the project area and the surrounding vegetation.

<u>Increased Soil/Substrate Erosion and Flooding</u>

The potential for land erosion and flooding is greatly increased as a result of vegetation removal. A plant's roots act as a mesh within the substrate increasing its cohesiveness and improving drainage. Areas where bare ground is exposed tend to erode faster than areas inhabited by plants as they help percolate rainwater into the substrate below. There was evidence on site that some soil compaction and erosion was occurring due primarily to the degraded nature of the community. As such any further vegetation removal would intensify these impacts.

Recommended Mitigation

i. If possible, trees with trunks of DBH 20 cm and greater should be left intact.
ii. Remove trees only as would be necessary. A tree removal protocol should be developed for site preparation prior to project initiation.
iii. Prepare vegetation restoration plan to be implemented once construction is complete.

<u>Storage and Transportation of Raw Materials</u>

Plant growth and health can be significantly affected by dust, grime and toxic emissions. Leaching from storage areas can disturb the pH balance in the soil and result in plant loss.

Recommended Mitigation

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 paints and chemicals into the sediment.
ii. In terms of transporting equipment, the paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.

Fauna

Overall, the proposed development will have an impact on the fauna on the property with special emphasis on the birds, as a result of the modification or removal of some of their habitat such as the mudflats, mangrove forest and the old fish ponds. However during the survey no animals with special conservation status were encountered on the property.

Recommended Mitigation

- Planting of trees on the property will increase avifauna and terrestrial invertebrates' number.
- The re-vegetation of the site will not have a significant impact on the crocodile population. However the vegetation can help hide the juvenile crocodiles from predators.
- A winter bird survey should be a part of the monitoring plan for the project.

The removal of the vegetation will change the bird species composition in the area. In order to reduce the negative impact of the development, trees can be planted which could attract a number of birds.

Marine Benthic Environment

Runoff and or siltation as a result land based activities may result in reduced water quality resulting in affecting marine benthos.

Recommended Mitigation

- Construct berms around the construction site
- Sediment barriers/silt screens are recommended.

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.

Employment

There is the potential for increased employment during the pre-clearance and construction phases. It is anticipated that approximately 70 persons will be employed directly during the site clearance and an average of 200 persons to a maximum of 400 -450 persons at the peak during construction.

Recommended Mitigation

No mitigation required.

Traffic Management (Commuters and Pedestrians)

The construction process may necessitate the re-routing of some vehicular and pedestrian traffic and introducing traffic delays thereby increasing in travel time. Any re-routing of vehicular traffic has the potential to lead to increase fares. Increased accident potential from additional trucks traversing the main roads is also a possibility.

Recommended Mitigation

During the site preparation and construction phases, the following should be enforced:

i. Trucks should operate ideally during off peak hours.

ii. Loading of trucks as per NWA axel load guidelines.
iii. Traffic diversion routes must be identified and constructed as necessary.
iv. Adequate caution signage as per NWA guidelines and the use of flagmen where necessary.
v. Trucks must be properly covered and loaded so as to not let loose material fall during transport.

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

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

Hydrology and Runoff

Runoff was estimated for both existing (predevelopment) and post development scenarios. The post development scenario for the site considered climate change impacts.

The flows from this area will increase from 15 to 22 percent for the 10 to 100 year event due to the increased impermeable areas after the construction of the power plant.

Recommended Mitigation

i. In order to minimize quantity of waste water, rain water from clean areas such as roads, paved areas free from contamination and buildings, etc. will be collected through open ditches (and/or) road side gutters. Collected rainwater will be routed to the holding area before being re-routed to the sea. This will allow for sediments to fall out before discharge to the sea. The recommended volume for the holding area should contain the first flush or ½ inch of rainfall before it discharges to the sea.
ii. Oily water on the site will generally originate from two area, plant floor and car park area. Floor water will originate from a number of activities; these will include wash down operations, maintenance operations, and spills during loading. Oily water in car park area may be as a result of spills from delivery trucks or any other vehicles undergoing mechanical problem or maintenance. Floor water will be directed to floor drains which will terminate at oil water separators. Similarly car park runoff will be directed to storm drains which will terminate in oil water separators as well. Class 1 separators are recommended for both circumstances given the bay is an environmentally sensitive area.

Noise

The predicted noise from the proposed power plant was determined by using SoundPlan version 7.3. The noise spectrum for both the Steam Turbine Generators and the Gas Turbine Generators and other major equipment provided by the manufacturer was used to calibrate the model. Once the model was calibrated then structures such as the auxiliary buildings, tank farm, ground and other buildings within the area were added. The noise impact from the proposed plant at the fence line (industrial), institutional (schools) and residential location were assessed and reported. All predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guideline

Recommended Mitigation

No mitigation is required.

<u>Vibration</u>

The operation of the power plant has the potential to create vibration that may cause a nuisance to both employees and residents alike.

Recommended Mitigation

i. Ensure that the equipment are placed on the manufacturer's recommended dampening system.
ii. Monitor the following:
    a. Speed (RPM) and Power (MW)
    b. Bearing vibration: seismic, shaft rider, or shaft x-and-y proximity probes (as applicable)
    c. Journal bearing and thrust bearing metal temperature
iii. Install the continuous monitoring system for GE steam turbines - The Turbine Supervisory Instrumentation (TSI) System. This monitoring includes the typical radial displacement vibration and axial position measurements used for GE steam turbines.
iv. Vibration-monitoring capability and evaluation is one of the most important portions of the TSI system for trending and predicting changes in turbine health and thermodynamic performance. Overall, vibration monitoring provides the means to track various problems.

<u>Pollution of Water Resources</u>

Non-hazardous and Hazardous Wastes

Non-hazardous and hazardous wastes include general solid waste, waste oils, oil contaminated rags, hydraulic fluids, used batteries, empty paint cans, waste chemicals and used chemical containers, oily sludge from oil water separators and scrap metals among others. These have the possibility of polluting nearby surface water bodies as a result of improper disposal practices.

Recommended Mitigation

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.

Natural Disasters

With any natural disaster comes the possibility of fuel/oil spill as a result of storage tank or pipeline damage. This may affect nearby surface water bodies and/or groundwater.

Recommended Mitigation

Each storage tank should be surrounded by a bund which is designed to contain at least 110% of the storage tank capacity.

The tanks should also be designed for the seismic rating of the region and the tank profile should 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.

Oily Water Management

Oily water on the site will generally originate from two areas, plant floor and the car park area. Floor water will originate from a number of activities; these will include wash down operations, maintenance operations, and spills during loading. Oily water in the car park area may be as a result of spills from delivery trucks or any other vehicles undergoing mechanical problem or maintenance.

Recommended Mitigation

i. Direct rainfall into the areas or floor washing water will be led to an oil separator by gravity and connected to the industrial waste piping network. The Oil removal system receives oil-contaminated water from all over the plant. Oil removed from the Oil/water separator will be stored within the separator for periodic removal and off-site disposal.

Sewage and Wastewater Management

Water for plant and sanitary processes will be obtained from a well source. The wastewater produced from the power plant operations will include wastes from the following sources:

- RO plant reject water (brine)
- Demineralization waste water
- Filter backwash water
- Cooling tower

Recommended Mitigation

All wastewater from the plant will be collected in a concrete tank and pre-treated to a satisfactory level and routed through a holding area to make it fully compliant with NEPA effluent quality standards before being re-routed back to the flume. The effluent quality will also be monitored by a continuous monitoring system. Sewage effluent from various buildings will be piped to the central sewage treatment plant.

Cooling Water Management

The cooling water from the plant will be discharged from the plant at a rate of 282,812 GPM and at a higher temperature than that of the seawater. The background or ambient temperature of seawater was measured at 30.71 degrees Celsius on average whereas the discharge from the plant will be at 35.5 degrees Celsius.

In order to predict the behaviour of the plume in terms of its movement and temperature, scaled and calibrated numerical models are generally employed. The nearfield and far field modelling are generally separated to because of scaling differences. Nearfield models simulate the behaviour of the Gully in the vicinity of the discharge point.

Air Quality

The following conclusions may be made as a result of the conduct of the air dispersion modelling analyses for the proposed LNG-fired power plant:

- The emission rates derived from the use of emission factors for each combustion turbine burning LNG, comply with the CO and PM emission standards, but exceeded the NO_x standards. It was deduced that in order to achieve compliance with the NO_x emission standard, certain changes with the design of the diluent injection technology to be employed for NOx reduction will have to be made.
- The model predictions for the LNG-fired proposed power plant revealed compliance with the CO, TSP, NO_2 and SO_2 ambient air quality standards and the priority air pollutant guideline concentrations for the requisite averaging periods. The incremental impact of the criteria air pollutants were also less than the established values that would have created a significant air quality impact.
- Based on the modelling results, the replacement of the existing JPS oil-fired power plant with the proposed LNG-fired power plant would cause a marked improvement to the prevailing SO_2 ambient air quality concentration within the air shed, while its impact on the prevailing TSP, CO and NOx concentrations will only have marginal improvement.
- Since the proposed LNG fired power plant sources demonstrated compliance with the ambient air quality standards and the guideline concentrations, as well as with the significant impact incremental values, it is envisaged that approval will be granted for the establishment of the facility. Nevertheless, it is anticipated that certain changes would need to be done for each combustion turbine’s NOx emissions to achieve compliance with the NOx emission standard for a 40 MW capacity LNG-fired unit.

2.0 INTRODUCTION

The Jamaica Public Service Company (JPS), the sole distributor of electricity in Jamaica, is planning to construct a 190 MW nominal combined cycle power plant, adjacent to JPS' existing Old Harbour facility, which currently has 220 MW of generation. It is intention that this new facility will repower the existing power plant at Old Harbour plant and replace the inefficient heavy fuel oil being used currently. Specifically, it is intended that liquefied natural gas (LNG) will be used to fuel the proposed power plant.

Impacts from the construction and operation of the proposed facility will potentially arise and it is considered 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) have been executed by the contracted entity, CL Environmental Co. Ltd., and this report serves to compile and present the findings of the EIA. It should be noted that the fuelling of the proposed power plant with LNG is considered a separate project, for which an additional EIA will be required.

3.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

3.1 EIA FRAMEWORK

3.1.1 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[1]:

- 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.

3.1.2 National Environment and Planning Agency

The National Environment and Planning Agency (NEPA) is the government executive agency and represent 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. The Agency is moving towards one application to NEPA for new developments and new modifications that will review

[1] Wood, C., "Environmental Impact Assessment: A Comparative Review" p. 2. (from Caldwell, 1989, p.9)

and approve environmental aspects as well as planning, building control and zoning considerations. It is this agency that will review the Environmental Impact Assessment.

The National Environment and Planning Agency (NEPA) has been given responsibility for environmental management in Jamaica under the NRCA Act of 1991. Since the promulgation of the Act, the NRCA has been developing local standards. The Act was strengthened by supporting regulations, which became effective in January 1997. The underlying principles, which have been used in the development of the Act, are:

- The Polluter pays Principle
- The Cradle to Grave approach to waste management

3.1.3 Permits and Licenses

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. An applicant for a Permit or License must complete a Permit Application Form (PAF) as well as a Project Information Form (PIF) for submission to the NRCA/NEPA.

3.1.4 EIA Components

3.1.4.1 Process

Under Section 9 of the NRCA Act, all activities associated with Power Plant facilities (e.g. wind farms, hydro, thermal and nuclear) such as the proposed power plant will require a Permit for construction and may, under Section 10 of the Act, require an EIA. The EIA Process is described below:

- 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. Appendix 1 gives the approved final TORs for the proposed 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.

3.1.4.2 Public Participation

There are usually two forms of public involvement in the EIA process. The first is direct involvement of the affected public or community in public consultations and surveys 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 is at the discretion of the NRCA and takes place after the EIA report and addendum, if any, has been prepared and after the applicant has provided the information needed for adequate review by NRCA and the public.

Community interaction and transparency is a critical area of focus for the success of this development and the second level of involvement described above is possible. Please see Appendix 2 for the NRCA reference document entitled "Guidelines for Public Participation" in EIAs.

3.2 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.

3.2.1 Development Control

This section deals with planning and development issues that can affect the establishment of a Power Generating Plant at Old Harbour Bay. 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. Described in subsequent sections below are the relevant legislations and regulations that may affect the project. 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.

3.2.1.1 Local Improvement Act 1944

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

3.2.1.2 Parish Councils Act 1901 (Amended 2007)

Under the Parish Council Act each Local Planning Authority 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.

3.2.1.3 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 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 3-1, the Development Order relevant to this proposed is the St Catherine Coastal Development Order. Please see section 5.6.2.3 (Zoning) for further details.

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

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

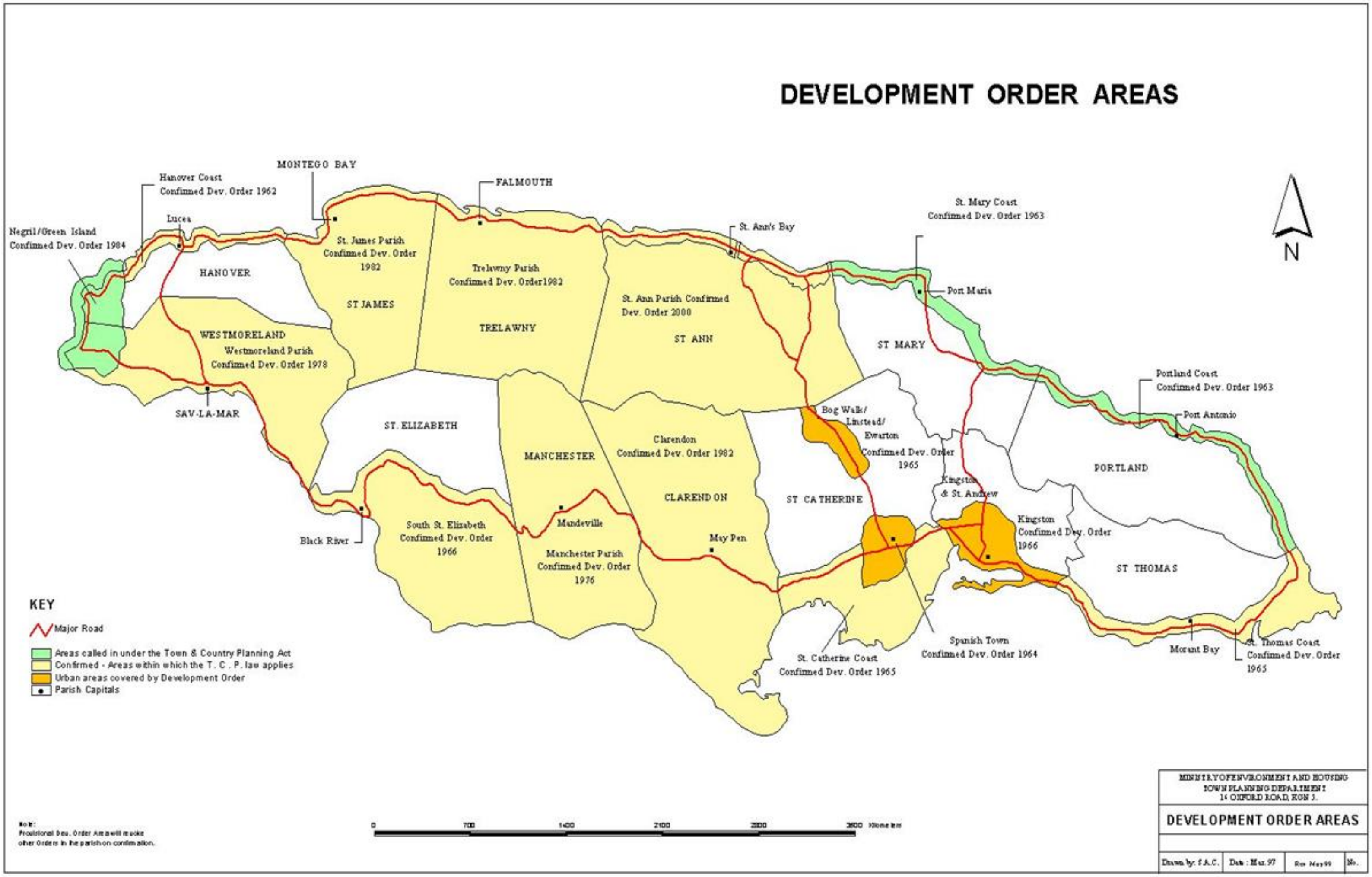
This Act was promulgated in 1995. Under this legislation, the OUR receives and processes applications for a licence to provide a prescribed utility service and make such recommendations to the Minister in relation to the application as the Office considers necessary or desirable. In relation to environmental 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.

3.2.1.5 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.



Source: National Environment and Planning Agency[2]

Figure 3-1 Development Order Areas in Jamaica

2 http://www.nepa.gov.jm/symposia_03/Laws/Maps/Map_of_Development_Orders.htm

3.2.1.6 Vision 2030 and National Energy Policy

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 expansion 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, power plant with a newer, higher capacity, dual fuel capable plant.

3.2.2 Environmental Conservation

3.2.2.1 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) [3]:

1) National Nature Reserve/Wilderness Area (Equivalent to IUCN Category I)
2) National Park, Marine Park (Equivalent to IUCN Category II).
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. However, as seen in Table 3-1, there are a greater number of protected area categories existing at present than being proposed, with varying responsible agencies and legislative tools.

Table 3-1 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

[3] 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)

CATEGORY	RESPONSIBLE AGENCY	LAW
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 3-2 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 3-3 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

The Natural Resources Conservation Authority (NRCA)/National Environment and Planning Agency (NEPA) is the lead agency with responsibility for the protected area system; however a number of other government , local management entities, non-governmental entities, privet sector and individuals are outlined as important role players as well.

As seen in Figure 3-2, 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.

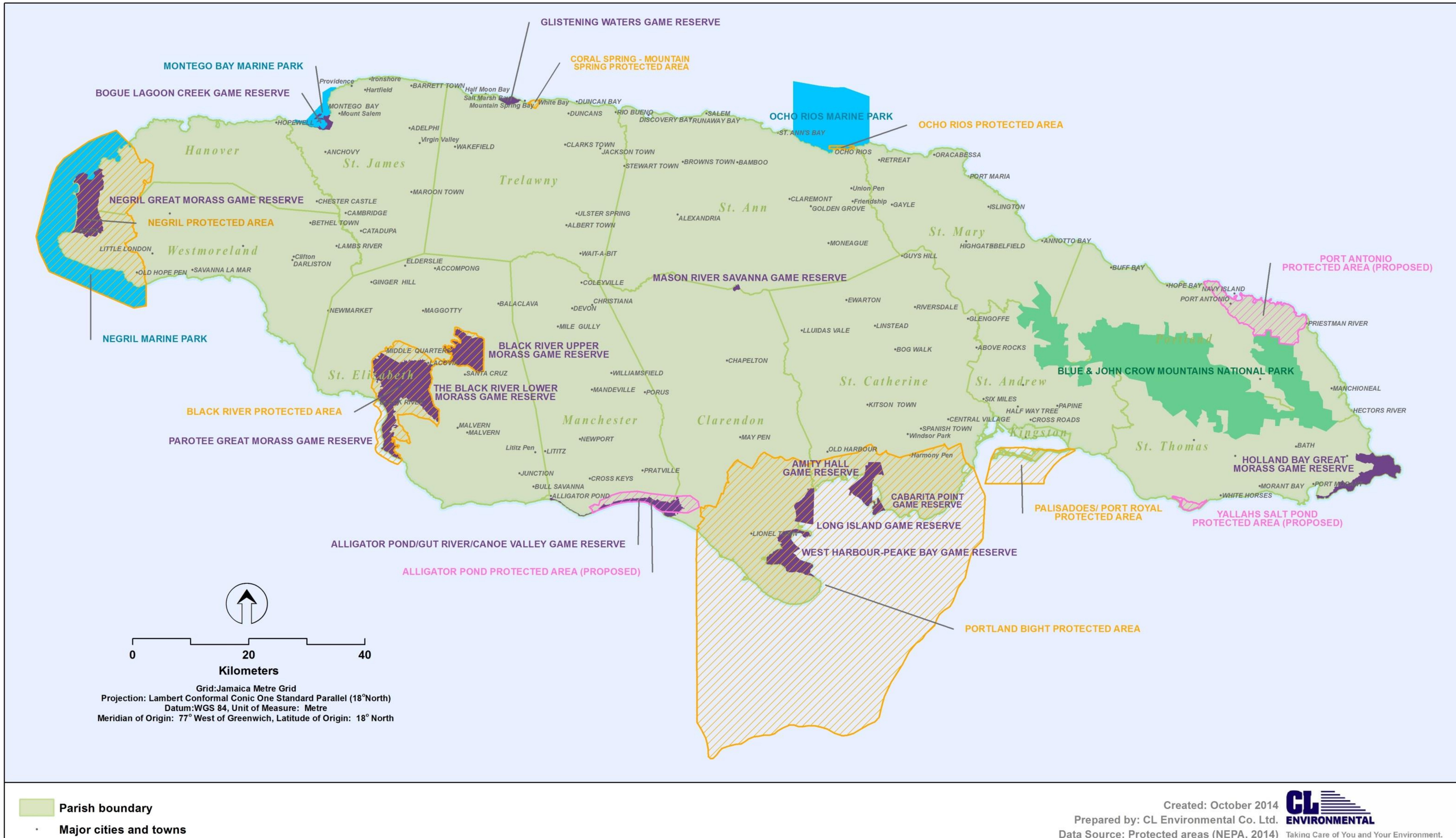


Figure 3-2 Protected areas system in Jamaica

3.2.2.2 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. As part of the April 2015 amendment, regulations 3, 7 and 24, concerning permit application forms, duration and fees respectively, were substituted.

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.

3.2.2.3 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. 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).

3.2.2.4 Wild Life Protection Act 1945

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 including six species of sea turtle, one land mammal, one butterfly, three reptiles and a number of game birds. A list of these protected species is provided in this Act under the Second and Third Schedules and is presented in Figure 3-3. 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.

3.2.2.5 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.

3.2.2.6 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.

3.2.2.7 The Forest Act 1996

The 1996 Forest Act repealed the 1937 legislation and was the legal basis for the organization and functioning of the Forestry Department. The Forestry Department is the lead agency responsible for the management and conservation of the forest resources in Jamaica. A "Forest Reserve" is defined to be any area of land declared by or under this Act to be a forest reserve. In 1938, the Forest Branch gazetted some 78,800 hectares of Crown Lands as forest reserves, this making up more than 75% of the present day forest reserves (Figure 3-4). The Great Goat Island forest reserve is situated 4km southeast of the project area.

Protected Jamaican Animals

Common Names	Scientific Names
Sperm Whale	*Physeter macrocephalus*
Baird's beaked Whale	*Berardius bairdii*
Short-finned pilot Whale	*Globicephala macrorhynchus*
Humpback Whale	*Megaptera novaeangliae*
Common Bottlenose Dolphin	*Tursiops truncatus*
Pantropical spotted Dolphin	*Stenella attenuata*
West Indian Manatee	*Trichechus manatus manatus*
Caribbean Monk Seal (Pedro Seal)	*Monachus tropicalis*
Jamaican Hutia (Coney)	*Geocapromys brownii*
American Crocodile	*Crocodylus acutus*
Jamaican Iguana	*Cyclura collei*
Yellow Snake/Jamaican Boa	*Epicrates subflavus*
Green Turtle	*Chelonia mydas*
Hawksbill Turtle	*Eretmochleys imbricata*
Loggerhead Turtle	*Caretta caretta*
Atlantic Kemps Ridley	*Lepidochelys kempii*
Leatherback turtle	*Dermochelys coriacea*
Reid Seahorse	*Hippocampus reidii*
Jamaican Kite Swallowtail	*Eurytides marcellinus*
Giant Swallowtail Butterfly	*Papilio homerus*
Black Coral	*Antipathes* species
White Coral	Scleractinian or Madreporarian

All birds are protected except the following:

Cattle Egret	*Bubulcus ibis*
Rock Dove (Pigeon)	*Columba livia*
Ringed-turtle Dove (Barble Dove)	*Streptopelia risoria*
European Starling	*Sturnus vulgaris*

nepa National Environment and Planning Agency

Protected Jamaican Animals Cont'd

All birds are protected except the following:

Saffron Finch (Wild Canary)	*Sicalis flaveola*
House Sparrow	*Passer domesticus*
Yellow-crowned Bishop	*Euplectes afer*
Red Bishop	*Euplectes orix*
Nutmeg Mannikin	*Lonchura punctulata*
Chestnut Mannikin	*Lonchura Malacca*
Shiny Cowbird	*Molothrus bonariensis*
Chickens	*Gallus gallus*
Geese	*Anser* spp.
Turkey	*Meleagris gallopavo*
Guinea fowl	*Numida meleargris*
Pea fowl	*Pavo cristatus*
Budgerigars	*Melopsittacus undulates*
Cockatiel	*Nymphicus hollandicus*
Ducks excluding endemic and migratory species	

GAME BIRDS (These are protected outside of the bird shooting season)

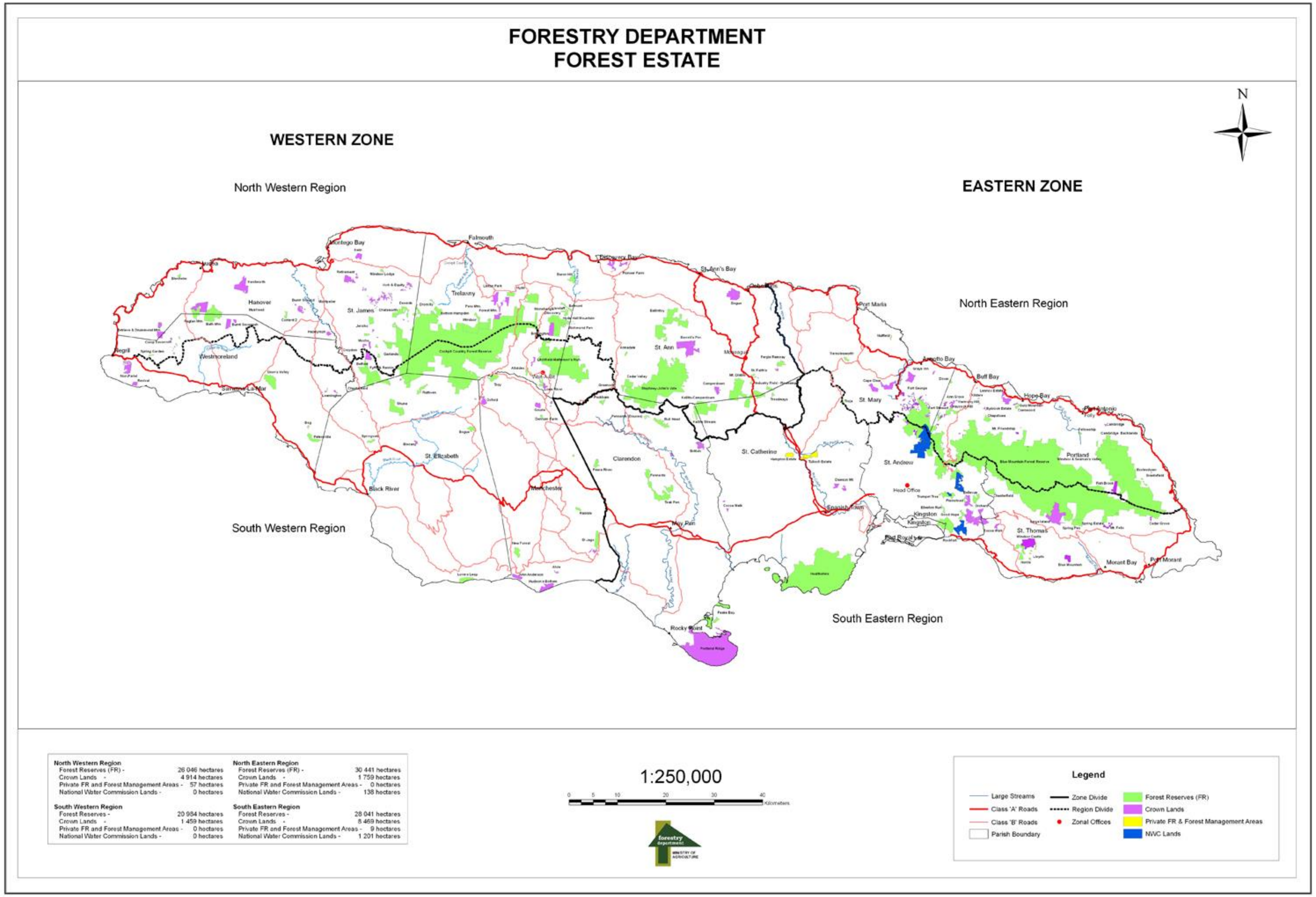
Mourning Dove (Long-tailed Pea Dove)	*Zenaida macroura*
White-winged Dove	*Zenaida asiatica*
White-crowned Pigeon (Bald pate)	*Columba leucocephala*
Blue-winged Teal	*Anas discors*
Green-winged Teal	*Anas crecca*

Prepared by the Biodiversity Branch, National Environment and Planning Agency
Updated March, 2005

Source: National Environment and Planning Agency (NEPA) [4]

Figure 3-3 Protected animals in Jamaica

[4] http://www.nepa.gov.jm/publications/brochures/flyers/protected%20Jamaican%20animals.pdf



Source: Forestry Department [5]

Figure 3-4 Map showing forest estates across the island, including reserves, crowned lands, private areas and NWC lands

[5] http://www.forestry.gov.jm/images/res250k_bg.jpg

3.2.2.8 The Beach Control Act 1956

This Act was passed 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. The Beach Control Authority (Licensing) Regulations of 1956 require a permit for any works on a beach, coastline or foreshore. Application for this permit must be made to NEPA.

3.2.3 Public Health & Waste Management

3.2.3.1 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.

3.2.3.2 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 3-4 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

3.2.3.3 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.

3.2.3.4 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.

3.2.3.5 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.

3.2.3.6 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 area under 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.

3.2.3.7 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 Abetment Act (1997), Jamaica has no other national legislation for noise.

3.2.3.8 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.

3.3 REGIONAL AND INTERNATIONAL LEGISLATIVE AND REGULATORY CONSIDERATIONS

3.3.1 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.

3.3.2 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.

3.3.3 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).

3.3.4 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)

CITES generally seeks to protect endangered plants and animals and owing to the cross boundary nature of animals and plants, this protection requires international cooperation. It aims to ensure that international trade of wild animal and plant species does not threaten the survival of the species in the wild, and it accords varying degrees of protection to over 35,000 species. This convention was drafted in 1963 at a meeting of members of the International Union for Conservation of Nature (IUCN) and finalised in 1973. After being opened for signatures in 1973, CITES entered into force on 1 July 1975.

3.3.5 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[6]. 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).

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

3.3.5.1 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

3.3.5.2 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 & 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 Appendix 3 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

This power plant is more than 50 MW. This EIA is, as required, “commensurate with the project’s potential impacts” and contains the items required in the World Bank Operational Procedures (OP 4.01) updated February 2011, including:

- Executive Summary
- Policy, legal and administrative framework
- Project description

- Baseline data
- Environmental Impacts
- Analysis of Alternatives
- Environmental Management Plan (EMP) considering
    - Mitigation
    - Monitoring
    - Capacity development and training (to ensure maintenance)
    - Implementation Schedule and Cost Estimates for mitigation, monitoring and capacity building
    - Integration of the EMP with the Project
- Appendices including list of report preparers (individuals and organizations), references (published and unpublished), record of interagency and consultation meetings, tables presenting the relevant data referred to or summarized in the main text and list of associated reports (e.g., resettlement plan or indigenous peoples development plan).

4.0 COMPREHENSIVE DESCRIPTION OF THE PROPOSED PROJECT

4.1 THE PROPONENT

Jamaica Public Service Company (JPS) is the sole distributor of electricity in Jamaica and is a proud inheritor of a tradition that dates back to 1892, when Jamaica first received electricity. This placed Jamaica in the enviable position of being one of the first in the world to have electricity, and only thirteen years after American scientist Thomas Edison had invented the electric lamp. In that year, the first electricity service in the island was supplied by the Jamaica Electric Light Company from a plant at Gold Street, in Kingston. In 1897, another company, the West India Electric Company, established an office in Kingston at 151 Orange Street. They built the hydroelectric plant on the Rio Cobre River at Bog Walk, which consisted of three machines, each with the capacity to deliver over 300 kilowatts of energy. West India Electric not only extended electricity service to other areas, but also introduced a new element to the city scene – electric tramcars. Tramcars later replaced the horse drawn cabs, which had been providing public transport, and remained in service until 1948.

Early in 1907, a severe earthquake destroyed a section of Kingston, disrupting city life and public services. Following this, West India Electric leased the property and businesses of Jamaica Light & Power Company Ltd, successors to the Jamaica Electric Light Company and integrated the Gold Street station into the Bog Walk Supply system. This resulted in a significant improvement in the service available to customers. In the early days, several towns had their own electric companies; but through a process of consolidation, buy-outs and amalgamations, Jamaica Public Service Company Limited emerged and was registered in 1923. At that time, JPS had 3,928 customers, a far cry from today's customer base of over 585,000. JPS was granted an all-island franchise in 1966, and today remains the sole public supplier of electricity.

The nature of the ownership of JPS has changed several times throughout time. The company started out as a private company, owned by foreign shareholders. In 1970, the Government of Jamaica acquired controlling interest. In 2001, ownership of JPS returned to private hands when Mirant Corporation, a US-based energy service provider acquired 80 percent of the company, with the Government retaining almost 20 percent. The remainder, amounting to less than 1 percent, is owned by a small group of shareholders. In 2007, Mirant sold its majority shares to Marubeni Caribbean Power Holdings (MCPH) Inc., a subsidiary of Marubeni Corporation of Japan. In early 2009 Abu Dhabi National Energy Company (TAQA) of the United Arab Emirates, joined Marubeni as co-owner of the Jamaica Public Service Co. Ltd. Majority shares were therefore jointly held by Marubeni TAQA Caribbean. In the first quarter of 2011, TAQA withdrew from the partnership with Marubeni in the Caribbean, due to a change in its corporate strategy. TAQA signalled its intention to focus primarily on the power sector in the Middle East and North Africa region. In the second quarter of 2011, Korea East West Power (EWP) entered into a Purchase and Sale Agreement with Marubeni Corporation for joint ownership of majority shares (80%) in the company. Today, Marubeni Caribbean and Korea East-

West Power Company Ltd are the majority shareholders in the Jamaica Public Service Company Ltd with the Government of Jamaica owning most of the remaining shares and a small group of minority shareholders maintains a less than 1 percent stake (Source: http://www.jpsco.com/ accessed July 25, 2012).

4.2 PROJECT CONCEPT AND DESCRIPTION

4.2.1 Background

The Office of Utilities Regulation (OUR) invited proposals for the Supply of up to 480 MW of Base-Load Generating Capacity on a Build, Own and Operate (BOO) Basis to increase the generating capacity on the island. This did not materialize. Subsequently, the OUR invited proposals to expand the generating capacity on the Island by installing an additional 360 MW Power Plant. This development was to be done by 2016. However, EWI licence was revoked and JPS is now planning to construct approximately 180 -200 MW of combined cycle plant as a repowering of our existing power plant.

JPS negotiated over the past year though a licence amendment that was gazetted, the right to replace its own generation. The Plan to build a 190 MW new gas-fired plant was endorsed by the Electricity Sector Enterprise Team (ESET) on February 4, 2015. This represents base load generation to replace existing oil fired units of equal capacity. The target capacity was determined through various resource scenarios which optimize use of existing contract generation and renewables. The plant is a combined cycle 3x1 configuration designed to have maximum flexibility and to integrate renewables.

This 190 MW Nominal combined cycle development will be undertaken from Q1 2016 to Q1 2018. This new capacity will be base-loaded and is intended to replace the heavy fuel oil burning aged steam unit plants. Jamaica Public Service Company Limited (JPS) was awarded the right to go forward with the project.

4.2.2 Project Location and Siting

The Old Harbour 190 MW Nominal combined cycle power plant is to be located approximately 75.6 kilometres (47 miles) from the city of Kingston near the community of Old Harbour on the south coast. The proposed is adjacent to JPS' existing 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 community of Old Harbour Bay, located on the south-western coast of Jamaica in the parish of St. Catherine, was estimated to have a total population of 8,537 in 2009. Located approximately 5km 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 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 (Figure 4-1). It also shows areas to be reserved for construction, as well as areas to be preserved in their existing state are depicted. The proposed site is largely flat area with clay type soils with site elevation varying from approximately 1.5 meters to 3.0 meters above mean sea level.

The proposed site of the new power plant is on the storage area for the existing Old Harbour 220 MW plant and is located near the Intermediate Acacia Forest (Thorn Savannah) ecosystem (Figure 4-2). This ecosystem is comprised mainly of Acacia sp. trees and stands. The Intermediate is distinguished from the Secondary Acacia Forest ecosystem 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). Typical bird species within this zone of vegetation are warblers.

The Intermediate Acacia Forest ecosystem is less significant/ecologically important than the Mangrove Ecosystem and Salina Ecosystem. Although the relative species diversity and abundance of avifauna tends to be average for this type of ecosystem, avifauna species tend to be more robust than their marine/salina counterparts and they, therefore, have more habitat options to migrate to, during development and construction within this vegetation zone. C.L. Environmental, 2007

The proposed site for the power plant is on the existing JPSCo Old Harbour plant in an area used for storage and an area immediately west of the storage area. The additional land area west of the storage area will be purchased from the National Land Agency (NLA) (please see Appendix 4 for the No Objection Letter regarding the purchase of this land). The project site is located in the Portland Bight Protected Area (Figure 4-3).

4.2.3 Rationale and Objectives

The current 220 MW Old Harbour Power Plant utilizes heavy fuel oil for power generation and is considered inefficient. This new 190 MW Nominal combined cycle development will be undertaken from Q1 2016 to Q1 2018.

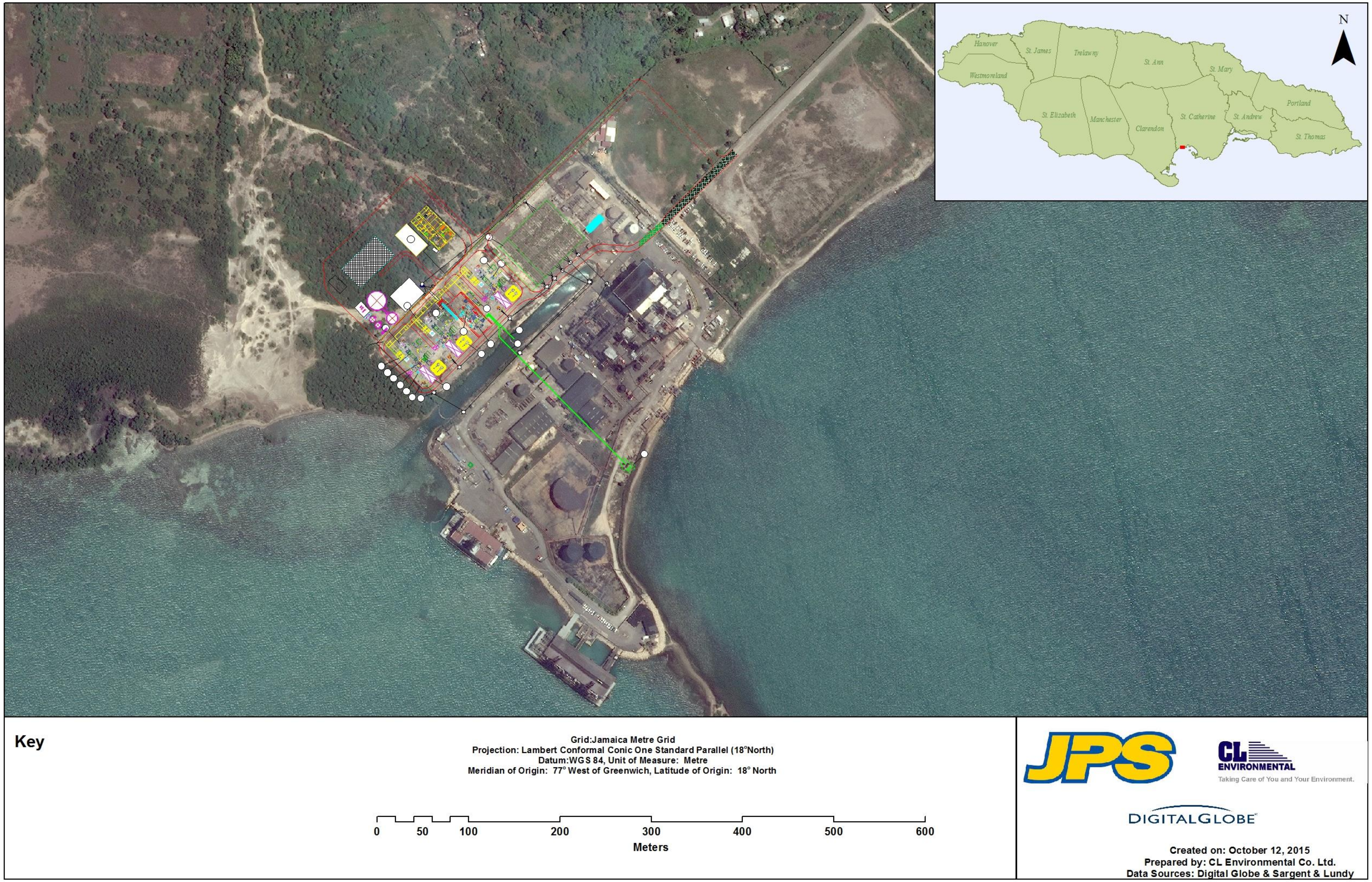


Figure 4-1 General layout of the proposed JPS 190MW Combined Cycle Power Regasification Plant

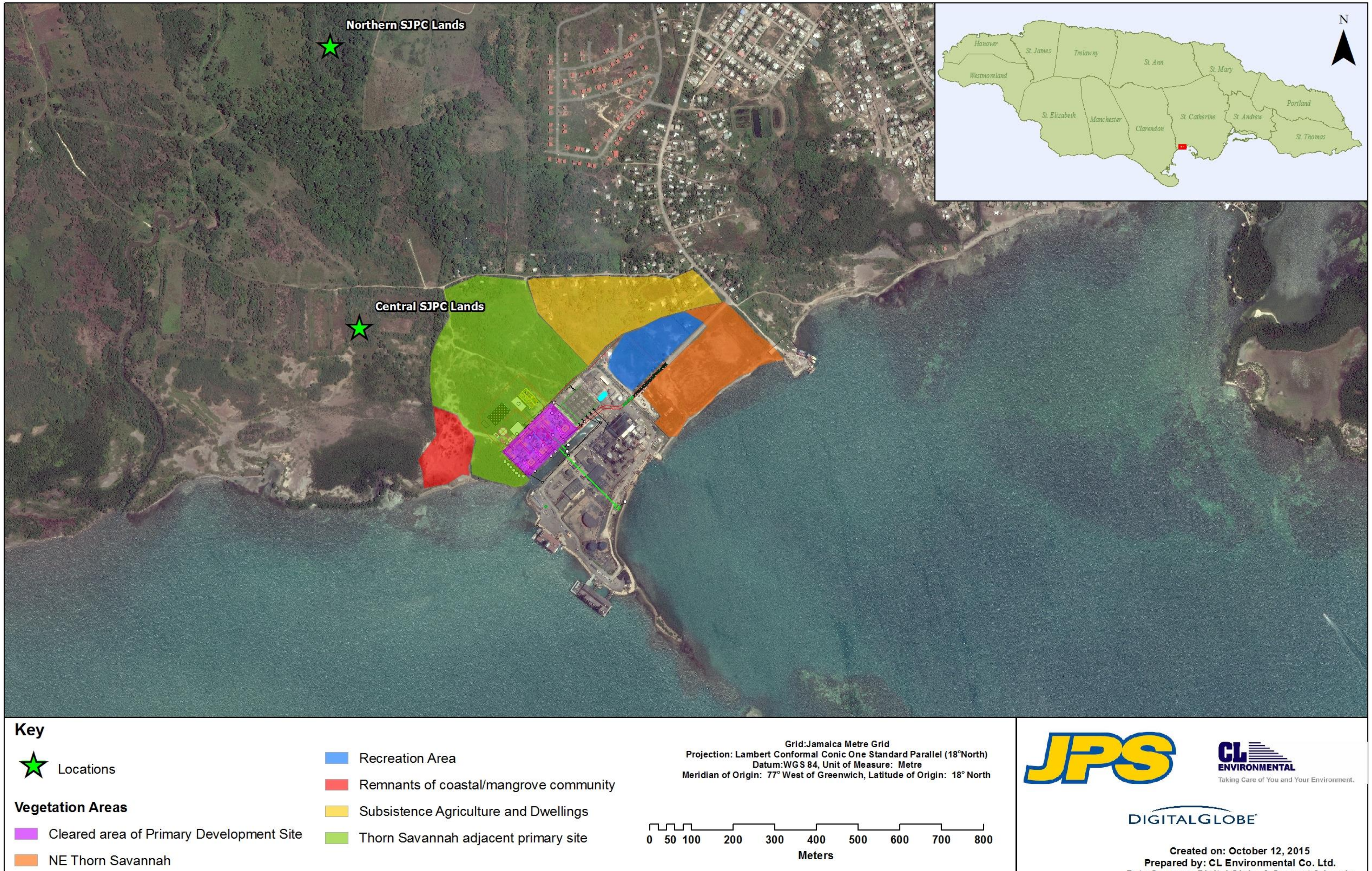


Figure 4-2 General Layout of the proposed 190 MW power plant with vegetation areas

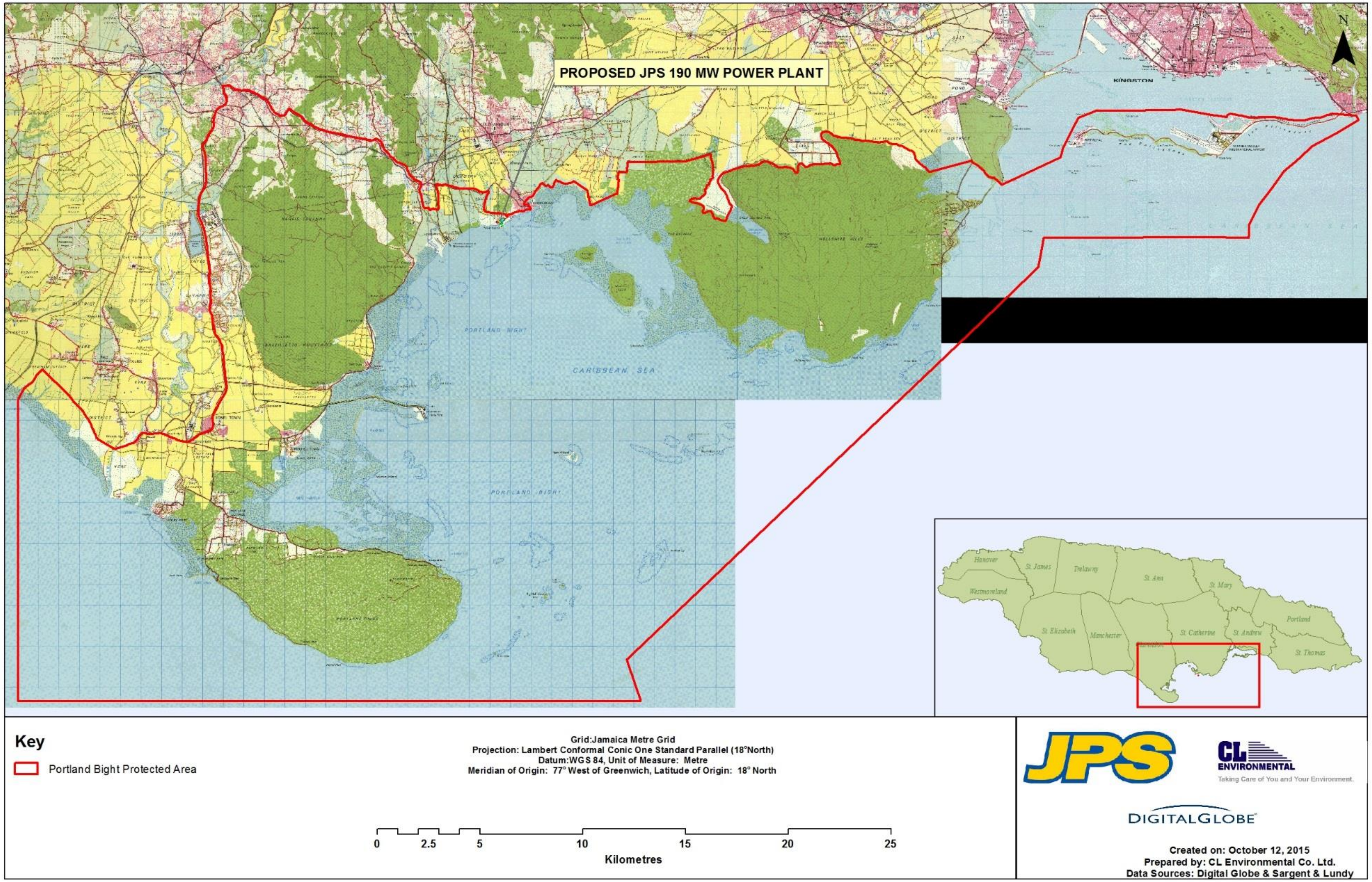


Figure 4-3 Portland Bight Protected Area boundary

4.3 PROJECT INFRASTRUCTURE

4.3.1 Power Plant

The new plant proposed herein will consist of one (1) power block of nominal 190MW combined cycle plant. The block's configuration consists of 3 combustion turbine generators x 3 heat recovery steam generators (HRSGs) x1 steam turbine generator. The combustion turbines will be dual fuel capable, however, the plant is designed for using natural gas fuel only. Each gas turbine unit is a 40 MW class, the steam turbine is a 75 MW class, providing nominal 190 MW block size in the 3 x 3 x 1 combined cycle configuration with duct firing. The exhaust gas from the gas turbine is led to the associated HRSG for generating the steam which in turn will be fed to a common steam turbine generator. The HRSGs will be dual pressure, non-reheat type, with duct burners, in order to obtain optimum exhaust gas energy utilization based on thermo-economic considerations.

The plant is designed for both base load and cycling duty (two shift operation) in order to be able to comply with all instructions from the system load dispatcher. The plant will operate with a 98% average annual equivalent availability factor (EAF) for the life time of the plant. This reliability is based on the inherent reliability of the Original Equipment Manufacturer (OEM) turbine packages, the unique features of the OEM gas turbines that allow for optimum maintenance schedules, a robust balance of plant (BOP) design, all coupled with a competent operations and maintenance staff that will be provided. In addition, the company intends to enter into a long term service agreement (LTSA) with the OEM for scheduled maintenance on the gas turbines. This will ensure that maintenance is done in accordance with OEM requirements, with genuine OEM parts and service, and in an expeditious manner.

A metering system is used in order to measure net energy output from the plant, and to monitor and co-ordinate operation of the facility. The location of the metering system will be in a 138 kV substation control building, and potential transformers for the metering system will be located on the 138 kV side of each generator transformer feeders in the 138 kV switchyard to measure net electrical energy outputs.

Continuous emissions monitoring (CEM) ports will be provided for the measurement of air emission levels in the exhaust stack of each HRSG.

Plant effluents will be treated to comply with the effluent discharge limit criteria (National Resources Conservation Authority's (NRCA) Jamaican National Trade Effluent Standards) and discharged to Old Harbour Bay through the existing cooling water discharge flume of the Old Harbour power plant. The Global Positioning System (GPS) location for the discharge point will be determined following the dispersion modelling exercise. The EIA will assess the suitability of the location for the discharge of plant liquid effluent.

The plant will be designed to meet the regulatory standards and is designed for an operating life of at least 25 years.

The design of the buildings will meet or exceed the requirements as established in the latest updates to the National Building Code and Caribbean Uniform Building Code. The civil structures for the project will be designed to meet the seismic requirement for ground acceleration of 0.4 g with a 10% probability of occurrence over a 50 years period and withstand maximum hurricane intensity wind speeds of 67.0m/s (241 km/h).

4.3.2 Fuel Supply

Natural gas will be supplied by a third party and subject to a separate Environmental Impact Assessment (EIA). The fuel supply plan will entail the importation of Liquefied Natural Gas (LNG) from the United States which will be supplied to a Floating Storage and Regasification Unit (FSRU). The FSRU would provide a level of storage and would convert the fuel into a gaseous form which would be piped to the JPS 190 MW facility either by terrestrial or marine pipeline, the determination of which will depend on the findings of the EIA.

4.3.3 Water Supply

4.3.3.1 Raw / Fire Water Storage Tank

The onsite wells pump water to the Raw / Fire Water Storage Tank. Sodium Hypochlorite is injected into the well water prior to entering this tank to minimize biological growth. The raw water for distribution to the plant is via an internal standpipe in the tank to the suction of the two (2) Raw Water Pumps. A Fire water reserve is stored in the bottom portion of this tank below the standpipe level. Concentrate water from the Electrodeionization units (a part of the Demineralized water Treatment System) is also returned to the Raw / Fire Water Storage Tank as a clean water recycle stream. Also taking suction from the standpipe are the two (2) Filter Backwash Pumps.

After the raw water utility users (i.e. hose stations, pump seals, etc.) are supplied off the main raw water line, a 5-10 micron tubular filter is provided to remove any suspended solids in the raw water. This filter will be automatically backwashed periodically as solids build-up on the filter media as detected by a high differential pressure across the filters. The low turbidity of the well water is indicative of a clean water stream and should result in fewer backwashes of these filters.

Filtered raw water is supplied to the Demineralized Water System and Potable Water System for further treatment.

4.3.3.2 Reverse Osmosis (R.O.) and Potable Water Systems

The Demineralized Water Treatment System consists of two (2) parallel 100%, double pass, Reverse Osmosis Trains. The Reverse Osmosis system is designed for up to 77% recovery. Each train consists of a cartridge filter, high pressure pump, first pass membranes, interstage booster pump, second pass membranes, and Electrodeionization unit for polishing. The resultant demineralized water is stored in a Demineralized Water Storage Tank. Demineralized Water Pumps supply this water to the Condensate Tank as make-up to the boiler feedwater cycle.

The projected demineralized water quality will meet G.E. specifications as described below:

- pH 6.0-8.0
- Specific conductance: 0.1 μS / cm
- Chlorides: < 3 ppb
- Total SiO_2: < 10 ppb
- Sodium < 3 ppb
- Total organic carbon < 100 ppb

The two (2) x 100 % treatment system has been designed for generating 1.1 m^3/h of chlorinated potable water. The potable water produced will meet the NSF 61 and WHO standards and will be used for drinking water, administrative building and safety showers.

Filtered raw water is pumped to the Potable Water Treatment system which consists of two (2) 100% nanofiltration skids. Each skid contains a 5 micron bag type filter, high pressure booster pump, and a single pass nanofiltration unit. As with the Reverse Osmosis system, sodium bisulfite is injected for de-chlorination and also an antiscalant is injected to help maintaining the cleanliness of the nanofiltration system membranes.

As the permeate flows to the Potable Water Storage tank, sodium hypochlorite is injected to maintain residual chlorine in the Potable Water Tank and distribution system. Two (2) 100% Potable Water Distribution Pumps supply water at a consistent pressure to the distribution system feeding drinking water, building potable water users, and for emergency eyewash & showers. The Potable Water Treatment system also has a dedicated Clean in Place skid for periodic cleaning of the nanofiltration membranes.

Figure 4-4 illustrates the flow of all water and wastewater throughout the proposed plant.

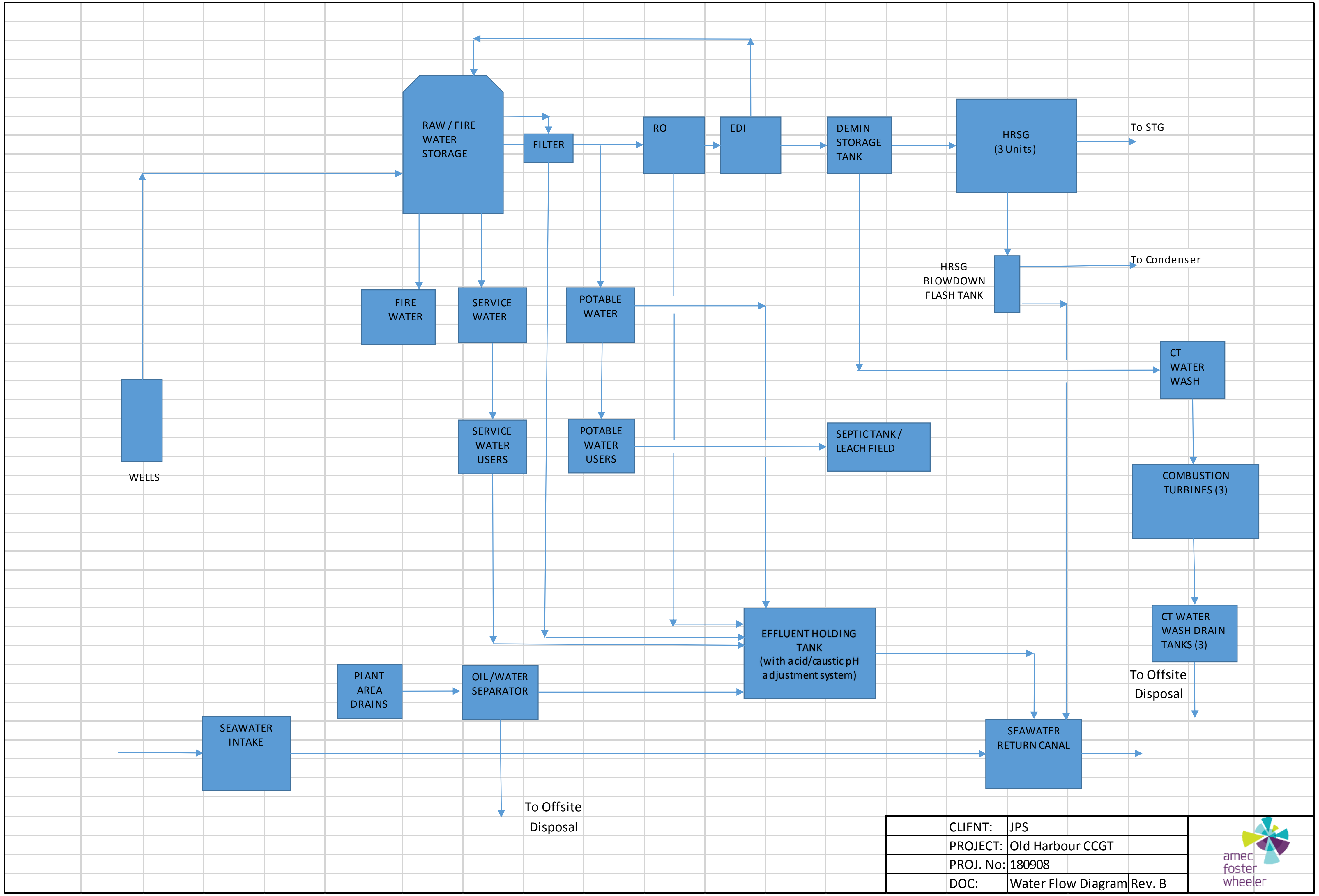


Figure 4-4 Flow of water and wastewater throughout the proposed power plant

4.3.4 Wastewater Handling Systems

Area drains in the HRSG, Gas Turbine, Condenser, and Steam Turbine areas will be directed to a common Power Generation Area Wastewater Pit. From this pit two (2) vertical sump pumps will transfer the wastewater to an oil / water separator unit. The accumulated oil will be removed periodically using a vacuum truck and transported off-site for disposal. Clean water from the oil / water separator is pumped to the Effluent Holding Tank.

The Effluent Holding Tank receives wastewater from the oil / water separator, concentrate from the two (2) Reverse Osmosis Trains (normally only one in service), filter backwash water from the tubular filters ahead of the Reverse Osmosis System and concentrate from the Potable Water Treatment Nanofilter trains (normally only one in service).

The Effluent Holding Tank Pumps send the wastewater from the tank to the Seawater Return Canal to mix with the circulating water prior to discharge. This wastewater is monitored for pH and the flow is measured. Acid and caustic storage and metering pumps are provided to maintain the pH within the limits specified in the discharge permit.

Wastewater from the HRSG blowdowns and sample panel drains are combined with seawater, flow through the Closed Cooling Water System heat exchangers and are discharged to the Seawater Return Canal. Due to the low turbidity in the well water and the water, wastewater treatment systems do not generate any additional solids. The clarifier and its auxiliary equipment has been removed. Based on the well water information, the total suspended solids (TSS) in the discharge will be below the limit of 50 mg/L TSS.

The combustion turbines have a water wash system used for both online and offline cleaning. Demineralized water is supplied to this system and mixed with a detergent and sprayed into the turbine during a cleaning cycle to help keep the internal surfaces clean. During the online cleaning the water is evaporated. During the offline cleaning the water, residual detergent, and suspended solids from deposits (combustion products) are drained to a drains tank adjacent to the combustion turbine. The wastewater in this tank is drained out using a vacuum truck and hauled offsite for disposal.

Sanitary waste will be collected and transferred to a septic tank that will be located at the northwest corner of the Plant. Depending on the findings of Final Geotechnical Study, if required a sanitary lift station will be installed at the point where the site topography does not allow for gravity flow of sanitary waste from plant users to the tank. A drain field (leach field) will be built next to the septic tank that will be designed and sized per site specific percolation tests and that will conform to local and/or governing agency regulations.

Figure 4-5 illustrates the sewerage system.

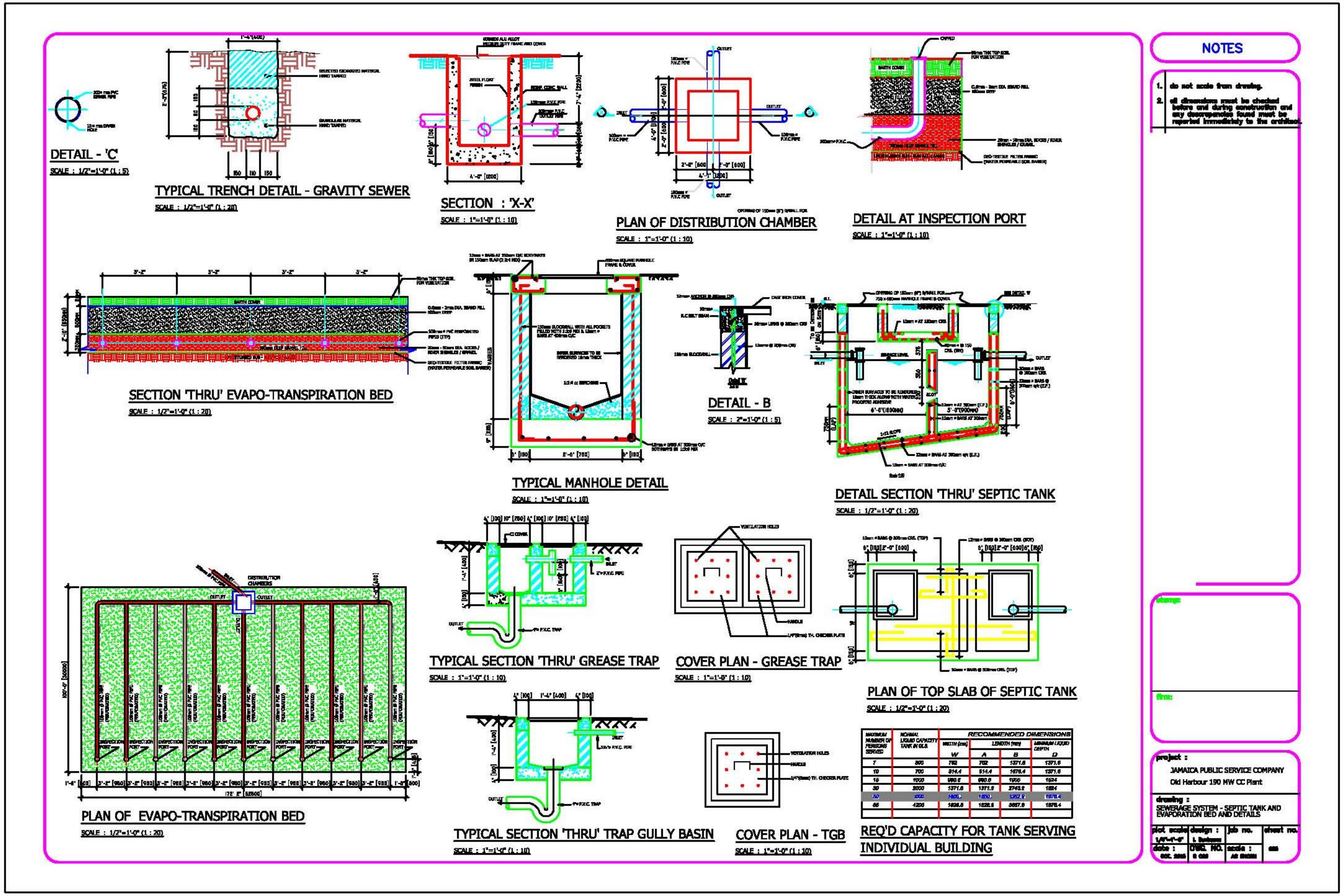


Figure 4-5 Sewerage System drawing for proposed power plant

4.3.5 Storm Water Drainage

Figure 4-6 illustrates the storm water drainage for the proposed power plant site.

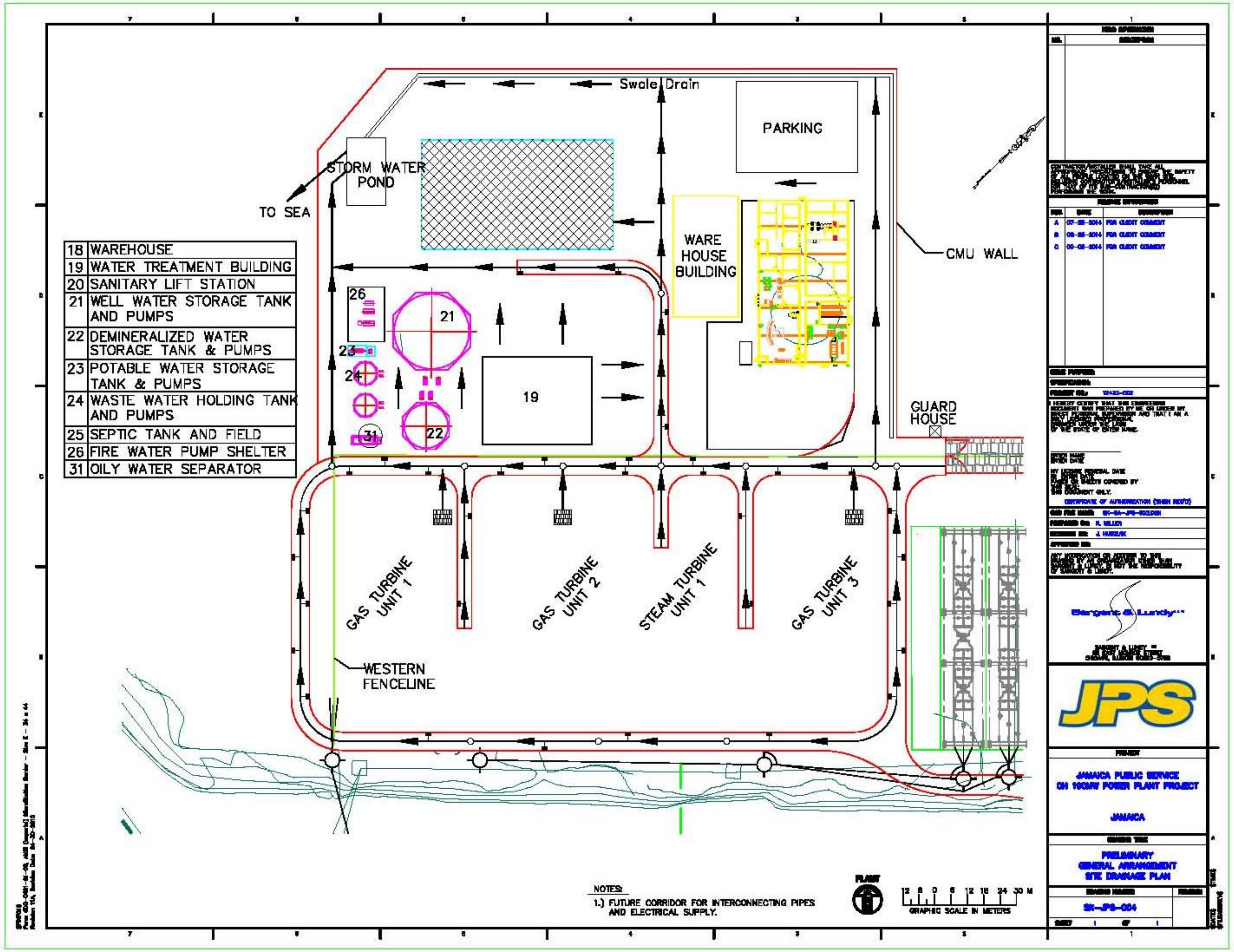


Figure 4-6 Storm water drainage drawing for proposed power plant site

4.3.6 Seawater Intake System

Water for the circulating water system will be drawn from the ocean through the seawater intake structure. The circulating water system will provide cooling water for the once through condenser of the steam turbine and the auxiliary heat exchanger for the closed cooling water system. The intake structure will include the intake siphon, bar grills with trash rake cleaning, traveling screens, pump house forebay and provisions for stop logs to isolate intake chambers. The vertical circulating pumps and associated electrical facilities will be located indoors inside the pump house.

The cooling water will be drawn through an intake structure. Three (3) x 50 % capacity streams consisting of removable coarse bar screens, stop gates, rotating self-cleaning band screens, and debris filters will be provided. The overall screening will be sized to suit the maximum allowable particle size of 6 mm in the cooling water system to protect the once-through condenser. As in Jamaica Public Services' current design, the screen openings will be designed to allow maximum velocity or 0.76 m / s at average daily flow to protect marine life. The low water depth will be approximately three (3) m. A total flow of 68,410 m^3 / h will be drawn through the intake structure.

In order to meet the maximum allowable circulating water temperature rise of 2.2 °C, a portion of the ocean water (37,740 m^3 / h) bypasses the condenser and auxiliary heat exchangers and will be mixed with the condenser and heat exchanger return water prior to discharge to the ocean.

4.3.7 Auxiliary Heat Exchanger

Two (2) x 100 % shell and tube heat exchangers will be provided for the auxiliary cooling system. Each unit will cool 985,610 kg / hr of water from 49.8 ºC to 44 ºC using 1,045,981 kg / hr of 33.1 ºC sea cooling water. The heat exchangers are industrial grade, single pass, with all titanium grade, two (2) tube side components and all 304L stainless steel shell side components and all 304L stainless steel shell side components and require no further finishing.

Closed loop cooling water of condensate quality will be provided to the shell side of the heat exchanger. The shell side of the exchanger has an inlet water pressure of 2.5 bara and a pressure drop of approximately 0.7 bar. The tube side sea cooling water has an inlet pressure of 6.9 bara and a pressure drop of approximately 0.1 bar. Overall heat exchanged is 24,484 MJ / h.

One (1) vertical, shop fabricated, stainless steel, Auxiliary Cooling Water Head Tank will make up the difference in volume of the closed loop cooling system brought on by changes in temperature and density of the users. The auxiliary cooling water tank will be designed, constructed, and tested to ASME Section VIII, Division 1 and rated for full vacuum service. The tank's working volume is 12.5 m_3.

One (1) vertical, shop fabricated, HDPE, Chemical Mix Tank will be provided to add chemicals to be used in the closed cycle cooling system as needed. The tank will consist of a mixer with an attached motor on the tank roof. The tank's working volume is 0.34 m_3.

4.3.8 Steam/Water Chemical Feed System

The chemical feed systems for the feedwater cycle includes packaged skids for ammonia, sodium hypochlorite, sodium bisulfite, and phosphate injection system. The chemical feed system allows the Owner to operate with all volatile treatment (AVT) on a normal basis.

The chemical feed systems for the circulating water include packaged feed systems for ammonia, bisulfite, hypochlorite, and trisodium phosphate with bulk storage for seven (7) days and metering skids to inject chemicals into the circulating water to control pH and corrosion. There will also be sodium bisulfite injection into the seawater return piping for dechlorination. All HRSG and chemical feed skids will be installed outdoors. Chemical feed systems will be in a separate curbed area with nearby safety showers. On all skids, the pumps are provided with local control capabilities. On each skid, there will be two (2) feed pumps arranged as one duty pump and one spare pump.

4.3.9 Fire Protection System

A complete fire protection system will be provided for personal safety and property protection through prompt detection, alarm, suppression and extinguishing of fires in accordance with NFPA and local code requirements. The fire protection system's major components consist of the following:

- Fire pump system: One 340.67 m^3 / h primary electric motor driven fire pump and one 340.67 m^3 / h backup diesel driven fire pump will be provided. The equipment will be located in the pump house, ventilated and protected by a sprinkler system. The system will also include a flow meter, relief valve, muffler and 1 m^3 fuel tank.
- Complete underground fire loop: A fire loop PVC header will be provided. All trenching, backfill, thrust blocks and restraints will be accordance with NFPA. The system supply will include hydrostatic commissioning and flushing per NFPA.
- Valve sheds: Three (3) 2.43 m x 2.44 m x 2.29 m enclosures will be provided including heating, cooling, lighting and receptacles.

4.3.9.1 Fire Suppression

The following Fire Suppression systems will be provided:

- Combustion turbine generator
  - The CT manufacturer will provide a CO_2 extinguishing system.
  - Interconnecting piping and installation will be provided.
- Steam turbine generator
  - One (1) turbine generator pre-action type system will be provided.
  - One (1) open sprinkler deluge system will be provided for lube oil fire protection.
  - Four (4) surface mounted class III hose station with 23 m collapsible hose and valve with cap and chain.
- LNG fuel gas
  - This will have deluge protection over the exterior surface area and equipment in the LNG area.

- CTG step-up transformer
  - Deluge protection will be provided over the exterior surface area of the transformer.
  - Deluge protection will also be provided over the containment area surrounding the transformer.
- Control and administration area
  - One (1) wet system will be provided for a light hazard protection in accordance with NFPA.
  - One (1) pre-action system will be provided for the control, electrical and DCS rooms in accordance with NFPA.
- Maintenance and warehouse
  - One (1) wet system will be provided for an ordinary hazard protection at the exposed roof level.
- Water treatment building
  - One (1) wet system will be provided for extra hazard protection at the exposed roof level.
- Chemical storage building: Addressable monitoring devices will be provided to monitor the wet system (flow and tamper switches).
- LNG fuel gas area
  - Addressable monitoring devices will be provided for three (3) deluge sprinkler systems (alarm pressure, tamper, and hi / low air switches) and three (3) linear heat detection zone for deluge sprinkler release.
- CTG step-up transformer area(s)
  - Addressable monitoring devices will be provided for three (3) deluge sprinkler systems (alarm pressure, tamper, and hi / low air switches) and three (3) linear heat detection zone for deluge sprinkler release.
- STG step-up transformer
  - Addressable monitoring devices will be provided for a deluge sprinkler system (alarm pressure, tamper, and high / low air switches) and a linear heat detection zone for deluge sprinkler release.
- Diesel generator building
  - Heat detectors will be provided.
- CEMS enclosure(s)
  - Addressable smoke detectors, addressable manual pull stations and horn / strobes will be provided.

4.4 PROJECT CONSTRUCTION

4.4.1 Schedule

Site preparation will commence by the first quarter 2016 and construction of the JPS power plant is scheduled to commence in by the second quarter of 2016. Commercial operation of Unit #1 is expected 22 months after the commencement of construction and the commercial operation of the other two units are slated one month after each other (Figure 4-7).

4.4.2 Construction Activities to be Carried Out

4.4.2.1 Site Development and Earthwork

All excavations will be carried out and supported in such a manner as to prevent flooding or ponding of water, damage or interference to structure services, or stored equipment/materials.

I. Clearing and Grubbing
    a. Areas to be graded will be cleared of all bushes and trees to within 6 inches (150 mm) of grade. All stumps and roots will be removed. Waste from clearing will be disposed of in an off Site disposal area in accordance with all environmental regulations.

II. Stripping
    a. All topsoil and other organic materials will be stripped from the areas to be graded before starting earthwork. Topsoil will be placed in a stockpile for later recovery and use for landscaping the Site.

III. Disposal of Unusable Materials
    a. All excess excavated materials and all excavated materials unusable for fills shall be disposed of at an approved off site facility.

IV. Site Grading
    a. Facility grading includes the following items:
        i. Shaping the natural grade to accommodate permanent facilities and construction facilities while minimizing earthwork;
        ii. Obtaining proper cross section, longitudinal slopes, and curvature for roads;
        iii. Obtain stable area slopes to provide drainage without ponding;
        iv. Construct adequate surface drainage to discharge the 10 year runoff without flooding roads and the 50 years runoff without flooding any area in the Facility; and
        v. Construct stable, erosion-resistant earthen side slopes.

V. Erosion Control
    a. Temporary facilities will be provided to control erosion and turbidity of runoff during earthwork operations and from graded areas until they are surfaced or seeded. Temporary facilities may include: Silt fences and Other requirements to satisfy relevant Codes and Standards, rules and regulations

VI. Compaction Requirements
    a. Compaction will be conducted based on the specification required in each area of the Facility.

VII. Lining
    a. The following liner thicknesses are minimums and shall be determined by appropriate Codes and Standards and shall meet local and national regulations. The following Facility areas shall be lined for protection of the groundwater.

Area	**Minimum Lining**
Exterior chemical spill containment compounds	**Concrete with epoxy coating or 1 foot (300 mm])**
Oil transformer spill containment compounds	Graded rock fill over **6 inches (150 mm)** concrete

4.4.2.2 Civil Works

I. Earthworks
   a. The earthwork to be carried out, will be subjected to engineering designs based on the geotechnical investigation, and bathymetric and topographical surveys.

II. Piling
   a. Suitable foundation type will be based on the soil investigation. Where the geotechnical report recommends the use of piles; piles will be designed, manufactured and installed according to ACI 543 and ACI 543R. The size, type and capacity of the piles selected will be capable of resisting the loads and will be suitable for the soil and groundwater properties.
   b. 40 MPa grade concrete will be used for piles. Accurate records of all pile installation will be maintained. Piles will be tested per:
      i. ASTM D1143 (Compression load)
      ii. ASTM D3689 (Uplift load)
      iii. ASTM D3966 (Lateral load)

4.4.3 Sources of Raw Material

Material will be sourced from licensed quarries; this will be carried out by the EPC contractor based on required raw material constituents.

4.4.4 Transportation of Heavy Equipment - Route from Port Esquivel to proposed Project Site

A route survey was conducted by Zoukie Trucking in February 2011 to determine the potential obstacles along the possible transportation routes. The assessment was done based on information supplied by the Client which consisted of the loads with different configurations. Based on this assessment standard size cargo can be transported along the normal route with normal access not interrupting vehicular traffic. Standard size loads are considered 8ft wide or less, 9 ft tall or less, 45ft in length or less.

For oversize loads, excess in height, width, weight, different routes can be chosen depending on the nature of each load. There is only one route (from Port Esquivel) which does not have permanent overhead obstructions and this is similar to the route in Figure 4-8, but to detour around the underpass. There would be two underpasses along this route. One is very high and doesn't pose an obstruction and one is low - 16.9 feet. Plate 4-1 depicts the first underpass one would encounter from Port Esquivel. This bridge does not pose a problem as it relates to transporting the oversized loads. Plate 4-2 shows the underpass to enter Old Harbour Bay. This underpass is 16.9 feet high and poses a problem with oversized loads.

A solution to this problem is to bypass the underpass by entering the highway heading to Kingston and making a U turn to exit on the opposite side of the road to continue to Old Harbour Bay. In order to make the U turn, special arrangements will need to be made with the Highway Authority (National Road Operating and Constructing Company) to remove approximately 100 feet of railings along the highway and also for traffic management (Figure 4-8 and Plate 4-3). There are a number of overhead wires that will need to be lifted or raised prior to the transports (Plate 4-4). These wires are mainly through Old Harbour town area and the residential areas. There are also areas on the road heading to Old Harbour Bay which will need to be widened in order to create space to manoeuvre the oversize loads (Plate 4-5). General cargo and equipment will be transported by truck from Kingston.

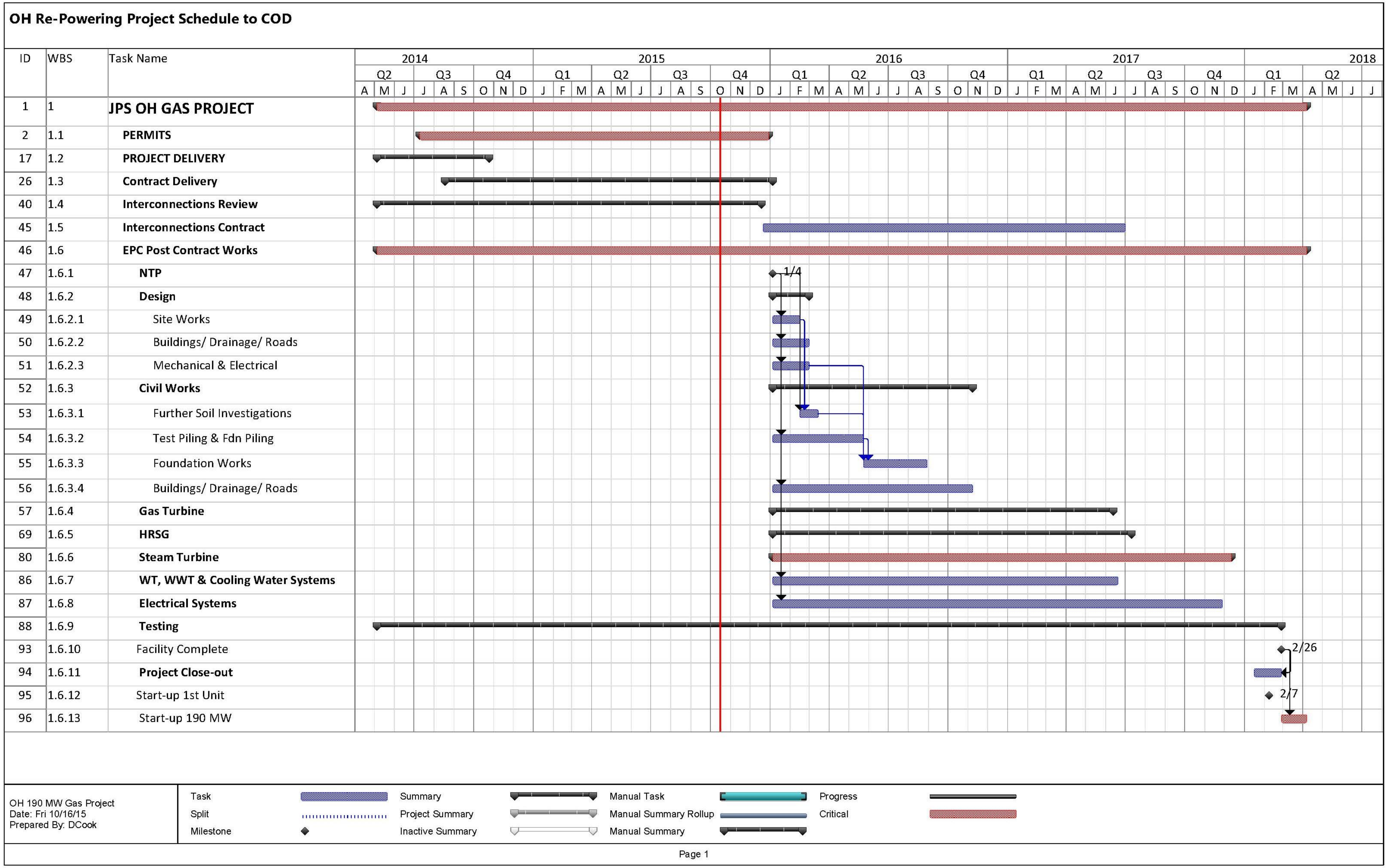


Figure 4-7 Proposed JPS 190 MW Old Harbour repowering project schedule

Figure 4-8 Proposed transportation route to plant site via Old Harbour

Plate 4-1 Underpass at the exit of Port Esquivel (Source: Zoukie Trucking)

Plate 4-2 Low underpass on the way to Old Harbour Bay (Source: Zoukie Trucking)

Plate 4-3 Possible location for the removal of the railings for the U Turn (Source: Zoukie Trucking)

Plate 4-4 Overhead wires in Old Harbour Town (Source: Zoukie Trucking)

Plate 4-5 An area on the road heading to Old Harbour Bay that needs to be widened (Source: Zoukie Trucking)

4.4.5 Organization Chart

The Organizational Chart for the construction phase of the JPS 190MW Old Harbour Plant Re-Powering Project is depicted in Figure 4-9.

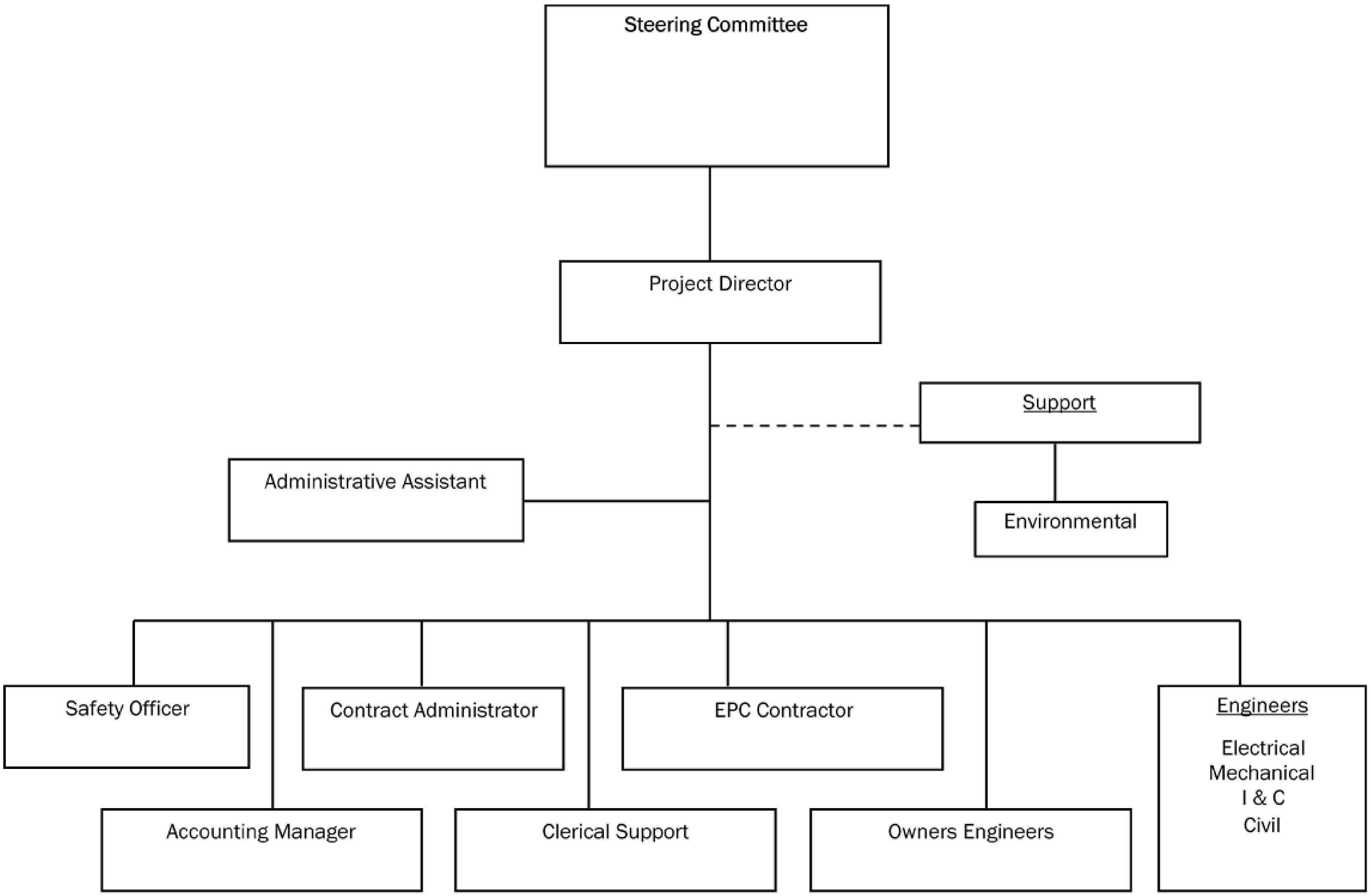


Figure 4-9 Organizational Chart for Construction Phase of the JPS Old Harbour Plant Re-Powering Project

4.5 POST CONSTRUCTION PLANS - PROJECT OPERATIONS AND MAINTENANCE

The plant will be operated and maintained by competent staff taken from the retired assets, other plants and possible new recruits. The proposed staff complement is 45 and these persons will be employed on a staggered basis, with the first set of staff to be brought in more than 12 months prior to commercial operation date (COD) (Table 4-1). Staff will be recruited primarily from Jamaica. Some entry level personnel without prior power generation experience may be employed and will be provided training and developmental experiences. An extensive training programme will be undertaken as part of the pre-commissioning activities. The staff will be trained by experienced expatriate persons with specialized skills for the initial years. These expatriates may include field engineers and technicians from the OEMs and experienced professionals from the majority shareholder's independent power divisions.

The company will implement a detailed "Operational Readiness" plan which will outline all of the steps and time schedule necessary to prepare for successful operation of the facility. Pre-operational activities will include preparing operating procedures, checklists, and operator rounds; setting up of an Enterprise Asset management platform ,work management systems for preventative, predictive and scheduled maintenance programmes; ordering and receiving spare parts and other inventory; supporting the EPC contractor's commissioning activities; implementing the training and qualification programmes; setting in place other procedures and programmes for human resources, administration, purchasing and accounting, environmental, health and safety, etc.

4.5.1 Operations

The operations management of the plant operation will be led by an Operations Manager supported by a 24-hour shift team with week day support from operations specialists. Based on industry best practice for combined cycle plants, as well as JPS's own successful local experience, a four-shift, 12-hour shift cycle will be used comprising the following: Shift Supervisors (5), Unit Controllers (5), Unit Operators (12). The week day team of operations specialists (including Operations Engineer and Station Chemist) will provide technical support to the shift team.

The Organizational Chart for the operation of the JPS Old Harbour Plant Re-Powering Project is depicted in Figure 4-10.

Table 4-1 Staffing Plan for Operations Phase

Position	Number in Position
Station Manager	1
Administrative Assistant	1
HSSE Specialist	1
Operations Manager	1
Operations Engineer	1
Chemist	1

Position	Number in Position
Shift Supervisor	5
Unit Controller	5
Unit Operator	12
Maintenance Manager	1
Maintenance Engineer	1
Administrative Officer	1
Maintenance Supervisor	2
Maintenance Technician	10
Stores Supervisor	1
Bearer/Driver	1
Clerk	1
Total	**45**

4.5.2 Maintenance

The maintenance plan is designed to ensure that the plant operates safely, efficiently with very high level of reliability and availability consistently throughout its operating life time. The maintenance program activities will include equipment routine maintenance, preventative maintenance periodic inspection, minor inspection and major inspection.

The program will be underpinned by a Service Agreement (SA) from reputable vendors.

Routine maintenance requirements for the plants will be the responsibility of the maintenance team who will be led by the maintenance manager, and will include a work crew comprising one maintenance engineer, 2 supervisors/planners, ten maintenance technicians skilled in the areas of I&C, mechanical, and electrical and other support staff.

The program will be underpinned by a Contractual Service Agreement (CSA) with the manufacturer. The plant will operate for a combined 32,000 hours (8,000 Factored Fired Hours per year/gas turbine) before major inspection, which results in major servicing occurring approximately every four (4) years. Once the servicing schedule is adhered to the plant should have an operational availability of 98%.

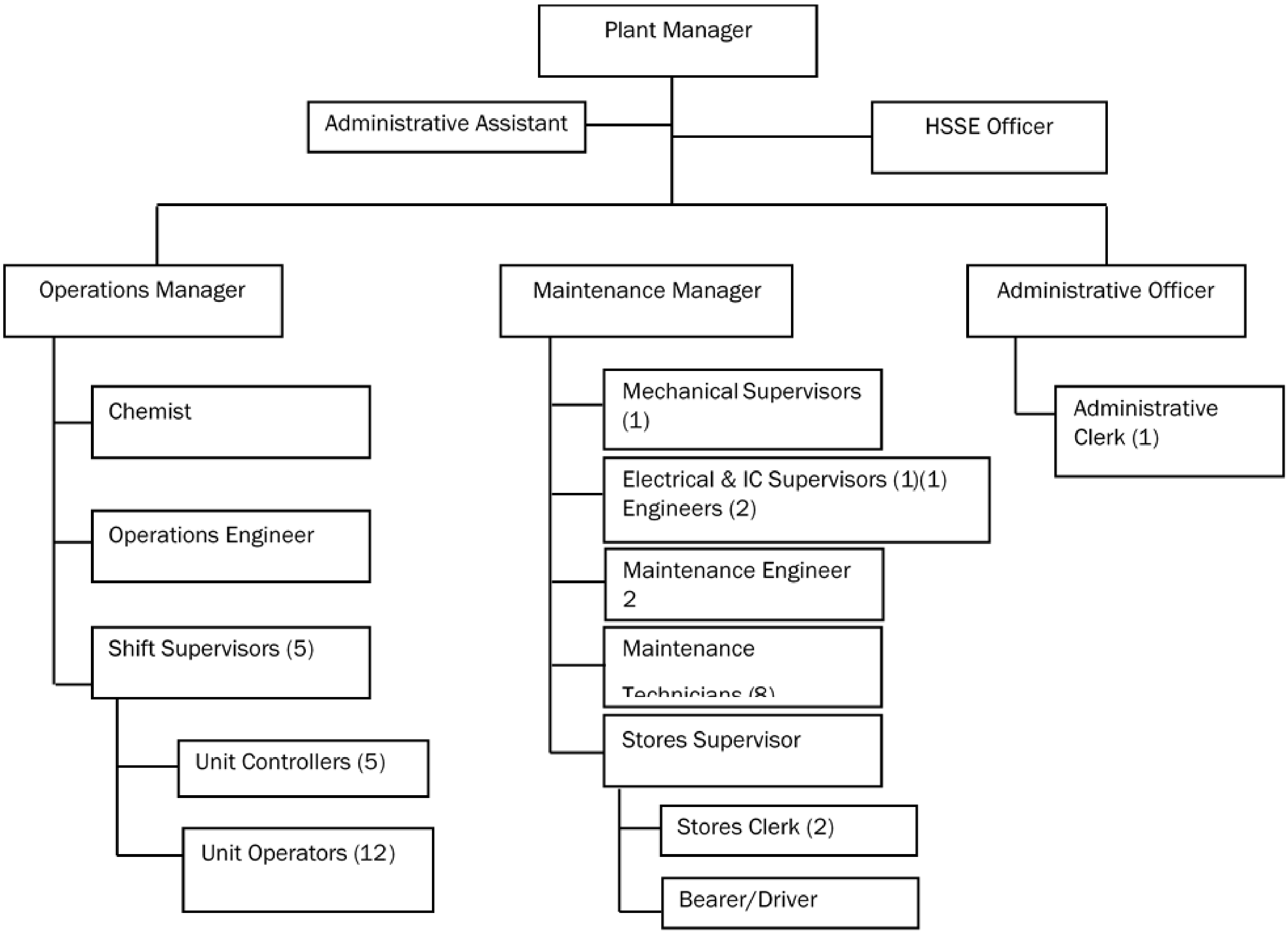


Figure 4-10 Organizational Chart for Commercial Operation Phase of the 190MW Old Harbour Plant Re-Powering Project

5.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 PHYSICAL

5.1.1 Climate and Meteorology

5.1.1.1 Climate within Study Area

2012 Study

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 Dr Bird Barge security post building). This weather station had 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 – August 23rd, 2014:

- Average temperature was 26.73 ^{o}C and ranged from a low of 18.4 ^{o}C to a high of 36.3 ^{o}C.
- Average relative humidity was 80.85% and ranged from a low of 40% to a high of 97%.
- Average wind speed was 3.17 m/s and ranged from a low of 0 m/s to a high of 15.6 m/s.
- Dominant wind direction was from the east.
- Mean barometric pressure was 1013.3 millibar and ranged from a low of 982.4 millibar to a high of 1019.8 millibar.

The total amount of rainfall over the period was 3946.15mm. This is divided as is:

- 2169.82 mm from January 6 – December 31, 2011
- 917.28 mm in 2012
- 626.56 mm in 2013
- 232.49 mm from January 1 – August 23, 2014.

Figure 5-1 to Figure 5-4 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 high rainfall in March and May.

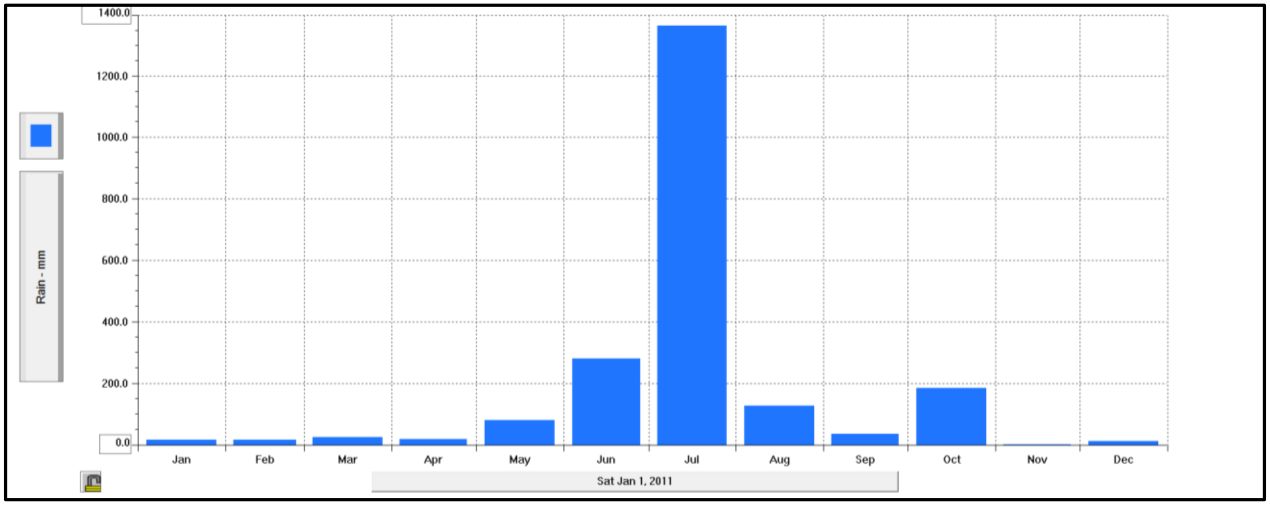


Figure 5-1 Rainfall rates for 2011

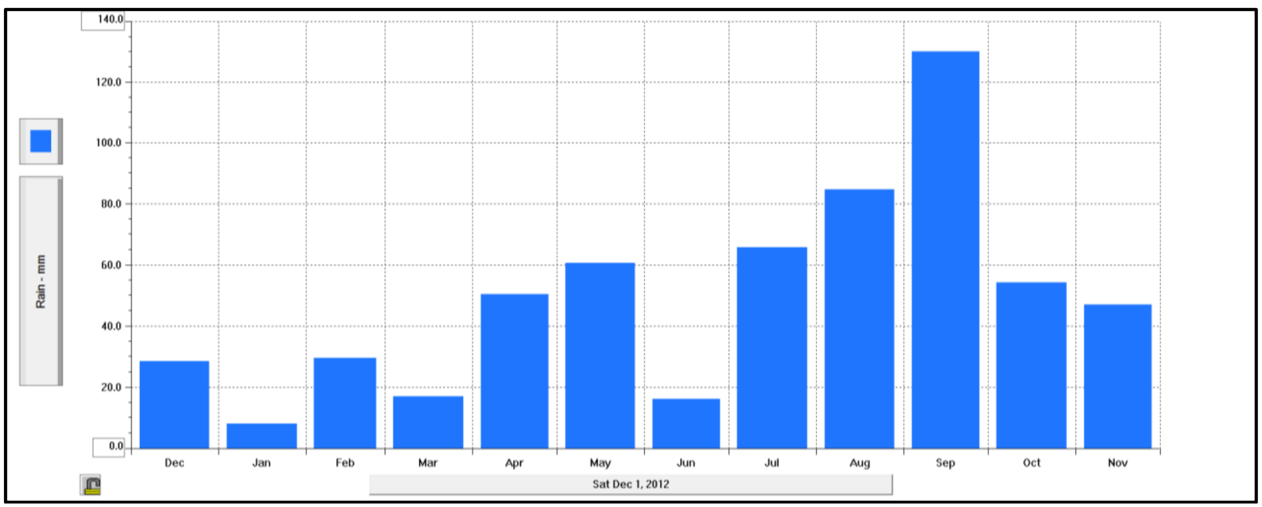


Figure 5-2 Rainfall rates for 2012

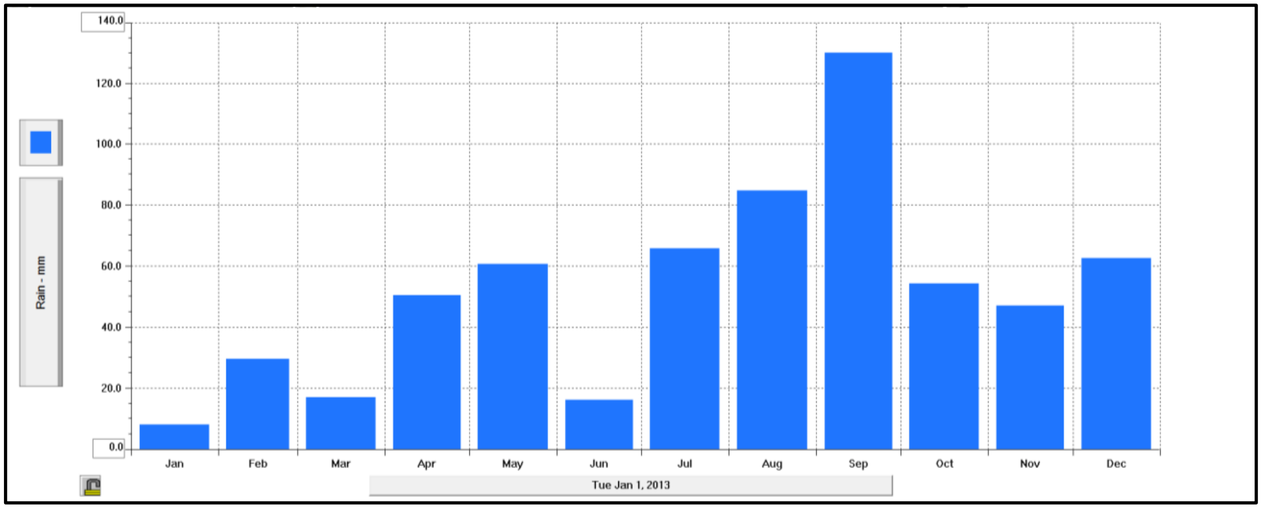


Figure 5-3 Rainfall rates for 2013

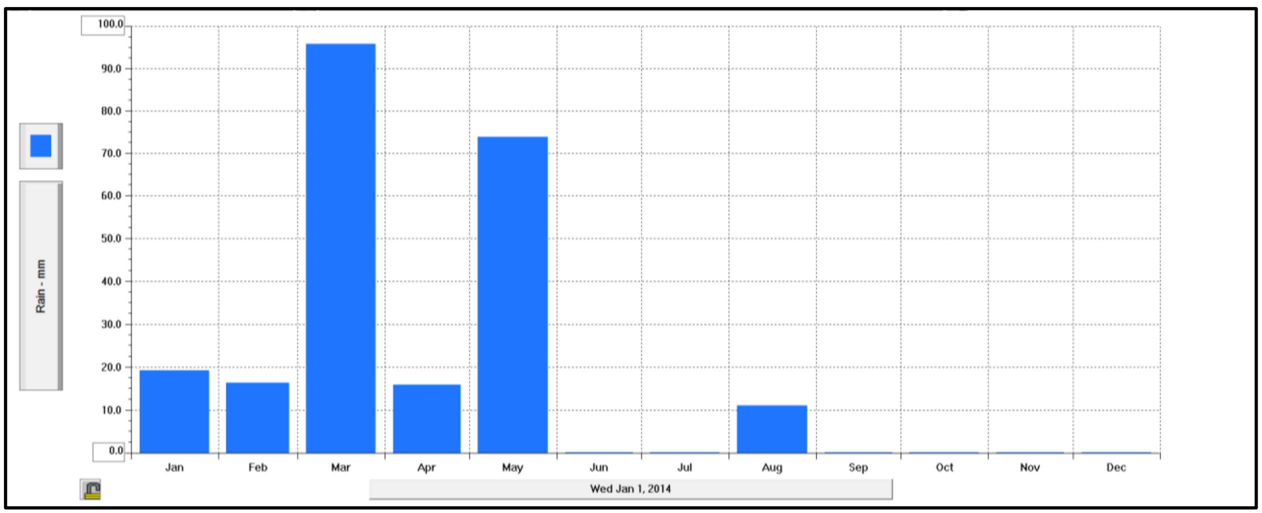


Figure 5-4 Rainfall rates for 2014

5.1.1.2 Historical Climate Data

Rainfall

30 YEAR CLIMATOLOGICAL DATA (1951-1980)

As seen below in Table 5-1 and Figure 5-5 temperatures are greatest during the months of June through September. Lowest mean minimum temperature of 15.3 ^{0}C 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 5-1 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

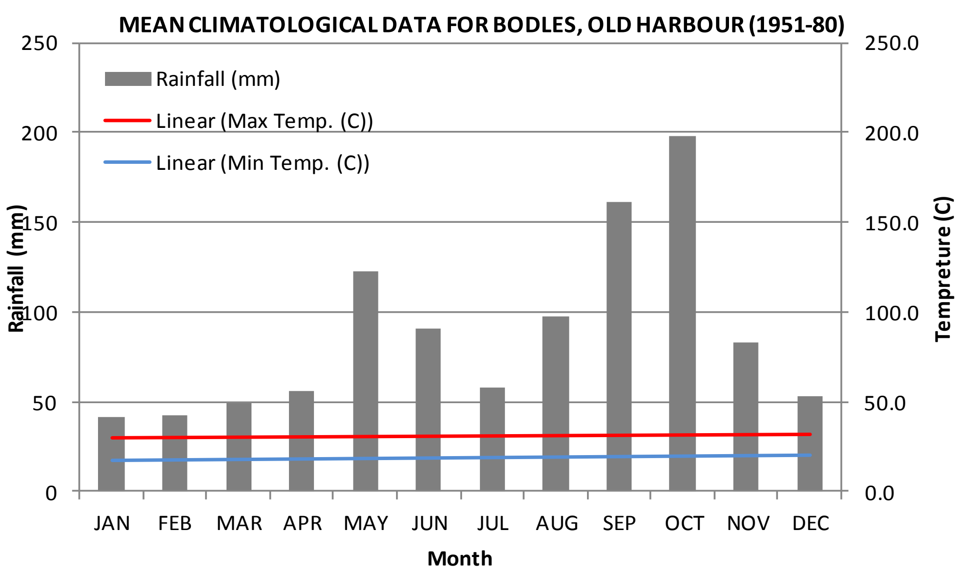


Figure 5-5 Mean Climatological data for Bodles (1951-1980) – Jamaica Meteorological Service.

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 5-2 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%

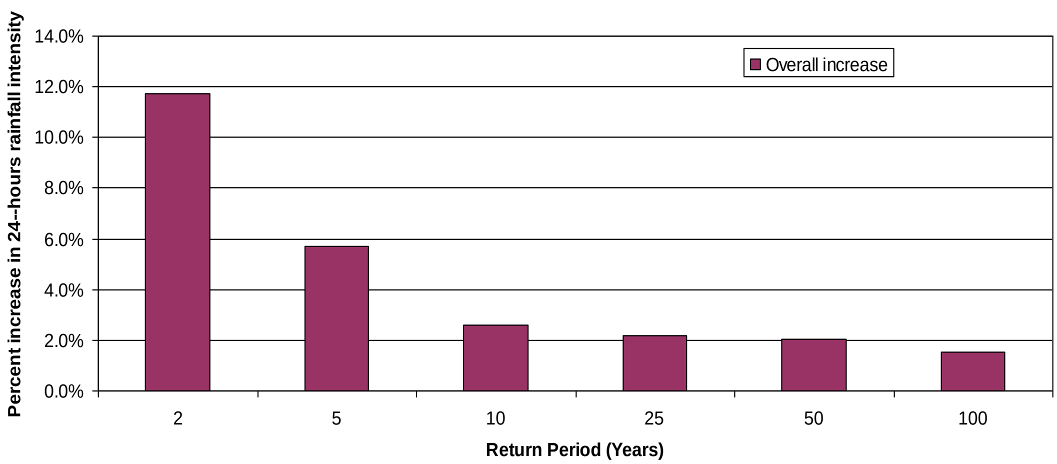


Figure 5-6 Overall increase in 24-hours rainfall intensity for the period between 1988 and 2009.

Given the design life of the project is 25 years, due consideration should be given to the changes in extreme rainfall as the old data appears to be irrelevant in light of the new data supplied by the Meteorological Office of Jamaica. See Figure 5-7 and Figure 5-8 below for the rainfall changes estimated for the 50year and 100year 24 hour extreme rainfall.

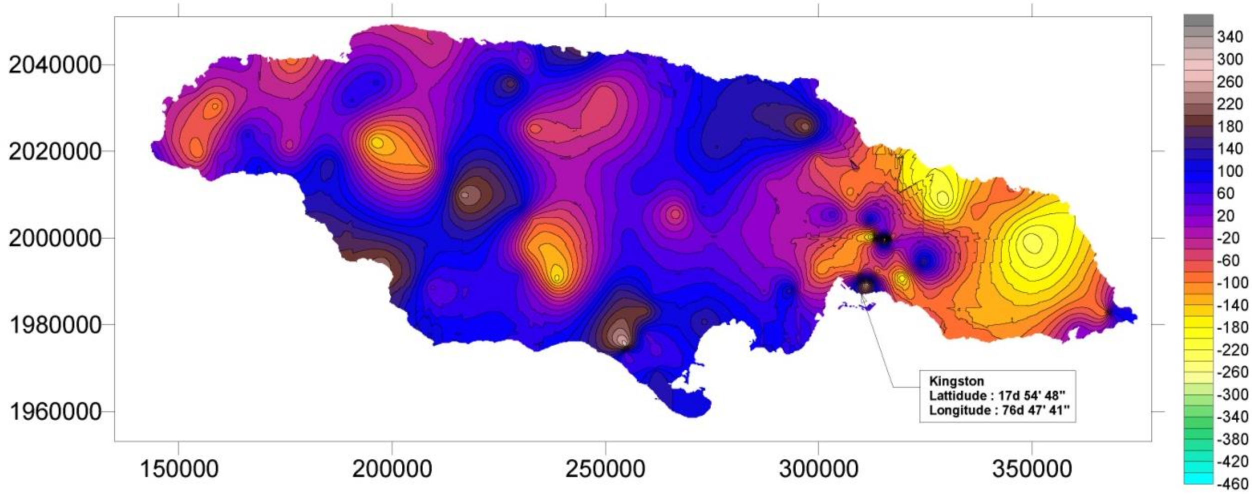


Figure 5-7 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 50 Year Return Period Event.

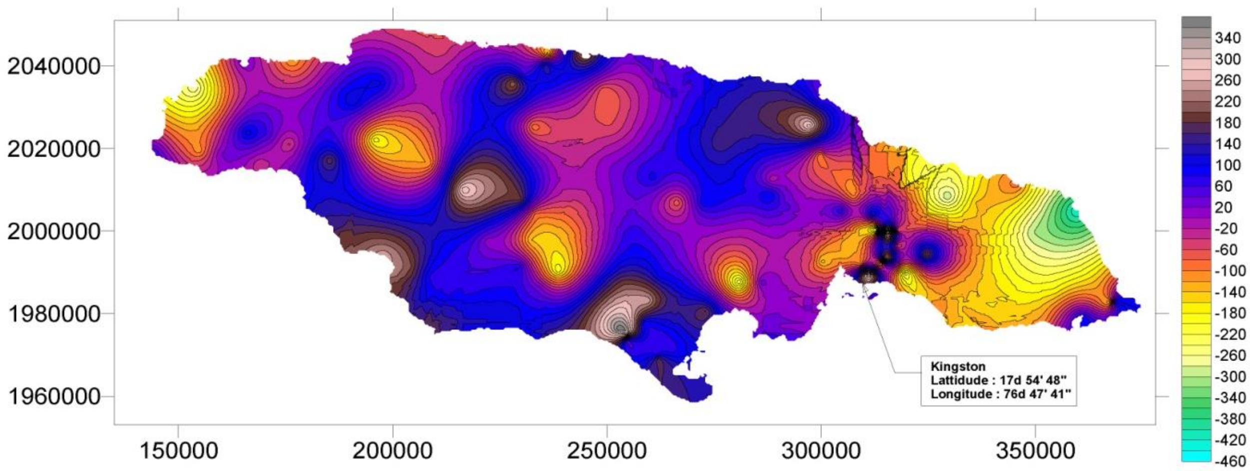


Figure 5-8 Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 100 Year Return Period Event.

5.1.2 Topography and Landscape

The site is located on very gently sloping lands which falls off to the sea in the south. This area is also within the flood plain of the Bowers Gully which flows from the hills in the north. Topographical data obtained from the Survey department 12,500 map series revealed the Bowers Gully catchment encompasses steep mountainous regions to the North which have elevation of up to 610 metres above mean sea level (msl). The area encompassed by the project site has elevations varying from 0.5m to 2.0m above msl. See Figure 5-9 and Figure 5-10 for the topography map of the wider project area derived from the survey department' 12500 map series. The general area surrounding the site has slopes of less than two percent (2%), whereas the hills in the north are dominated by slopes between 20 and 30 percent.

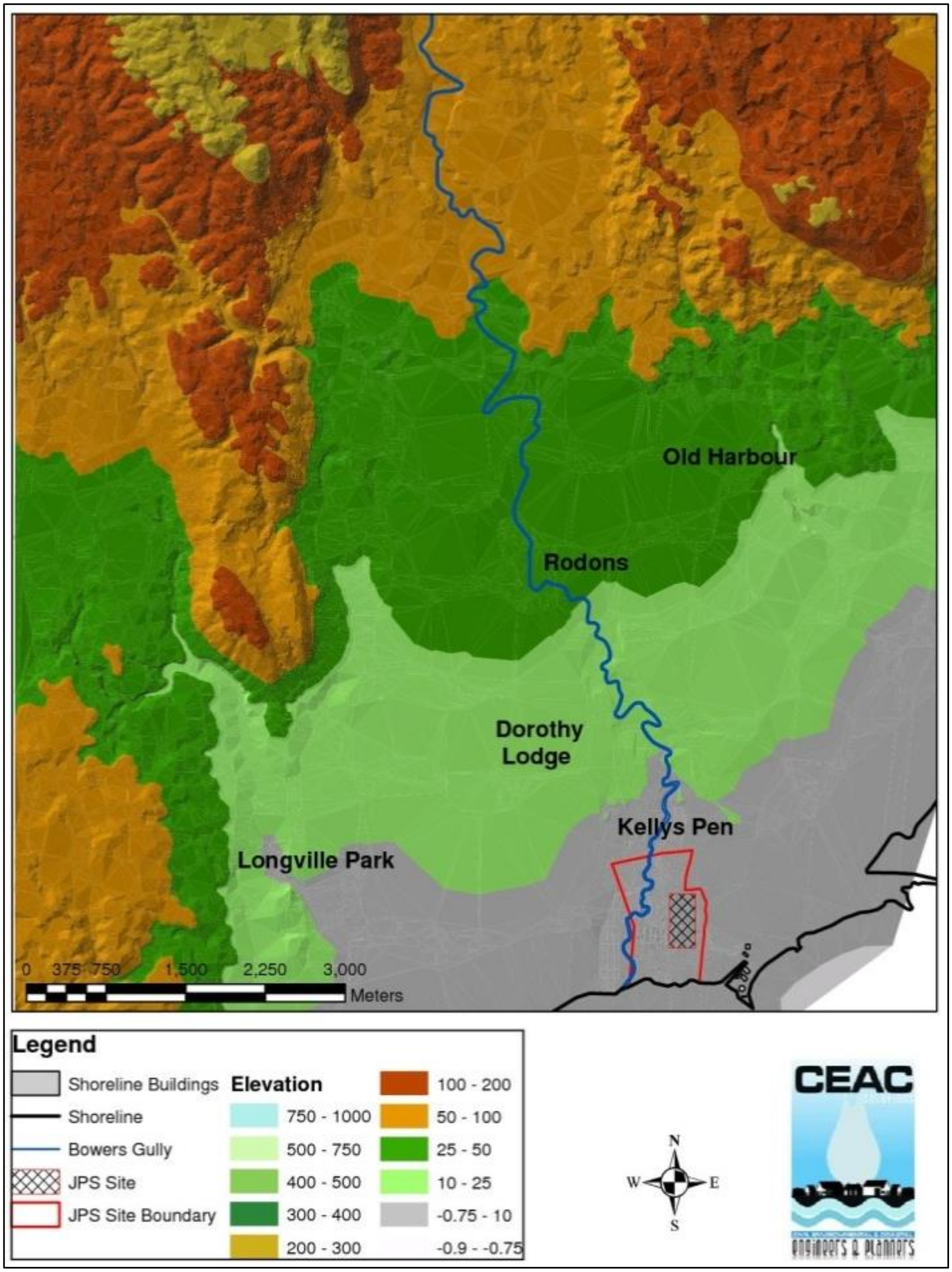


Figure 5-9 Digital terrain map of the project area created from Survey Department 1:12,500 map series.

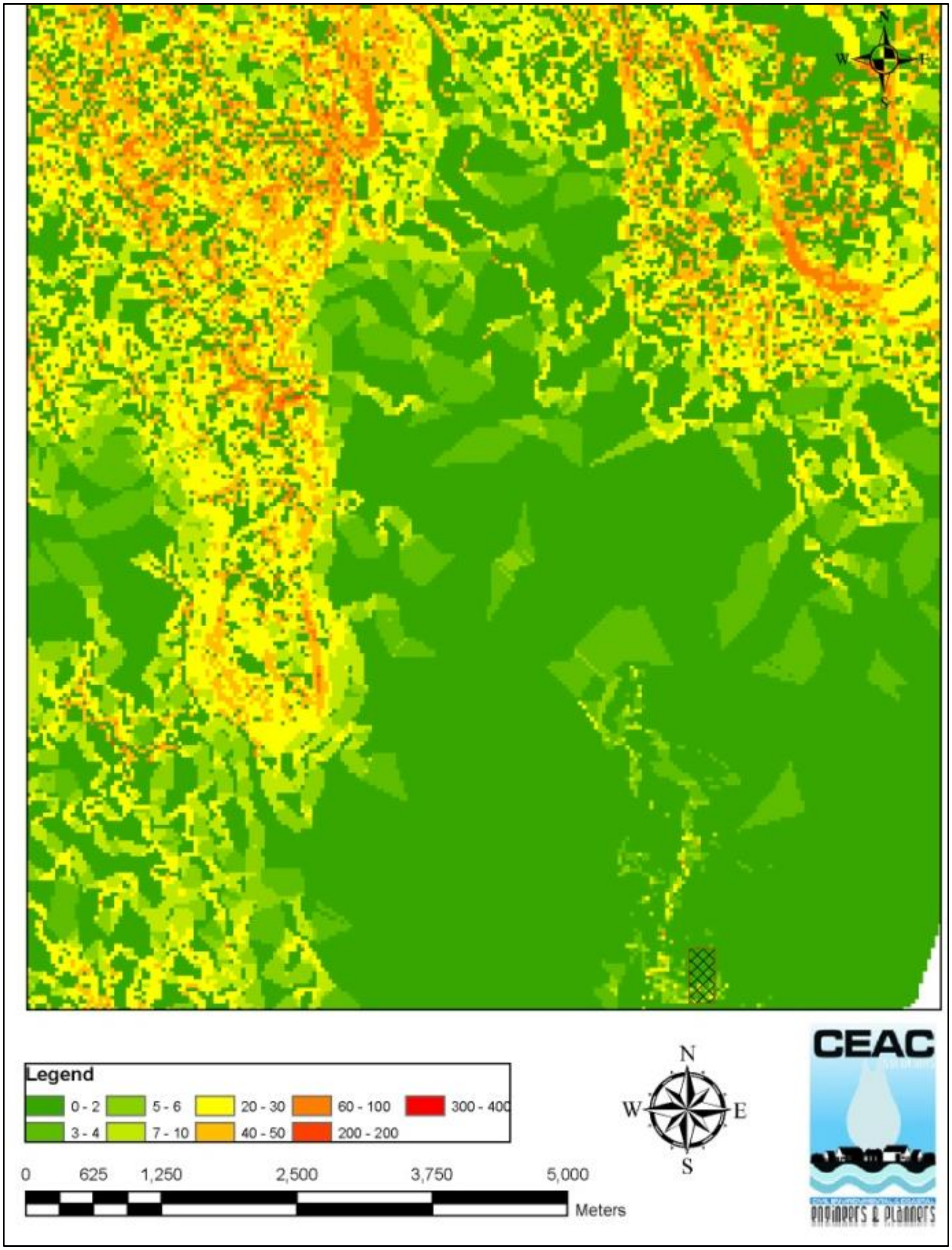


Figure 5-10 Slope analysis of the project is showing the percent slope of the terrain.

5.1.3 Geology and Structure

5.1.3.1 Geology

The geology of the area adjacent to the site consists of unconsolidated sands and sandy clays, and carbonaceous sandy clays and clays of Holocene age (last 12,000 years, marked as Qm on Figure 5-11). 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 5-11; data from Porter and Bateson, 1974, Fernandez, 1983; Halcrow, 1998). This depression probably marks the position of an old channel of the Rio Cobre excavated during one or more low sea-level stands of the Pleistocene Epoch. Its continuation is evident through Old Harbour Bay. Regionally, the lower part of the Holocene section is probably dominated by clays, possibly older than Holocene (Fernandez, 1983; Aspinall and Shepherd, 1978), grading up into sandier deposits in the higher part of the section. All these are underlain by lithified rocks of the White Limestone Group. A low raised beach (about 1 metre in elevation) was reported at Old Harbour Bay (Porter and Bateson, 1974).

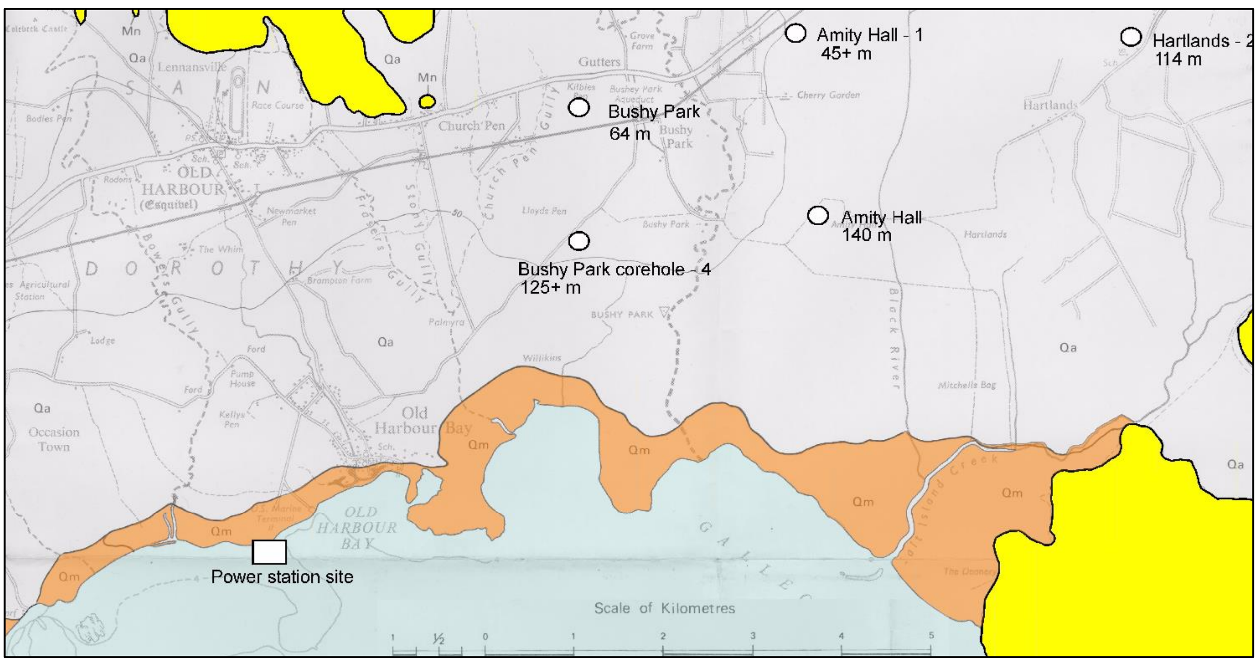


Figure 5-11 Regional geology of the site. Yellow, White Limestone Group; grey, Quaternary sediments of the Rio Cobre alluvial fan; brown, Holocene superficial sediments and soils of the coastline. Large striped rectangle is the proposed new site.

5.1.3.2 Borehole Logs

Logs for boreholes BH A to BH D were available for inspection, all of which were sited on the area of interest. All boreholes were done in locations where the major foundations of the proposed plant will be situated (Gas Turbines 1 – 3 and the Steam Turbine). Logs can be seen in the NHL Engineering June 30, 2015 Soil Investigation Report.

5.1.3.3 Structure

There is no evidence of structural complications within the superficial sediments of the area. Evidence of such features as faults is difficult to obtain from unconsolidated deposits. Fernandez (1983) demonstrated the existence of faulting in the White Limestone bedrock. Examination of his borehole logs also indicates the probability of normal faulting (possibly growth faults) in the post-White Limestone sediments, which thicken towards the central axis of the St. Catherine Plains Quaternary basin.

5.1.4 Soils

5.1.4.1 Soil Distribution

The spatial distribution of the soils present at the proposed site is shown in Figure 5-12 and has been modified from Campbell et al (1986) and their soil names and codes followed. Ground truthing of these were carried out during the site visit. The published soil and land use surveys (Netherlands; Campbell et al 1986 and Vernon and Jones, 1958) identify 4 soil types (Lodge Clay; Lodge Clay, Saline-Sodic phase; Whim Clay Loam (PRb3); Salina undifferentiated (TMX1)) in the study area and we follow their classification in the descriptions below.

Lodge Clay (POc1)

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).

Lodge Clay Saline- Sodic Phase (POc1/sa)

Lodge Clay Saline- Sodic phase (POc1/sa) described by (Campbell et al 1986) is equivalent to the lodge clay loam (saline) mapped by Vernon (1958). It is characteristically similar to the Lodge Clay (POc1) but saline and sodic in the subsoil. It is a moderately well (internally) drained old alluvium that occurs primarily on the lower slopes (slope range 0-2°) of the coastal (clay) plain towards the sea (Campbell et al 1986) and has erosional hazards. The soil is non-saline at the surface becoming moderately saline at depth (Campbell et al 1986; Ministry of Agriculture and Fisheries 2009).

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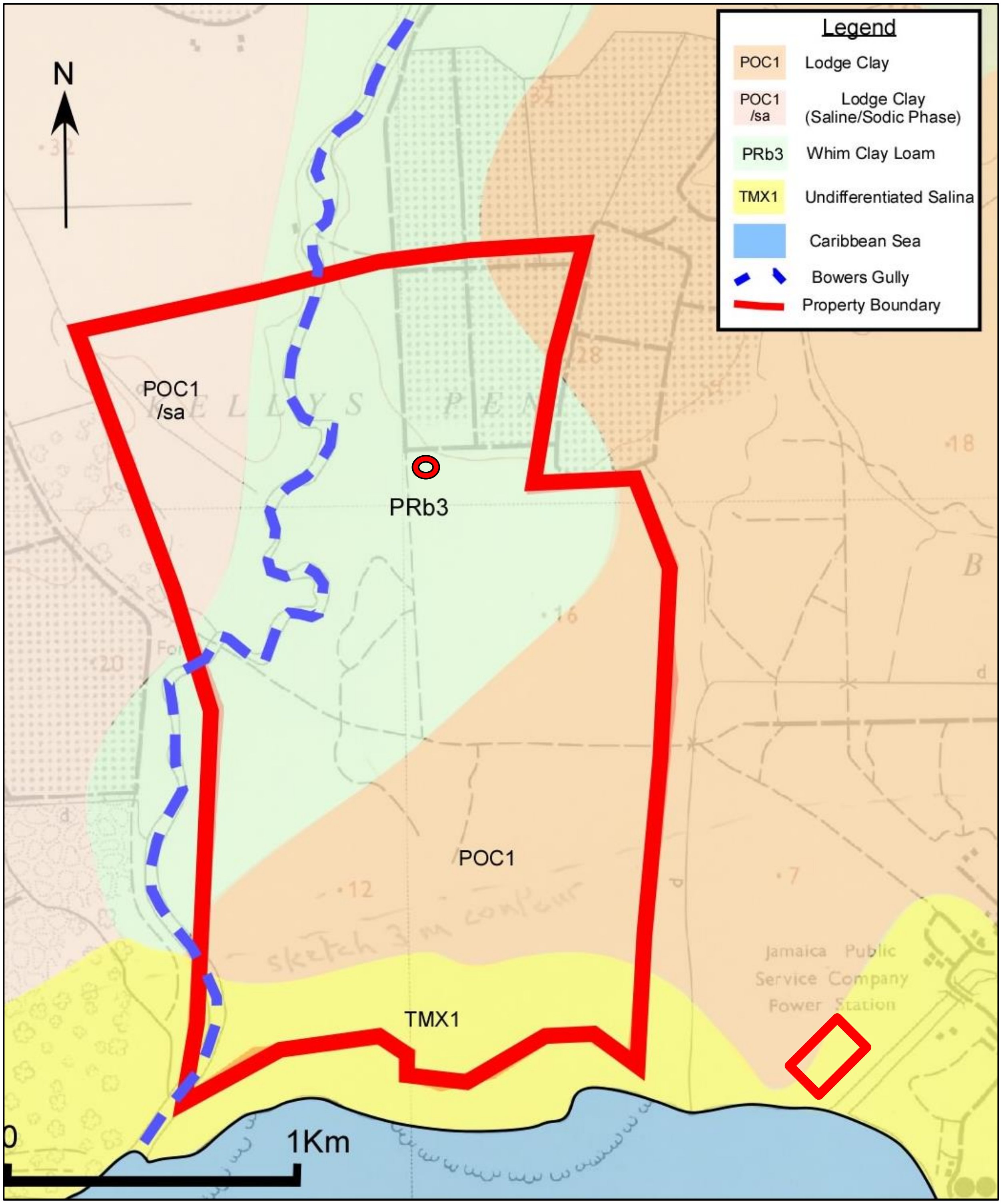


Figure 5-12 Map showing the spatial distribution of soils associated with the area of interest (map modified from Campbell et al 1986).

Whim Clay Loam (PRb3)

Whim clay loam (PRb3) is a well-drained stratified soil developed on recent alluvium of river plains from alluvial soil derived from mixed rocks of the upper catchment of the Bowers Gully. The soils occur on level smooth sites along major stream channels. Soil thicknesses may exceed 60" (1.5 m) and the Agricultural Chemistry Division report (1964) reports that soil colour and weight increases with depth. Colour varies from a dark brown sandy loam or sandy clay to a yellowish brown. It has moderate internal drainage and occurs on slopes of 0-2° (Ministry of Agriculture and Fisheries 2009).

Salina Undifferentiated

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 typic halaquepts (Campbell et al 1986)

5.1.4.2 Geotechnical Survey

NHL Engineering Ltd. conducted a geotechnical survey on the proposed site located in Old Harbour, St. Catherine in April 2015. The field investigation entailed the drilling and sampling of four (4) locations to a depth of 40m (131'). The testing results revealed that four (4) distinct types of soils were encountered: a mixture of loose compact sands with some gravels and silts, very soft/very loose silty clays, very stiff – hard silty clays with some silts and sands and dense – very dense sands with some gravels and silts (Figure 5-13). Ground water was encountered the boreholes at an average depth of 2.4 m below existing ground elevation. These results indicate the foundation need specialist attention in terms of their design. Shallow isolated pad or strip foundations placed on this site will be susceptible to settlement and displacement without replacement or soil modification. A Soils engineer is therefore to be consulted to design the fill and foundation that are required to mitigate against differential settlement of the power plant. Detailed results can be found in the 'Soil Investigation Report' prepared by NHL Engineering Ltd (June 2015).

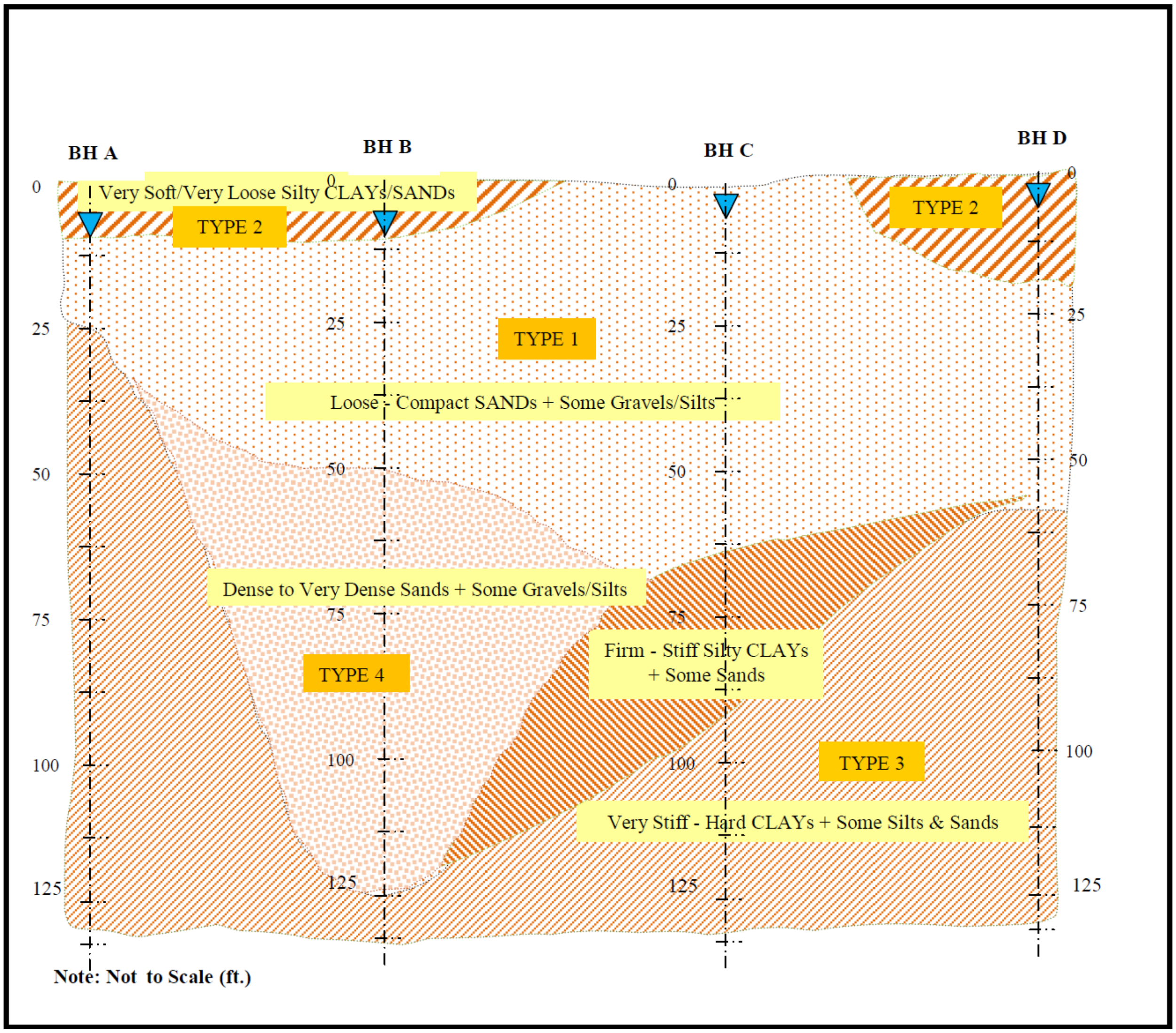


Figure 5-13 Presumptive profile boreholes A, B, C and D

5.1.5 Well Analysis

The Bodles Rosehall and Experimental wells are located in the western section of the St. Catherine plains approximately 2.2 kilometres southwest of Old Harbour.

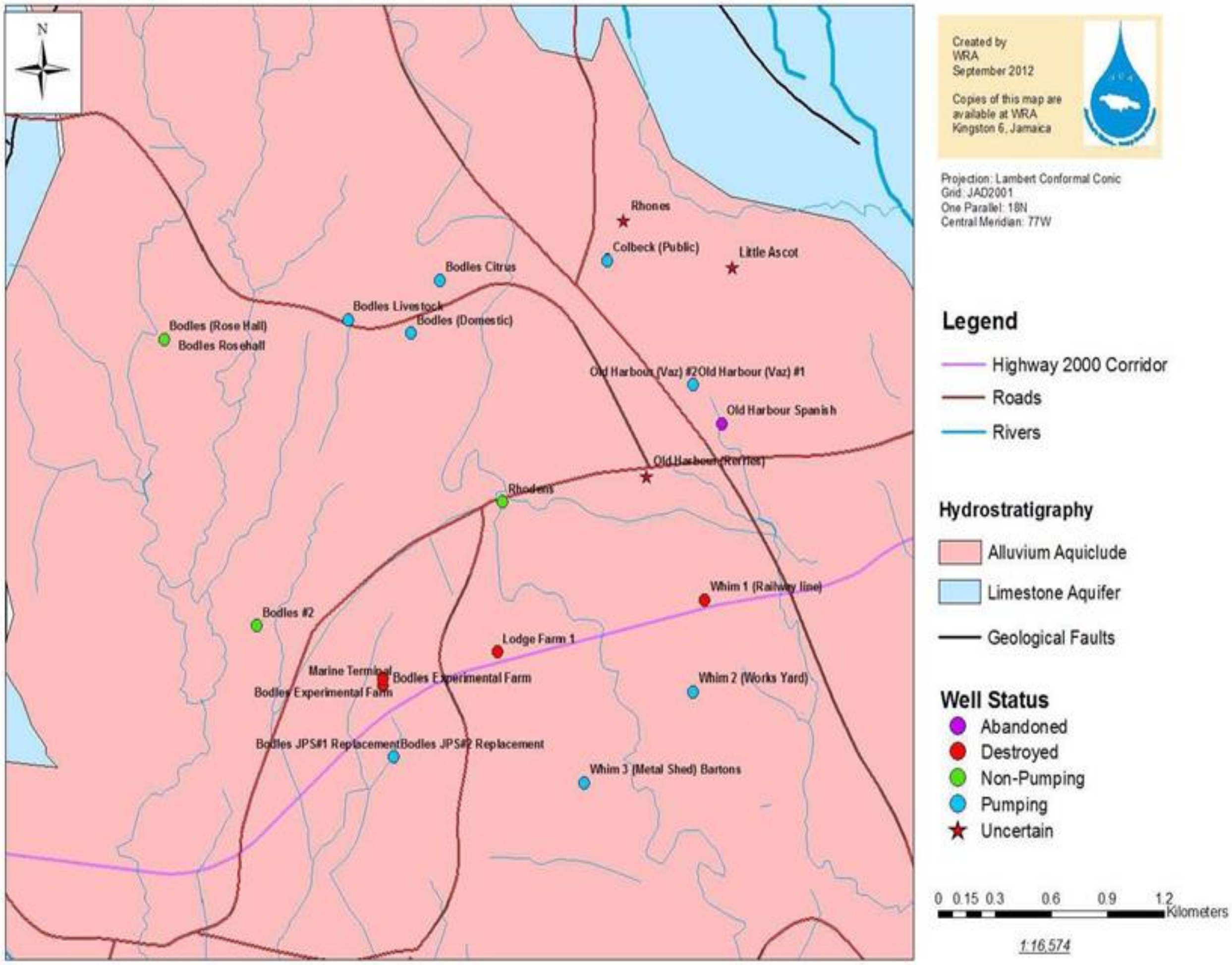


Figure 5-14 Map Showing Bodles Hydrostratigraphy (Source: WRA assessment Bodles Rosehall and Bodles Experimental Wells).

5.1.5.1 Bodles Rosehall

A pump test was done on the Bodles Rosehall well in 2000 and had a specific capacity of 111,741.55m³/day/m which was calculated at its highest rate of 14,526.4m³/day. The static water level was 29.87 metres below ground level and a measured drawdown of 0.13 metres at yield testing. This high productivity maybe as a result of the prevailing geology in the Bodles area indicating the well taps a conduit with high flows (underground river) where recharge equals discharge during testing.

Information from the well record includes:

- Diameter: 508mm
- Depth: 53.34 metres
- Casing:
    - Plain 508mm casing from 0.31m – 27.13m
    - Slot 508mm casing from 27.13m – 42.34m

Information from Telelog:

- Diameter: 508mm (20 inches)
- Depth : 53.34m (175 feet)
- Casing : Plain 508mm from 0.31m -27.13m
- Slot 508 mm from 27.13m -33.22m
- Slots 457.2mm from 33.22m -43.89m
- Open Hole from 43.89m -53.34m

5.1.5.2 Bodles Experimental Farm

The Bodles Experimental Farm well was a moderate producer at its yield testing in 2000 with a specific capacity of 769.3m^3/day/m when tested at its highest rate of 2,594.67m^3/day. The static water level was 21.52 metres below ground level and a measured drawdown of 3.37 metres at yield testing. The stabilisation of the drawdown indicated that the aquifer was continuously recharged. However, with ground elevation at 23.32 metres above sea level a licenced volume of 1,000m^3/day was assigned which would result in pumping water levels of 0.8 metres above sea level. Any higher pumping would result in below sea level pumping thereby inducing seawater intrusion.

Information from well record:

- Diameter: 250mm
- Depth : 35.97metres
- Casing: no information

The water supply to the proposed plant will use the existing supply from the existing Old Harbour Power Plant and cooling water from once through cooling using seawater.

5.1.6 Hydrology and Runoff

The site as is does not receive flows from offsite sources. The site catchment is therefore contained within its boundaries. Hydrologic analysis of the site was undertaken to determine runoff for the 10, 50, and 100 year return rainfall events. Hydrological modelling of the watersheds encompassed three main elements:

- Precipitation
- Rainfall abstraction model (Curve number method) – determines how much of the precipitation is initially absorbed before runoff takes place
- 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.

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

The Curve Numbers used were those developed by the NRCS on the basis of soils group, soil cover or land use, and antecedent moisture conditions. The values used were for AMC II which represents average conditions.

Historical precipitation data was obtained from the Meteorological office of Jamaica and analysed to determine the different return periods. The peak runoffs were calculated using the type III rainfall distribution curve, the hydraulic properties of the soils in the catchment as well as the existing land use properties. The primary inputs into the model can be summarized as follows:

- Drainage area size (A) in square miles (square kilometres);
- Time of concentration (Tc) in hours;
- Weighted runoff curve number (RCN), (based on soils and land use);
- Rainfall distribution;
- Total design rainfall (P) in inches (millimetres).

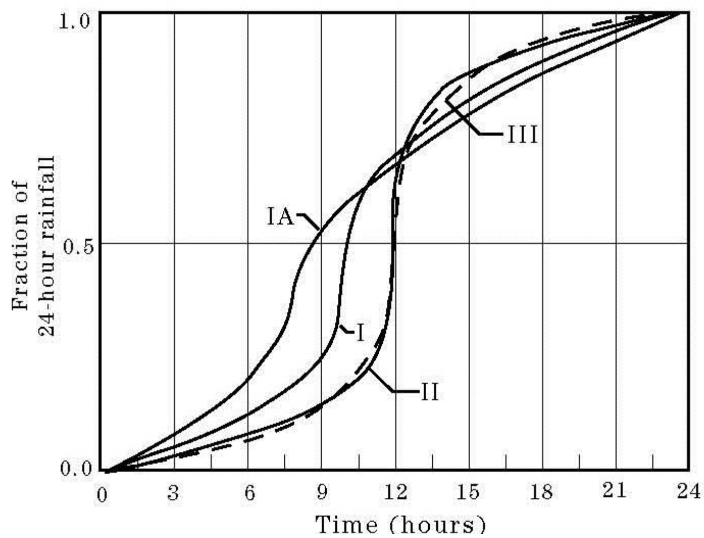


Figure 5-15 CS 24-hour Rainfall Distributions.

Runoff was estimated for the site in its current "undeveloped" or existing condition. A post development scenario was also modelled (see Land Impacts, section 7.2.1.1). Existing predevelopment flows were estimated as follows for the three return period storms investigates follows:

- 10yr = 198 m^3/s
- 50yr = 406 m^3/s
- 100yr = 473 m^3/s

5.1.7 Bathymetry

5.1.7.1 Existing Data

Detailed bathymetric data for the project area was essential for formulating both the hydrodynamic model (Finite Element Model, FEM) and wave model. This also allowed for the generation of a Digital Elevation Model (DEM) which was used to specify volumes of excavation required for the power plant. Existing bathymetric data within the Portland Bight area was available from:

- Admiralty Charts;
- CEAC (2009) study for Jamalco and Rinker Minerals at Rocky Point;
- CEAC (2010) study for the National Works Agency for beach stabilization of Old Harbour;
- CEAC (2011 and 12) study JPS 360 MW power plant.

5.1.7.2 Bathymetric Survey (2014)

The 2012 Study of the SJPC 360 MW Power plant had bathymetric data in the project area, but these were based on a lower precision instrument as well as the sea floor could have experienced minor changes since then. An additional survey was carried out on August 13 to 15, 2014 in order help close the gaps between existing surveys.

Single beam sonar with real time kinematic (RTK) GPS correction was used for this exercise. The general specifications of the survey was to national standards and are listed as follows:

- Survey on 30 meters (perpendicular to shore) grid x 100 meters tie lines grid, 200 KHz sounder, at 1 second intervals at a maximum speed of 6 knots. No surveys will be done in heave or swell conditions exceeding 1.0 metres in wave height or in water depths less than 1 metre;
- Chart datum determination from temporary tide gauge to national survey system;
- Automatic tide correction by dynamic real time ellipsoid height GPS measurements. Statistic Ellipsoid height from pre-survey field checks in the area and correlation to Chart Datum;
- All surveys to 0.05 metres depth accuracy and +/- 0.1 metres horizontal accuracy, using real-time Trimble DSM 232 DGPS system and ODOM sounder;
- Shallow and deep water bar check before survey.

The areas surveyed were:

- Port Esquivel outfall and intake sites over a nominal area of 800 x 400 meters;
- Old Harbour Bay FSRU site over a nominal area of 300x1400 meters;
- Gap in reef offshore Doctor Bird 1/fuel line over a nominal area of 200 x 900 meters.

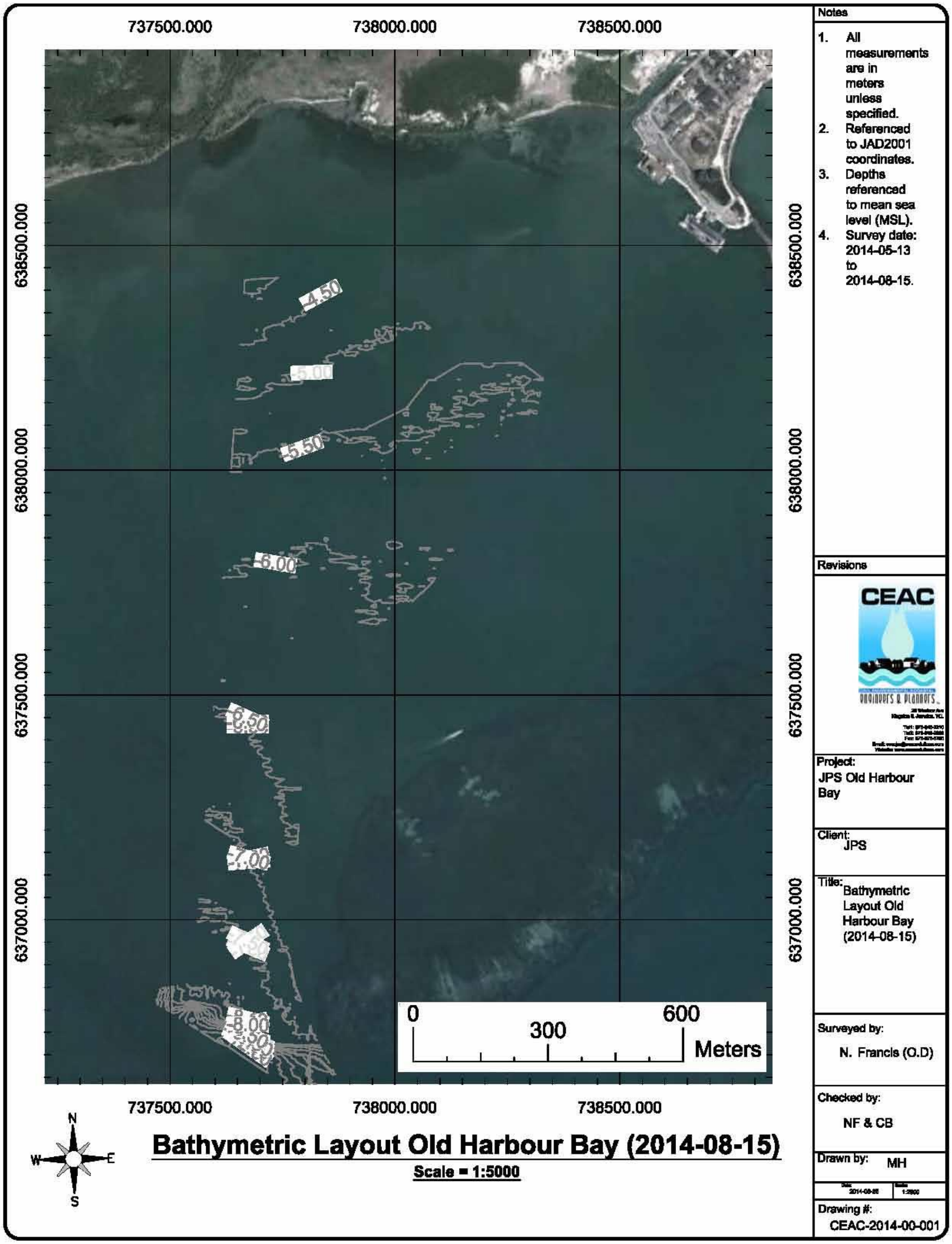


Figure 5-16 Map of bathymetric survey contours

Shallow (<3.0 metres) and deep water (<15.0 metres) bar checks were carried out before the survey to verify the accuracy of the survey. A simplified bathymetric chart is shown in Figure 5-16, indicating depths of 4.0 to 12.0m across the surveyed area. The contours in the area also indicated an area extending to the west of the Doctor Bird 1 having a trench with bottom elevations of -4.5 to -5m. The data obtained revealed that the bathymetry is relatively shallow out to the reefs which are approximately 1.6 km from the shoreline. The seafloor slopes gently at an average of 2 percent from the shoreline out to the reefs, with depths of 5 to 6 meters between the reefs and the shoreline.

5.1.8 Hydrodynamics

5.1.8.1 Current Drogue Survey

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. This information was acquired by carrying out drogue tracking missions. A two-day drogue tracking programme was executed by the CEAC team on August 21st, 2014 and August 22nd, 2014. Four (4) drogues were placed within the Old Harbour Bay; two (2) surface and two (2) sub-surface drogues (with sail depths ranging from 2 to 4 metres) were placed near shore and further offshore. 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 analysed in order to determine current speed and directions, and current speed vectors were produced for the rising and falling tides.

Plate 5-1 Drogues during the tracking mission in Old Harbour Bay

Winds during Drogue Tracking Session

It was necessary to collect wind data as well, specifically wind speed and direction on the days when drogues were done. This parameter is vital in calibrating the hydrodynamic model before it can be used to predict the circulation patterns in the bay.

NOAA BUOY DATA

The online database of National Oceanic and Atmospheric Administration (NOAA) was consulted for the deep water/offshore winds which occurred during the drogue tracking sessions on August 21st and 22nd. The data obtained shows that the wind speeds varied between 7 to 11 m/s during the day on the 21st and 4 to 9 m/s on the 22nd. The wind directions changed frequently on the 21st while they were fairly stable between 0 to 90 degrees on the 22nd.

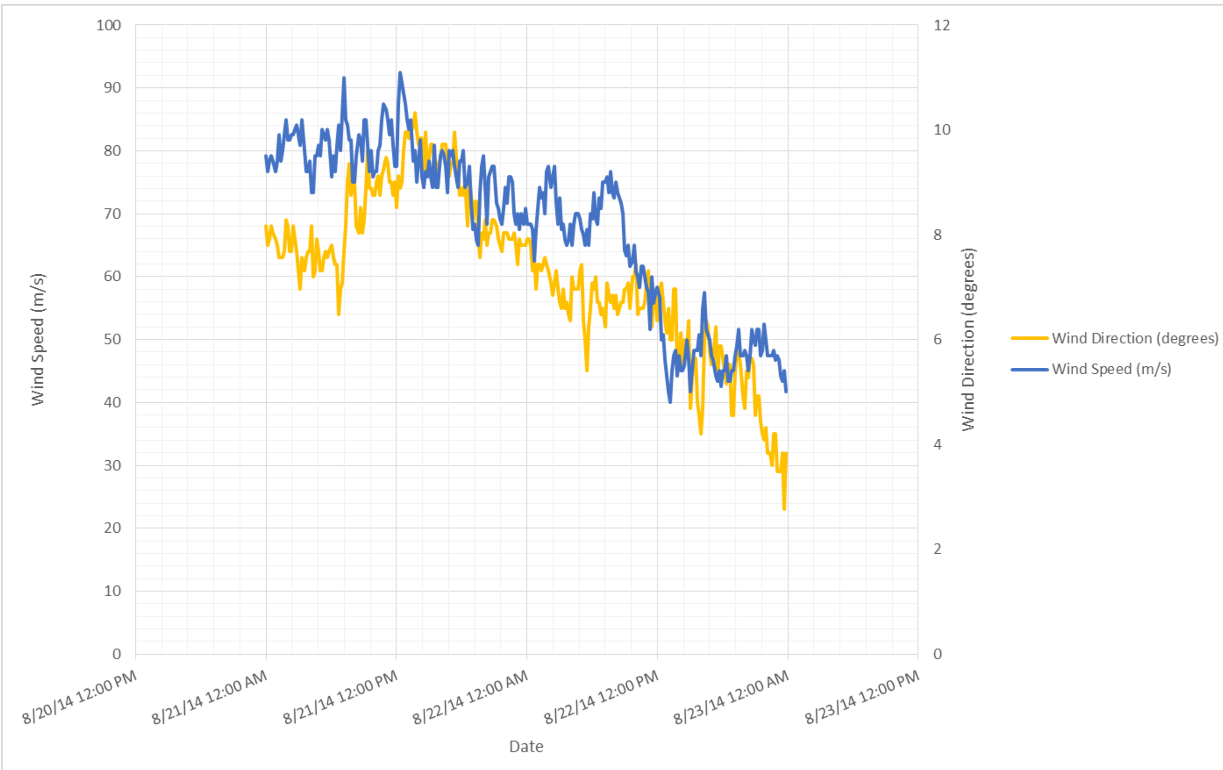


Figure 5-17 Variation of the wind speeds and directions on the measured by the NOAA Buoy to the SW of Jamaica between August 21st and 22nd 2014

WIND SUMMARY

The average wind speeds and directions during the drogue tracking exercises are seen in Table 5-3 below. The two wind stations have shown marked differences in the wind speeds and directions recorded. The onshore met station whilst being closer to the site is less likely to have captured the wind speed that was experienced on the sea. This is due to the fact that the wind speeds are normally changed at the coast as a result of the change in surface friction characteristics. The directions however are normally correct. These factors were taken into consideration when calibrating the hydrodynamic model.

Table 5-3 Average wind speeds and directions during drogue tracking sessions

	Time			Wind (Onshore)		Wind (NOAA Buoy)	
				Avg. Dir	Avg. speed (m/s)	Avg. Dir	Avg. speed (m/s)
Session 1	11:00	-	12:00	SE	8.7	NE	0.1
Session 2	12:30	-	14:00	SE	10.0	E	0.1
Session 3	07:30	-	10:20	NE	1.9	NE	0.08
Session 4	13:00	-	15:00	NE	1.5	NE	0.05

January 2014 (Onsite Anemometer)

A temporary weather station maintained by environmental consultants, CL Environmental Ltd, was located north of the JEP barges on the JPS property. Wind readings were obtained for the days of the drogue tracking missions, the data was analysed, and graphs plotted. From Figure 5-18 and Figure 5-19 we see distinctive peaks of wind speed and wind direction respectively. The general trend shows that the peak wind speeds occur after 12 pm each day. The maximum wind speed observed during the period was 14.2 m/s. These high wind speeds tend to blow to a generally westerly direction (blowing from east to west).

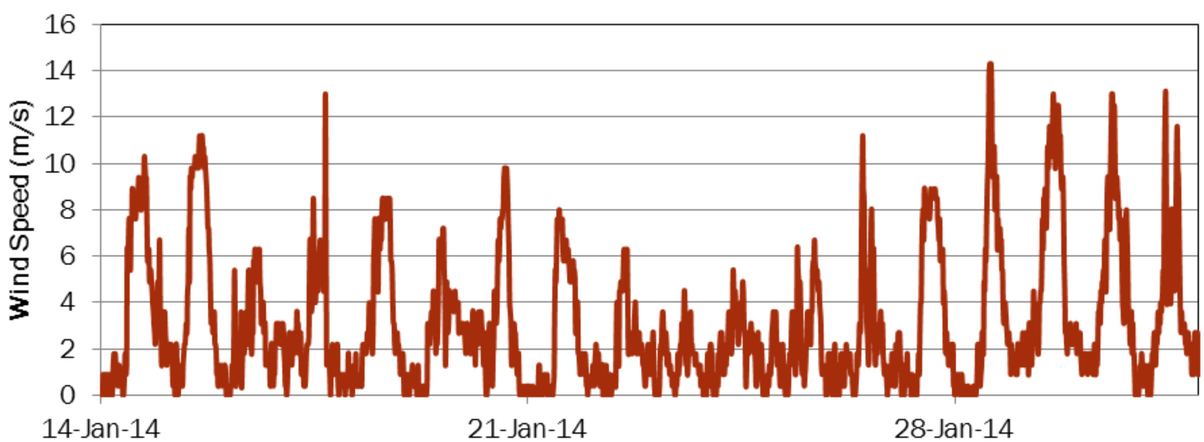


Figure 5-18 Graph showing wind speed from JPS weather station from January 14,2014 to January 31,2014

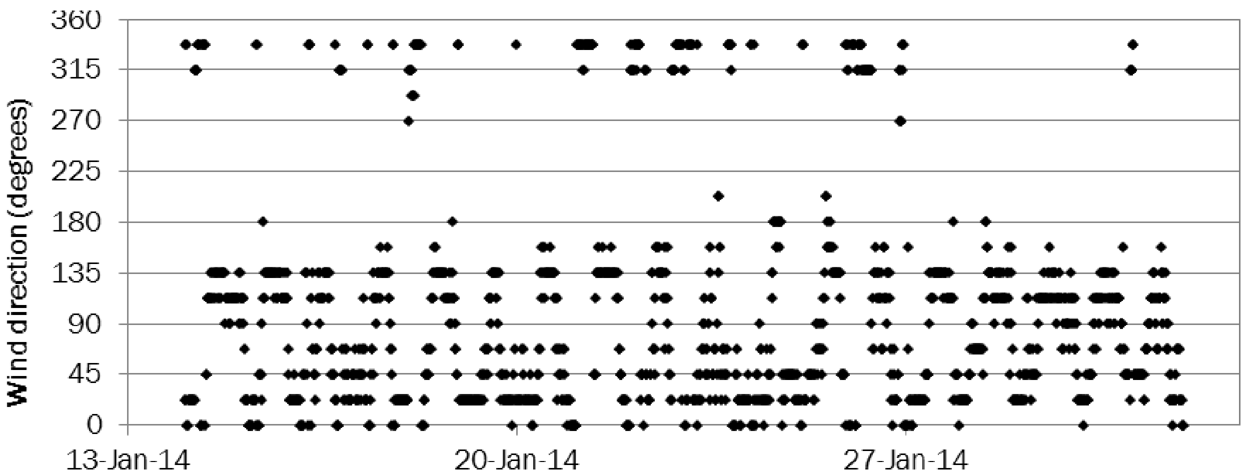


Figure 5-19 Graph showing wind direction from JPS weather station from January 14, 2014 to January 31, 2014

Drogue Tracking Results

FALLING TIDE

Sessions 1 and 3 were conducted during falling tide conditions. The average wind speed recorded for session 1 was 10.8 m/s and that for session 3 was 2.8m/s. The average wind directions were SE for both days.

Near Shore

During sessions 1 and 3, the surface drogues near shore were tracked moving in north westerly and south westerly directions, at speeds of 9.7 cm/s and 6.7 cm/s respectively. The sub-surface drogues deployed near shore travelled in a north westerly and westerly direction at average speeds of 6.5 cm/s and 3.1 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.

Deep Off Shore

The offshore drogues were only tracked in session 3. The surface drogues were observed moving in a westerly direction at speeds of 10.5 cm/s. The sub-surface drogues travelled south westerly with average speeds of 7.1 cm/s, indicating that they were current driven. The current speeds were greater than the wind speeds indicating winds are not the only drivers of currents further offshore.

Table 5-4 Summarized drogue tracking session #1 - Falling tide conducted on August 21st, 2014

Drogue #	Time	Depth of Sail	Notes	Easting	Northing	Location	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion	
6B	11:30	SURFACE	deploy	276500	1979666	ADCP1	141.174	1449	9.743	9.743	304.028	North Westerly
6B	11:54		remove	276383	1979745							
5	11:30	2m	deploy	276485	1979662		104.809	1374	7.628	6.533	298.312	North Westerly
5	11:53		measurement	276394	1979714		26.249	521	5.038			
5	12:02		measurement	276369	1979722		46.043	664	6.934			
5	12:13		remove	276331	1979748							

Table 5-5 Summarized drogue tracking session #3 - Falling tide conducted on August 22nd, 2014

Drogue #	Time	Depth of Sail	Notes	Easting	Northing	Location	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion	
6B	7:57	SURFACE	deploy	276623	1979621	ADCP1	48.415	1061	4.563	6.647	224.401	South Westerly
6B	8:15		measurement	276593	1979583		103.175	1759	5.866			
6B	8:44		measurement	276536	1979497		68.819	1477	4.659			
6B	9:09		remove	276480	1979457							
6B	9:15		deploy	276520	1979652		109.124	1412	7.728			
6B	9:38		measurement	276448	1979570		236.764	2272	10.421			
6B	10:16		remove	276264	1979421							
5	7:57	2m	deploy	276621	1979624		33.242	1050	3.166	3.135	249.938	Westerly
5	8:14		measurement	276597	1979601		44.204	1694	2.609			
5	8:43		measurement	276562	1979574		68.622	1665	4.121			
5	9:10		remove	276497	1979552							
5	9:15		deploy	276506	1979668		37.054	1342	2.761			
5	9:37		measurement	276469	1979670		73.110	2424	3.016			
5	10:18		remove	276396	1979666							
11	8:05	SURFACE	deploy	276775	1978204	ADCP2	162.807	1692	9.622	10.476	247.866	Westerly
11	8:33		measurement	276640	1978113		177.260	1647	10.763			
11	9:01		measurement	276485	1978027		179.335	1436	12.489			
11	9:25		remove	276325	1977946							

Drogue #	Time	Depth of Sail	Notes	Easting	Northing	Location	Distance Travelled	Time	Speed	Average Speed	Average Direction of Motion	
							(m)	(s)	(cm/s)	(cm/s)		
11	9:27		deploy	276675	1977967		137.004	1592	8.606			
11	9:54		measurement	276538	1977968		106.607	978	10.900			
11	10:10		remove	276436	1977937							
8	8:05		deploy	276770	1978181		129.850	1721	7.545			
8	8:34		measurement	276660	1978112		150.233	1650	9.105			
8	9:02		measurement	276531	1978035		115.109	1438	8.005			
8	9:26	4m	remove	276422	1977998					7.050	243.928	South Westerly
8	9:28		deploy	276694	1977958		80.000	1612	4.963			
8	9:54		measurement	276614	1977958		48.104	854	5.633			
8	10:09		remove	276569	1977941							

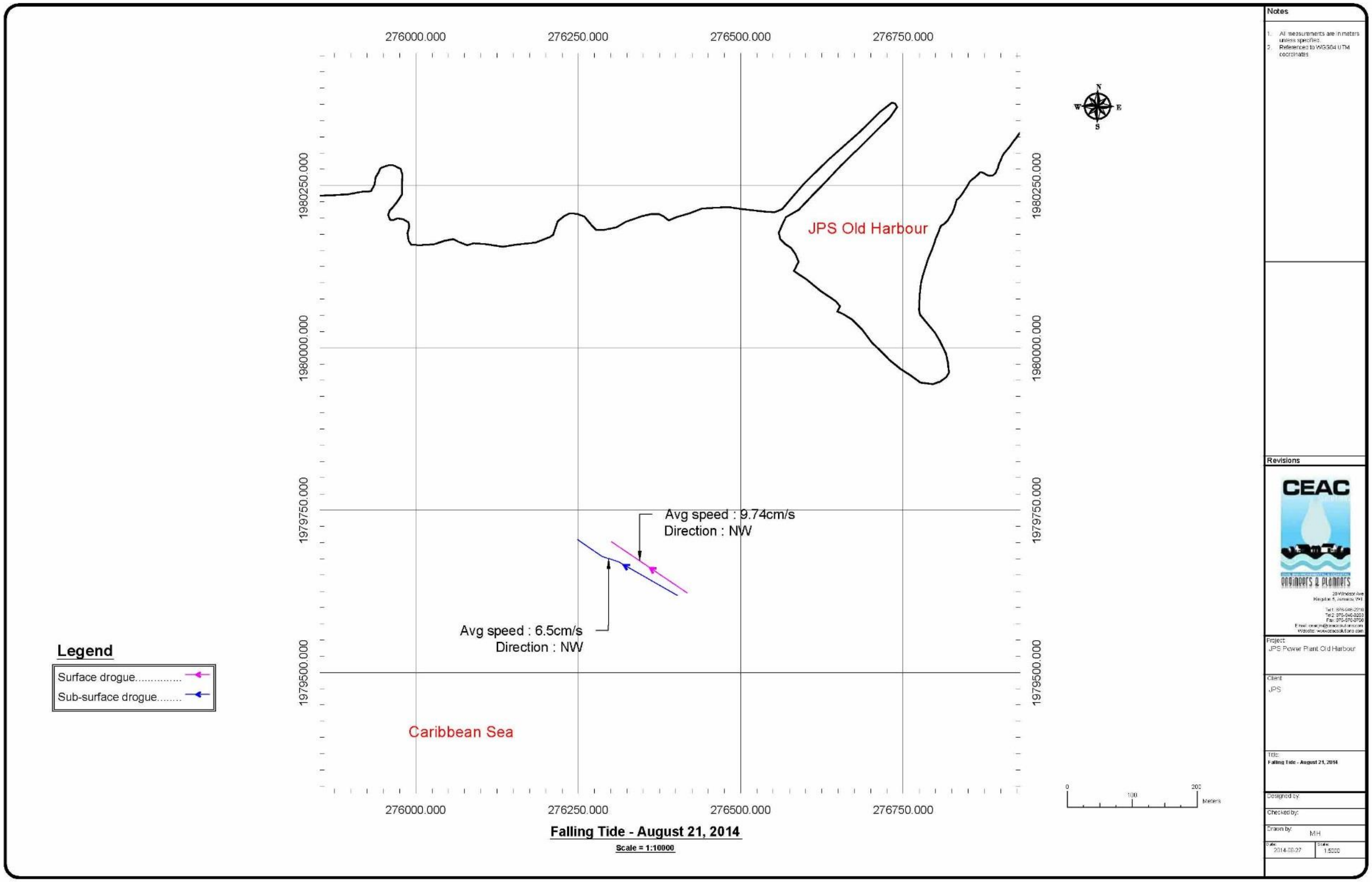


Figure 5-20 Approximate path and direction of the drogues during drogue session #1 Surface drogues are in pink, while sub-surface drogues are in blue.

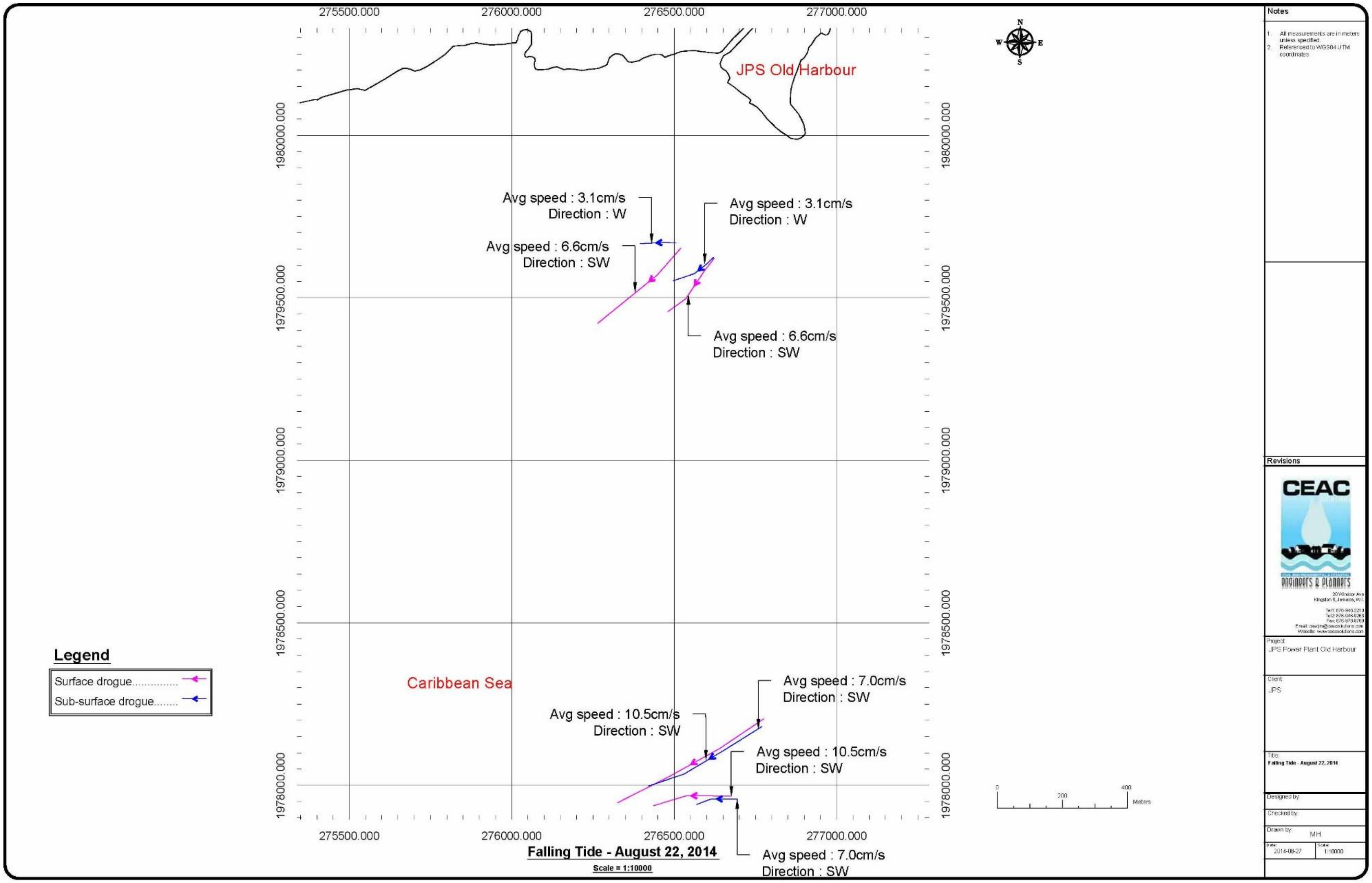


Figure 5-21 Approximate path and direction of the drogues during Drogue session #3.

RISING TIDE

Sessions 2 and 4 were conducted during rising tide conditions. The average wind speed recorded for session 2 was 10.8 m/s and that for session 4 was 3.9 m/s. The average wind directions were SE for session 2 and SE for session 4.

Near Shore

During session 2, the surface drogue near shore was observed moving in a north westerly direction at a velocity of 9.7 cm/s. The sub-surface drogue travelled in the same direction at an average speed of 8.4 cm/s. The movement of the drogues indicate the nearshore currents appear to be mostly wind driven.

During session 4, the surface drogue near shore was observed moving in a north westerly direction at a velocity of 7.5 cm/s. The sub-surface drogue travelled in the same direction at an average speed of 4.2 cm/s. The nearshore currents appear to be mostly wind driven.

The directions of the nearshore drogues correspond to the wind directions measured by the onshore both the onshore and offshore wind stations, indicating the nearshore currents are predominantly wind driven.

Deep Off Shore

The surface drogues placed outside the reefs in the bay were observed to be moving in a north westerly direction at a speed of 10.7 cm/s during this session. The sub-surface drogue (4m) travelled north westerly at an average velocity of 10.4 cm/s.

The directions of the offshore drogues correspond to the wind directions measured by the onshore wind station, indicating the nearshore currents are predominantly wind driven.

Table 5-6 Summarized drogue tracking session # 2 – Rising tide conducted on August 21st, 2014

Drogue #	Time	Depth of Sail	Notes	Easting	Northing	Location	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion	
6B	12:17	SURFACE	deploy	276516	1979656	ADCP1	92.650	1168	7.932	9.678	297.852	North Westerly
6B	12:37		measurement	276438	1979706		175.514	1771	9.910			
6B	13:06		measurement	276285	1979792		138.293	1607	8.606			
6B	13:33		remove	276159	1979849							
6B	13:36		deploy	276599	1979611		127.094	1202	10.574			
6B	13:56		measurement	276491	1979678		58.310	513	11.366			
6B	14:04		remove	276437	1979700							
5	12:17	2m	deploy	276526	1979658		93.941	1158	8.112	8.408	294.744	North Westerly
5	12:37		measurement	276443	1979702		141.873	1723	8.234			
5	13:06		measurement	276311	1979754		130.920	1609	8.137			
5	13:32		remove	276187	1979796							
5	13:36		deploy	276596	1979607		113.159	1124	10.068			
5	13:55		measurement	276502	1979670		45.541	608	7.490			
5	14:05		remove	276459	1979685							

Table 5-7 Summarized drogue tracking session #4 - Falling tide conducted on August 22nd, 2014

Drogue #	Time	Depth of Sail	Notes	Easting	Northing	Location	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion	
11	14:08	SURFACE	deploy	276508	1979666	ADCP1	84.723	1072	7.903	7.531	347.406	North Westerly
11	14:25		measurement	276491	1979749		69.231	758	9.133			
11	14:38		measurement	276478	1979817		75.710	905	8.366			
11	14:53		measurement	276462	1979891		9.487	201	4.720			
11	14:57		remove	276459	1979900							
5	14:08	2m	deploy	276503	1979675		56.921	1017	5.597	4.274	345.742	North Westerly
5	14:25		measurement	276485	1979729		38.833	815	4.765			
5	14:39		measurement	276477	1979767		45.398	908	5.000			
5	14:54		measurement	276471	1979812		2.236	129	1.733			
5	14:56		remove	276470	1979814							
6B	13:04	SURFACE	deploy	276842	1977985	ADCP2	115.884	745	15.555	10.713	328.831	North Westerly
6B	13:17		measurement	276787	1978087		123.004	912	13.487			

Drogue #	Time	Depth of Sail	Notes	Easting	Northing	Location	Distance Travelled (m)	Time (s)	Speed (cm/s)	Average Speed (cm/s)	Average Direction of Motion	
6B	13:32		measurement	276730	1978196		56.727	848	6.690			
6B	13:46		measurement	276693	1978239		74.632	1048	7.121			
6B	14:03		remove	276650	1978300							
8	13:05	4m	deploy	276855	1977984		46.228	737	6.272	10.379	326.359	North Westerly
8	13:17		measurement	276826	1978020		58.694	933	6.291			
8	13:33		measurement	276784	1978061		61.522	840	7.324			
8	13:47		measurement	276741	1978105		215.188	995	21.627			
8	14:03		remove	276650	1978300							

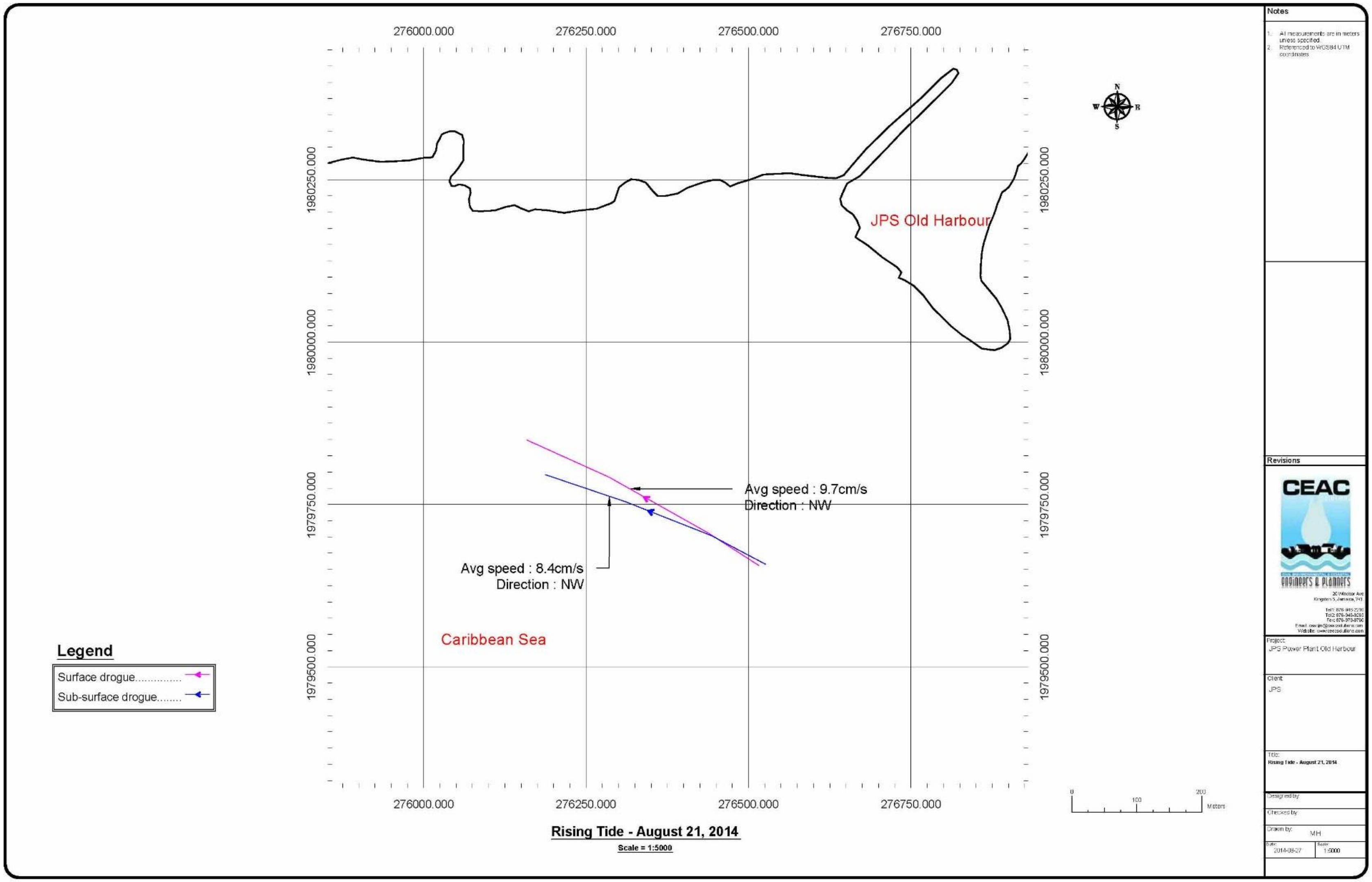


Figure 5-22 Approximate path and direction of the drogues during drogue session #2. Surface drogues are in pink, while sub-surface drogues are in blue.

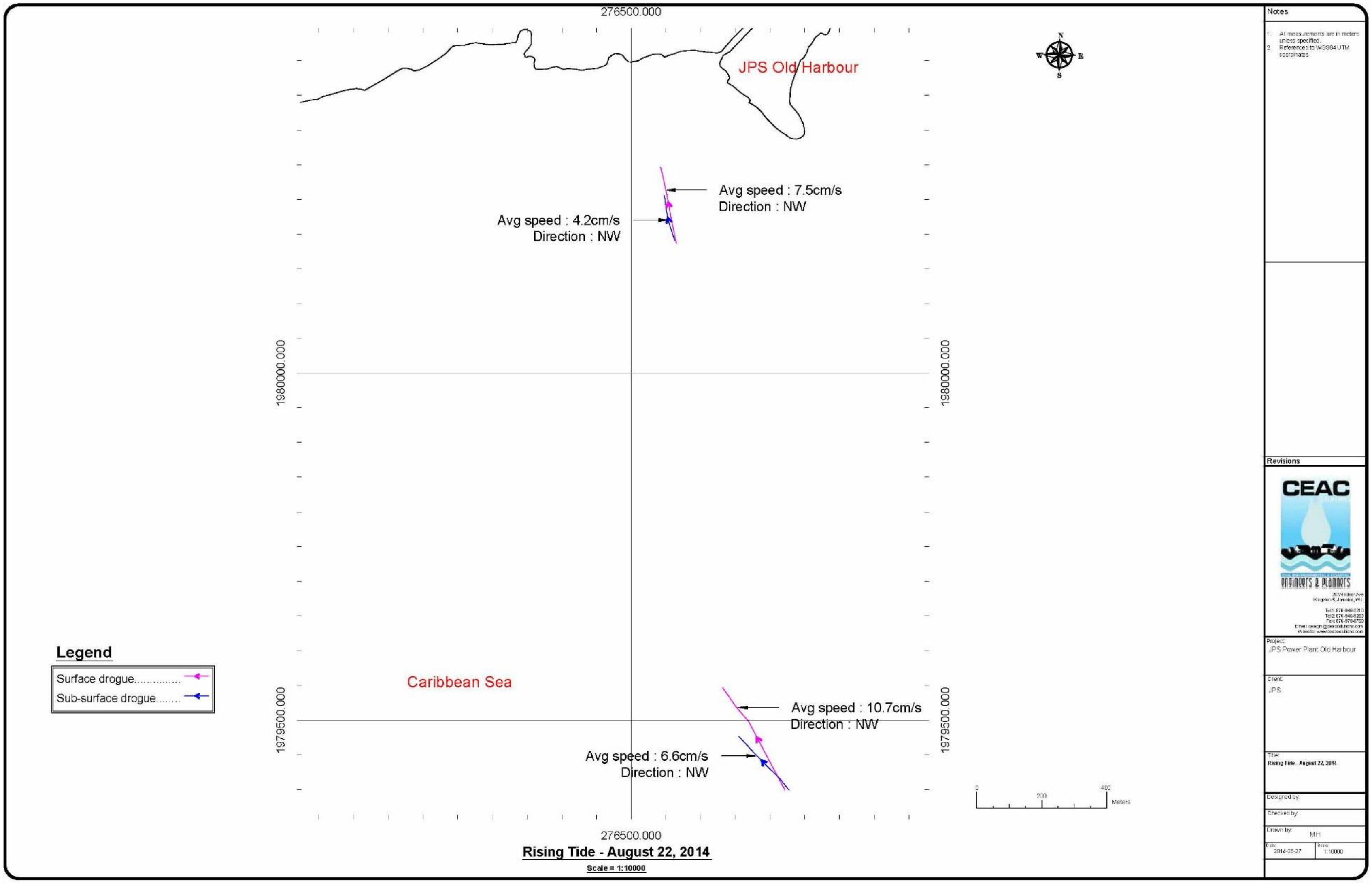


Figure 5-23 Approximate path and direction of the drogues during drogue session #4 Surface drogues are in pink, while sub-surface drogues are in blue.

Summary

The two days of drogue tracking involved four (4) sessions total; two (2) falling tides and two (2) rising tide. The currents in this area appear to be mostly wind driven during the rising and falling tides session. In regards to nearshore, the current speeds varied from 6.6 cm/s to 9.7 cm/s and 3.1 cm/s to 6.5 cm/s for the surface and sub-surface drogues respectively for the falling tides. The current speeds varied from 7.5 cm/s to 9.7 cm/s and 4.3 cm/s to 8.4 cm/s for the surface and sub-surface currents during the rising tides.

Further offshore, the current speeds averaged 10.5 cm/s and 7.1 cm/s for the surface and sub-surface drogues respectively for the falling tides. The speeds during the rising tide averaged 10.7 cm/s and 10.4 cm/s for the surface and sub-surface currents.

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.

5.1.8.2 Moored ADCP Current Survey

Methodology

An 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. Two (2) ADCP devices were deployed (near-shore and off-shore) over a five (5) weeks period from July 14th to August 27th, 2014. Unfortunately, due to interference with the recording instrument, current data for the July 27th to August 8th was lost.

Waves and Tides

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

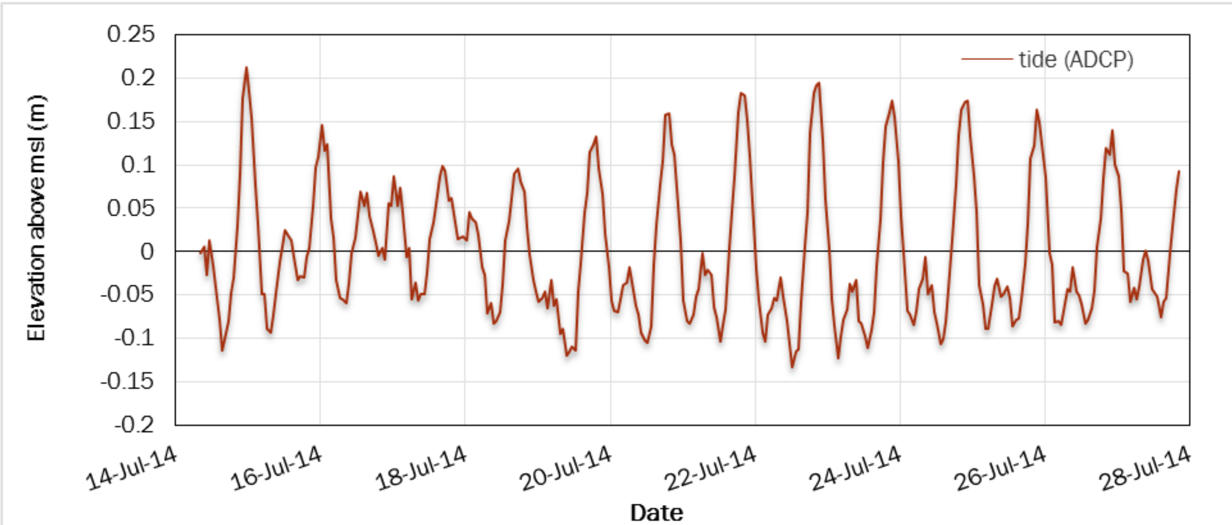


Figure 5-24 Tide signal recorded using the ADCP at location #1 during the period 14th of July to 27th of July, 2014 for project area – outside of reef

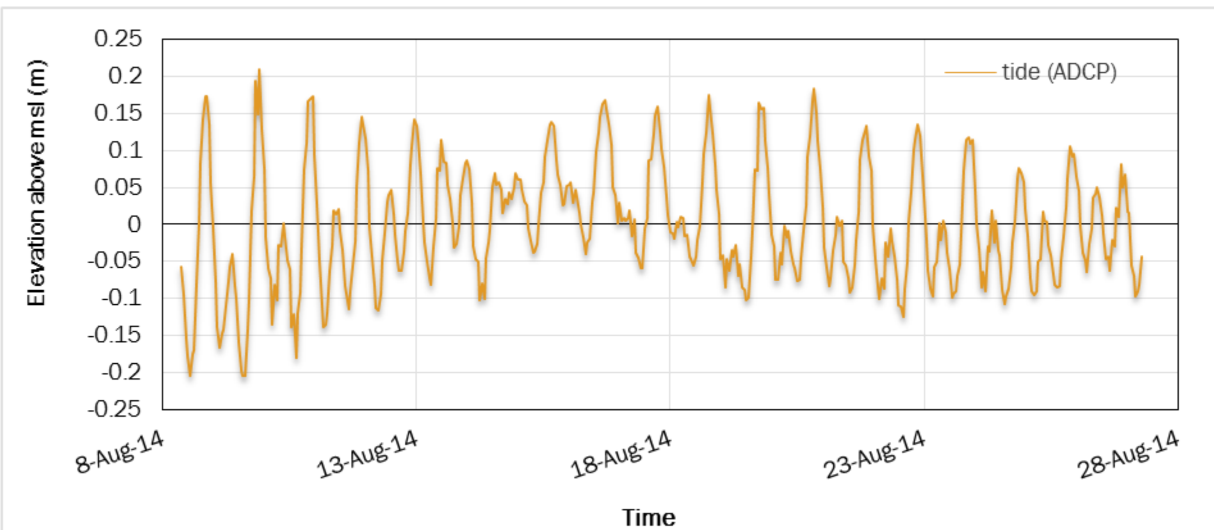


Figure 5-25 Tide signal recorded using the ADCP at location #2 for the period 8th of August to 27th of August, 2014 for project area – outside of reef

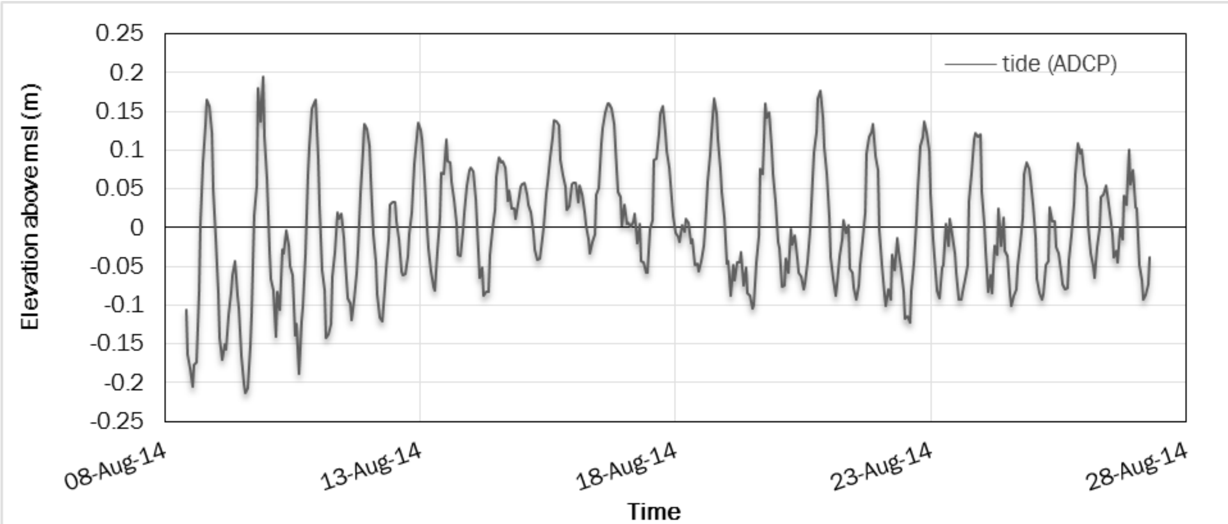


Figure 5-26 Tidal signal recorded during the ADCP deployment #3 for the period 8th of August to 27th of August, 2014 for project area – inside of reef

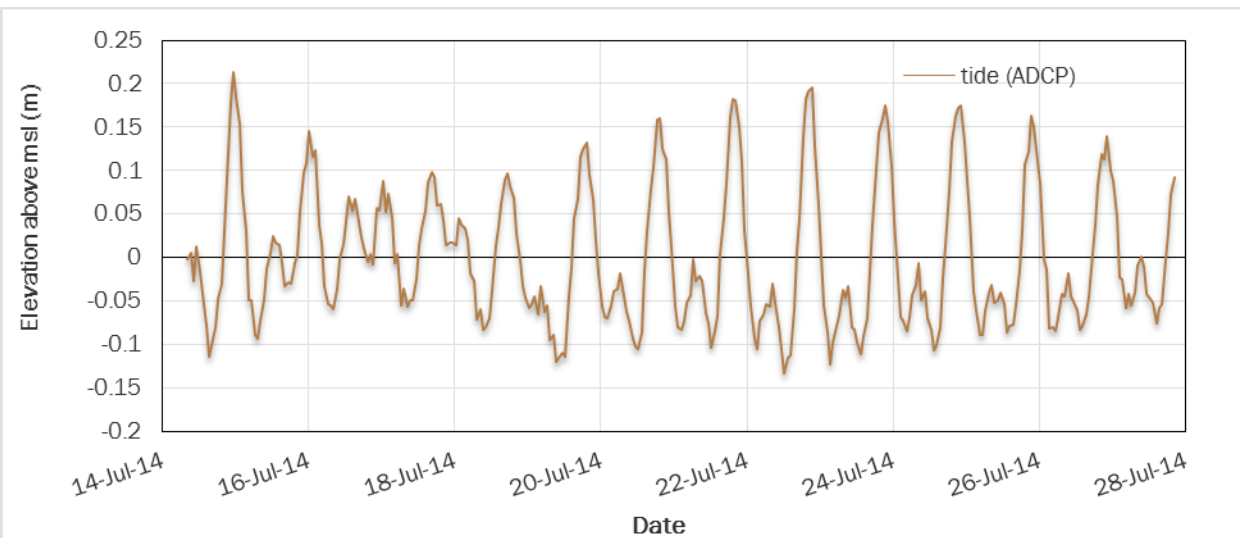


Figure 5-27 Tidal signal recorded during the ADCP deployment #3 for the period 27th of August to 15th of September, 2014 for project area – inside of reef

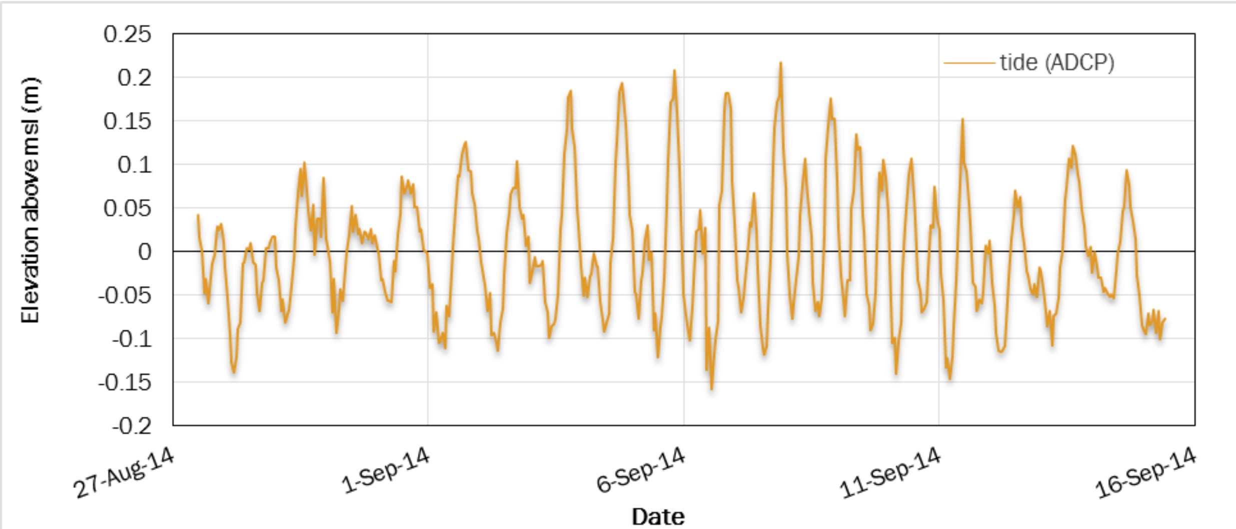


Figure 5-28 Tidal signal recorded during the ADCP deployment #5 for the period 27th of August to 15th of September, 2014 for project area – outside of reef

5.1.8.3 Tidal Harmonics

Tidal variations can be represented by summing a series of harmonic terms. Each harmonic term has the cosine form:

$$H_n \cos(\sigma_n t - g_n)$$

Where:

H_n is amplitude in metres,
g_n is a phase lag in degrees,
σ_n is an angular speed and t is time

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 choosing a combination of R and N that causes 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 5-8 through Table 5-12, 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 5-8 Tidal constituents obtained from the harmonic analysis of the raw ADCP data collected July 14th, 2013 to July 27th, 2014 (outside reef)

Tide Constituent	M2	S2	O1	K1	N2	P1	L2
Speed	12.42	12	25.82	23.93	12.66	24.07	12.19
Phase lag	-1.93	-0.39	0.77	9.67	-1.73	0.87	-2.55
Amplitude	0.049	0.041	0.050	0.164	0.029	0.107	0.010

Table 5-9 Tidal constituents obtained from the harmonic analysis of the raw ADCP data collected August 8th, 2013 to August 27th, 2014 (outside reef)

Tide Constituent	M2	S2	O1	K1	N2	P1	L2
Speed	12.42	12	25.82	23.93	12.66	24.07	12.19
Phase lag	-5.82	-0.12	-3.84	10.71	0.74	2.01	-4.31
Amplitude	0.076	0.022	0.050	0.148	0.023	0.138	0.019

Table 5-10 Tidal constituents obtained from the harmonic analysis of the raw ADCP data collected August 8th, 2013 to August 27th, 2014 (inside reef)

Tide Constituent	M2	S2	O1	K1	N2	P1	L2
Speed	12.42	12	25.82	23.93	12.66	24.07	12.19
Phase lag	-5.28	0.36	2.70	10.95	1.17	-3.99	-3.75
Amplitude	0.078	0.019	0.050	0.135	0.024	0.123	0.021

Table 5-11 Tidal constituents obtained from the harmonic analysis of the raw ADCP data collected August 27th, 2013 to September 15th, 2014 (inside reef)

Tide Constituent	M2	S2	O1	K1	N2	P1	L2
Speed	12.42	12	25.82	23.93	12.66	24.07	12.19
Phase lag	-0.73	1.26	1.18	10.70	-3.59	1.83	-0.46
Amplitude	0.058	0.050	0.050	0.098	0.032	0.049	0.032

Table 5-12 Tidal constituents obtained from the harmonic analysis of the raw ADCP data collected August 27th, 2013 to September 15th, 2014 (outside reef)

Tide Constituent	M2	S2	O1	K1	N2	P1	L2
Speed	12.42	12.00	25.82	23.93	12.66	24.07	12.19
Phase lag	-6.42	1.50	-5.02	10.71	3.22	1.67	-0.36
Amplitude	0.056	0.046	0.050	0.091	0.030	0.036	0.021

Figure 5-29 through Figure 5-33 shows a comparison plot of the predicted versus actual tides recorded. These tides were found to be comparable to the British admiralty tidal Predictions for Port Esquivel.

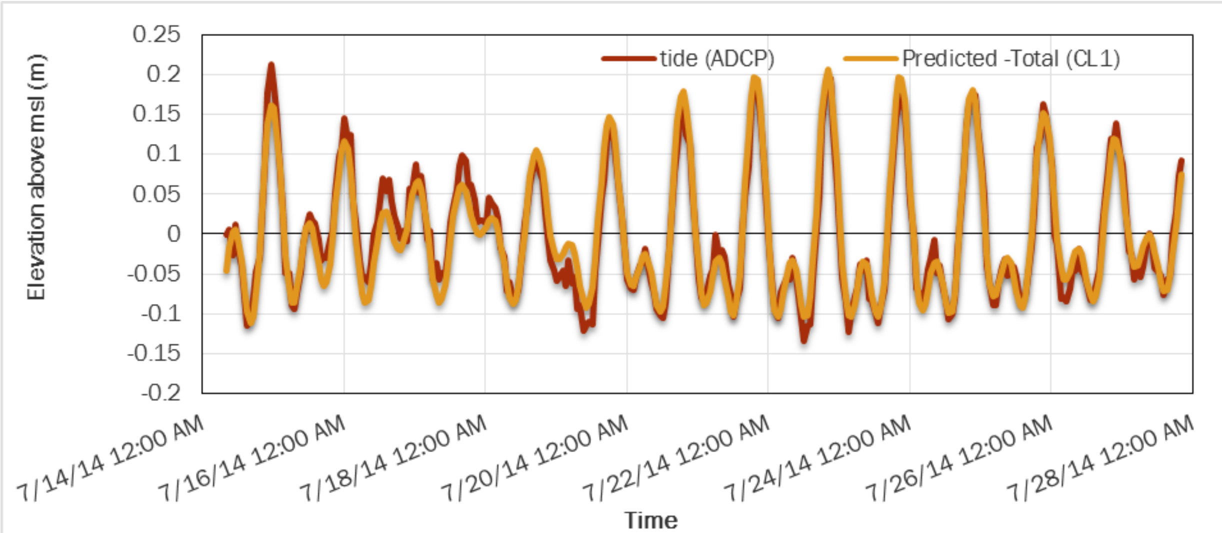


Figure 5-29 Measured and predicted tidal signature for the project area for the period July 14th, 2013 to July 27th, 2014 (outside reef)

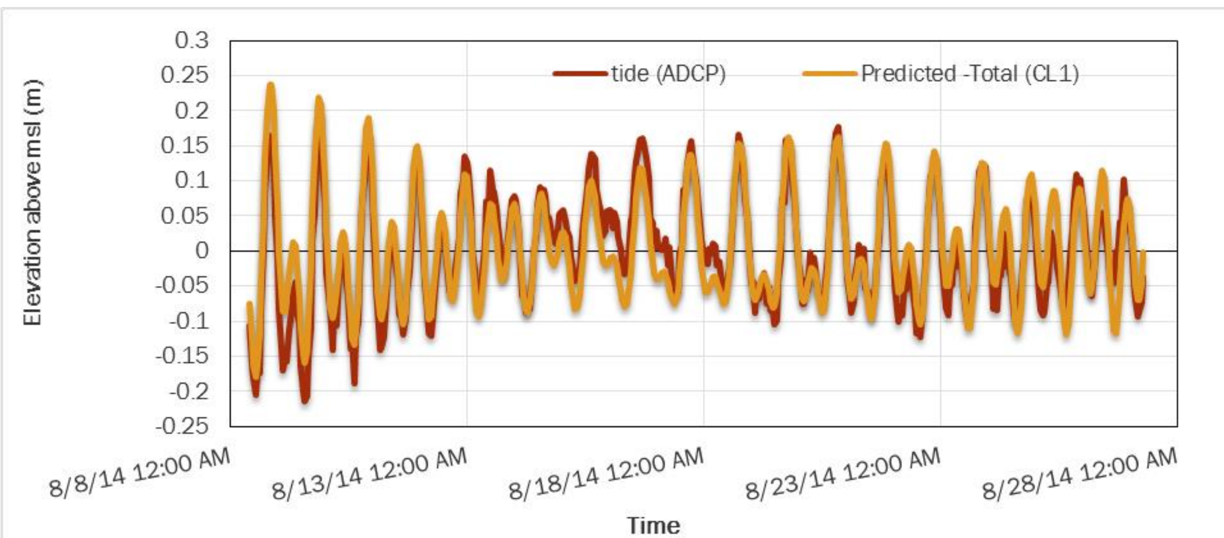


Figure 5-30 Measured and predicted tidal signature for the project area for the period August 8th, 2013 to August 27th, 2014 (outside reef)

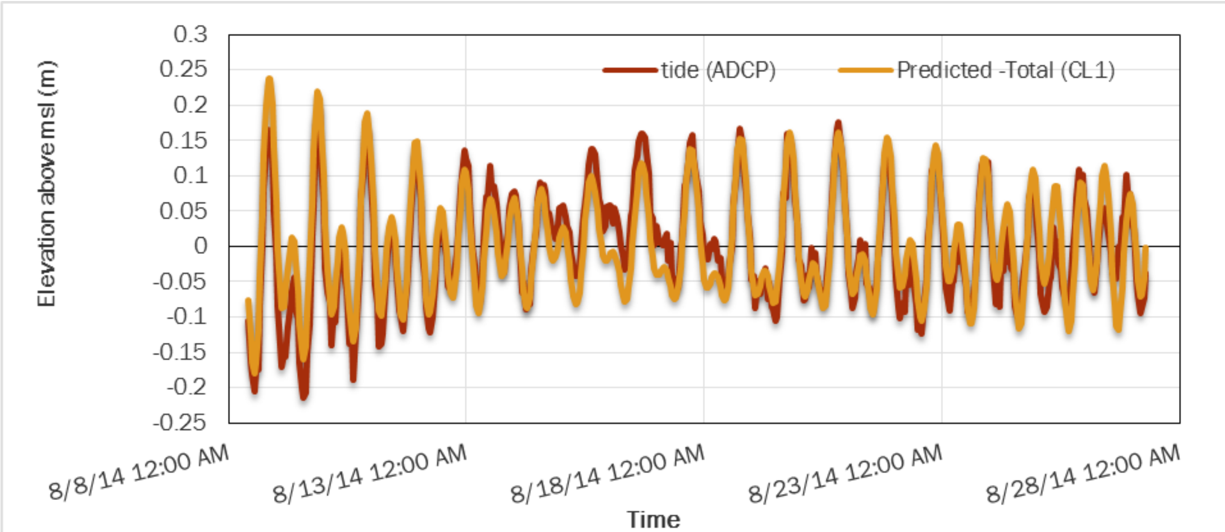


Figure 5-31 Measured and predicted tidal signature for the project area for the period August 8th, 2013 to August 27th, 2014 (inside reef)

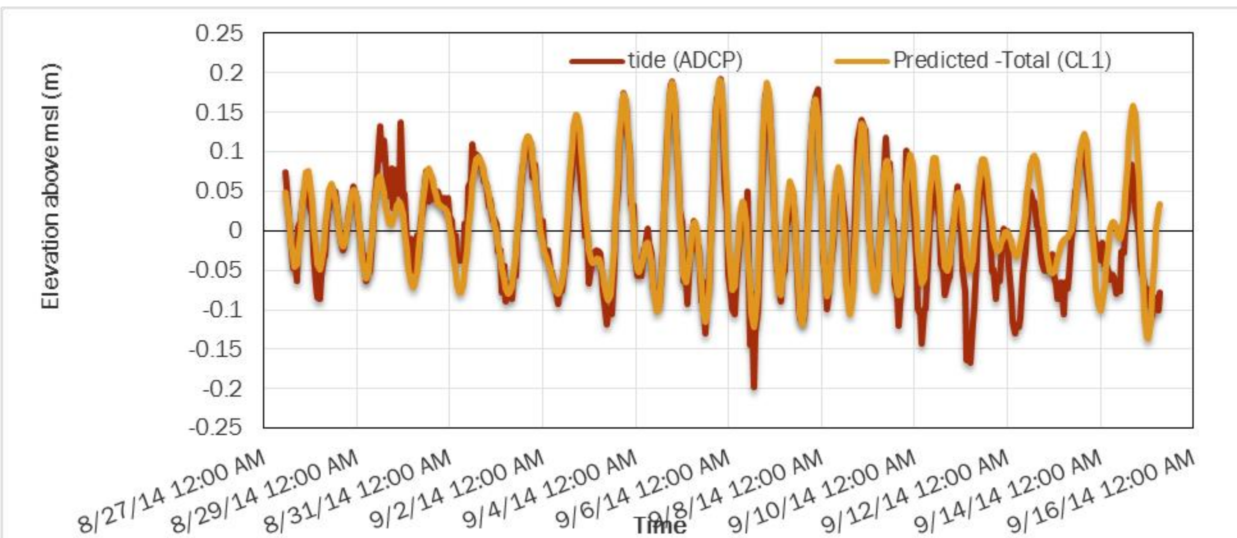


Figure 5-32 Measured and predicted tidal signature for the project area for the period August 27th, 2013 to September 15th, 2014 (inside reef)

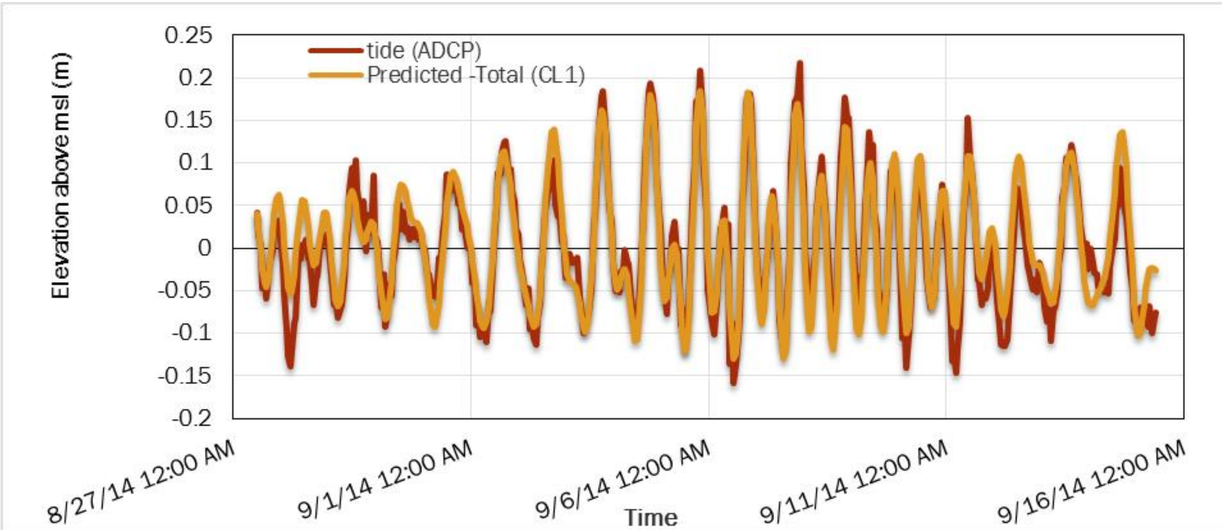


Figure 5-33 Measured and predicted tidal signature for the project area for the period August 27th, 2013 to September 15th, 2014 (outside the reef)

5.1.8.4 Historical Wind Data

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

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

NOAA Climate Service

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 5-34. The data was analysed 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.

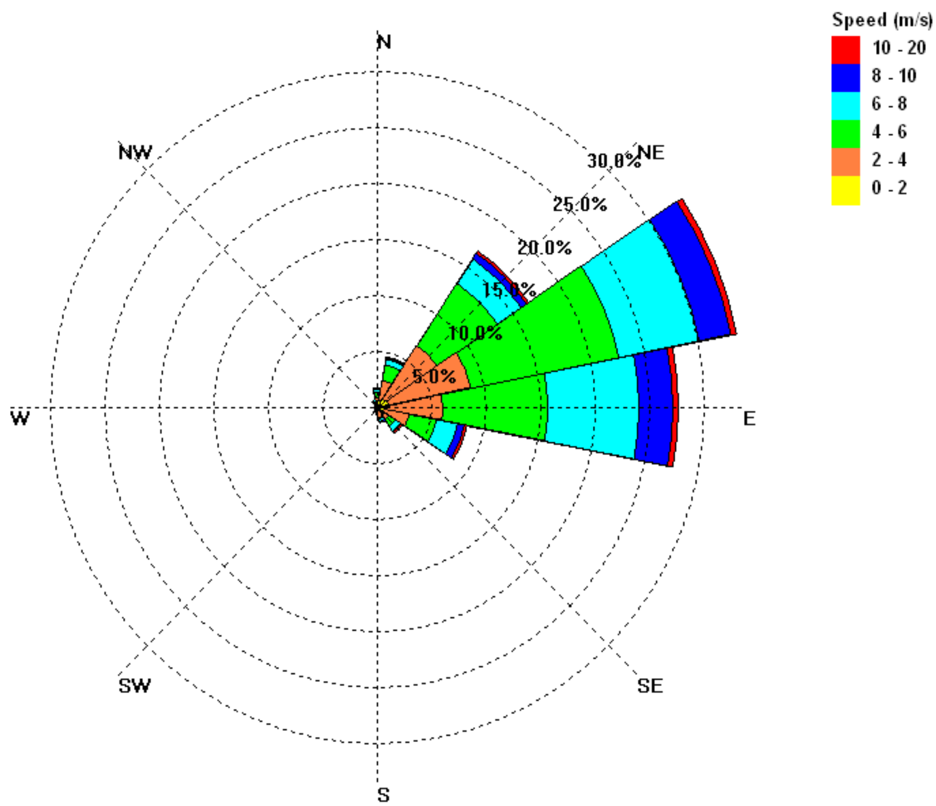


Figure 5-34 Wind Rose of NOAA Wind Data for 1999 - 2007

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.

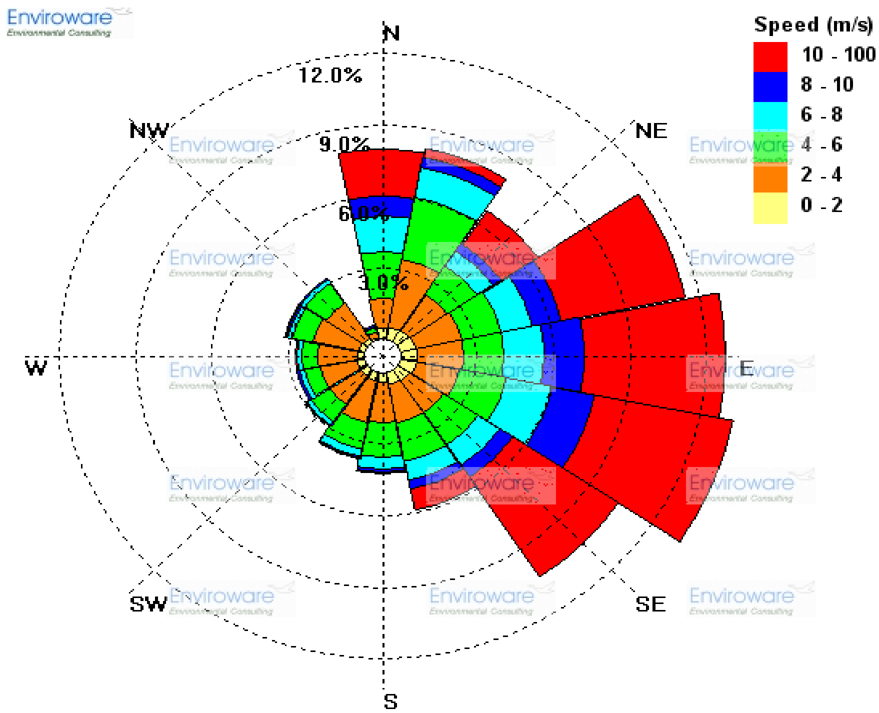


Figure 5-35 Wind Rose of Norman Manley International Airport wind data (2004-2009)

5.1.8.5 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 parameterisation 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 was constructed for the existing configuration of the bay and it extends some 34 kilometres in a southerly direction. The outer deep water areas were gridded with large mesh which gradually decreases on approach to the project area (Figure 5-36) in order to strike a balance between accuracy and modelling speed. The eastern and western boundaries were used as the open boundaries on which tides were applied.

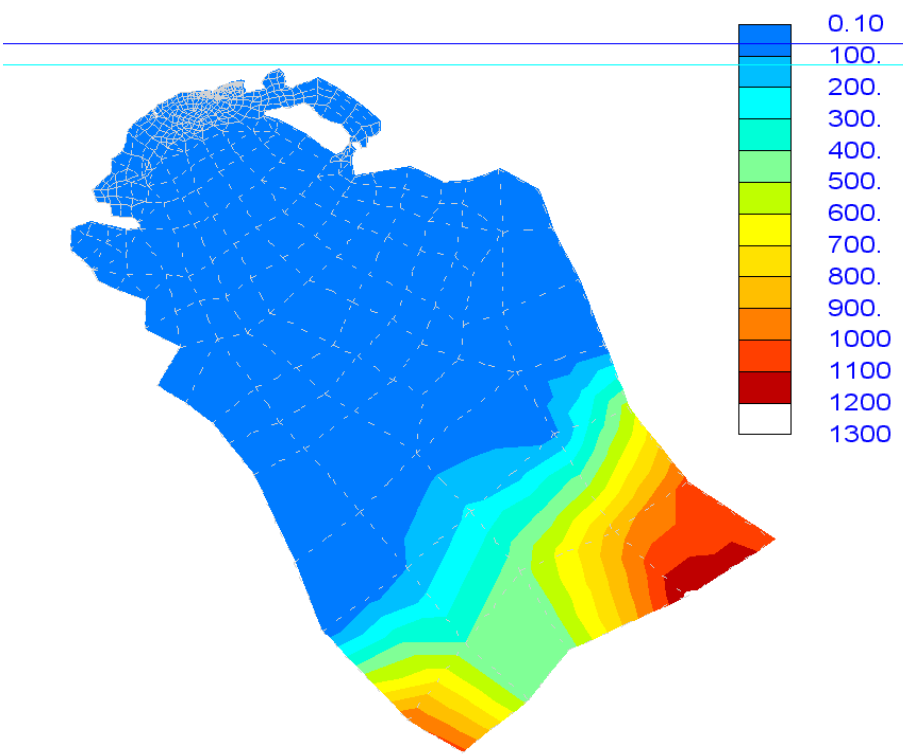


Figure 5-36. Overview of entire Finite Element Mesh (FEM) used for this project showing depth in metres

Model Calibration

The RMA10 model was calibrated and validated on both drogue and new ADCP dataset, 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. See Figure 5-37, Figure 5-38 and Figure 5-39 for the predicted currents.

The predicted current speeds and directions, versus the data from the drogue tracking sessions are summarized in Table 5-13. The model predictions were within the data ranges for the observed occurrences in most instances. The calibration data essentially indicates that there is reasonable agreement between the model and the data.

Table 5-13 Calibration data for FEM for the existing bathymetric configuration based on drogue and wind data for the 2006/06/20

Session	Location	Observations		Model Predictions	
		Speed (cm/sec)	Direction	Speed	Direction
1	Nearshore	9.25	W	9-10	W
	Offshore	12.63	NW	8-9	W
	Deep offshore	14.72	W	6 - 9	SW - NW
2	Nearshore	13.34	W	8-9	W-SW
	Offshore	6.61	NW	6-8	W-SW
	Deep offshore	4.64	N	4-6	W-NW
3	Nearshore	9.52	W	9-11	W-SW
	Offshore	7.46	SW	6-8	SW
	Deep offshore	1.65	SW	9-10	SW

Validation

The model was validated using the ADCP X and Y components of the measured current speeds. The correlations were 0.66 and 0.74 for the Vx and Vy components respectively, when obvious outliers were not considered. The predicted current speeds and directions, versus the data from the ADCP deployments are summarized in Table 5-14 for the correlation coefficient and variance between the predicted and observed currents. The model predictions agreed with the observations in most instances and indicate that the model can be used with confidence.

Table 5-14 Correlation coefficient and bias between the observed (ADCP for October 15 2014 and November 15 2013) and predicted (hydrodynamic model) currents.

Direction (vector)	Vx (m/s)	Vy (m/s)
Correlation (model predictions VS ADCP readings)	0.66	0.74
Variance	0.7%	1.0%
Std. Deviation	0.08	0.10

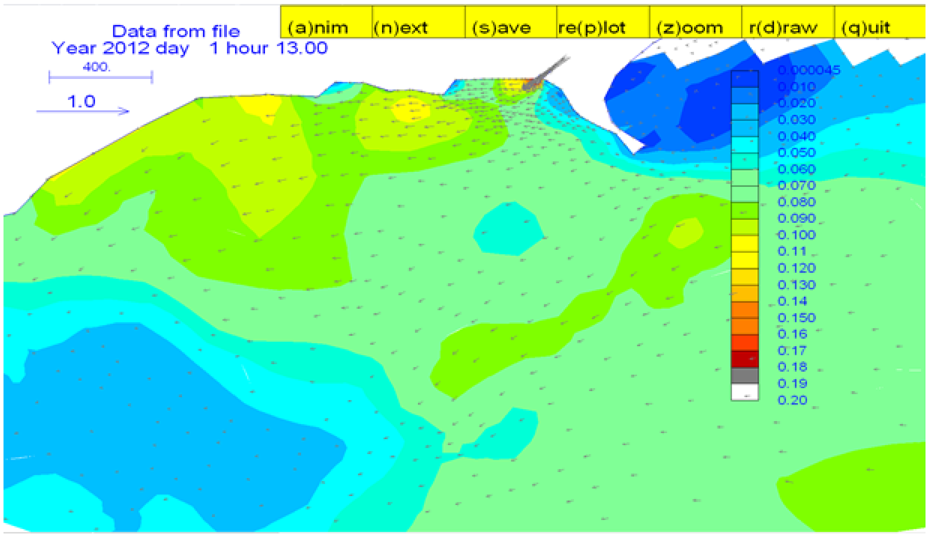


Figure 5-37 Calibration plot of currents (in m/s) for day one corresponding to drogue session 1

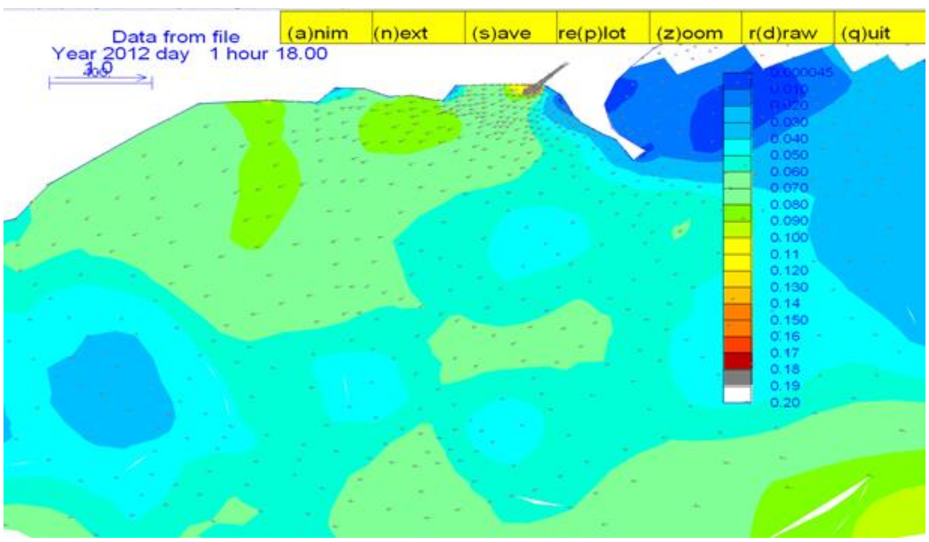


Figure 5-38 Calibration plot of currents (in m/s) for day one corresponding to drogue session 2

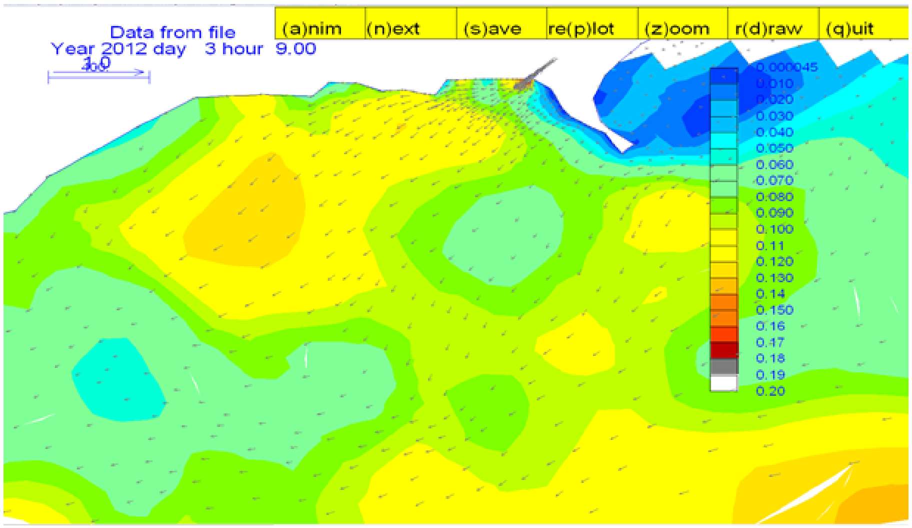


Figure 5-39 Calibration plot of currents (in m/s) for day one corresponding to drogue session 3

Operational Wind Results

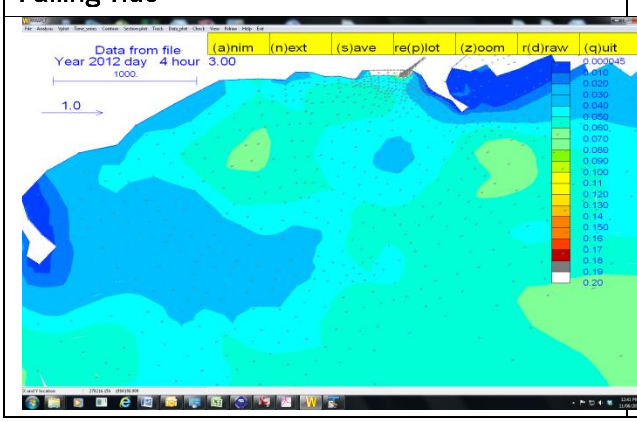
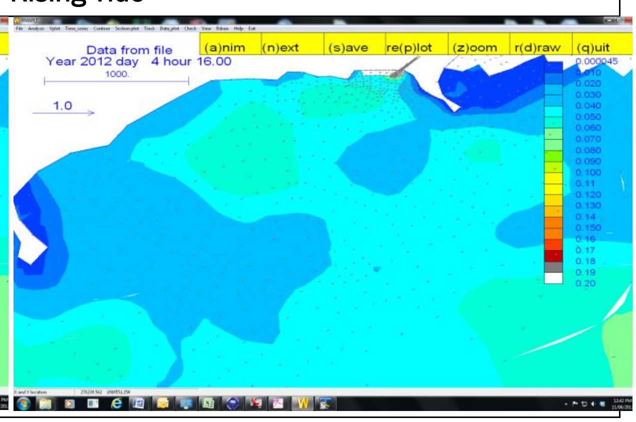
The operational wind speed and direction scenarios investigated are shown in Table 5-15.

Table 5-15 Summary of wind speeds and directions investigated

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

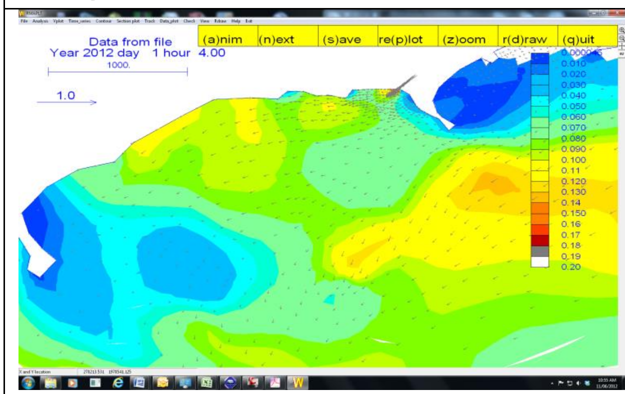
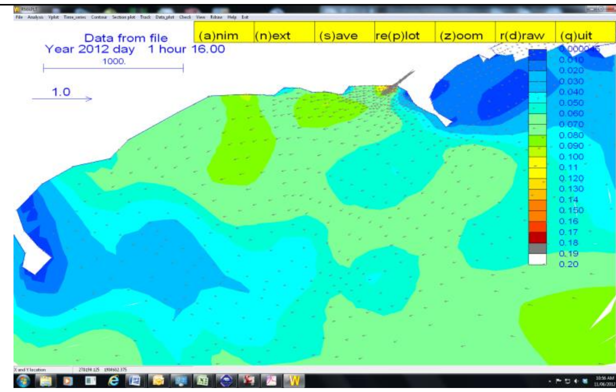
Surface current predictions for the slow wind speed meteorological conditions indicate that current velocities below 6 cm/sec can be expected within the bay. The current directions are predominantly towards the west which indicates the surface currents are predominantly wind driven. See Table 5-16.

Table 5-16 Falling Tide and Rising Tide – Slow Wind Conditions

Falling Tide	Rising Tide
	

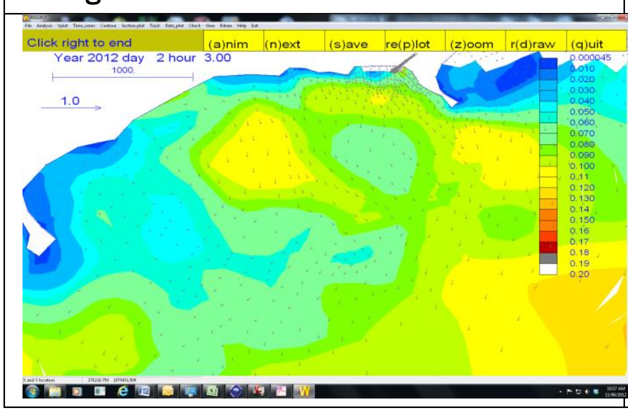
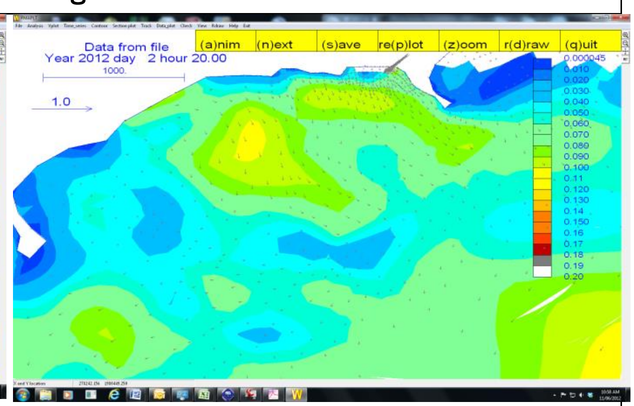
Surface current predictions for the average wind speed meteorological conditions for the existing shoreline configuration indicate that current velocities below 13 cm/sec for falling tides and 10 cm/sec for rising tides can be expected within the bay. The current directions are predominantly towards the west which indicates the surface currents are predominantly wind driven. See Table 5-17.

Table 5-17 Falling Tide and Rising Tide – Average Wind Conditions

Falling Tide	Rising Tide
	

Surface current predictions for the fast wind speed meteorological conditions for the existing shoreline configuration indicate that current velocities below 13 cm/sec for falling and rising tides can be expected within the bay. The currents are driven by the winds and tides. See Table 5-18.

Table 5-18 Falling Tide and Rising Tide – Fast Wind Conditions

Falling Tide	Rising Tide
	

5.1.9 Water Quality

5.1.9.1 Introduction

This section of the EIA report entails the results derived from water quality surveys conducted on July 9, July 22 and August 7, 2014. The water quality sampling stations are the same as those sampled in the 2012 SJPC 360MW Environmental Impact Assessment by C.L. Environmental.

5.1.9.2 Methodology

Three water quality sampling exercises were conducted on July 9, July 22 and August 7, 2014. Weather conditions were fair and sunny on all sampling events. Physical data (temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, and total dissolved solids - TDS) was collected *in situ* at identified aquatic locations within the project environs and potable water location, using a Hydrolab MiniSonde MS-5 meter (Appendix 5). 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) aquatic 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 5-19 and depicted in Figure 5-40.

Table 5-19 Water quality stations coordinates in JAD 2001

STATION NUMBER	JAD 2001	
	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

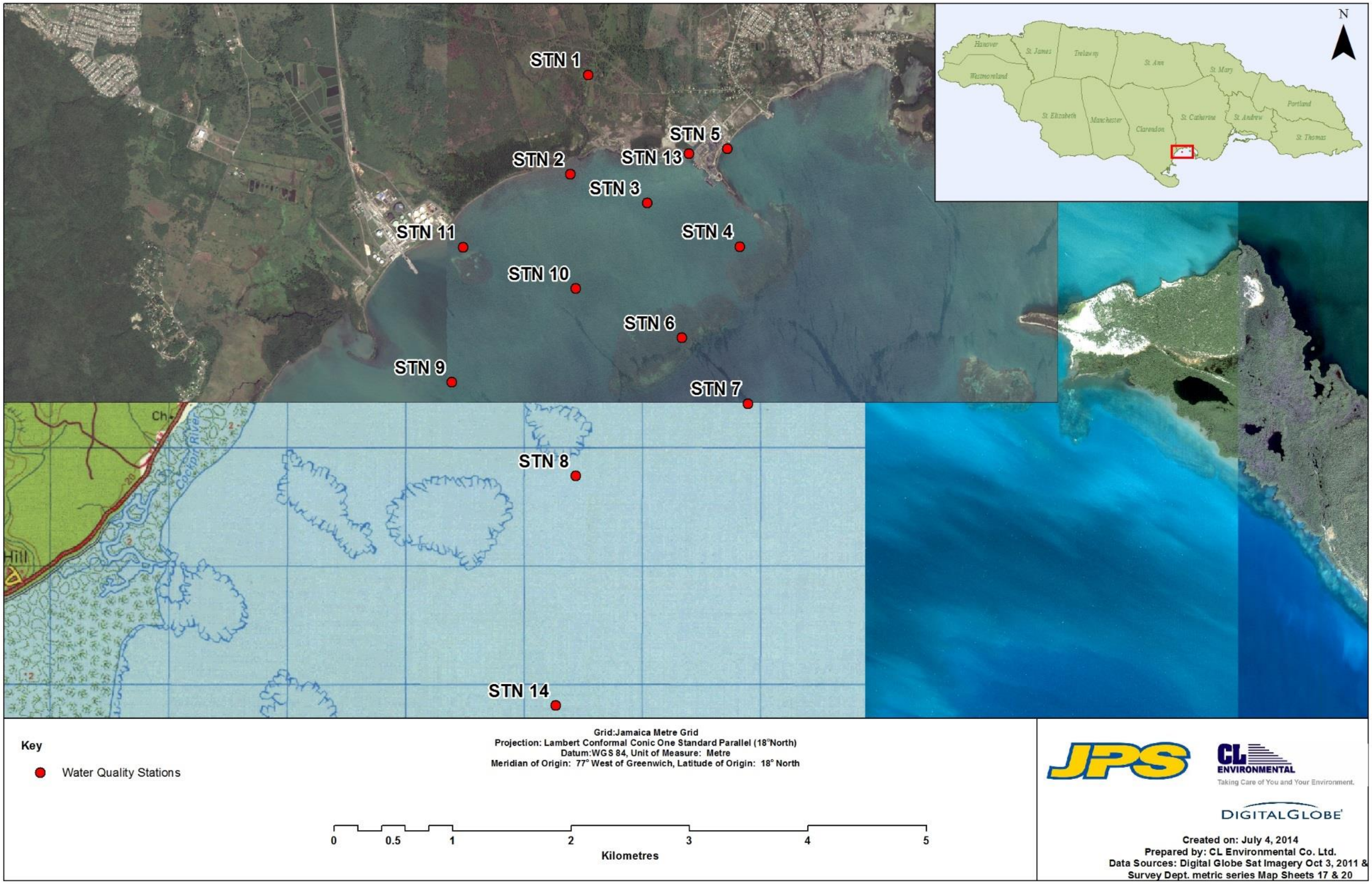


Figure 5-40 Map showing water quality sampling locations

The parameters analysed for the aquatic 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 water quality stations were accurately mapped using a Trimble® Geo XT GPS unit(s) allowing for spatial interpolation of the data (Temperature, conductivity and salinity).

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

5.1.9.3 Results

Table 5-20 shows the average physicochemical water quality data for each station while Table 5-21 shows the average biochemical data. Table 5-22 shows the minimum and maximum values for the biochemical water quality parameters.

Table 5-20 Mean Physicochemical water quality values

Stn.	Depth (m)	Temp. (°C)	Cond. (mS/cm)	Sal. (ppt)	pH	PAR (uE/m²/s)	D.O. (mg/l)	Turb (NTU)	TDS (g/l)
JWQ 1	0	29.82	59.05	39.56	7.92	-	4.74	23.03	37.81
JWQ 2	0	29.83	55.61	36.95	8.27	741.7	5.27	17.80	35.56
	1	29.91	55.54	36.93	8.26	689.3	5.23	19.43	35.55
JWQ 3	0	29.99	55.25	36.35	8.31	916.0	6.13	5.83	35.36
	1	29.81	55.25	36.70	8.31	636.3	6.12	5.90	35.35
	2	29.53	55.29	36.74	8.31	572.7	6.12	6.23	35.40
	3	29.40	55.29	36.75	8.31	362.0	6.08	6.50	35.39
	4	29.34	55.28	36.74	8.30	212.0	6.08	6.50	35.39
	5	29.35	55.40	36.82	8.29	137.0	5.77	9.43	35.46
JWQ 4	0	29.14	55.12	36.60	8.31	557.0	5.91	3.77	35.27
	1	29.14	55.13	36.60	8.31	410.7	5.91	3.77	35.28
	2	29.14	55.13	36.62	8.30	278.7	5.86	4.07	35.28
	3	29.15	55.19	36.63	8.30	242.7	5.83	4.27	35.30
	4	29.15	55.17	36.64	8.30	175.7	5.83	4.57	35.30
	5	29.24	55.39	36.81	8.27	117.0	5.36	11.70	35.46
JWQ 5	0	29.07	55.16	36.64	8.31	574.3	6.20	10.70	35.32
	1	29.08	55.20	36.66	8.31	383.0	6.20	10.30	35.33
	2	29.08	55.24	36.69	8.31	236.3	6.15	9.47	35.36
	3	29.40	55.27	36.73	8.31	41.5	6.16	14.10	35.38
JWQ 6	0	29.22	55.03	36.55	8.30	270.3	5.61	3.20	35.23
	1	29.23	55.05	36.56	8.30	231.3	5.57	3.30	35.24
	2	29.23	55.06	36.57	8.30	174.7	5.56	3.50	35.25

Stn.	Depth (m)	Temp. (°C)	Cond. (mS/cm)	Sal. (ppt)	pH	PAR (uE/m²/s)	D.O. (mg/l)	Turb (NTU)	TDS (g/l)
JWQ 7	0	29.20	54.94	36.48	8.33	219.0	6.21	4.23	35.17
	1	29.21	54.95	36.49	8.33	204.3	6.23	8.50	35.18
	2	29.21	54.96	36.50	8.33	159.0	6.24	7.87	35.18
	3	29.22	54.99	36.51	8.32	129.7	6.24	5.43	35.19
	4	29.21	54.99	36.51	8.32	115.3	6.23	4.87	35.20
	5	29.22	55.00	36.51	8.32	91.3	6.23	4.60	35.19
	6	29.22	55.00	36.52	8.32	70.3	6.23	4.47	35.21
	7	29.22	55.00	36.52	8.32	51.7	6.22	4.67	35.20
	8	29.23	55.02	36.53	8.32	37.3	6.22	4.70	35.22
	9	29.24	55.05	36.57	8.32	27.3	6.18	4.97	35.23
	10	29.31	55.29	36.73	8.30	21.0	6.00	5.77	35.30
	11	29.34	55.32	36.76	8.30	15.3	5.85	10.03	35.41
JWQ 8	0	29.28	54.97	36.67	8.34	299.0	6.21	8.90	35.19
	1	29.20	54.98	36.43	8.32	251.3	5.89	8.23	35.19
	2	29.20	54.98	36.49	8.31	164.7	5.86	8.40	35.19
	3	29.21	55.00	36.52	8.31	126.3	5.91	8.03	35.20
	4	29.23	55.03	36.54	8.32	104.3	6.04	7.17	35.22
	5	29.23	55.03	36.54	8.32	83.3	6.07	6.97	35.22
	6	29.23	55.03	36.54	8.32	55.0	6.10	6.50	35.22
	7	29.24	55.03	36.55	8.32	56.3	6.12	6.40	35.22
JWQ 9	0	29.73	55.17	36.64	8.34	384.0	6.22	6.87	35.31
	1	29.74	55.19	36.66	8.34	325.7	6.20	6.40	35.31
	2	29.74	55.19	36.66	8.33	268.3	6.20	6.23	35.32
	3	29.76	55.21	36.68	8.33	187.0	6.18	6.47	35.33
	4	29.77	55.21	36.68	8.33	115.0	6.19	6.67	35.33
	5	29.78	55.23	36.69	8.32	88.3	6.13	6.83	35.35
	6	29.76	55.26	36.71	8.31	54.3	5.98	8.83	35.36
JWQ 10	0	29.55	55.33	36.76	8.33	883.3	6.20	5.50	35.40
	1	29.55	55.32	36.76	8.33	667.3	6.18	5.73	35.41
	2	29.51	55.30	36.64	8.33	335.7	6.19	5.87	35.39
	3	29.49	55.29	36.74	8.33	224.7	6.17	5.97	35.39
	4	29.49	55.29	36.74	8.32	141.3	6.18	6.03	35.38
	5	29.45	55.29	36.73	8.32	87.3	6.14	6.27	35.38
	6	29.43	55.28	36.72	8.32	57.0	6.13	6.70	35.37
	7	29.43	55.27	36.73	8.31	53.0	6.07	9.17	35.37
JWQ 11	0	29.82	55.31	36.87	8.33	722.0	6.06	6.43	35.39
	1	29.84	55.31	36.85	8.32	527.3	6.03	8.87	35.40
	2	29.85	55.32	36.75	8.32	330.0	6.01	8.47	35.41
	3	30.12	55.39	36.82	8.31	285.5	5.83	11.00	35.45

Stn.	Depth (m)	Temp. (°C)	Cond. (mS/cm)	Sal. (ppt)	pH	PAR (uE/m²/s)	D.O. (mg/l)	Turb (NTU)	TDS (g/l)
JWQ 13	0	37.35	55.05	36.60	8.25	1156.0	5.94	7.37	35.06
	1	36.04	54.91	36.43	8.23	632.0	5.91	10.60	35.09
	2	36.25	55.12	36.59	8.19	957.0	6.14	18.90	35.25
JWQ 14	0	29.23	54.94	36.47	8.34	424.7	6.34	4.53	35.16
	1	29.23	54.95	36.48	8.34	360.3	6.30	4.33	35.17
	2	29.23	54.94	36.48	8.34	247.3	6.34	4.13	35.16
	3	29.24	54.95	36.31	8.33	227.7	6.35	4.23	35.17
	4	29.24	54.95	36.49	8.33	192.0	6.35	4.30	35.17
	5	29.24	54.95	36.48	8.33	126.7	6.34	4.30	35.17
	6	29.24	54.95	36.48	8.33	108.3	6.35	4.40	35.17
	7	29.24	54.96	36.49	8.33	87.0	6.36	4.70	35.18
	8	29.23	54.97	36.49	8.33	58.7	6.34	4.97	35.18
	9	29.21	54.97	36.53	8.33	42.0	6.33	4.93	35.19
	10	29.20	54.98	36.50	8.32	32.3	6.32	4.90	35.19
	13	29.24	55.04	36.56	8.31	11.0	6.16	9.30	35.23

Table 5-21 Mean biochemical water quality values

Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	Faecal Coliform (mpn/100ml)	DRO (mg/l)	GRO (mg/l)
JWQ 1	2.33	39.33	0.90	1.14	2.67	103.33	ND	ND
JWQ 2	2.00	19.00	1.00	0.88	2.67	10.00	ND	ND
JWQ 3	2.33	5.00	2.03	0.81	3.33	10.00	ND	ND
JWQ 4	1.67	7.00	1.23	2.11	2.67	10.00	ND	ND
JWQ 5	2.00	6.67	1.40	0.63	3.00	97.33	ND	ND
JWQ 6	2.33	5.00	1.87	2.06	2.67	83.33	ND	ND
JWQ 7	4.00	8.33	2.03	1.21	4.67	60.00	ND	ND
JWQ 8	1.33	4.67	1.60	2.00	3.33	10.00	ND	ND
JWQ 9	1.00	8.33	1.83	0.51	2.33	87.33	ND	ND
JWQ 10	2.67	5.67	1.10	0.47	1.67	46.67	ND	ND
JWQ 11	3.33	10.00	1.10	0.31	2.67	18.67	ND	ND
JWQ 13	1.67	7.33	2.07	2.48	2.33	18.67	ND	ND
JWQ 14	2.67	6.33	1.57	1.34	2.00	10.00	ND	ND

Table 5-22 Range of values (minimum and maximum) for biochemical parameters

Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	Faecal Coliform (mpn/100ml)
JWQ 1	0-4	35-46	0.5-1.2	0.16-2.2	2-3	<11-231
JWQ 2	1-3	3-39	0.4-1.4	0.12-1.27	2-3	<11
JWQ 3	2-3	4-6	1.7-2.3	0.13-1.56	2-4	<11

Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	Faecal Coliform (mpn/100ml)
JWQ 4	0-3	2-12	0.9-1.6	0.17-3.9	1-5	<11
JWQ 5	2	5-8	1.2-1.6	0.05-1.06	2-4	<11-231
JWQ 6	0-4	4-6	1.2-2.6	0.09-4.8	2-3	<11
JWQ 7	1-6	4-17	1.4-3.2	0.08-2.2	3-7	<11-160
JWQ 8	1-2	2-9	0.9-2.2	0.23-4	2-4	<11
JWQ 9	1	7-10	1.6-2.3	0.12-0.73	1-3	<11-230
JWQ 10	2-3	3-10	0.4-1.9	0.05-1.14	1-2	<11-120
JWQ 11	1-5	7-16	0.7-1.5	0.07-0.74	1-5	<11-36
JWQ 13	1-3	4-11	1.5-3.2	0.25-5.9	1-3	<11-36
JWQ 14	1-3	6-7	1.3-2	0.13-2.8	2	<11

Temperature

Average temperature values ranged from 29.07 – 37.35°C across the stations. The highest temperature value was reported at station JWQ13 (by the JPS cooling water outlet) and the lowest temperature was at station JWQ5. Compared to depth, the temperature at each station (excepting for station 13) varied little (Figure 5-41). Figure 5-42 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.

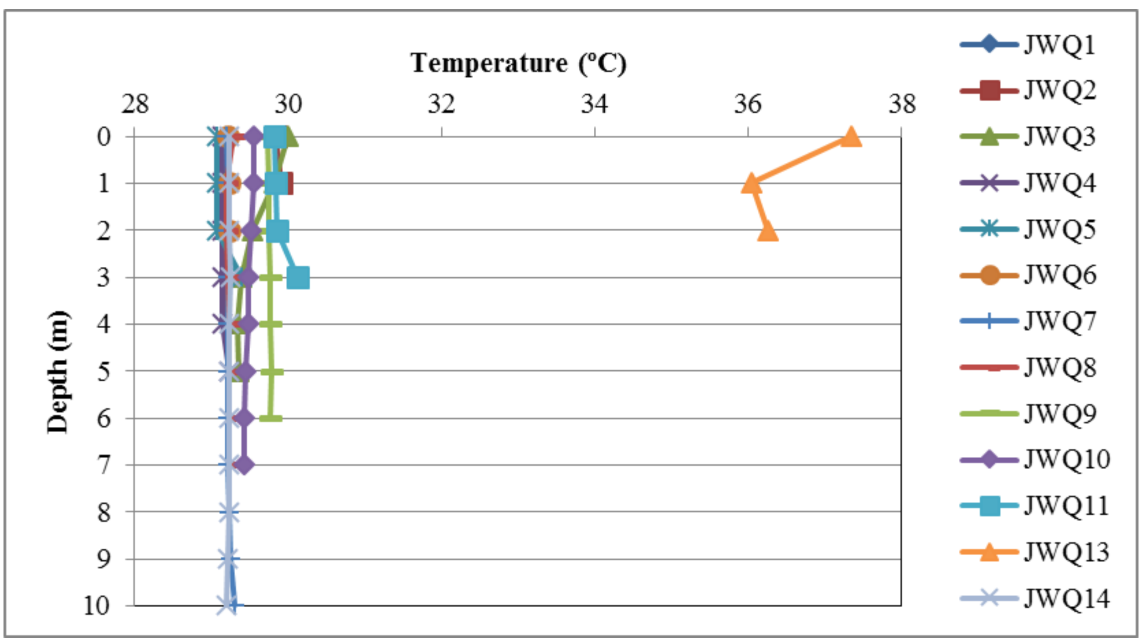


Figure 5-41 Temperature values at the various stations

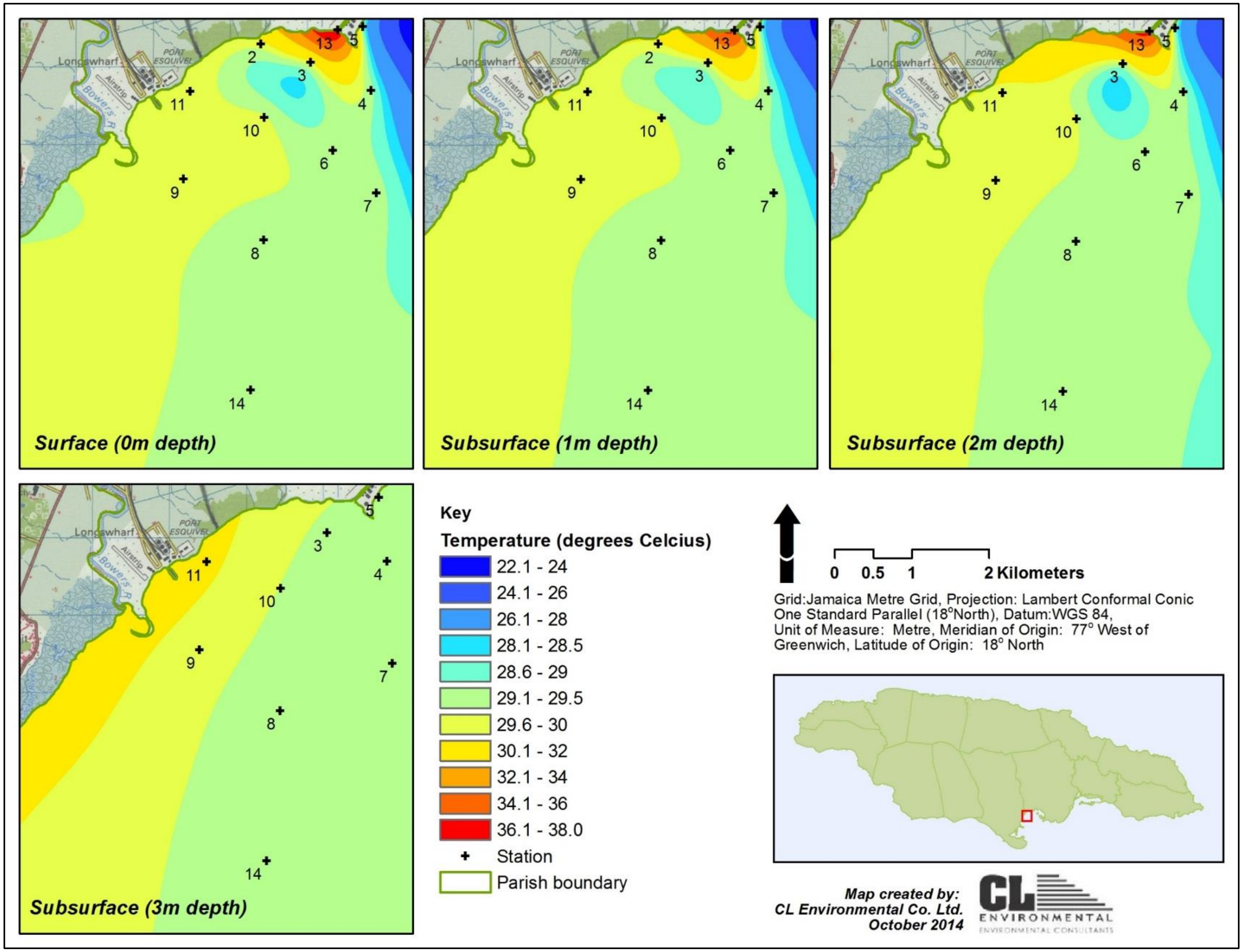


Figure 5-42 Spatial temperature comparison for 0m, 1m, 2m and 3m depths

Specific Conductivity (SpC)

Average specific conductivity values ranged from 54.91 – 59.05mS/cm across the stations. The lowest values were reported at station JWQ13 while station JWQ1 had the highest value. JWQ1 is located within the Bowers Gully. 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. When compared to depth, the values at each station varied little (except for Station 1) (Figure 5-43). Figure 5-44 shows the spatial conductivity comparison in contour form for depths of 0m, 1m, 2m and 3m. It clearly shows that the source of higher conductivity/salinity water (at the time of sampling) is from the Bowers Gully and gradually spreads outwards in a south southeasterly direction into and throughout the bay. 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 5-44 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.

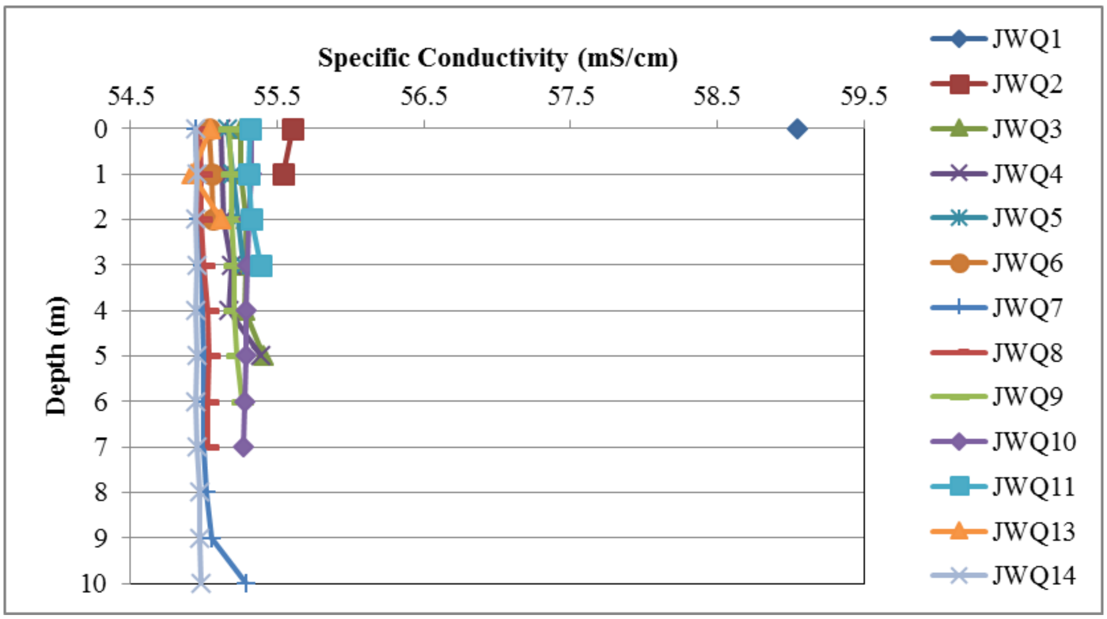


Figure 5-43 Conductivity values at the various stations

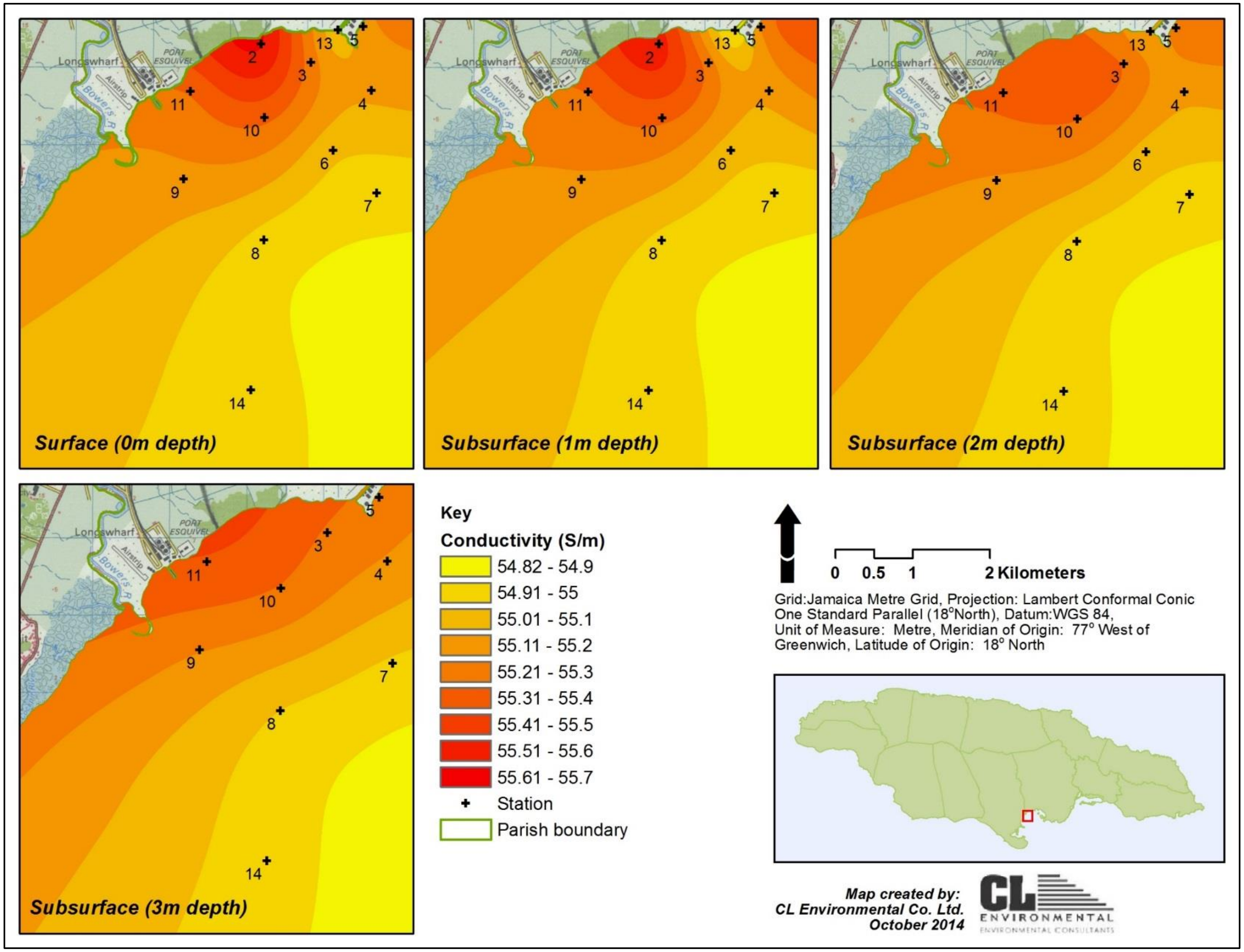


Figure 5-44 Spatial conductivity comparison for 0m, 1m, 2m and 3m depths

Salinity

Average salinity values ranged from 36.31 – 39.56ppt across the stations. The lowest values were reported at station JWQ14 while station JWQ1 had the highest value. JWQ1 is located within the Bowers Gully. This extreme salinity within the gully could be a combination of salt water intrusion from the sea and drought conditions throughout the island during the sampling period. When compared to depth, the values at each station varied little (except for Station 1) (Figure 5-45). Figure 5-46 shows the spatial salinity comparison in contour form for depths of 0m, 1m, 2m and 3m. It clearly shows that the source of more saline water (at the time of sampling) is from the Bowers Gully and gradually spreads outwards in a south southeasterly direction into and throughout the bay. 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 5-46 also shows a source of lower salinity water to be the JPS cooling water outlet (Station 13) compared to the salinity at Station 2.

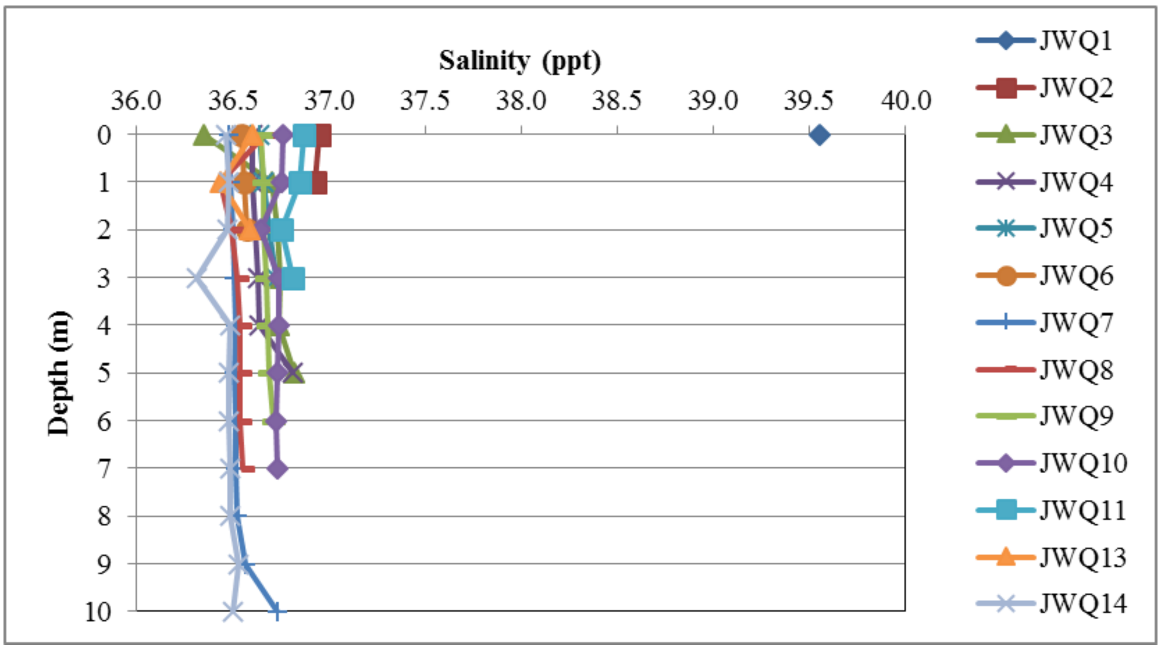


Figure 5-45 Salinity values at the various stations

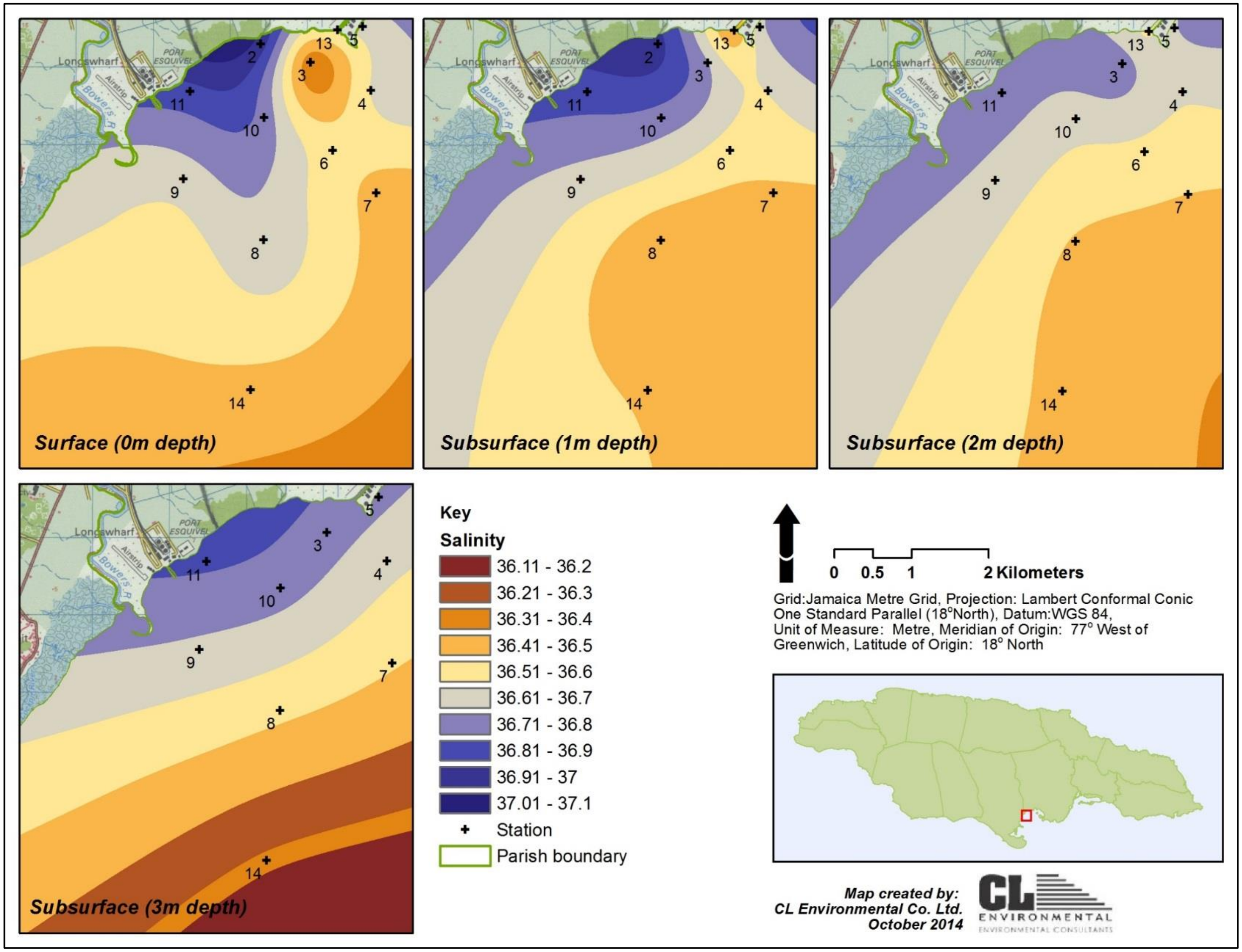


Figure 5-46 Spatial salinity comparison for 0m, 1m, 2m and 3m depths

pH

Average pH values ranged from 7.92 – 8.34 across the stations. The highest pH value was reported at stations JWQ9 and JWQ14 and the lowest pH was reported at station JWQ1. When compared to depth the pH values at each station showed little variation. All stations were within the NEPA Standard for Seawater of 8.0 – 8.4 for pH, excepting for Station JWQ1 located in the Bowers Gully (Figure 5-47).

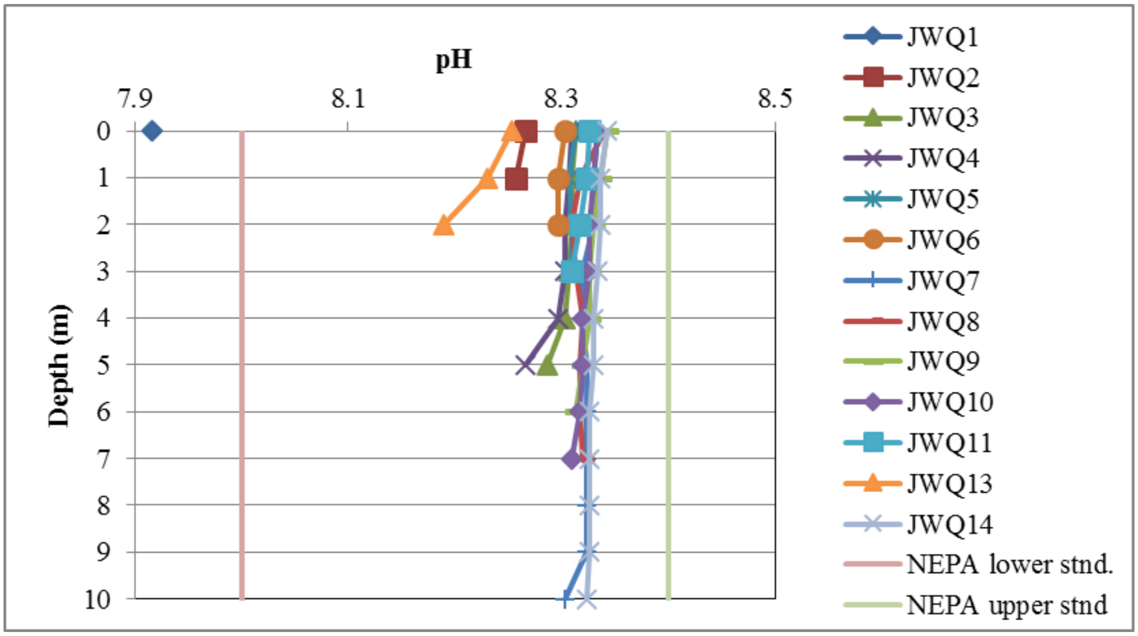


Figure 5-47 pH values at the various stations

Dissolved Oxygen (DO)

Dissolved oxygen values ranged from 4.74 – 6.36mg/l across the stations. The highest value was observed at station JWQ14, 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 JWQ1 as this station is located in the Bowers Gully. When compared to depth, the D.O. levels showed a slight decrease across the stations with a few stations showing a slight increase. Average D.O. values at all locations (except for Station JWQ1) were above the NEPA standard of 5 mg/l (Figure 5-48).

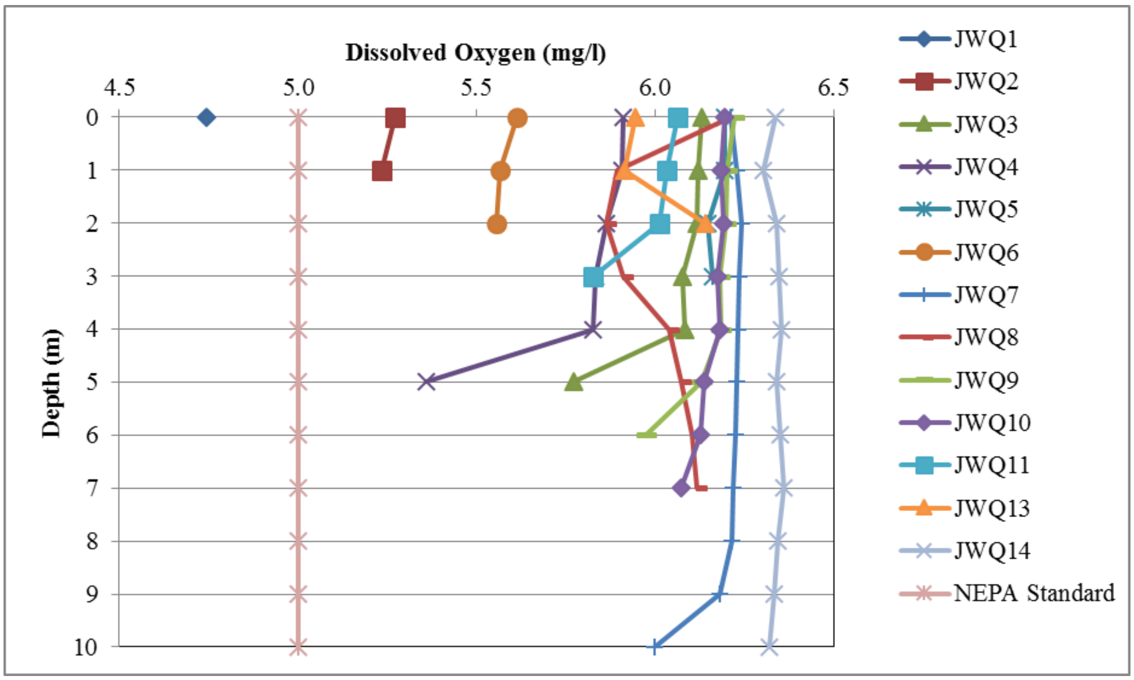


Figure 5-48 Dissolved oxygen values at the various stations

Turbidity

Turbidity values ranged from 3 – 23 NTU across the stations. The highest turbidity value was reported at station JWQ1 which is located in the Bowers Gully which is prone to high turbidity from land based sources of pollution and terrigenous sediments. The lowest value was observed at station JWQ6 which is located on a shallow area of reef northeast of the entrance to the shipping channel. Turbidity values varied when compared to depth at each station with a general increase with depth observed across the stations (Figure 5-49).

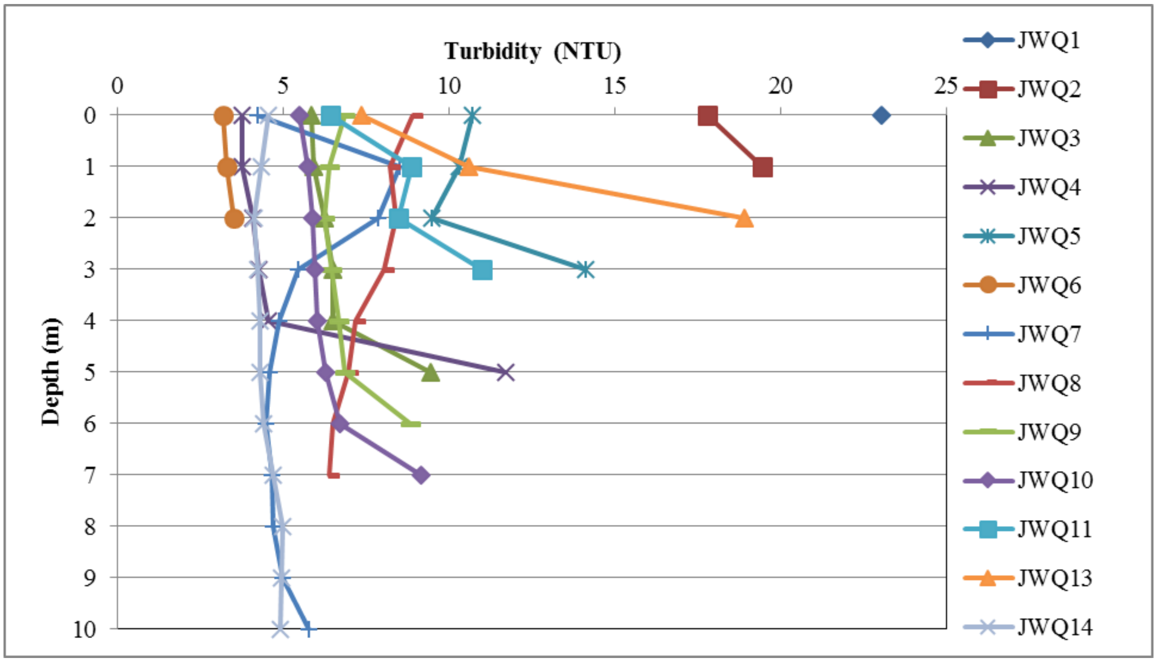


Figure 5-49 Turbidity values at the various stations

Total Dissolved Solids (TDS)

TDS varied little across the stations ranging from 35.06 – 37.81g/l. The lowest value was reported at JWQ13 and the highest TDS value was reported at station JWQ1 (Bowers Gully). When compared to depth at each station, the values showed little variation (Figure 5-50).

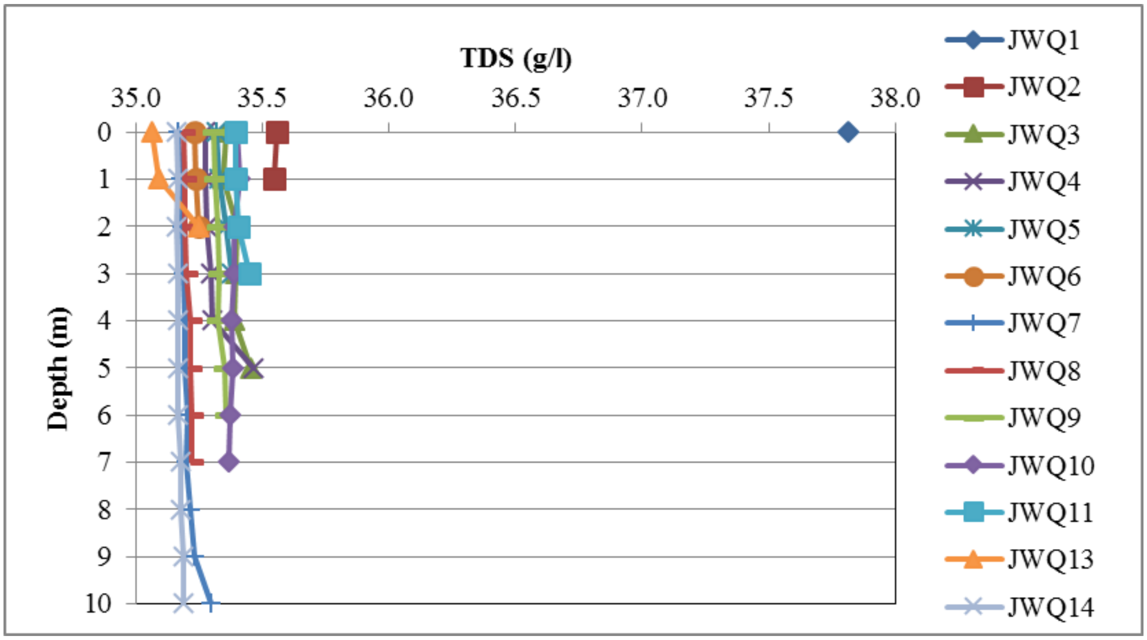


Figure 5-50 TDS values at the various stations

Photosynthetically Active Radiation (PAR)

PAR values ranged from 15.3 – 1156 uE/m² /s across the stations. The lowest PAR reading was obtained at station JWQ7 at 11m depth as this was one of the deepest stations. The highest value was obtained at station JWQ13 at 0m depth, closest to the water's surface, thus higher light penetration. 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. Station JWQ13 showed an increase in PAR from 1m to 2m; this is probably due to previous cloud cover at 1m depth (Figure 5-51).

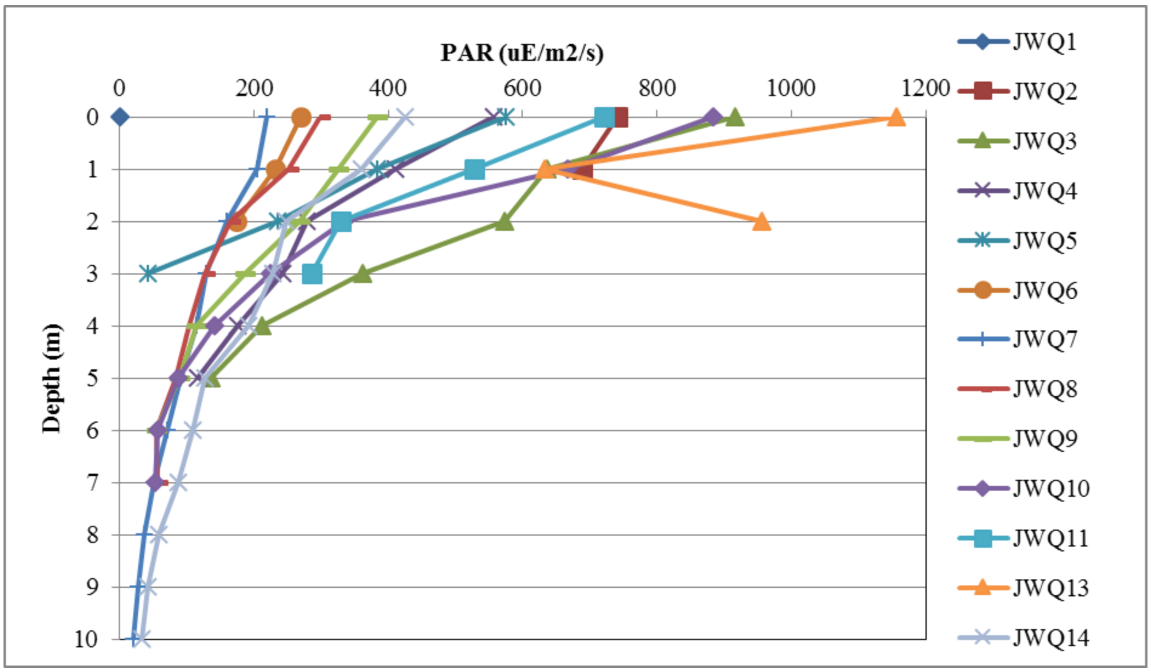


Figure 5-51 PAR values at the various stations

Light Extinction

Light extinction coefficients at each station ranged from 0.04 – 0.87. The highest value was obtained at station JWQ5 and the lowest was obtained at station JWQ2 (Figure 5-52). The extinction coefficient indicates the rate of loss of light through the water column with increasing depth. Station JWQ5 showed the greatest loss of light (0.87), which would indicate some particles (turbidity) in the water column affecting light penetration. This site is located by the cooling water intake point and visibility and circulation at this location is poor.

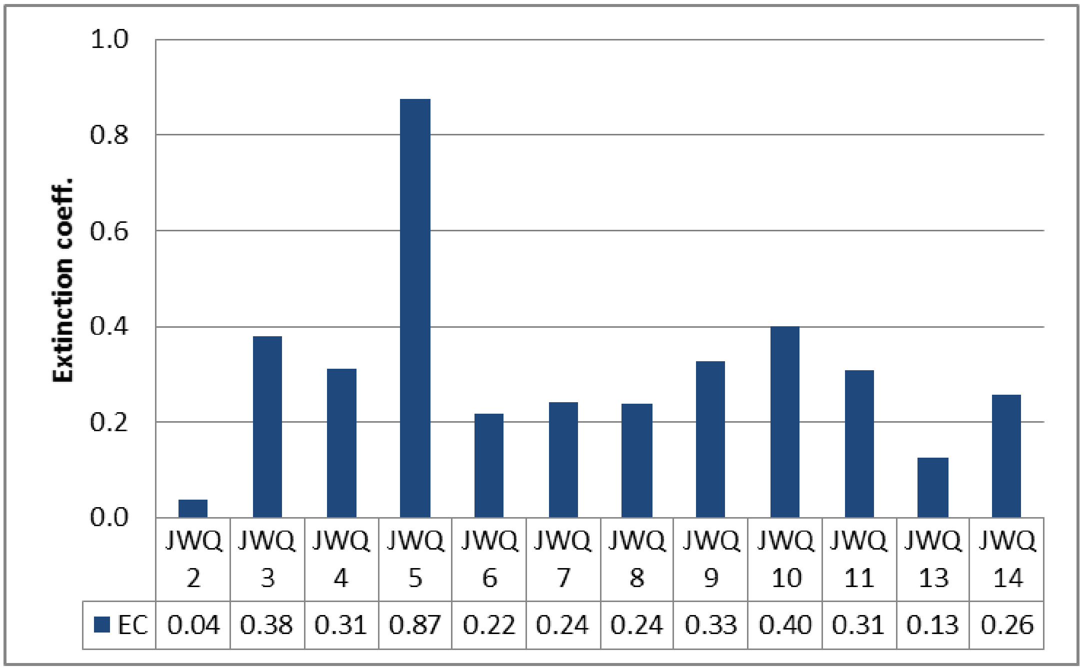


Figure 5-52 Light extinction at the various stations

Biochemical Oxygen Demand (BOD)

The BOD values ranged from 1 – 4 mg/l across the stations. The highest average BOD value was reported at station JWQ7 whereas the lowest value was observed at station JWQ9. All stations except for JWQ9 had values that were above the NEPA BOD Standard for Seawater of 1.16mg/l (Figure 5-53).

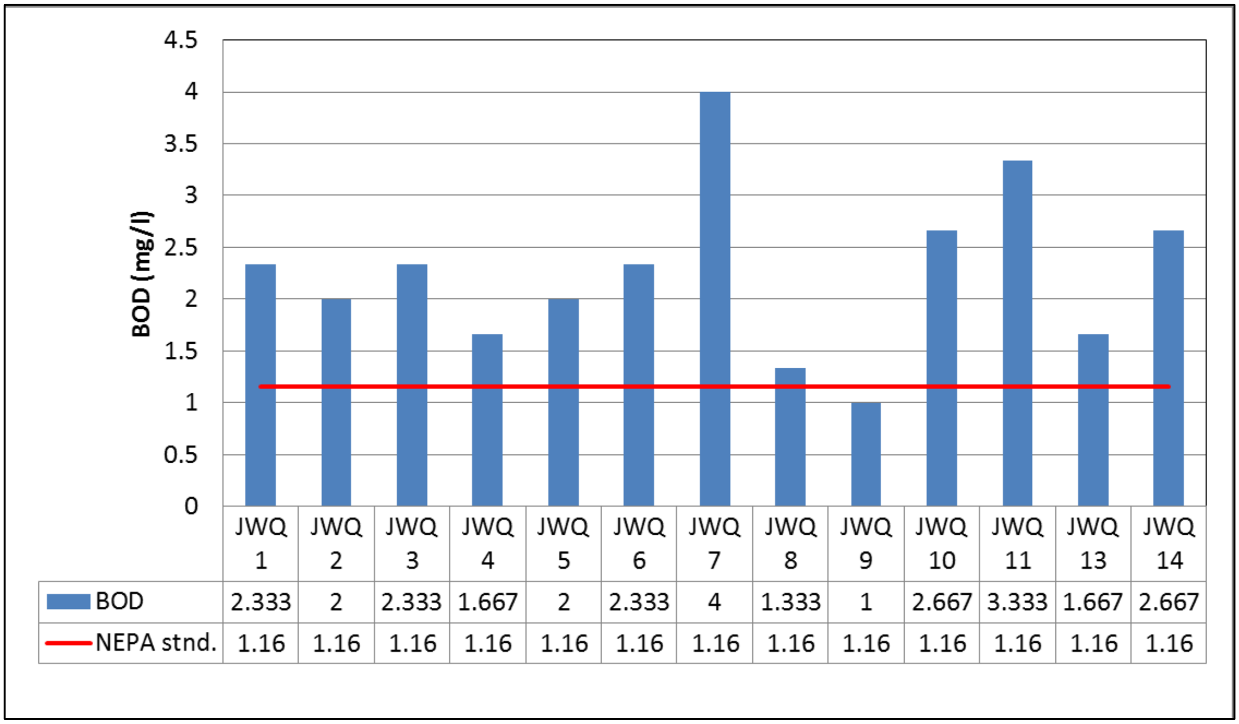


Figure 5-53 BOD values at the various stations

Total Suspended Solids (TSS)

Average TSS values ranged from 4.67 – 39.33mg/l across the stations. Station JWQ1 reported the highest value whereas the lowest value was observed at station JWQ8. The highest turbidity value was reported at station JWQ1 which is located in the Bowers Gully which is prone to high suspended solid content from land based sources of pollution and terrigenous sediments. The lowest value was observed at station JWQ8 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 5-54).

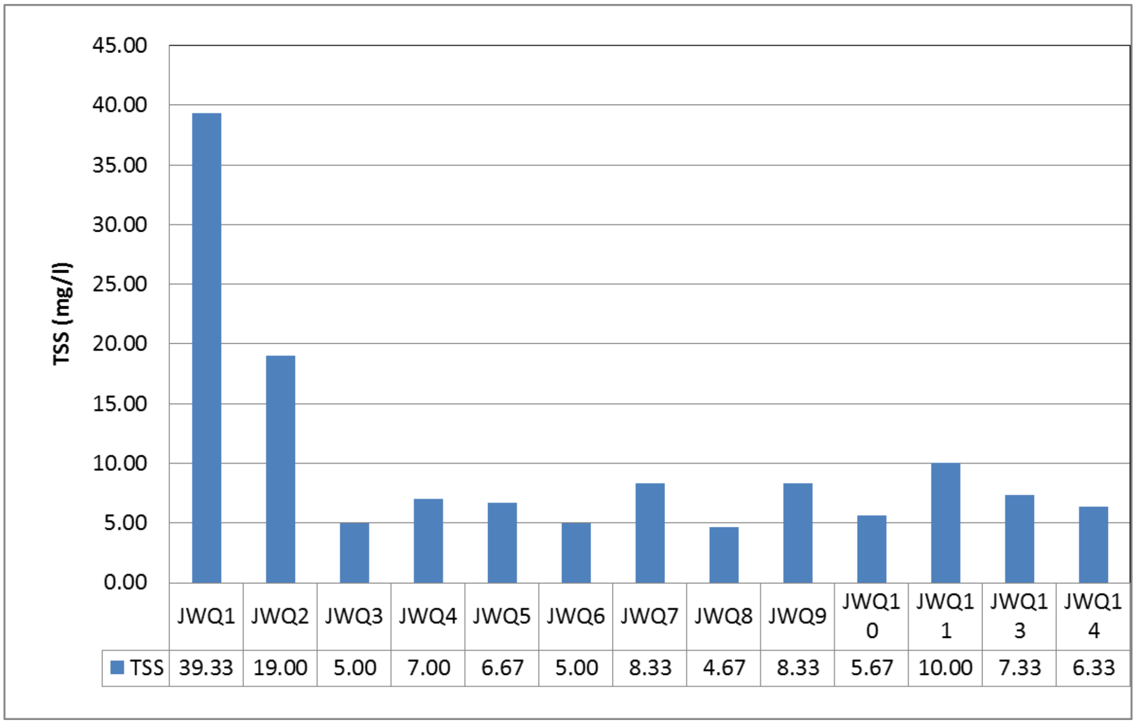
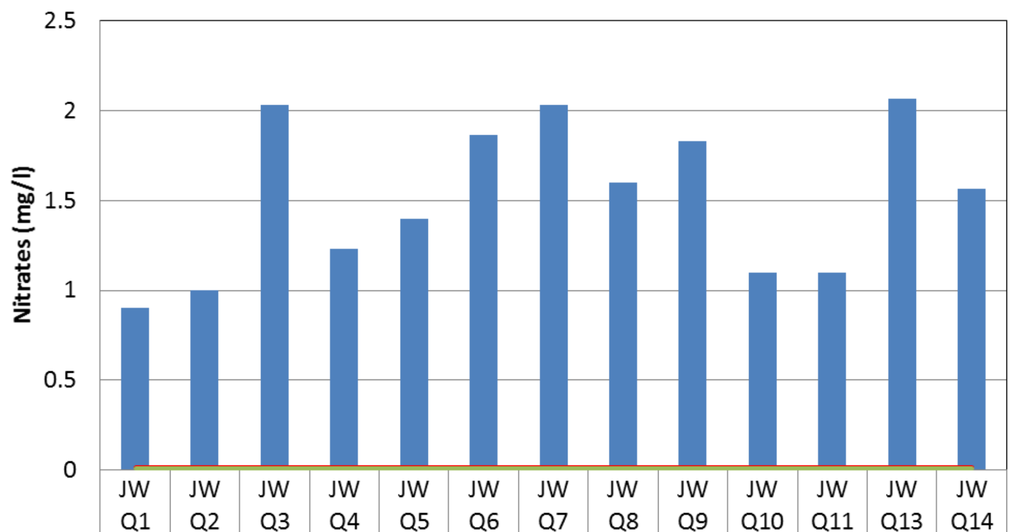


Figure 5-54 TSS values at the various stations

Nitrate

Nitrate values ranged from 0.9 – 2.067mg/l across the stations. The lowest nitrate value was reported at station JWQ1 which is the Bowers Gully. The highest nitrate value was observed at station JWQ13 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 5-55).

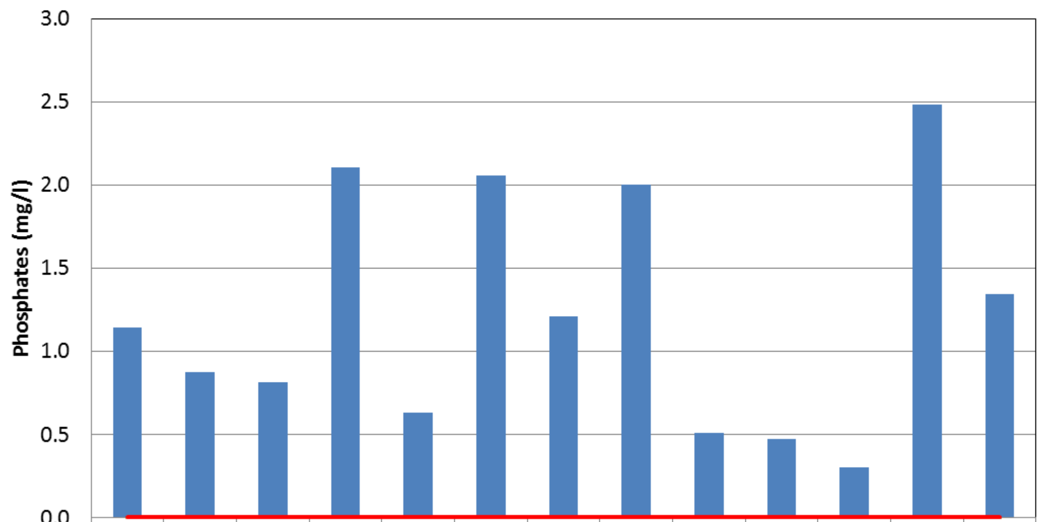


	JW Q1	JW Q2	JW Q3	JW Q4	JW Q5	JW Q6	JW Q7	JW Q8	JW Q9	JW Q10	JW Q11	JW Q13	JW Q14
Nitrates	0.9	1	2.033	1.233	1.4	1.867	2.033	1.6	1.833	1.1	1.1	2.067	1.567
NEPA stnd (upper)	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
NEPA stnd (lower)	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007

Figure 5-55 Nitrate values at the various stations

Phosphate

Phosphate values ranged from 0.3 – 2.5mg/l across the stations. The lowest phosphate value was reported at station JWQ11 while the highest phosphate value was observed at station JWQ13 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 5-56).

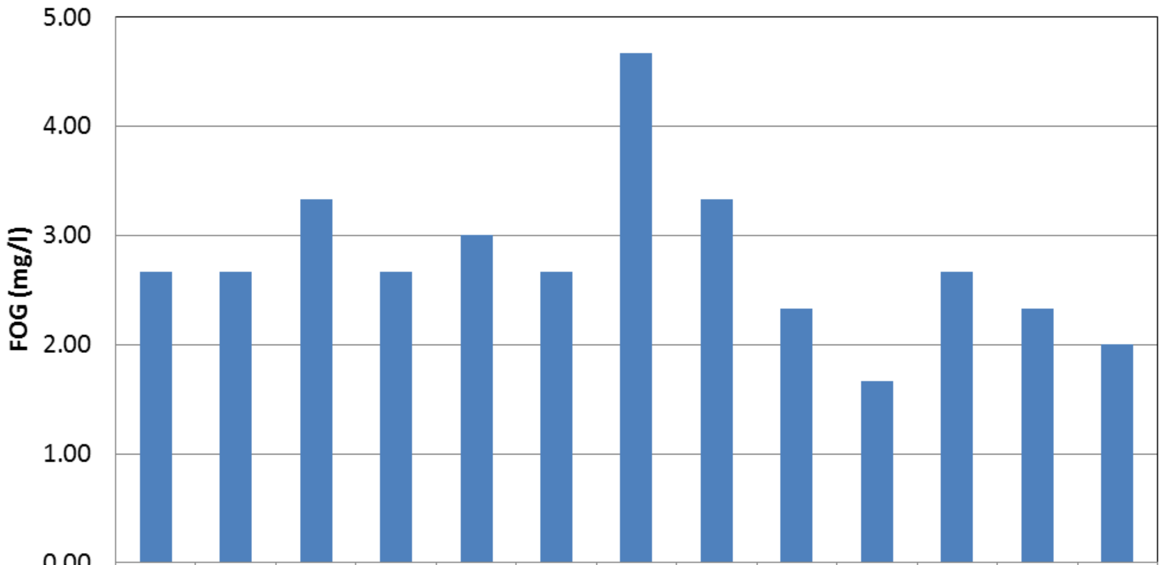


	JWQ 1	JWQ 2	JWQ 3	JWQ 4	JWQ 5	JWQ 6	JWQ 7	JWQ 8	JWQ 9	JWQ 10	JWQ 11	JWQ 13	JWQ 14
Phosphates	1.1	0.9	0.8	2.1	0.6	2.1	1.2	2.0	0.5	0.5	0.3	2.5	1.3
NEPA stnd (lower)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
NEPA stnd (upper)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

Figure 5-56 Phosphate values at the various stations

Fats, Oils and Grease (FOG)

FOG values ranged from 1.67 – 4.67mg/l across the stations. The highest value was reported at station JWQ7 while the lowest value was reported at station JWQ10. High FOG values are expected at Station JWQ7 as it is in close proximity to where the fuel delivery vessel anchors when delivering fuel to the Doctor Bird Barges and to JPS plant. In fact, during the third sampling event on August 7th, a fuel delivery vessel was anchored nearby Station 7 at the time of sampling (Figure 5-57).



	JWQ1	JWQ2	JWQ3	JWQ4	JWQ5	JWQ6	JWQ7	JWQ8	JWQ9	JWQ10	JWQ11	JWQ13	JWQ14
FOG	2.67	2.67	3.33	2.67	3.00	2.67	4.67	3.33	2.33	1.67	2.67	2.33	2.00

Figure 5-57 FOG values at the various stations

Faecal Coliform

Faecal coliform values ranged from <11 – 103.3 MPN/100ml across the stations. The highest value was reported at station JWQ1 while the lowest values were reported at stations JWQ 2, 3, 4, 8 and 14. Station JWQ1 is located in the Bowers Gully and is most prone to anthropogenic pollution sources hence the high coliform levels (Figure 5-58). Goat and cattle farming are also prevalent in the area close to the Bowers Gully where the sample was taken and informal settlements are also located in and around this area.

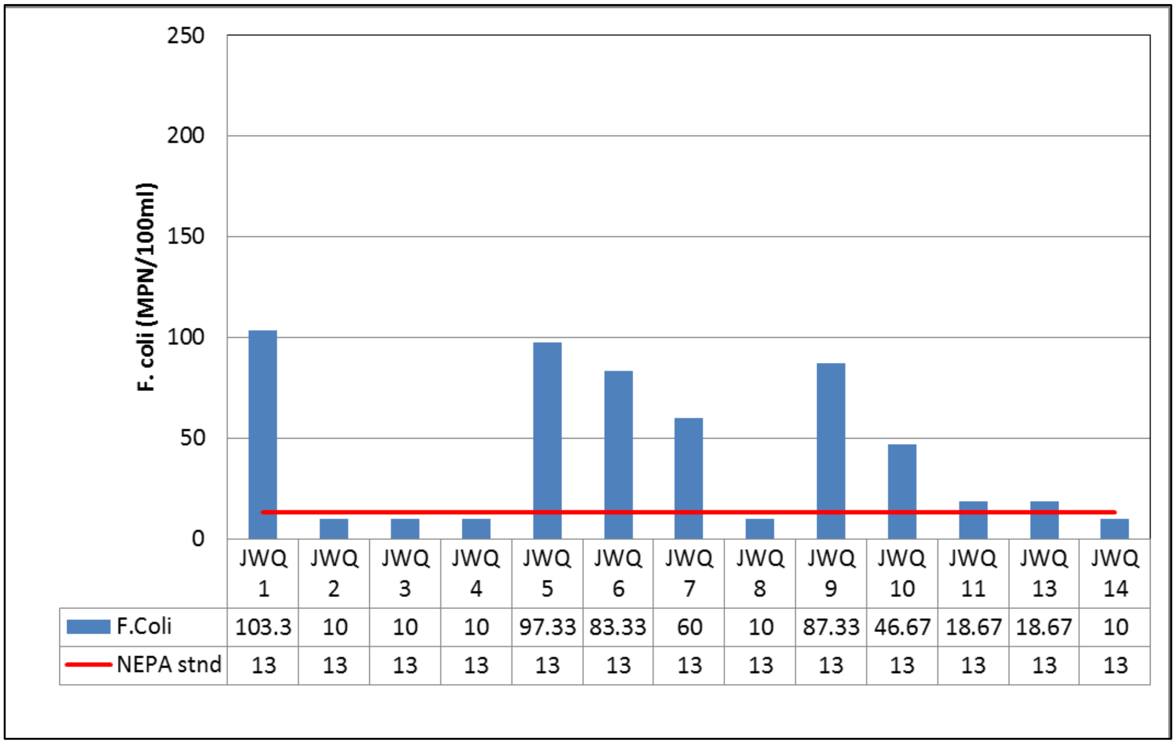


Figure 5-58 Faecal Coliform values at the various stations

Total Petroleum Hydrocarbons – DRO and GRO

No TPH (GRO and DRO) were detected at any stations on any of the sampling runs.

Potable Water (Station JWQ 12)

Table 5-23 and Table 5-24 show the potable water quality values for Station JWQ12, compared with the NEPA Draft Ambient Freshwater Standards, 2009 and World Health Organization Drinking Water Guidelines. The results for JWQ12 indicate that the water is of good quality. The TDS and conductivity values on all three sampling dates for Station 12 were above the respective NEPA Standard. The residual chlorine values on July 22nd and August 7th were above the respective WHO Guidelines. All other parameters for which WHO Guidelines exist were compliant.

Table 5-23 Physicochemical data for potable water station JPS 12.

Station	Sample Date	Temp. (°C)	Cond. (mS/cm)	Sal. (ppt)	pH	D.O. (mg/l)	Turb (NTU)	TDS (g/l)
JWQ 12	July 9th	29.44	1.613	0.85	7.57	7.35	1.00	0.88
JWQ 12	July 22nd	29.99	1.215	0.64	7.65	8.51	0.30	0.774
JWQ 12	Aug. 7th	30.96	1.23	0.65	7.45	6.46	0.40	0.78
NEPA Standard		-	*0.15–0.6*	-	*7 – 8.4*	-	-	*0.12-0.3*
WHO Guideline		-	-	-	-	-	-	-

Values in red are non-compliant with Standard/Guideline

Table 5-24 Chemical data for potable water station JWQ 12.

Station	Sample Date	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)
JWQ 12	July 9th	0.03	2.3	10	ND	0.077	ND	ND	ND
JWQ 12	July 22nd	0.56	2.4	69	ND	0.076	ND	ND	ND
JWQ 12	Aug. 7th	0.91	2.6	10	ND	0.078	ND	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)
JWQ 12	July 9th	0.013	ND	0.025	ND	ND	ND	ND	0.12
JWQ 12	July 22nd	0.02	ND	ND	ND	ND	ND	ND	0.11
JWQ 12	Aug. 7th	0.016	ND	ND	ND	ND	ND	ND	0.12
NEPA Standard		-	-	-	-	-	-	-	-
WHO Guideline		*2*	*0.01*	*0.4*	*0.07*	*0.01*	*0.006*	*0.07*	*1.5*

ND – None Detected

Values in red are non-compliant with Standard/Guideline

5.1.9.4 Comparison with 2012 Study

Physicochemical values were similar for the 2012 study and the current study. Station 1, located in the Bower's Gully, had lower salinity and conductivity values in 2012, ranging from 29.96 – 30.98 ppt and 46.11 – 47.49 mS/cm respectively. Average nitrate and phosphate concentrations were higher in the current study while FOG concentrations were slightly lower when compared to the 2012 study. In 2012, TPH (DRO) was detected at Station 3 (1.5mg/l) only, while no TPH was detected in any of the stations in the current 2014 study.

5.1.10 Sediments

5.1.10.1 Shoreline Sediments

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). See Figure 5-59 below for the sediment sample location points. Grain size analysis of these samples was conducted and the results of this analysis are summarized in Figure 5-59 and Table 5-25.

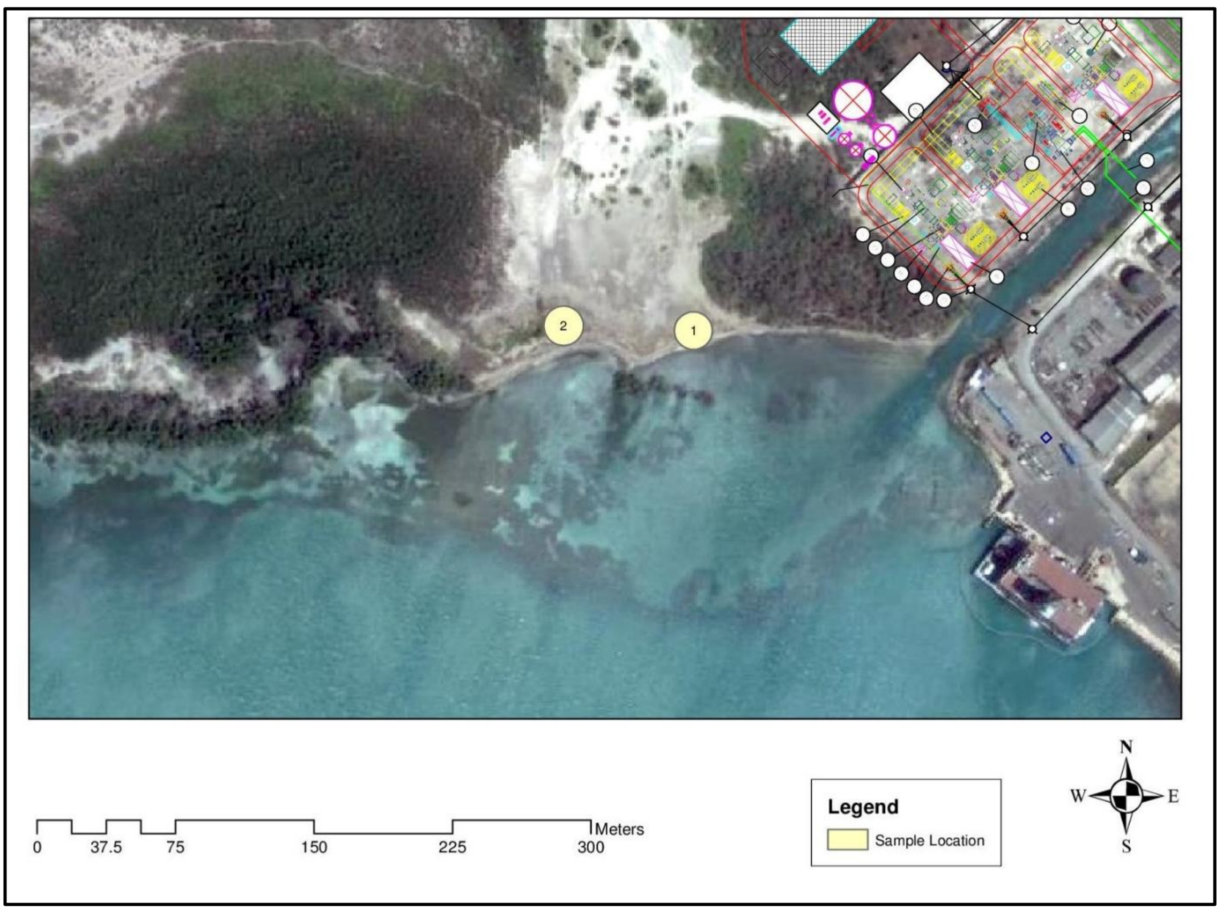


Figure 5-59 Sediment grain size sampling locations

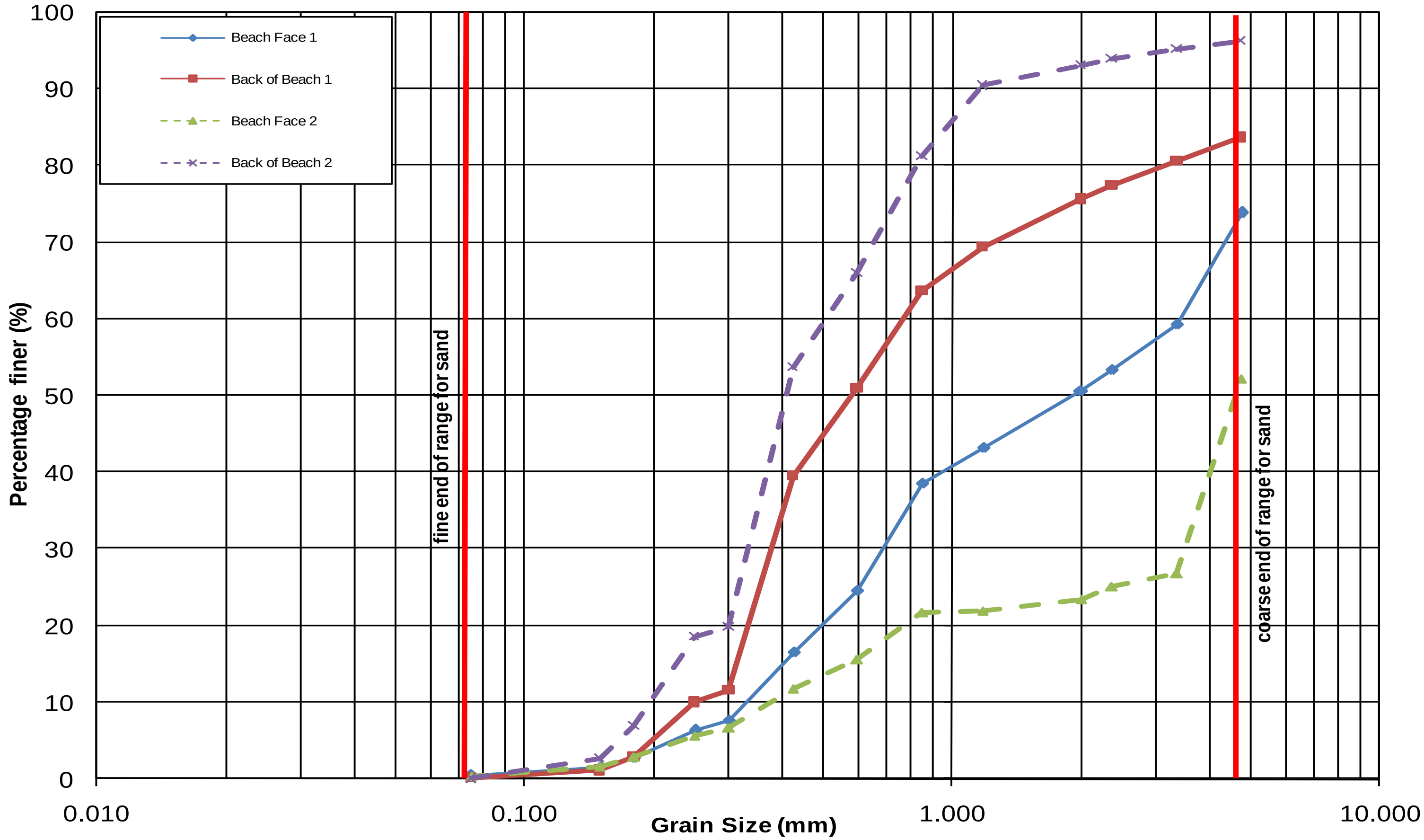


Figure 5-60 Sieve analysis results (graph).

Table 5-25 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 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 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.

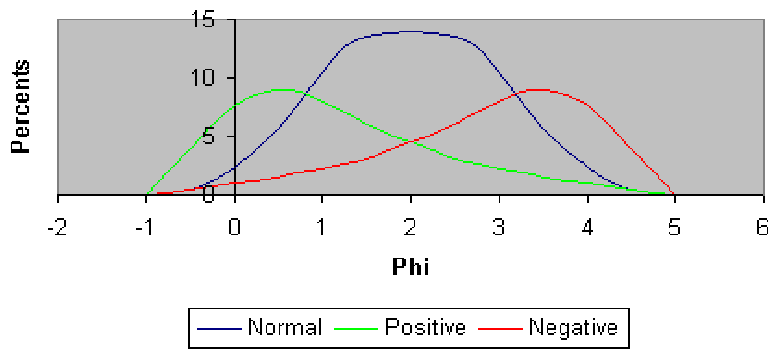


Figure 5-61 Skewness curves.

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 5-26.

Table 5-26 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 has a strong positive skewness ranging from 0.61 to 2.62. This is indicative 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.

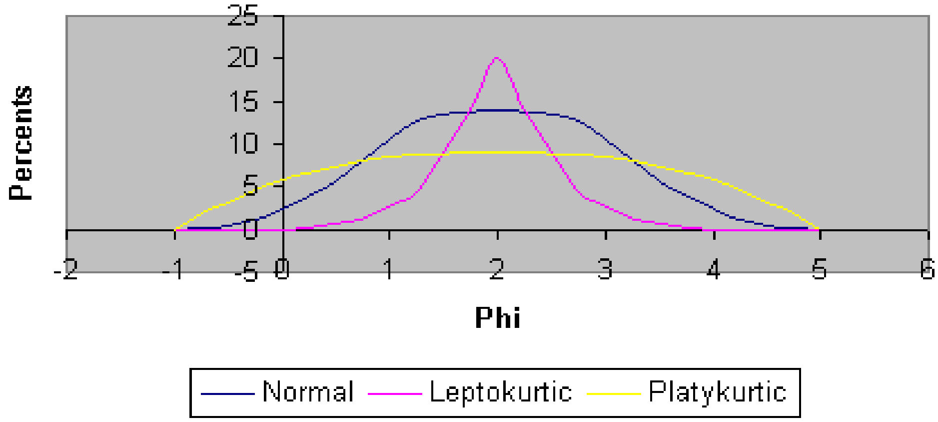


Figure 5-62 Kurtosis curves.

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 5-27 Descriptive limits of kurtosis.

Values from	To	Equal
0.41	0.67	very platykurtic
0.67	0.90	platykurtic
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.

5.1.10.2 Marine Benthic Sediments

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 5-28 and depicted in Figure 5-63. The samples were stored on ice in a cooler and transported to Test America Pensacola Laboratory in Florida for analyses.

Table 5-28 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

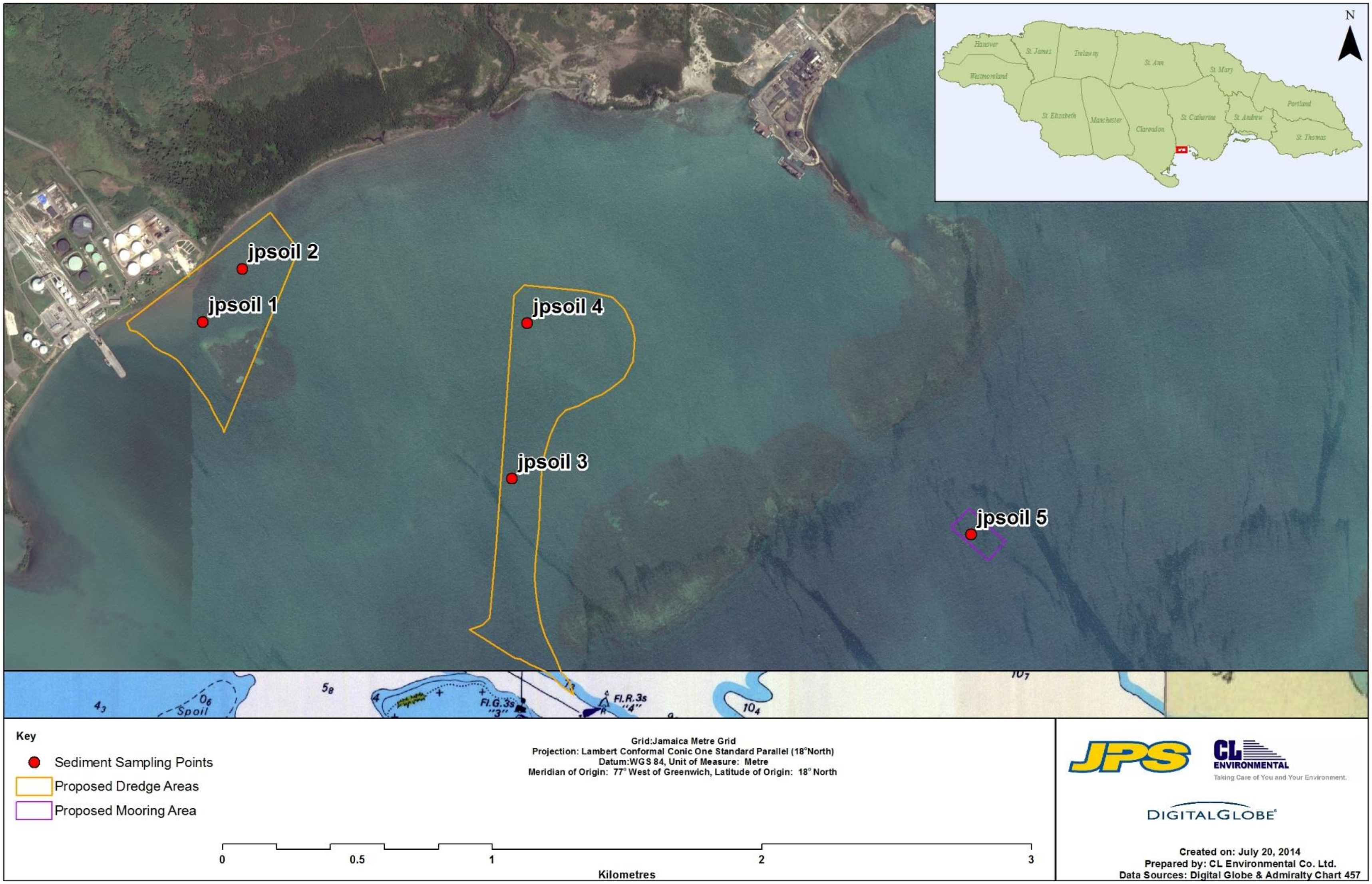


Figure 5-63 Map showing sediment sampling locations

Results

Table 5-29 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 5-30), all values were below reported averages.

Table 5-29 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 5-30 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 5-31). 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 5-32). 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 5-31 Heavy metal concentrations at various sites in Jamaica and worldwide

METAL	NEGRIL	OLD HARBOUR 360 MW	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
Mercury (Hg) (mg/KG)	ND	0.04 – 0.05	ND	0.2				
TPH (mg/KG)	140 - 1100	11 – 68.67	ND					

Table 5-32 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

5.1.11 Noise

5.1.11.1 Introduction

This report entails the results derived from the noise survey conducted for twenty four (24) hours between 7:00 hrs Tuesday 11th, to 7:00 hrs Wednesday 12th, November 2014. Noise sampling stations from the 2012 Environmental Impact Assessment (EIA) that were also assessed for this EIA were:

- Blackwood Gardens
- Old Harbour Bay Police Station
- Longville Park Housing Scheme

5.1.11.2 Methodology

A data logging noise survey exercise was conducted to establish baseline conditions along the proposed boundaries of the power plant and its environs. The data logging exercise was conducted for twenty four (24) hours between 7:00 hrs Tuesday 11th, to 7:00 hrs Wednesday 12th, November 2014. The readings were taken at nine (9) locations (Stations N1 – N9) listed in Table 5-33 and depicted in Figure 5-64.

Noise level readings were taken 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 6). 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. Plate 5-2 shows a photo of the noise meter setup.

Table 5-33 Station numbers and locations in JAD2001

STATIONS	LOCATIONS	JAD 2001 (m)	
		E	N
N1	North-Western Property Boundary	638937.99	738508.72
N2	South-Western Property Boundary	638860.04	738486.45

STATIONS	LOCATIONS	JAD 2001 (m)	
		E	N
N3	South-Eastern Property Boundary	638884.88	738573.82
N4	North-Eastern Property Boundary	638979.11	738614.94
N5	Informal Settlement Area	639265.58	738505.24
N6	Blackwood Garden Housing Scheme	738916.05	639430.47
N7	Old Harbour Bay Police Station	639705.67	739747.33
N8	New Harbour Village Phase II Housing Scheme	640820.15	738540.52
N9	Longville Park Housing Scheme	639734.29	733211.19

Plate 5-2 Example of noise meter setup

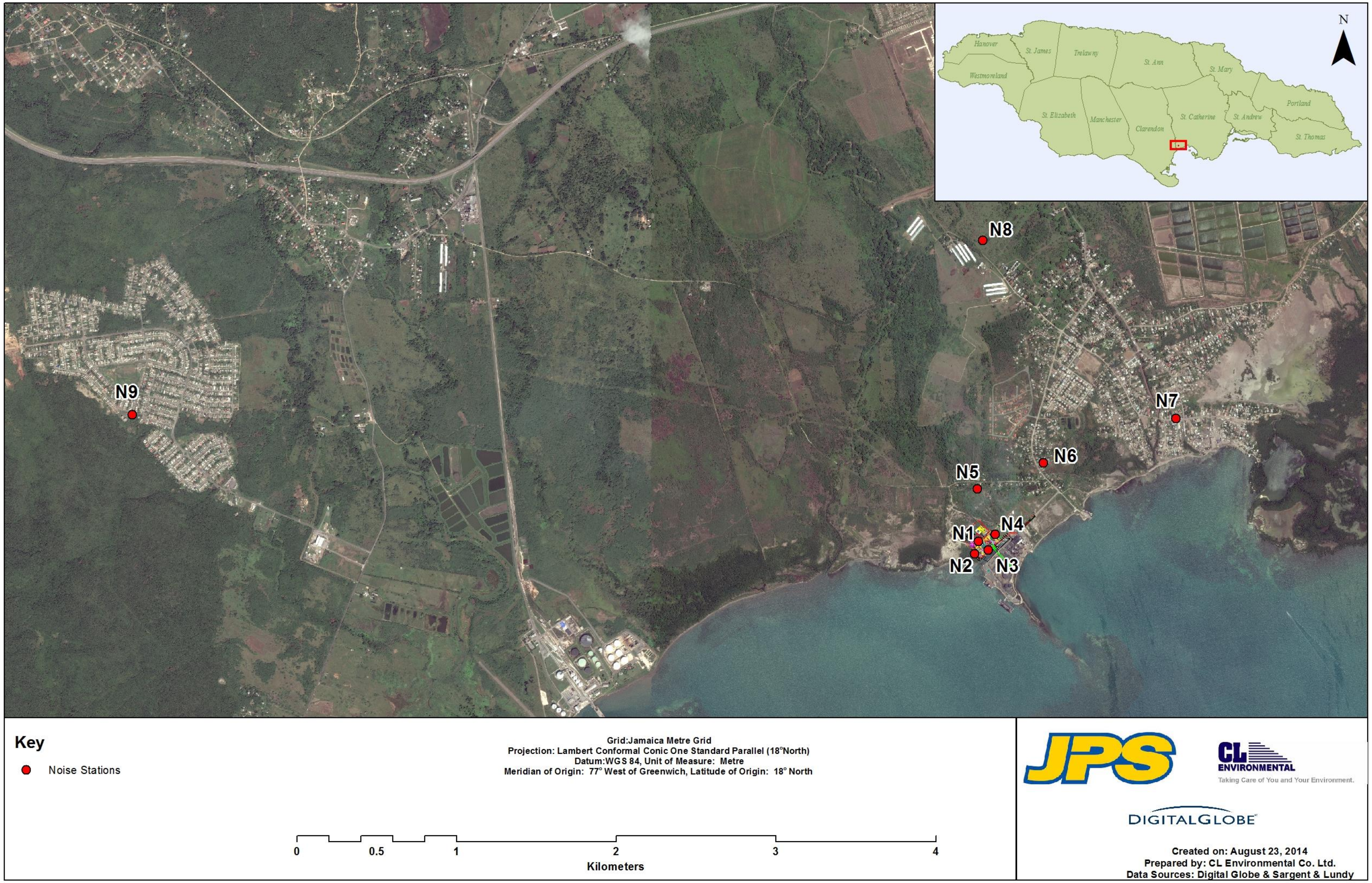


Figure 5-64 Locations of noise survey stations

5.1.11.3 Results

This section outlines the results of the twenty four (24) hour noise monitoring exercise at the nine (9) monitoring stations.

Station N1

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 54.2 dBA to a high (Lmax) of 84.3 dBA. Average noise level for this period was 64.9L_{Aeq} (24h). The fluctuation in noise levels over the 24 hour period is depicted in Figure 5-65.

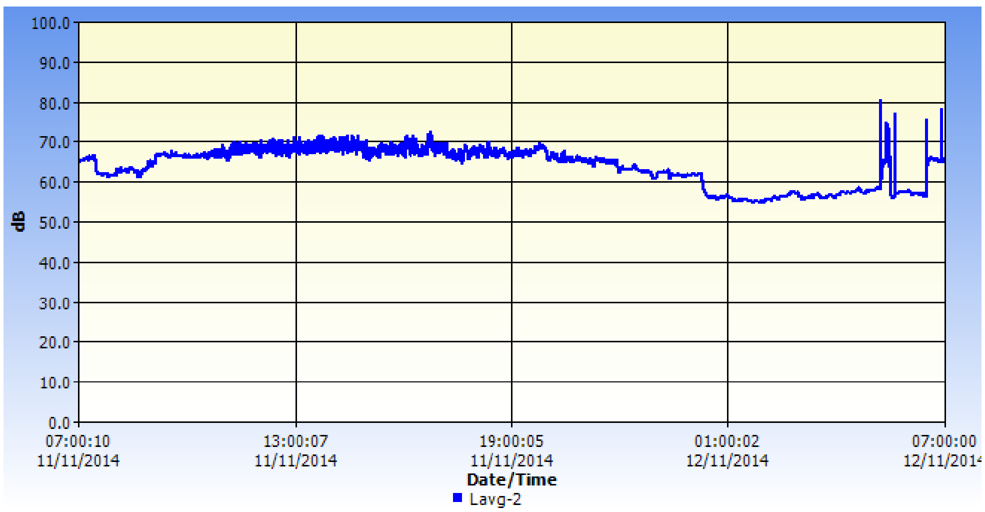


Figure 5-65 Noise fluctuation (Leq) over 24 hours at Station 1

OCTAVE BAND ANALYSIS AT STATION 1

The noise at this station during the 24 hour period was in the low frequency band centred around the geometric mean frequency of 50 Hz (octave frequency range is 45 - 56 Hz) (Figure 5-66).

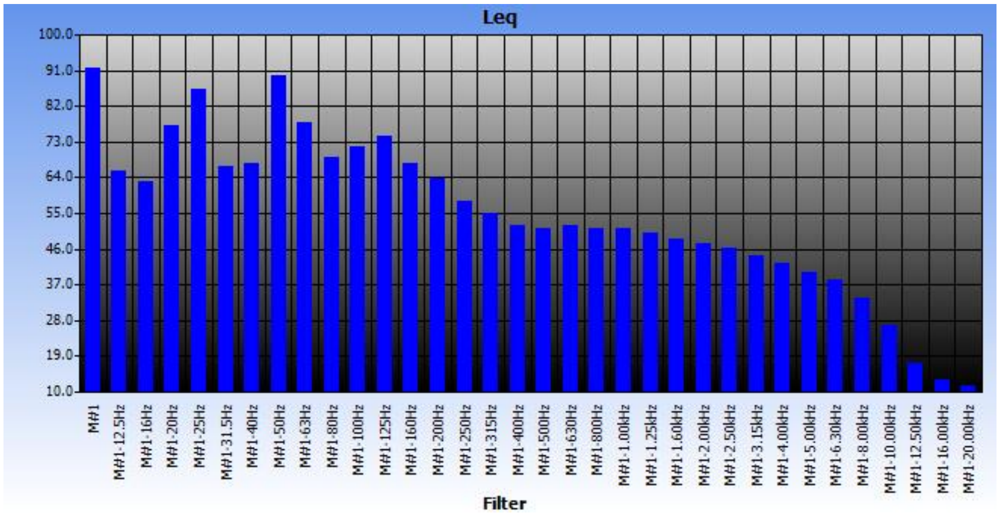


Figure 5-66 Octave band spectrum of noise at Station N1

L10 AND L90 – N1

The two most common **L_n** values used are **L_{10}** and **L_{90}** and these are sometimes called the 'annoyance level' and 'background level' respectively. **L_{10}** is almost the only statistical value used for the descriptor of the higher levels, but **L_{90}**, is widely used to describe the ambient or background level. L10-L90 is often used to give a quantitative measure as to the spread or "how choppy" the sound was.

L10 is the noise level exceeded for 10% of the time of the measurement duration. This is often used to give an indication of the upper limit of fluctuating noise, such as that from road traffic. L90 is the noise level exceeded for 90% of the time of the measurement duration.

The difference between L10 and L90 gives an indication of the noise climate. When the difference is < 5 dBA then it is considered that there are no significant fluctuations in the noise climate, moderate fluctuations 5-15 dBA and large fluctuations >15 dBA.

Figure 5-67 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations (L10 – L90) ≈ 91.67% of the time and moderate fluctuations (L10 – L90) ≈8.33% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 68.6 dBA and 56.1 dBA respectively.

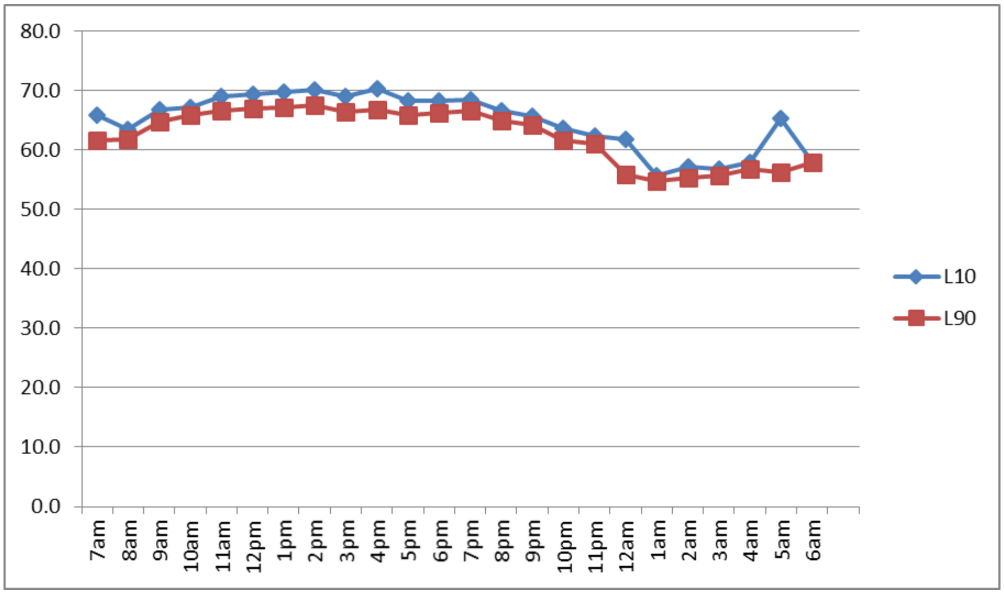


Figure 5-67 L10 and L90 for Station 1

Station N2

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 51 dBA to a high (Lmax) of 87.5 dBA. Average noise level for this period was 60.7 L_{Aeq} (24h). The fluctuation in noise levels over the 24 hour period is depicted in Figure 5-68.

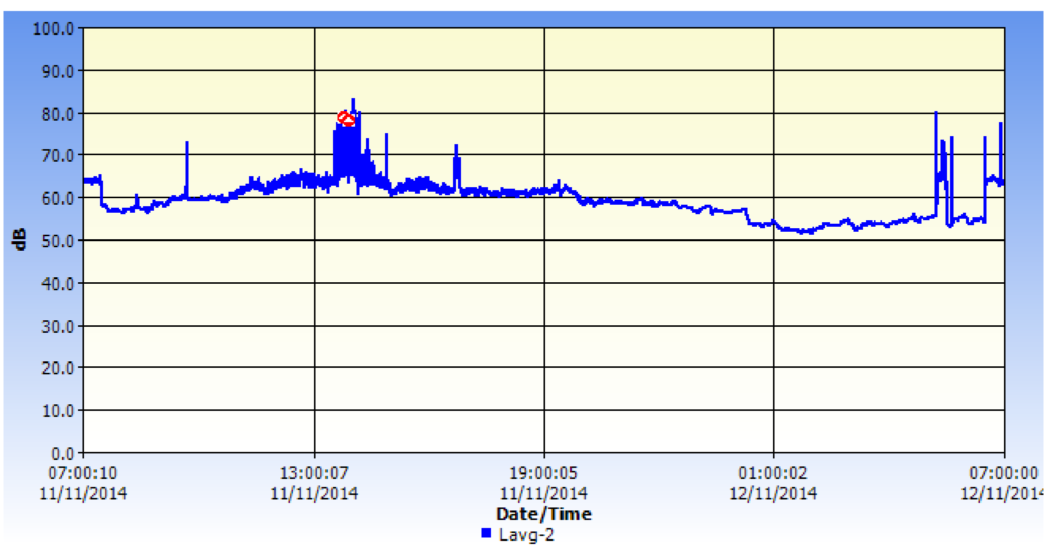


Figure 5-68 Noise fluctuation (Leq) over 24 hours at Station 2

OCTAVE BAND ANALYSIS AT STATION N2

The noise at this station during the 24 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28Hz) (Figure 5-69).

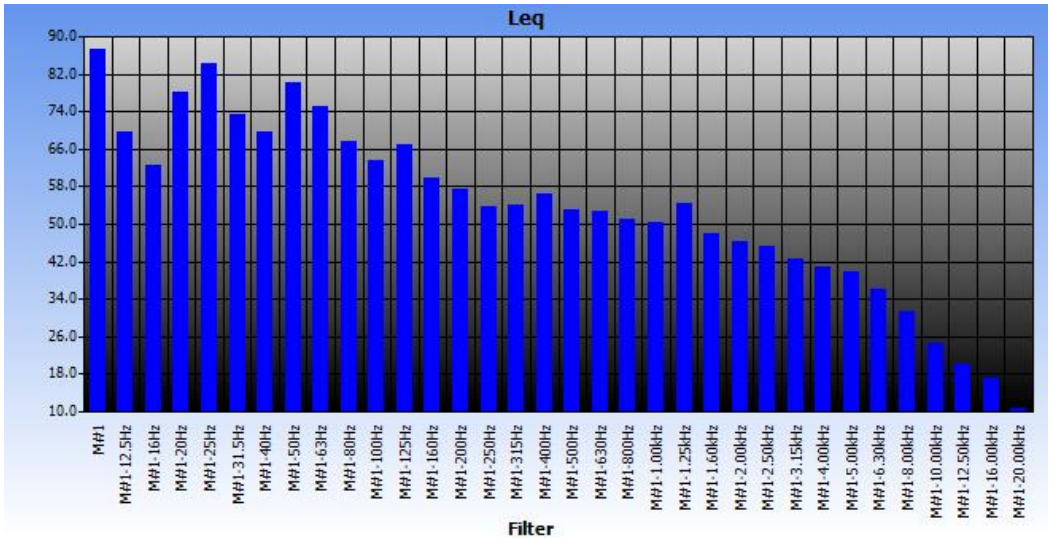


Figure 5-69 Octave band spectrum of noise at Station 2

L10 AND L90 – STATION N2

Figure 5-70 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations in the noise climate (L10 – L90) ≈83.3% of the time and moderate fluctuations (L10 – L90) ≈16.7 of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 63.7 dBA and 53.4 dBA respectively.

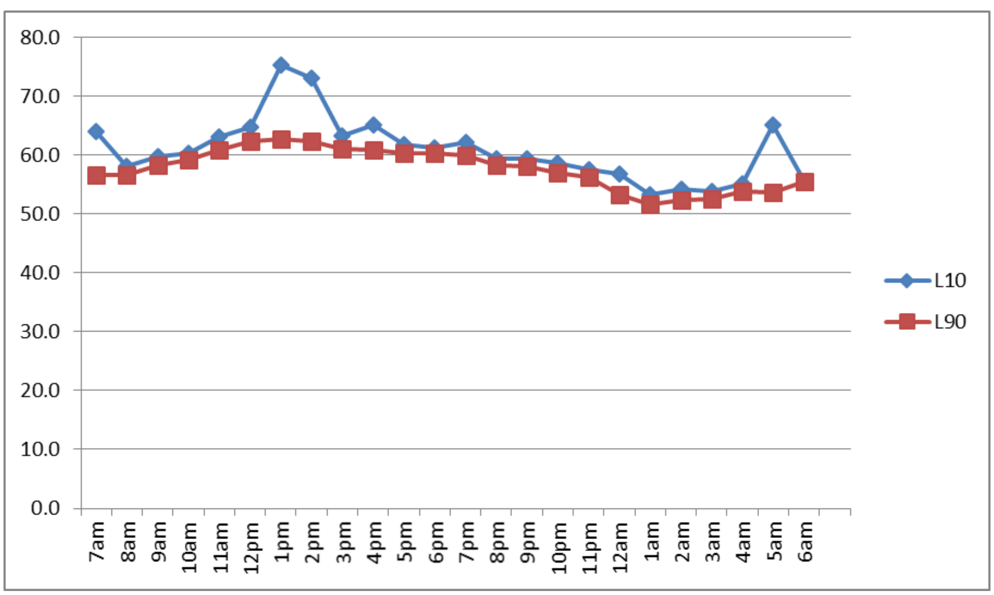


Figure 5-70 L10 and L90 for Station 2

Station N3

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 53.8 dBA to a high (Lmax) of 82.5 dBA. Average noise level for this period was 62.3 LAeq (24h). The fluctuation in noise levels over the 24 hour period is depicted in Figure 5-71.

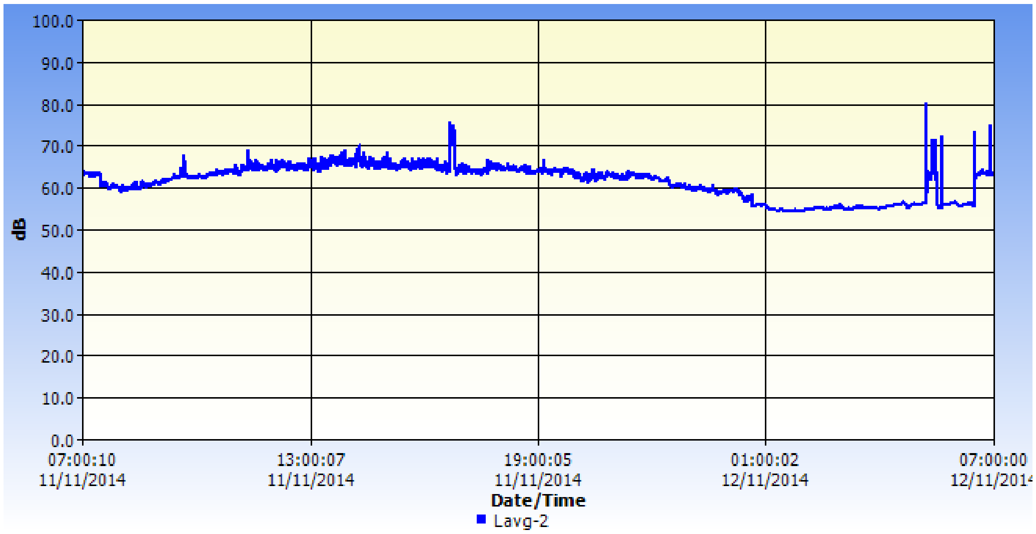


Figure 5-71 Noise fluctuation (Leq) over 24 hours at Station 3

OCTAVE BAND ANALYSIS AT STATION 3

The noise at this station during the 24 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz) (Figure 5-72).

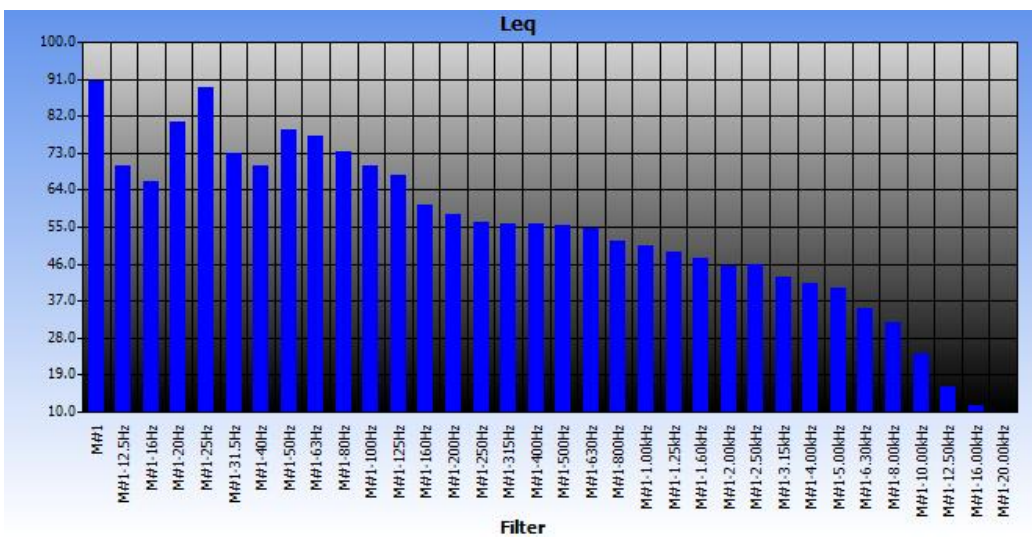


Figure 5-72 Octave band spectrum of noise at Station 3

L10 AND L90 – STATION N3

Figure 5-73 the noise assessment period. The data shows no significant fluctuations in the noise climate (L10 – L90) ≈91.67% of the time and moderate fluctuations (L10 – L90) ≈8.33% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 65.4 dBA and 55.1 dBA respectively.

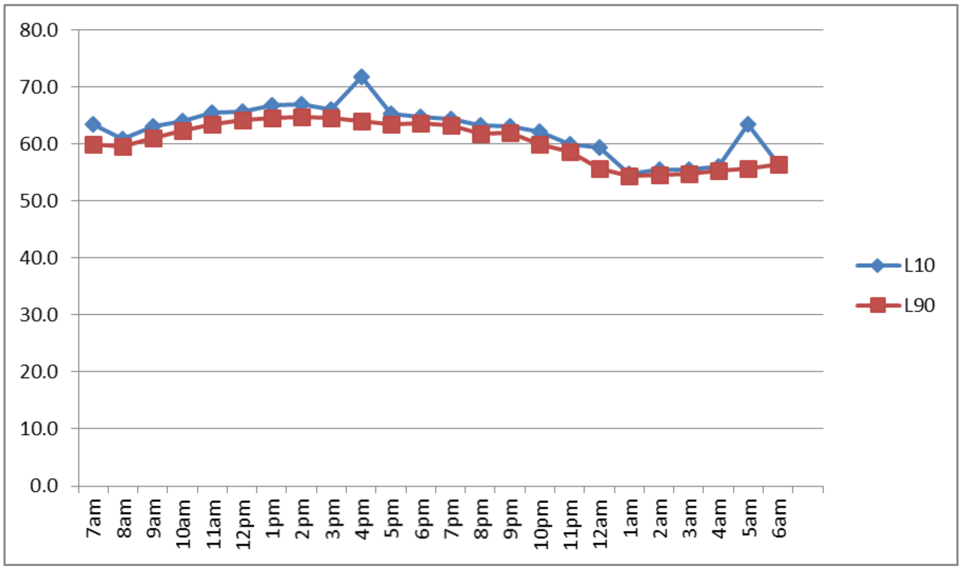


Figure 5-73 L10 and L90 for Station 3

Station N4

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 56.7 dBA to a high (Lmax) of 87.7 dBA. Average noise level for this period was 61.8 L_{Aeq} (24h). The fluctuation in noise levels over the 24 hour period is depicted in Figure 5-74.

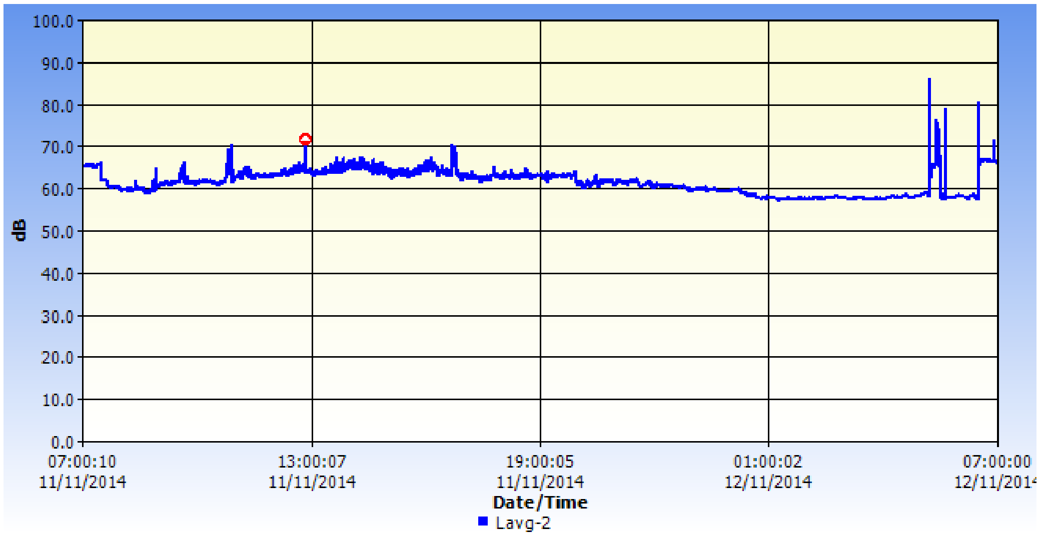


Figure 5-74 Noise fluctuation (Leq) over 24 hours at Station 4

OCTAVE BAND ANALYSIS AT STATION 4

The noise at this station during the 24 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz) (Figure 5-75).

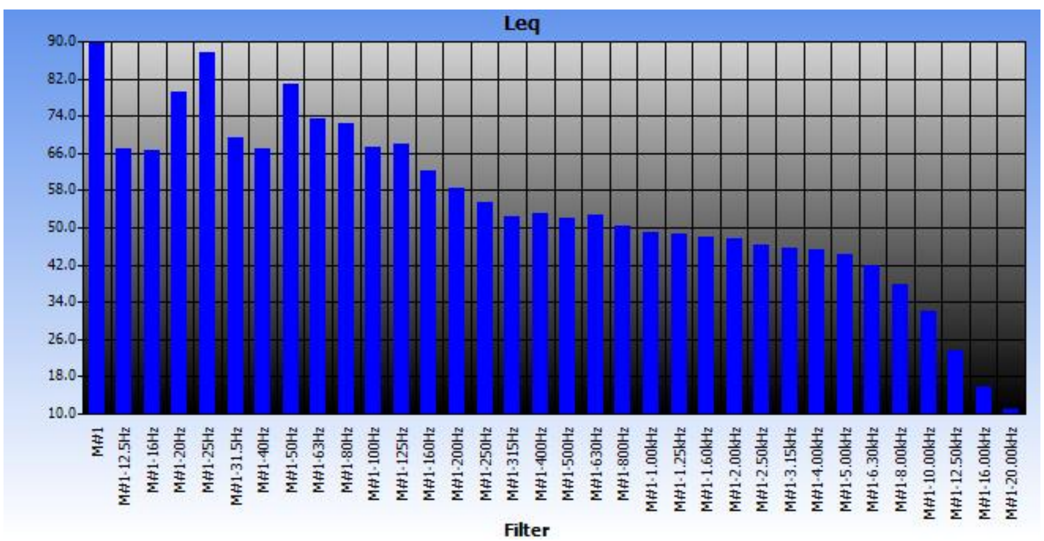


Figure 5-75 Octave band spectrum of noise at Station 4

L10 AND L90 – STATION N4

Figure 5-76 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations in the noise climate (L10 – L90) ≈91.67% of the time and moderate fluctuations in the noise climate (L10 – L90) ≈8.33% of the in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 64.7 dBA and 57.6 dBA respectively.

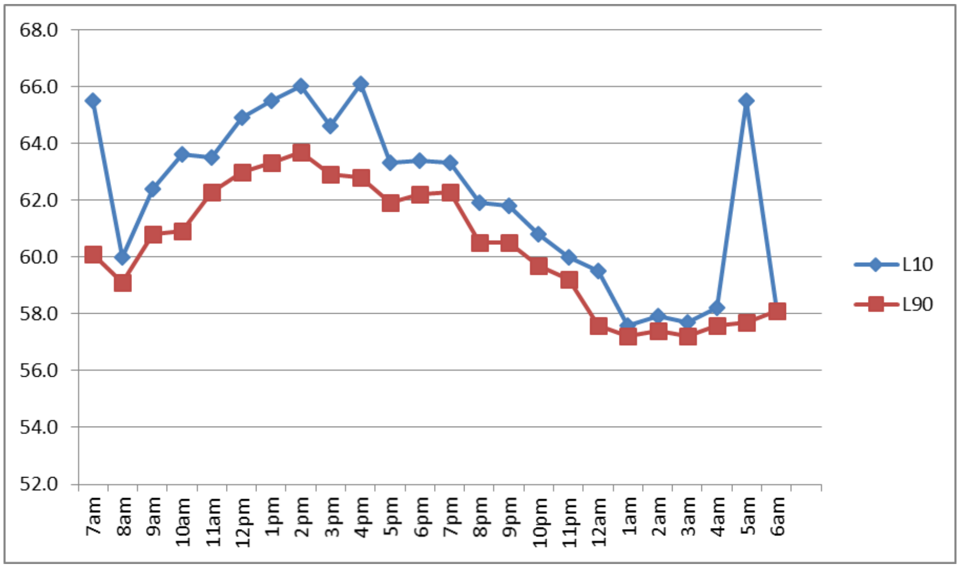


Figure 5-76 L10 and L90 for Station 4

Station N5

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 34.4 dBA to a high (Lmax) of 90.4 dBA. Average noise level for this period was 50.7 L_{Aeq} (24h). The fluctuation in noise levels over the 24 hour period is depicted in Figure 5-77.

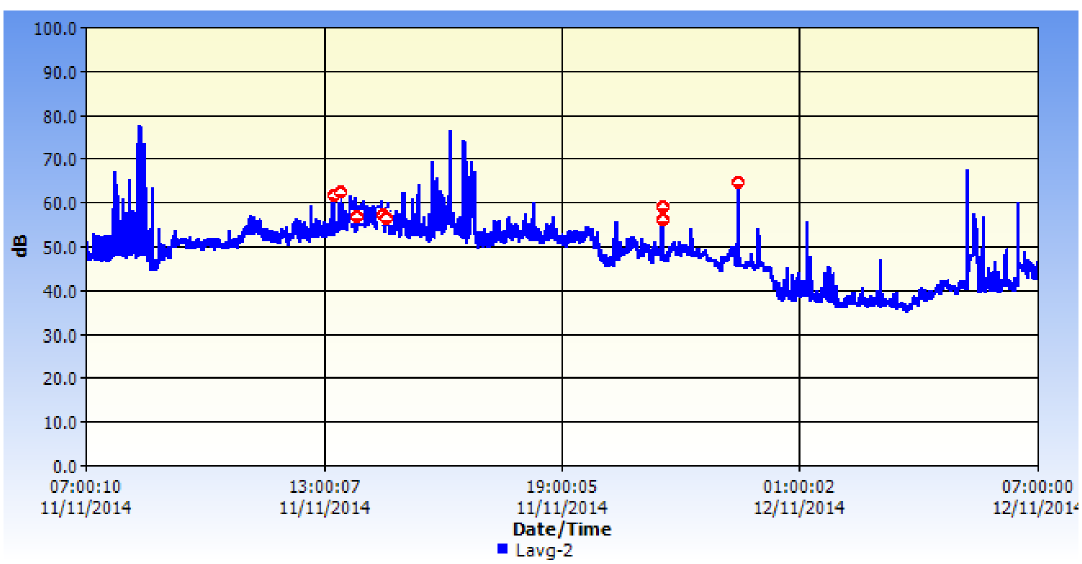


Figure 5-77 Noise fluctuation (Leq) over 24 hours at Station 5

OCTAVE BAND ANALYSIS AT STATION 5

The noise at this station during the 24 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz) (Figure 5-78).

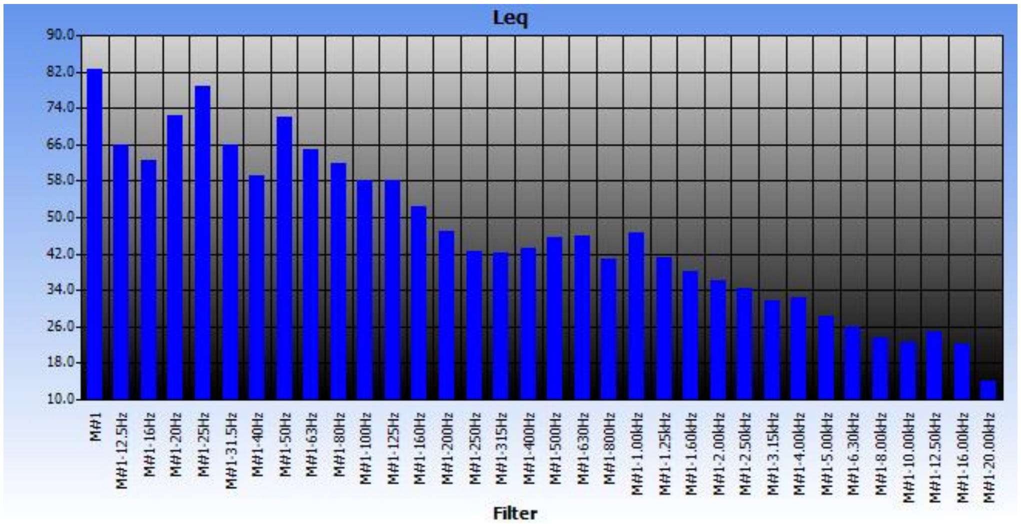


Figure 5-78 Octave band spectrum of noise at Station 5

L10 AND L90 – STATION N5

Figure 5-79 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations in the noise climate (L10 – L90) ≈75% of the time and moderate fluctuations (L10 – L90) ≈25% of the time in the noise climate at this station. The overall L10 and L90 at this station for the time assessed were 55.1 dBA and 37.9 dBA respectively.

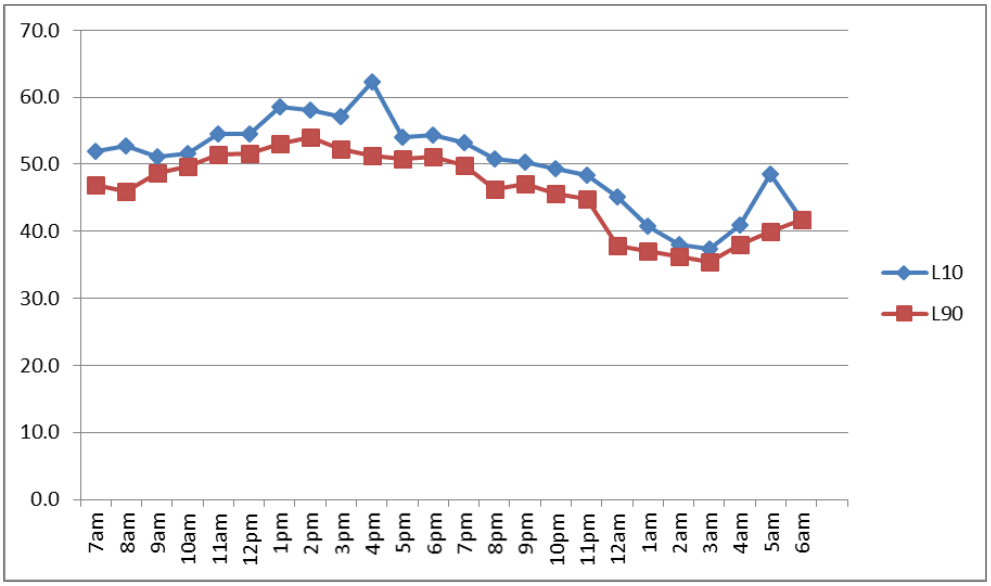


Figure 5-79 L10 and L90 for Station 5

Station N6

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 32.2 dBA to a high (Lmax) of 85.8 dBA. Average noise level for this period was 48.3 L_{Aeq} (24h). The fluctuation in noise levels over the 24 hour period is depicted in Figure 5-80.

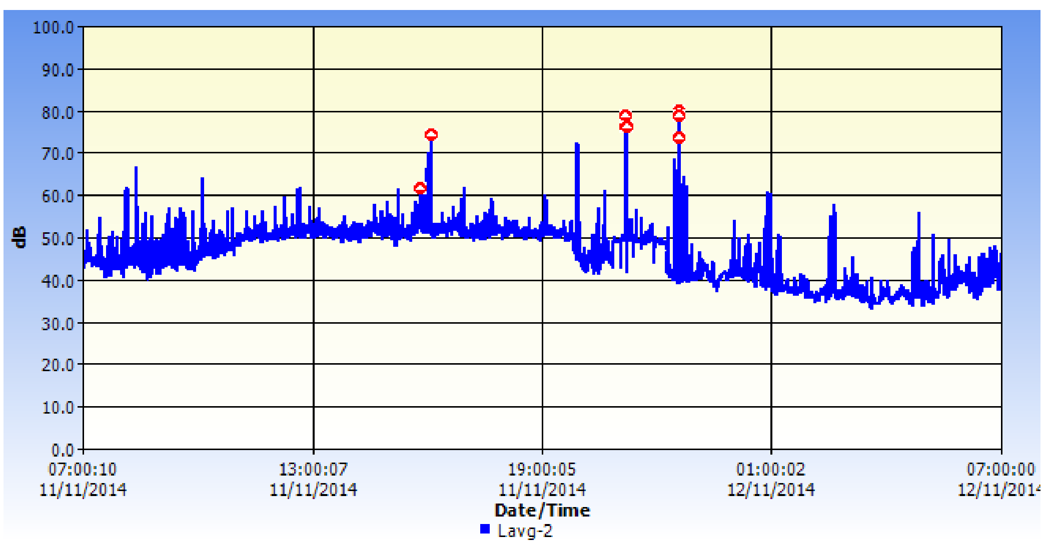


Figure 5-80 Noise fluctuation (Leq) over 24 hours at Station 6

OCTAVE BAND ANALYSIS AT STATION 6

The noise at this station during the 24 hour period was in the low frequency band centred around the geometric mean frequency of 50 Hz (octave frequency range is 45 - 56 Hz) (Figure 5-81).

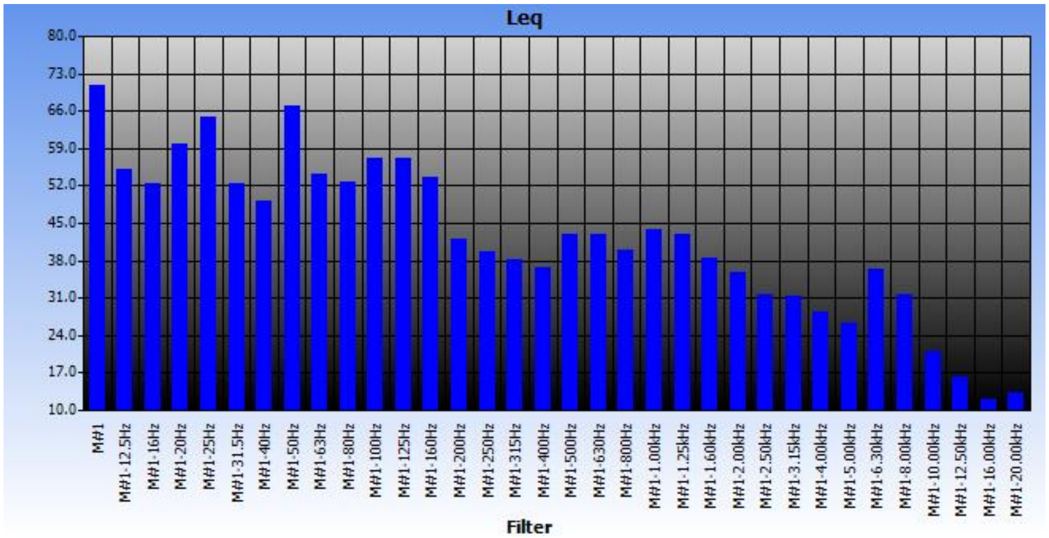


Figure 5-81 Octave band spectrum of noise at Station 6

L10 AND L90 – STATION N6

Figure 5-82 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) ≈33.33% of the time and no significant fluctuations in the noise climate (L10 – L90) ≈66.67% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 52.2 dBA and 36.6 dBA respectively.

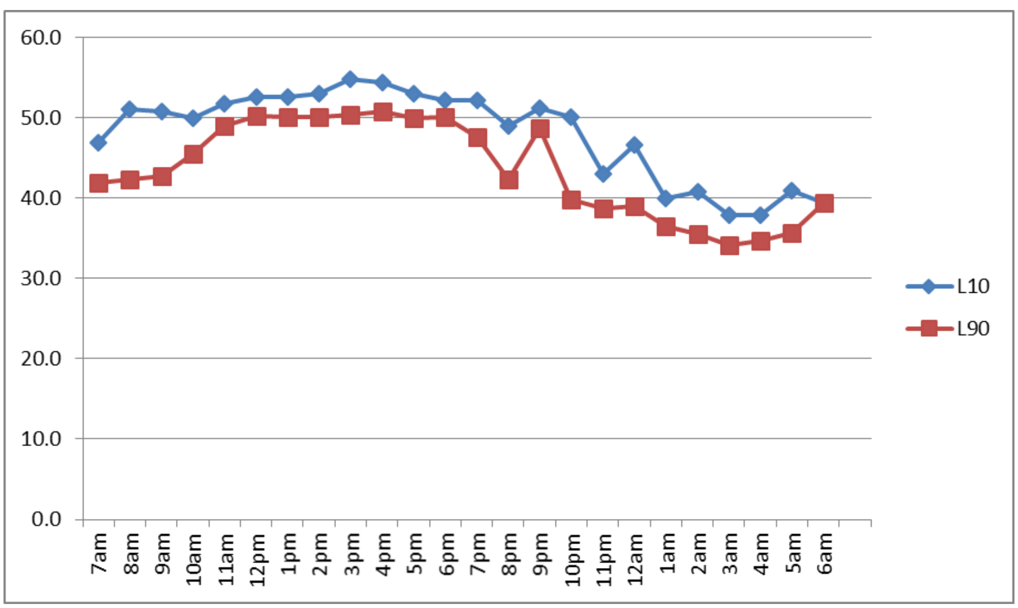


Figure 5-82 L10 and L90 for Station 6

Station N7

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 30.8 dBA to a high (Lmax) of 86 dBA. Average noise level for this period was 51.7 L_{Aeq} (24h). The fluctuation in noise levels over the 24 hour period is depicted in Figure 5-83.

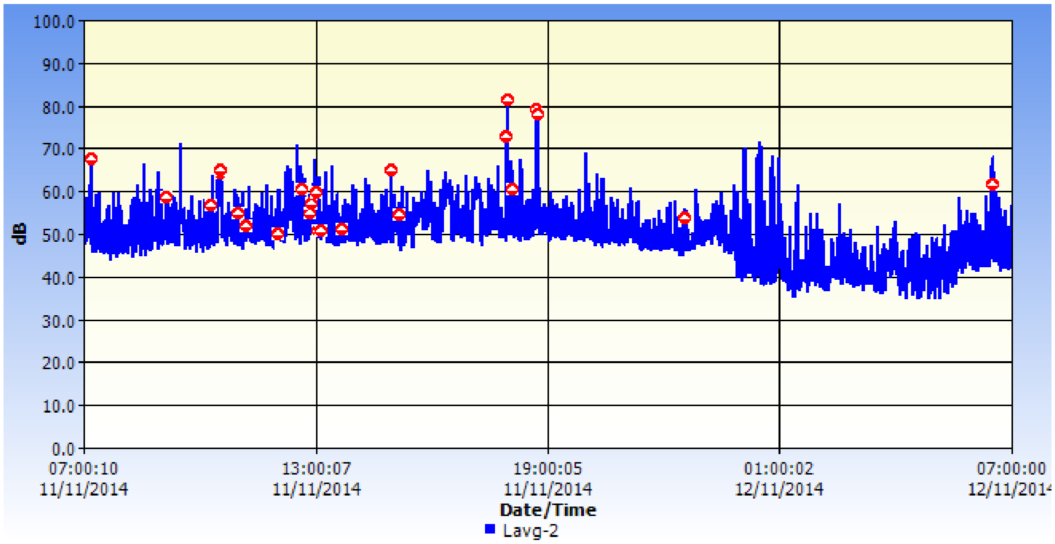


Figure 5-83 Noise fluctuation (Leq) over 24 hours at Station 7

OCTAVE BAND ANALYSIS AT STATION 7

The noise at this station during the 24 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz) (Figure 5-84).

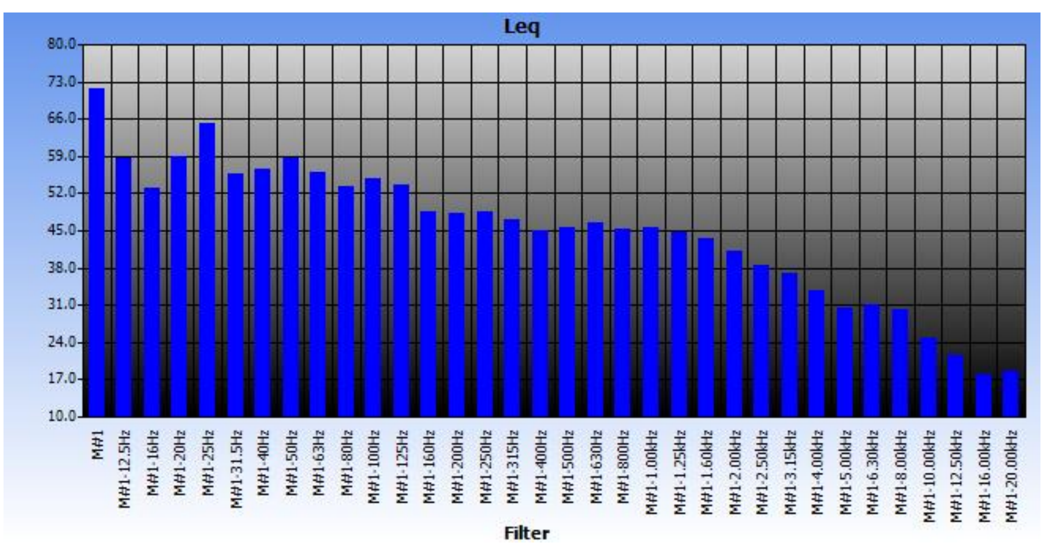


Figure 5-84 Octave band spectrum of noise at Station 7

L10 AND L90 – STATION N7

Figure 5-85 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈87.5% of the time, no significant fluctuations in the noise climate (L10 – L90) ≈8.3% of the time and large fluctuations (L10 – L90) ≈4.2% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 56.0 dBA and 40.9 dBA respectively.

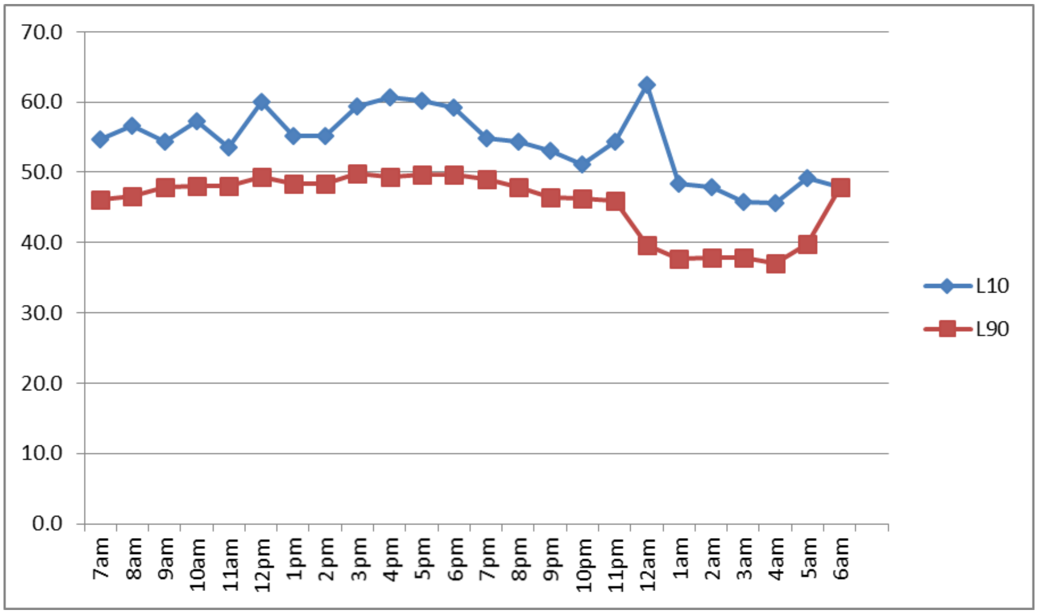


Figure 5-85 L10 and L90 for Station 7

Station N8

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 32.2 dBA to a high (Lmax) of 75.8 dBA. Average noise level for this period was 42.6 L_{Aeq} (24h). The fluctuation in noise levels over the 24 hour period is depicted in Figure 5-86.

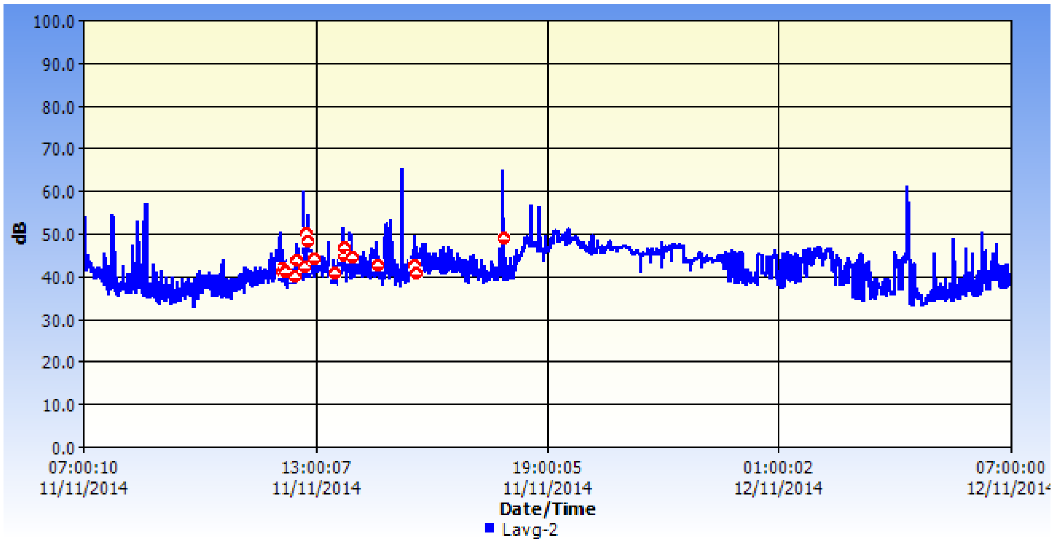


Figure 5-86 Noise fluctuation (Leq) over 24 hours at Station 8

OCTAVE BAND ANALYSIS AT STATION 8

The noise at this station during the 24 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz) (Figure 5-87).

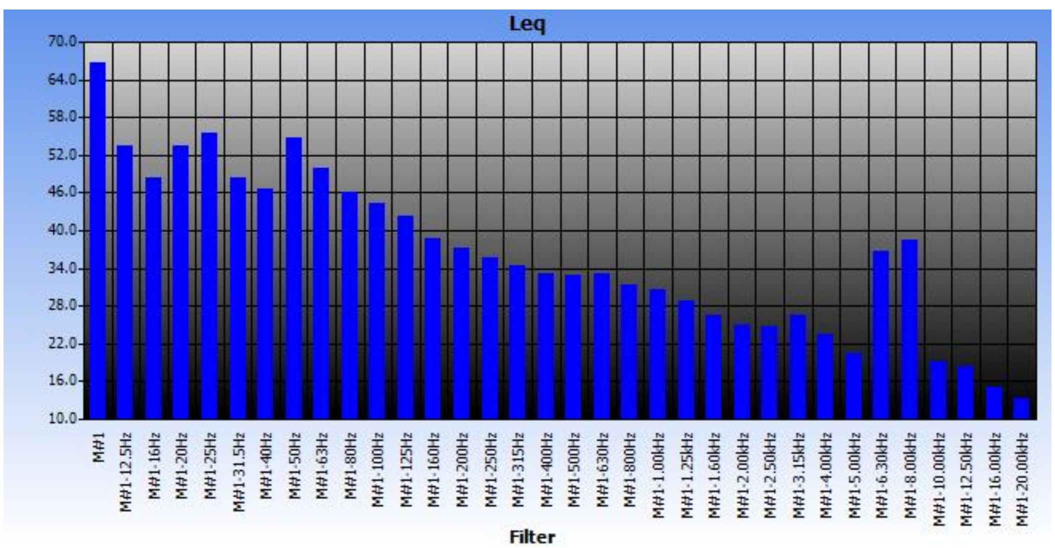


Figure 5-87 Octave band spectrum of noise at Station 8

L10 AND L90 – STATION N8

Figure 5-88 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈41.7% of the time and no significant fluctuations (L10 – L90) ≈58.3% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 46.6 dBA and 36.1 dBA respectively.

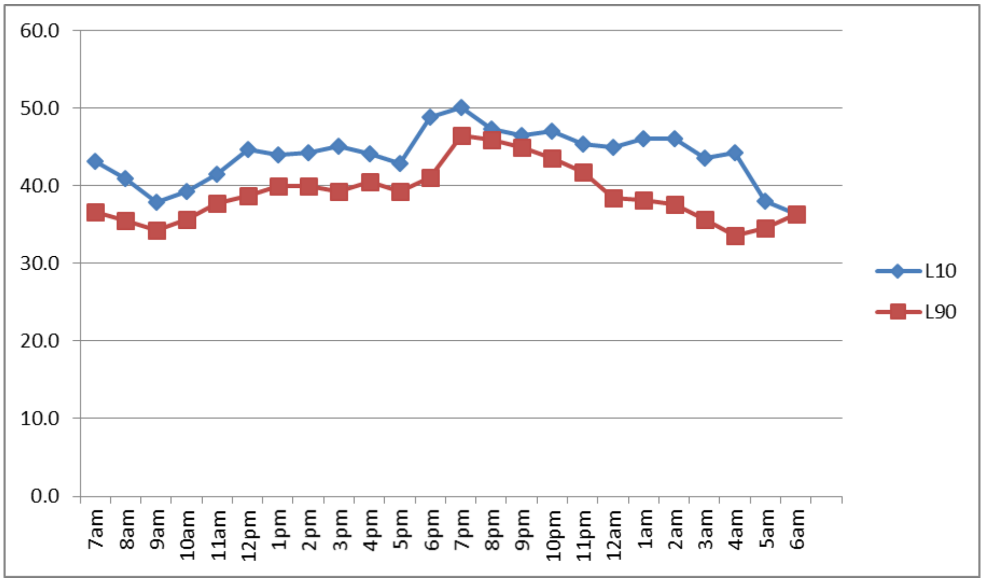


Figure 5-88 L10 and L90 for Station 8

Station N9

During the period, noise levels at this station ranged from a low (Lmin) of 31.5 dBA to a high (Lmax) of 71.6 dBA. Average noise level for this period was 42.9 L_{Aeq}. The fluctuation in noise levels over the period is depicted in Figure 5-89. Due to battery failure on the meter at this station, noise data was logged from 7:00:00am – 15:00:50pm (8 hours).

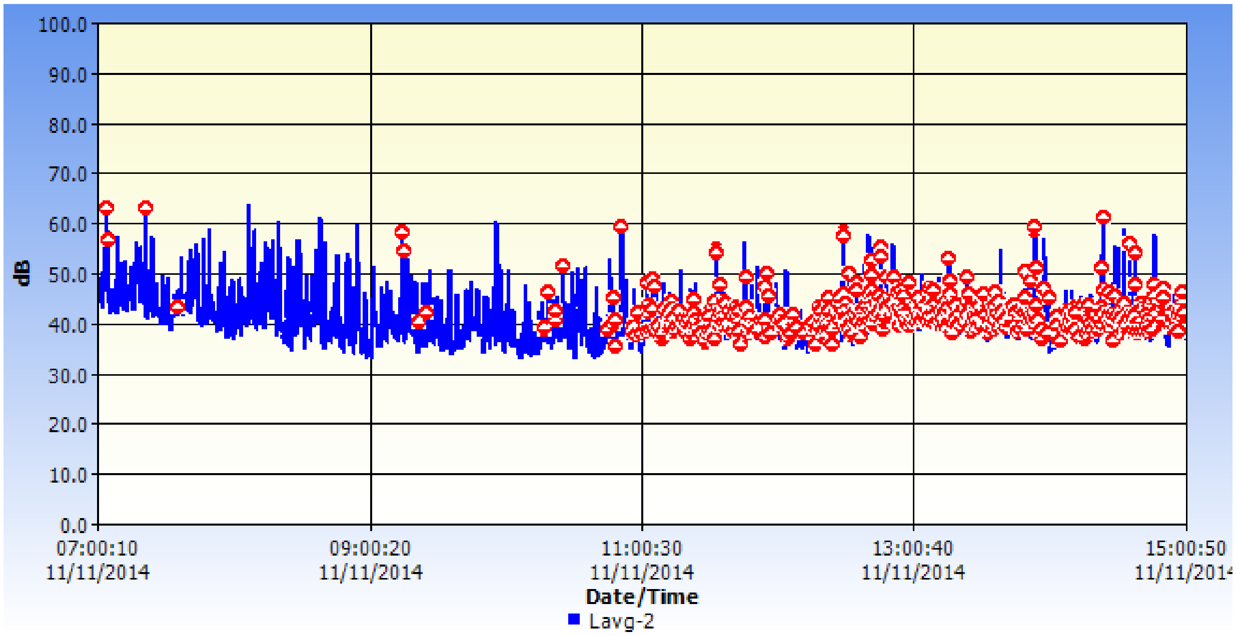


Figure 5-89 Noise fluctuation (Leq) over 24 hours at Station 9

OCTAVE BAND ANALYSIS AT STATION 9

The noise at this station during the period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz (octave frequency range is 11 - 14 Hz) (Figure 5-90).

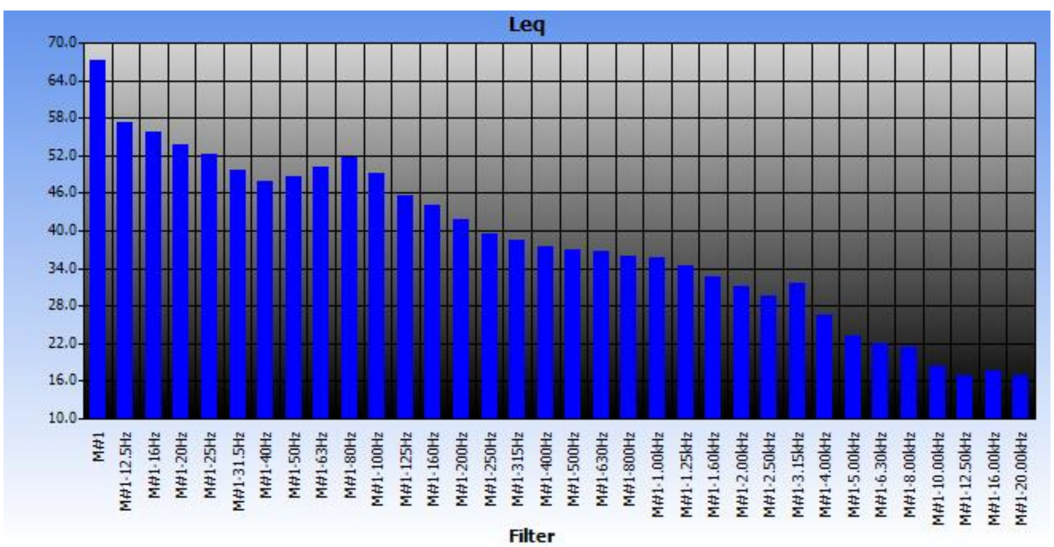


Figure 5-90 Octave band spectrum of noise at Station 9

L10 AND L90 – STATION N9

Figure 5-91 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The overall L10 and L 90 at this station for the time assessed were 46.8 dBA and 36.1 dBA respectively.

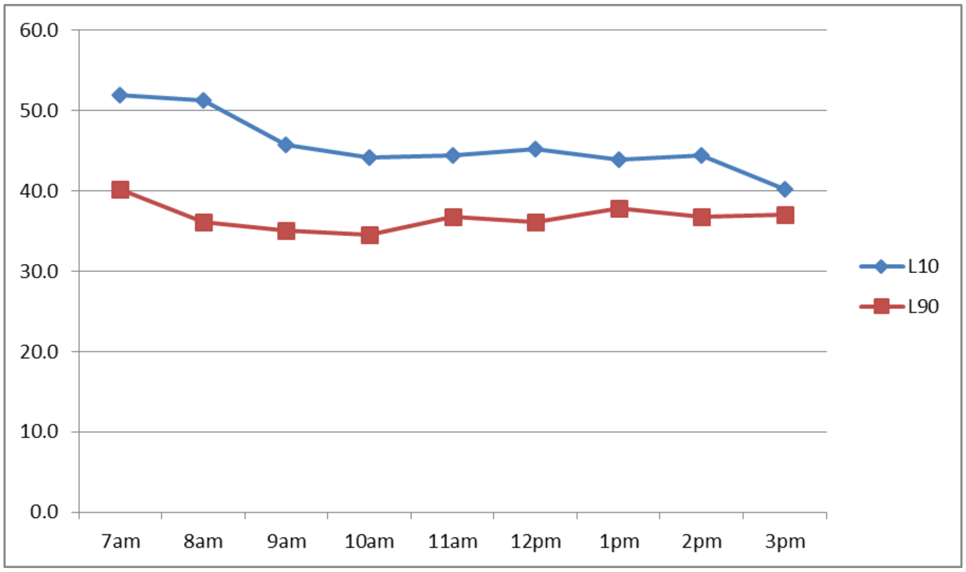


Figure 5-91 L10 and L90 for Station 9

5.1.11.4 Comparisons of Ambient Noise Levels with NEPA Guidelines

Comparison of the ambient noise levels in the study area with NEPA guidelines are shown in Table 5-34. All stations (N1-N8) were compliant with the NEPA noise guidelines during the daytime (7am – 10 pm) and during the night time (10 pm – 7 am).

Table 5-34 Comparison of noise levels at the stations with the NEPA guidelines

STN #	ZONE	7 am. - 10 pm. (dBA)	NEPA Guideline (dBA)	10 pm. - 7 am. (dBA)	NEPA Guideline (dBA)
N1	Industrial	66.9	75	59.6	70
N2	Industrial	62.4	75	56.5	70
N3	Industrial	64.0	75	58.0	70
N4	Industrial	62.9	75	59.8	70
N5	Residential	53.1	55	43.0	50
N6	Residential	50.5	55	42.4	50
N7	Residential	53.3	55	47.9	50
N8	Residential	43.1	55	41.9	50
N9	Residential	N/A	55	N/A	50

5.1.11.5 Comparison with 2012 Study

The average noise levels for the three noise stations in common with the 2012 study (Blackwood Gardens, Old Harbour Bay Police Station and Longville Park Housing Scheme) were lower for the current 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.

5.1.12 Air Quality

5.1.12.1 Historical Ambient Air Quality Data

Data from the Lauderwood Air Quality Monitoring Station operated by JPS are indicated in Table 5-35. All measurements for all five years are below the National Ambient Air Quality Standards for the respective averaging periods.

Table 5-35 Historical ambient air quality monitoring data including measured 1-h and 24-h maximum and annual mean SO2 concentrations, the 1-h maximum and annual mean NOx concentrations and the 1-h maximum O3

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
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

5.1.12.2 Particulates (PM10, PM2.5 and TSP)

Introduction

This report entails the results derived from the PM10, PM2.5 and Total Suspended Particulates (TSP) particulates survey conducted from November 11th – November 27th, 2014. None of the sampling locations from the 2012 EIA study were assessed for this present EIA.

Methodology

PM2.5, PM10 and Total Suspended Particles (TSP) particulate sampling was conducted for 24 hours using Airmetrics Mini-Volume Tactical Air Samplers. A total of two (2) sampling runs for each particle size class was conducted The first PM10 sampling exercise was conducted from 12:00am on November 11th, 2014 until 12:00am November 12th, 2014. The second PM10 sampling exercise was conducted from 12:00am on November 18th, 2014 until 12:00am November 19th, 2014. The first PM2.5 sampling exercise was conducted from 12:00am on November 20th, 2014 until 12:00am November 21st, 2014. The second PM2.5 sampling exercise was conducted from 12:00am on November 22nd, 2014 until 12:00am November 23rd, 2014. The first TSP sampling exercise was conducted from 12:00am on November 24th, 2014 until 12:00am November 25th, 2014. The second TSP sampling exercise was conducted from 12:00am on November 26th, 2014 until 12:00am November 27th, 2014.

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. 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.

Particulate measurements were conducted at five (5) locations (Figure 5-92) (Table 5-36).

Table 5-36 Particulate sampling locations

STATION	LOCATION	JAD 2001	
		Northing (m)	Easting (m)
P1	North-Western Property Boundary	638937.99	738508.72
P2	South-Western Property Boundary	638860.04	738486.45
P3	South-Eastern Property Boundary	638884.88	738573.82
P4	North-Eastern Property Boundary	638979.11	738614.94
P5	Old Harbour Bay Police Station	639705.67	739747.33

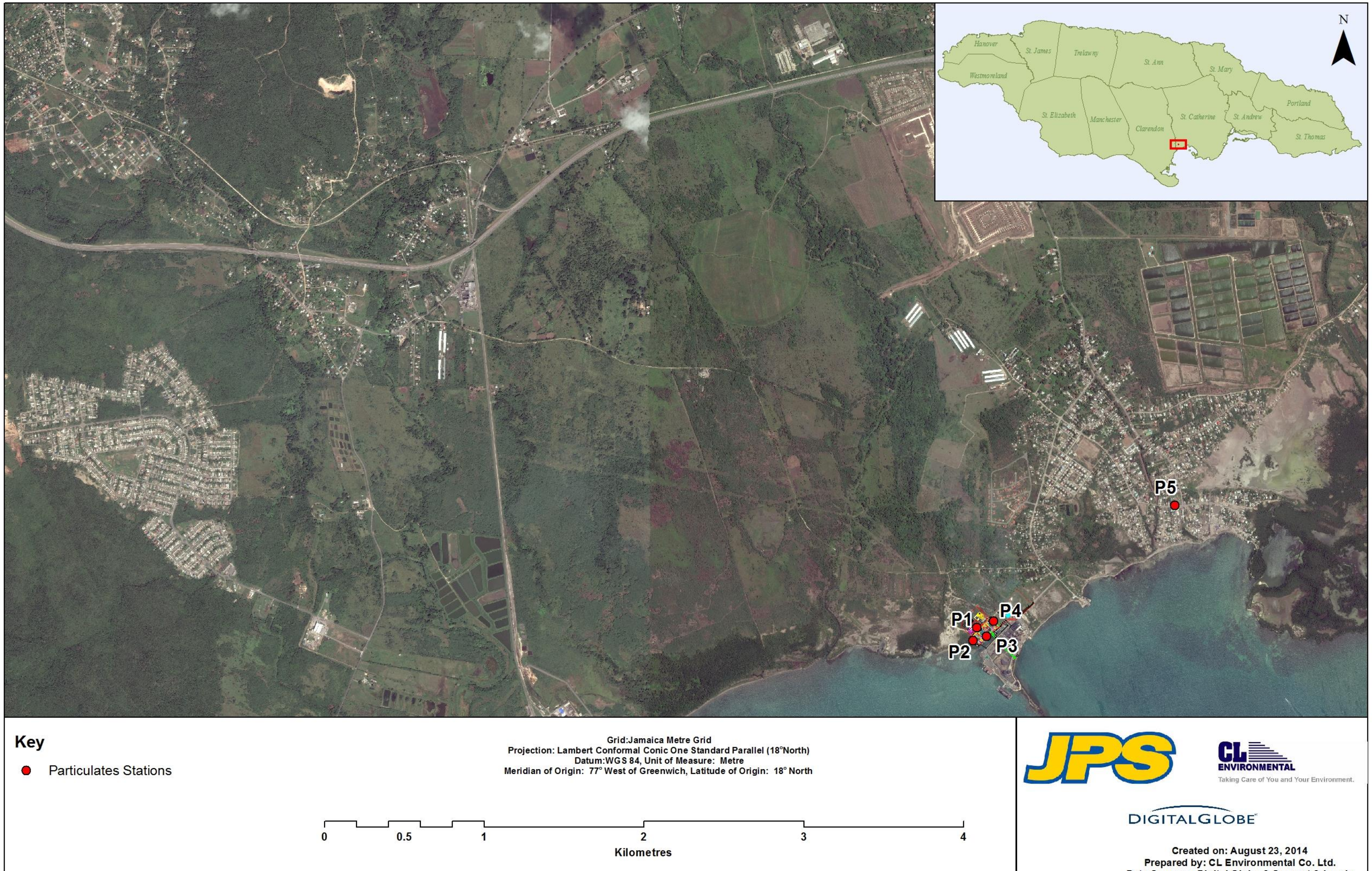


Figure 5-92 Map depicting the particulate sampling stations

Plate 5-3 Example of particulate sampler

Results

PM10 RESULTS

The PM10 results indicate that all locations had particulate values compliant with the 24-hour US EPA standard of 150 µg/m3. Results were similar for the locations at the boundaries of the proposed site, with the southwestern boundary having the highest mean value and the northwestern boundary having the lowest. Old Harbour Bay police station had the highest overall PM10 value; this station is prone to high particulate levels due to the road and vehicles which traverse this road stirring up dust.

The results of the PM10 sampling runs are shown in Table 5-37.

Table 5-37 PM10 Results

Station	Location	Range Result (µg/m^3)	Mean Result (µg/m^3)	US EPA Std. (µg/m^3)
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**

PM2.5 RESULTS

The PM2.5 results indicate that all locations had particulate values compliant with the 24-hour US EPA standard of 35 µg/m^3. Results were similar for the locations at the northeastern and northwestern boundaries of the proposed site; while those at the southeastern and south western boundaries were similar. On average, PM2.5 readings at the northern boundaries were higher than those on the southern boundaries. Old Harbour Bay police station had the highest overall PM2.5 value; this station is prone to PM2.5 particulates due to exhaust from the vehicles which traverse this road.

The results of the PM2.5 sampling runs are shown in Table 5-38.

Table 5-38 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**

TSP RESULTS

The TSP results indicate that all locations had particulate values compliant with the 24-hour NEPA standard of 150 μg/m³. TSP results were somewhat similar for the locations at the boundaries of the proposed site. The southeastern boundary had the highest TSP value on the proposed site, while the other three boundary locations had similar TSP values. Old Harbour Bay police station is prone to high particulate levels due to the road and vehicles which traverse this road stirring up dust and other coarse and fine particulates.

The results of the TSP sampling runs are shown in Table 5-39.

Table 5-39 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**

5.1.13 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.

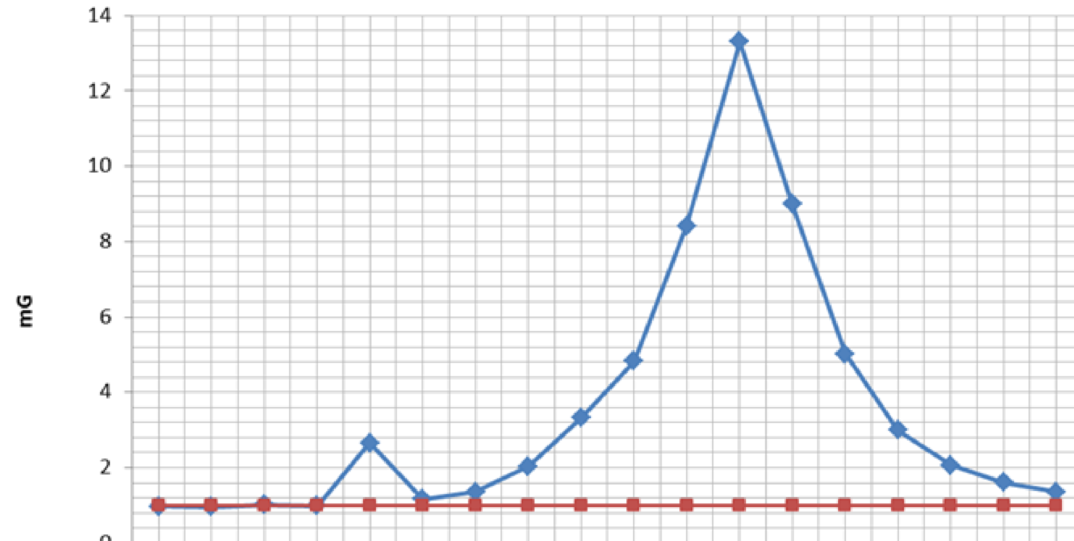
5.1.13.1 Methodology

EMF was measured at the 69 kV and 138 kV power lines on the proposed property and at approximately 10m intervals to determine the impact of distance from the source on EMF strength using a TM 192 triaxial Gauss meter. The readings were taken on May 19, 2012 between 9:00 and 11 am. The results for the previous EIA conducted for SJPC in 2012 are used, as it is not anticipated that the results will 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 5-40.



DISTANCE (m)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
XYZ (mG)	0.98	0.96	1.02	0.99	2.65	1.17	1.36	2.04	3.32	4.83	8.42	13.3	8.99	5.02	3	2.07	1.61	1.36
Upper Limit (mG)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Figure 5-93 EMF measurement results in relation to distance

Table 5-40 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

5.1.13.3 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 7.6m 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.

5.2 NATURAL HAZARDS

5.2.1 Riverine Flooding

Bowers Gully forms the lower part of a relatively complex drainage system with a catchment area in excess of thirty six square kilometres (Figure 5-94), part of the Central Inlier. Here the surface drainage is perennial, collected by the Myttins River and Cedar Gully. Below the confluence of these tributaries the system, known as the Plantain River, develops seasonal flow through limestone terrain before exiting onto the St. Catherine plain near Colbeck. By the time the river exits onto the plain, the system has lost most of its surface flow to the subsurface. However, Bowers Gully is susceptible to flooding under extreme precipitation conditions. Field investigations showed silt and clay overlying sand and gravel in the vicinity of the gully, indicative of flood events. This is a typical feature of fan deposits, particularly debris fans. Although the highest layers associated with the gully are clays, the presence of gravels lower in the exposures of the gully is suggestive of debris flows as well.

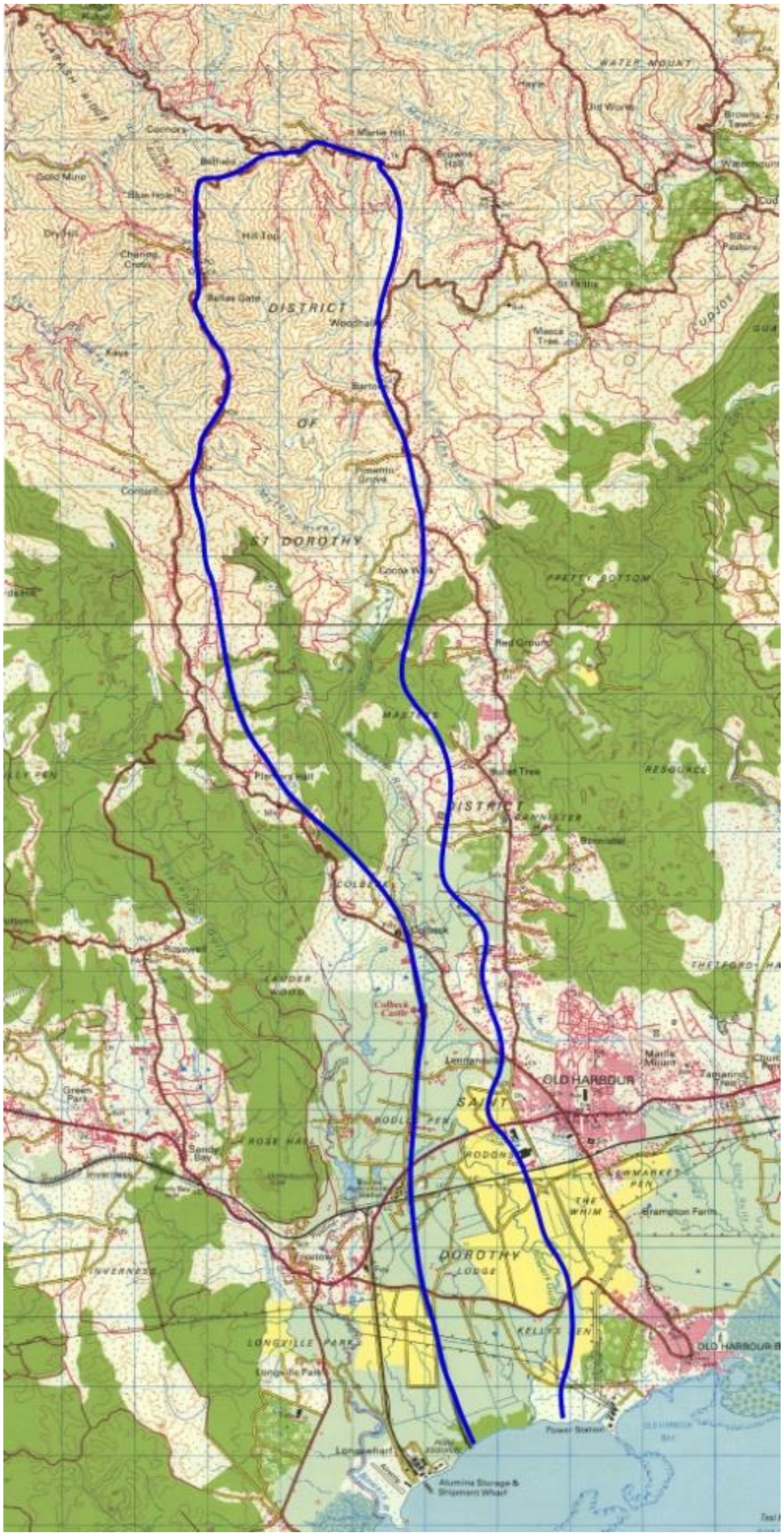


Figure 5-94 Approximate boundary of the Bowers Gully catchment. Grid squares are 1 km each side.

5.2.2 Hurricane Waves

The Old Harbour Bay is part of a larger bay known as the Portland Bight. The Portland Bight is exposed to the Caribbean Sea from a southerly direction, even though the Bay is partly enclosed, the potential is there for sufficiently large and destructive waves can enter from the Caribbean Sea. Similarly, Portland Bight is significantly large with a fetch of approximately 15.7 km in a southerly direction from the Old Harbour Bay to the Rocky point headland. It is therefore quite possible for local waves with significant wave heights to reach the shoreline.

A rapid assessment of both local and deep water waves that could potentially reach the shoreline from deep water was done using a database of hurricanes, dating back to 1886. The database was searched for storms that passed within a 500km radius from the site and the following procedure was carried out.

1. Extraction of storms and storm parameters from the historical database: A historical database of storms was searched for all storms passing within a 500km radius of the site.
2. 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.
3. 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.
4. 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 Weibull distribution. Table 5-41 shows the incident wave heights and periods obtained from the JONSWAP model.

Table 5-41 Incident wave heights and periods obtained for 1-in-50 year hurricane waves.

		SSW	S	SSE	SE	ESE
Local	**Hurricane**					
	Hs (m)	4.93	4.93	4.93	2.16	2.16
	Tp (s)	6.65	6.65	6.65	3.83	3.83
Deepwater	**Hurricane**					
	Hs (m)	5.9	5.9	5.9	7	7
	Tp (s)	12.1	12.1	12.1	13.2	13.2

Table 5-42 Bi-variant table showing incident wave heights and periods for the specific return periods and directions.

Return Periods	Wave height (m)											
	All		SW		W		E		SE		S	
	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp
1	2.0	7.2	1.0	5.1	1.0	5.1	1.0	5.1	1.0	5.1	1.0	5.1
2	3.6	9.5	3.3	9.2	3.5	9.5	4.6	10.7	4.0	10.1	3.4	9.3
5	4.9	11.0	4.1	10.1	4.6	10.7	5.7	11.9	5.2	11.4	4.4	10.5
10	5.7	11.9	4.4	10.5	5.1	11.3	6.3	12.5	5.9	12.1	5.0	11.1
20	6.4	12.6	4.7	10.9	5.6	11.8	6.8	13.0	6.4	12.6	5.4	11.6
25	6.6	12.8	4.8	11.0	5.7	11.9	6.9	13.1	6.6	12.8	5.6	11.7
50	7.3	13.4	5.1	11.2	6.1	12.3	7.3	13.4	7.0	13.2	5.9	12.1
75	7.7	13.7	5.2	11.4	6.3	12.5	7.5	13.6	7.3	13.4	6.1	12.3
100	7.9	14.0	5.3	11.5	6.4	12.6	7.7	13.7	7.5	13.5	6.3	12.5
150	8.3	14.3	5.4	11.6	6.6	12.8	7.9	13.9	7.7	13.7	6.5	12.6
200	8.6	14.5	5.5	11.7	6.7	12.9	8.0	14.0	7.8	13.9	6.6	12.8

5.2.2.1 Locally Generated Hurricane Waves

Methodology

The incident wave height and period to be used in the model corresponding to the locally generated waves was calculated using the JONSWAP equation. 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[7]. 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.

Results

The shoreline is most vulnerable to waves from the south eastern and southern direction. The JONSWAP equation determined that under hurricane conditions, a 100 year return period event moving in a south easterly direction will generate a wave height of 3.6 m and a wave period of 5.4 s. For the southern direction it will generate a wave height of 5.2 m and a wave period of 7.0 s; these results are summarized in Table 5-43. If climate changes are considered, the hurricane waves are expected to be increased. The results under future climate conditions (50 yrs. from present) are wave heights and periods of 5.4 m and 7.3 s for the south easterly event, and 3.7 m and 5.7 s for the southern event.

[7] Kamphuis, J (2002), Introduction to Coastal Engineering and Management, *Advanced Series on Ocean Engineering – Volume 16*

Table 5-43 Results from the JONSWAP method of determining wave height and period based on fetch limited conditions

Wind speed (m/s)	Wind direction	Fetch (km)	Duration (h)	Depth (m)	F*	t*	Feff*	Feff*	Hmo*	Tp*	Hmo (m)	Tp (s)	Set-up
73.7	SE	9	4	10	16	1919	147	16	0.01	1.51	**3.57**	**5.44**	1.01
73.7	S	19	4	10	34	1919	147	34	0.01	1.51	**5.19**	**6.98**	2.13

5.2.2.2 Nearshore Wave Climate

Methodology

The objective of this exercise is to derive a nearshore 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. These incident wave heights and periods were then used to determine the hurricane climate under future conditions (climate change). Both the existing and future climate condition results were utilized in the REFDIF model to generate the nearshore wave climate. See Table 5-44 for a summary of the incident wave conditions used for the analysis. Based on the deepwater wave climate, storm surge analysis, shoreline shape and the geographical location of the project area, it was determined that the project area or the proposed pipeline will be most vulnerable to waves from the southern and southeastern directions.

Table 5-44 Incident wave heights and periods obtained for hurricane waves generated locally and offshore (deepwater) used to derive the nearshore wave climate for the 100 year storm event.

Wave Climate	DP	Existing Climate Environment	
		Hs (m)	Tp (s)
Local	S	4.12	6.07
	SE	4.28	6.22
Deepwater	S	7.70	13.7
	SE	7.70	13.7

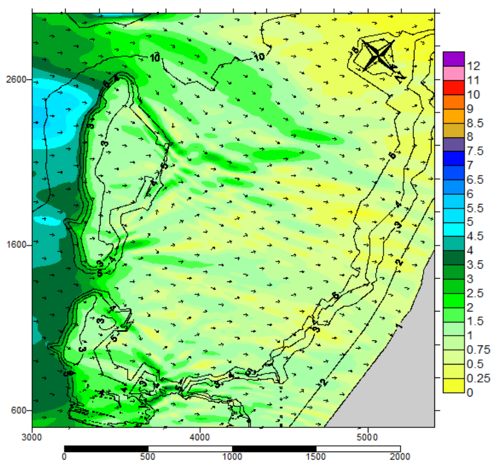
Results

During hurricane events there will be a wave setup and so an elevation of 2.44 m and 2.76 m was added to the simulation for the 100 year events under existing climate conditions. See Table 5-45 and Table 5-46 for the resultant wave plots from the REFDIF modelling exercise.

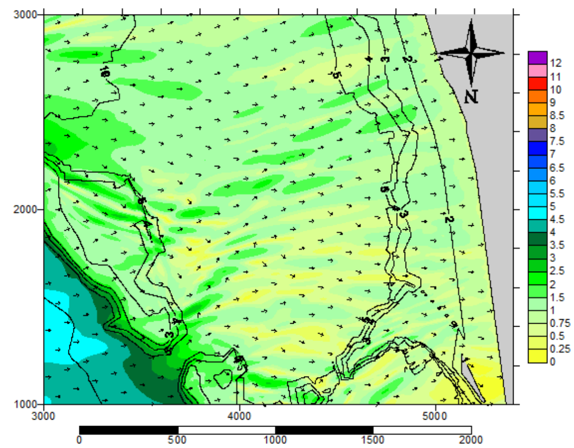
HURRICANE WAVES (LOCALLY GENERATED)

Considering the size of the bay, it was important that we model hurricane wind generated waves which could form within the bay. Given that wind generated waves originating nearshore in relatively shallow water need a long fetch to generate significant wave heights, we modelled two directions, S, and SE for both 50 and 100 years return periods. These directions show that a wave would have a fetch of approximately 14 km and so show great potential for significant wave generation. The wave plots generated from the model showed that during hurricane conditions, wave heights of up 1.5 m reaching the shoreline each direction, with the waves from the southern direction affecting the shoreline more severely.

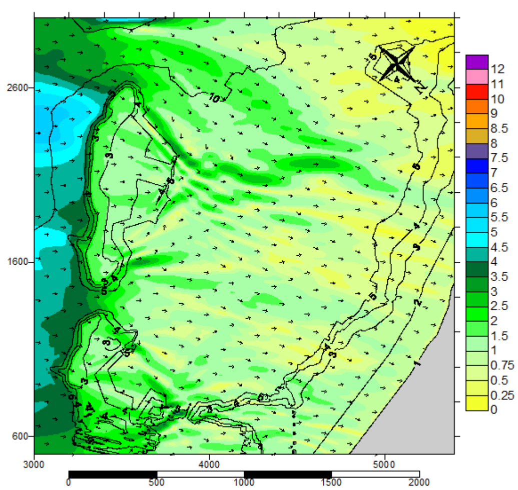
Table 5-45 Hurricane wave plots generated from the local hurricane wave climate for a 100 year return period event under existing and future climate conditions



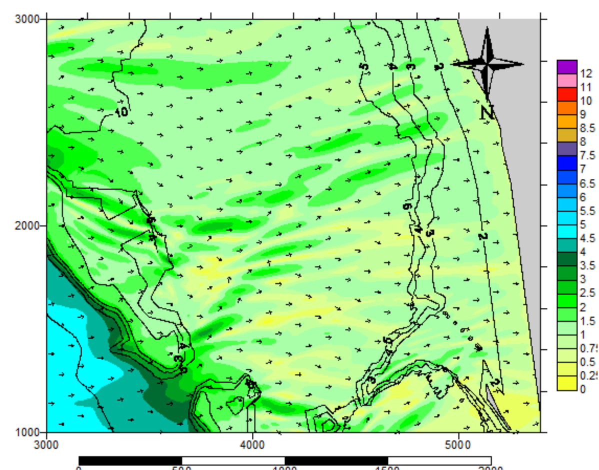
SE 50 year



S 50 year



SE 100 year

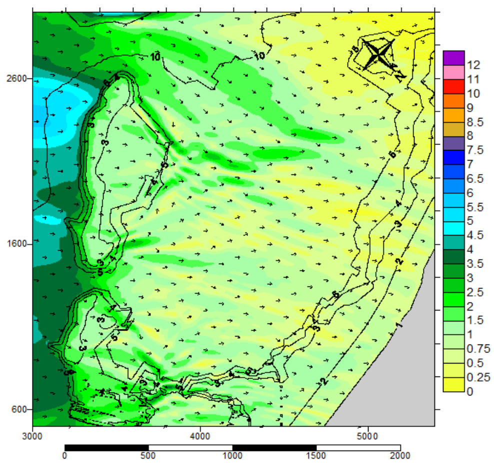


S 100 year

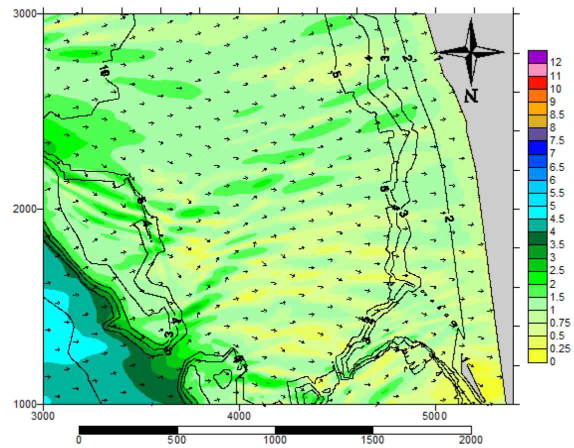
HURRICANE WAVES (DEEPWATER)

It was very important to model hurricane wind generated waves from deepwater. We modelled two directions, S, and SE for both 50 and 100 years return periods. These directions show that a wave would have a fetch of approximately 14 km and so show great potential for significant wave generation. The largest predicted wave heights to reach the shoreline were generated from the SE and S directions ranging from 1.5 to 2 m for the 100 year return period. While for the 50 year return period wave heights of up to 1.5m was noticed reaching the shoreline. The JPS shoreline is sheltered by the reefs located south east of the shoreline resulting in a reduction in the size of the waves reaching the shoreline.

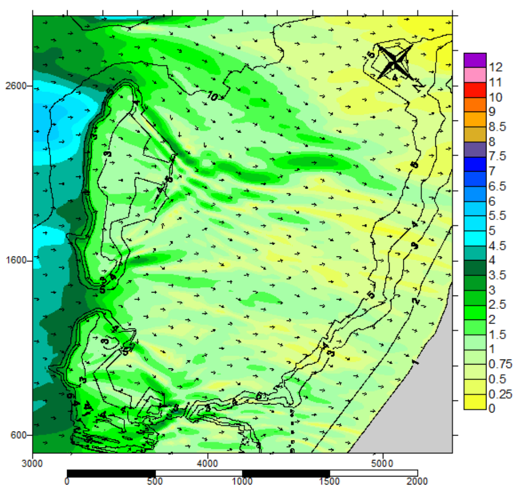
Table 5-46 Hurricane wave plots generated from the deepwater hurricane wave climate for a 50 and 100 year return period event



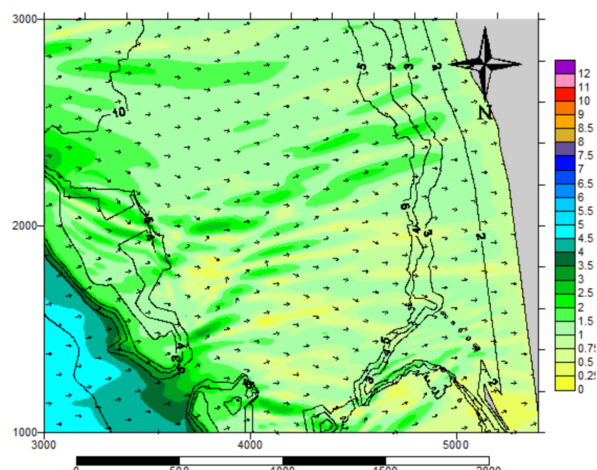
SE 50 year



S 50 year



SE 100 year



S 100 year

5.2.3 Storm Surge and Coastal Inundation

5.2.3.1 Anecdotal Information

Hurricane Ivan storm surge at the site was estimated to be 1 to 1.5 m, based on conversations with observers at the existing JPS plant. Figure 5-95 indicates the values for storm surge height and inundation distance for four localities at Old Harbour Bay during hurricane Dean, 2007. A storm surge of 3+ m was recorded at the Port Esquivel bauxite terminal just west of the site, and 3.1 m at the conch port of Old Harbour Bay, east of the site, with an inundation distance of about 180 m (Robinson & Khan, 2011). Hurricanes and tropical storms are frequently accompanied by heavy rainfall. It has also been widely suggested that the Atlantic-Caribbean region has already moved, into a cycle of more frequent and more severe tropical disturbances.

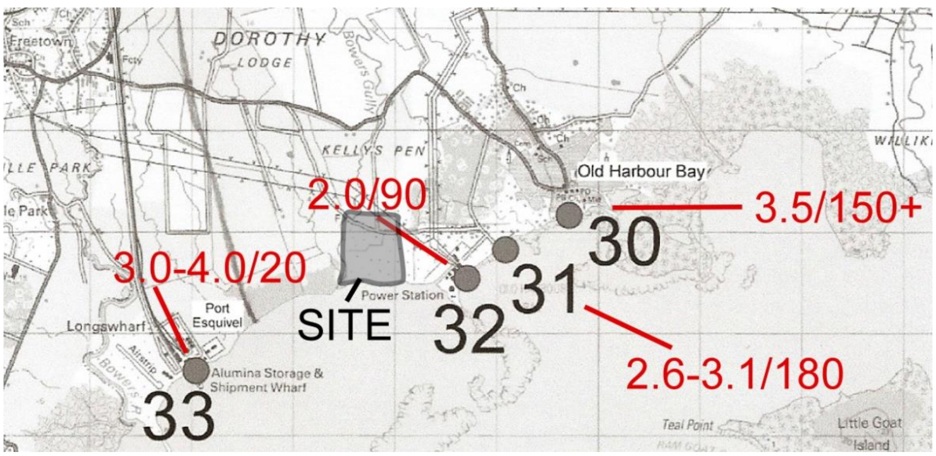


Figure 5-95 Hurricane Dean 2007 surge heights (first red number) and inundation distances (red number after the slash) for four localities in Old Harbour Bay. Locality 30, from Mines & Geology Division data; localities 31-33 from Marine Geology Unit data. Figure modified from Robinson & Khan, 2011, Fig. 15).

5.2.3.2 Rapid Assessment

It is important to define the design water levels in the project area in order to define the appropriate crest elevations for floor levels of importance structure as well as setbacks for buildings. A rapid assessment similar to that for the hurricane waves was carried out, the results of this assessment 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).
- Wind speeds in excess of 35 metres/second are expected to impact the site for a 50 year storm.
- The setup is expected to be in excess of 1.2m above MSL for a 50yr event.

5.2.3.3 Storm Surge and Overland Flooding

It is possible for storm surge to occur simultaneously with overland flooding in coastal areas such as the proposed site. 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. Information regarding historical hurricane and rainfall events was obtained by conducting interviews with residents along Terminal Lane and the fishing beach in Old Harbour Bay, with living first hand memory of hurricane events in the area. This information was also compared against a storm surge model written by CEAC Solution Company Ltd ant it was found that they had reasonable agreement.

Table 5-47 Observed average setup (based on interviews) versus model predicted setup.

Hurricane	Oberved-Average setup (m)	Predicted-Average setup (m)	Difference (m)
Dean	3.073	2.415	0.658
Ivan	3.250	4.462	-1.212
		Average	**-0.277**

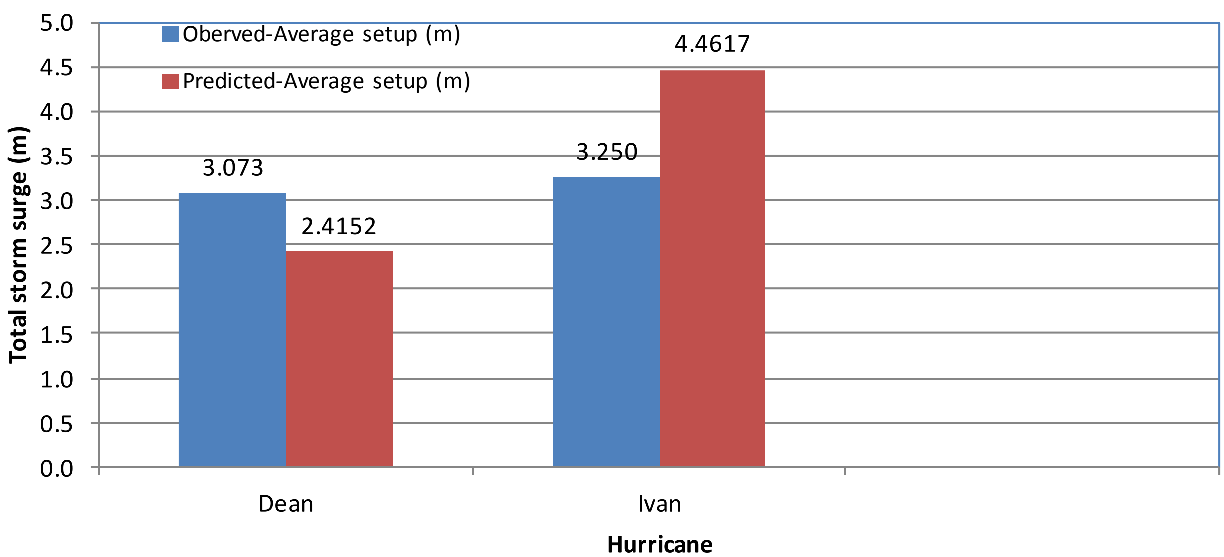


Figure 5-96 Observed average setup (based on interviews) versus model predicted setup.

The observed setups were subjected to extremal statistical analysis to estimate the return period of the setups experienced. The statistical tool used was the Weibull function which is widely used for this type of extremal data analysis due to it having three variables which enables it to obtain a better fitted curve than others which have only two variables.

A storm surge inundation map of the area was plotted to highlight the areas that would flood as a result of storm surge only. The resulting map shows the entire project site is susceptible to flooding as result of the 50 year storm surge (Figure 5-97).

Table 5-48 Predicted storm surge values.

Return Period	Predicted Storm Surge (from Observations) (m)
2	2.85
5	3.17
10	3.32
25	3.46
50	3.55
100	3.63

5.2.4 Long Term Sea Level Rise

A study was conducted by the Climate Studies Group at the University of the West Indies (UWI) Mona (Group, 2013). It assessed literature on current and projected trends in sea level rise with a particular emphasis on future values for Jamaica.

Global sea level trends 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[8] of 3.2 mm/yr ($\pm$ 0.4). Projected increases in global and Caribbean mean sea level by 2100 relative to the 1980-1999 is 0.37m[9] ($\pm$ 0.5 m relative to global mean) and this is equivalent to 3.7 mm/yr.

[8] IPCC 2013
[9] IPCC 2007

Figure 5-97 Storm Surge inundation Map showing the extents of the 10 year and 50 year storm surge incorrect map wrong site

5.2.5 Coastal Erosion Hazard and Vulnerability

5.2.5.1 Long Term Coastal Erosion Trends

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.

Methodology

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 5-98 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 5-98 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 5-49 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 5-49 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

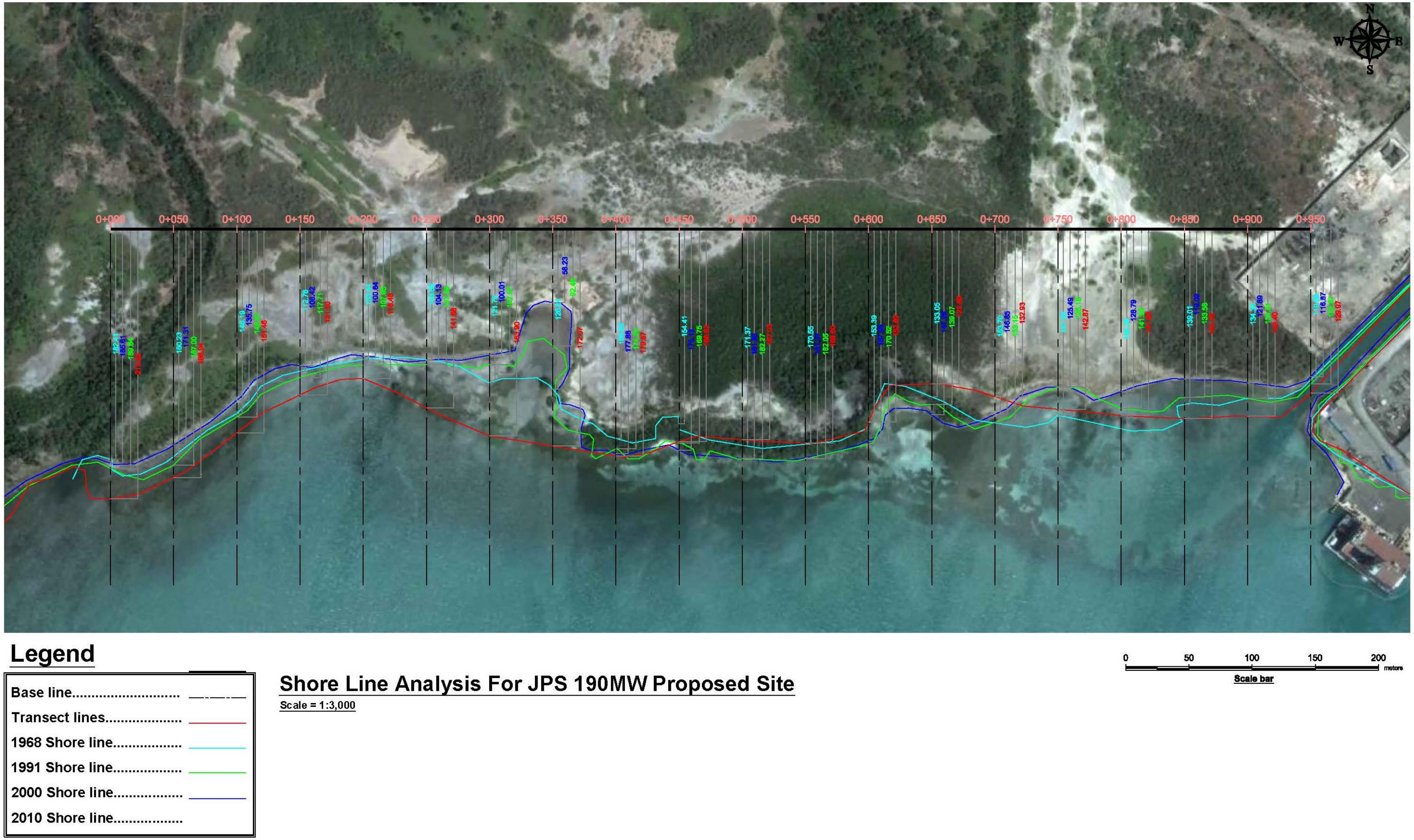


Figure 5-98 Historical Shoreline positions plotted over a satellite image of the area. The red, cyan green and blue lines represent the 1968, 1991, 2000 and 2010 shoreline positions respectively. The image is oriented north.

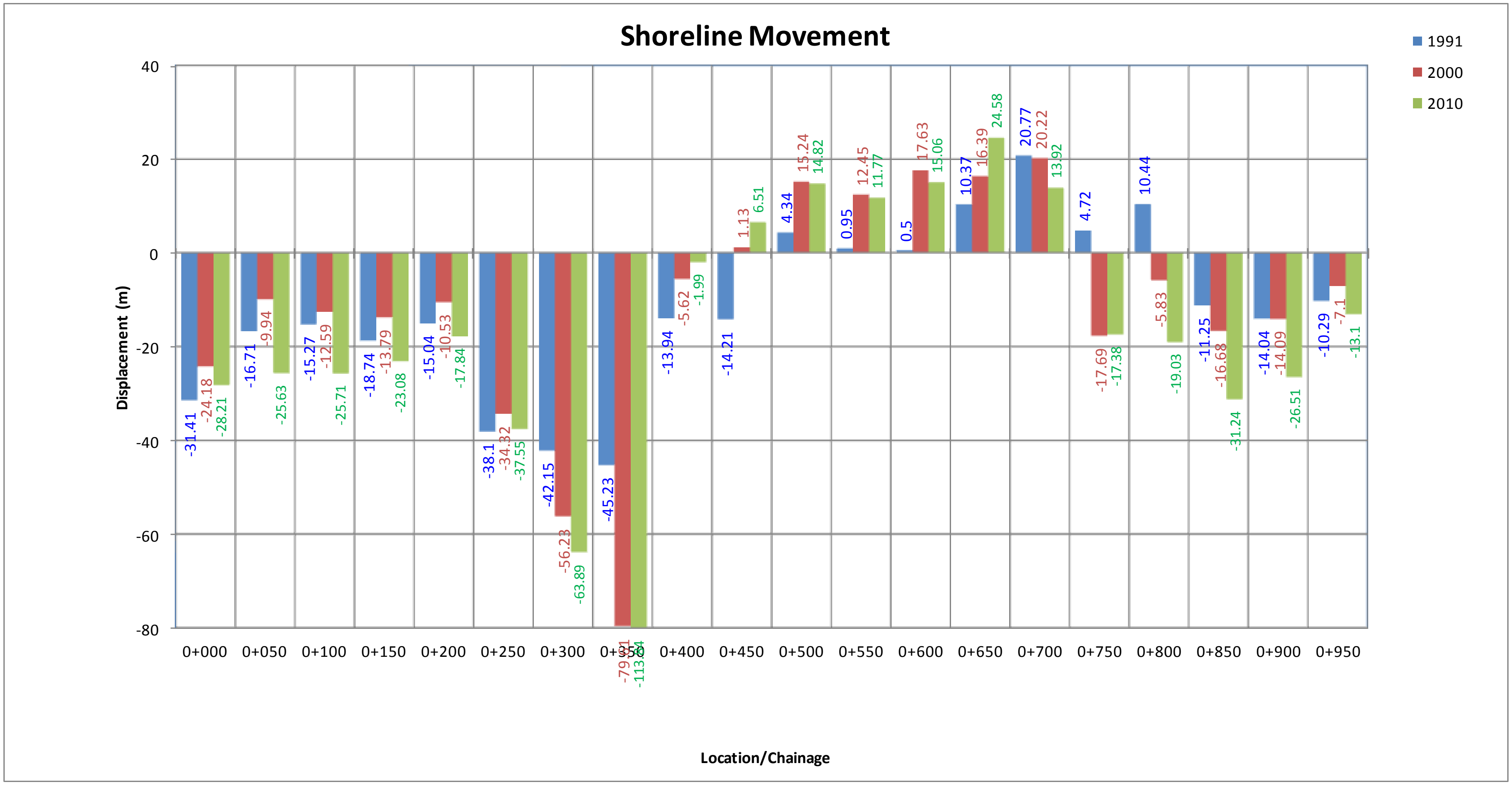


Figure 5-99 Graph showing the displacements of the shoreline for different years about the 1968 shoreline for Old Harbour Bay (1964 to 20010)

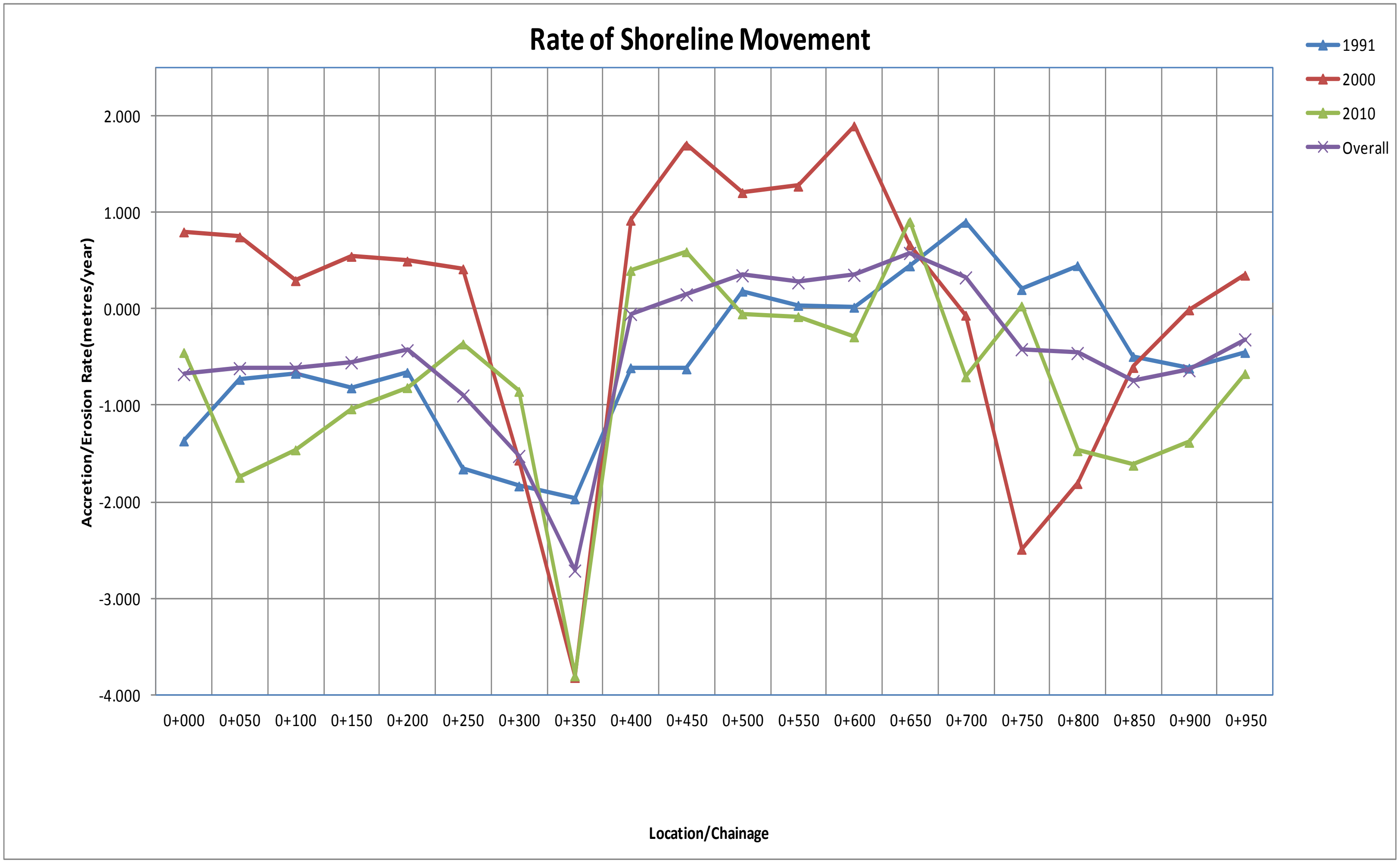


Figure 5-100 Graph showing the rates of erosion/accretion for the shoreline about the 1968 shoreline for different time intervals for Old Harbour Bay (1964 to 2010)

Estimation of Shoreline Retreat

BRUUN MODEL

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 Bruun Model equation.

CALCULATIONS

Overall the shoreline has been eroding based on the 42 years of imagery data examined. The Bruun model indicates some of the erosions (67 to 100 percent) measured from the imagery can be attributed to sea level rise. It would also indicate that short term erosions due to extreme events are not the key drivers of erosion but the rise rising sea levels.

Table 5-50 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. The historical erosions at each profile location (1-4) were compared to the Bruun estimated erosion due to sea level rise. The results indicated sea level rise may actually be a major contributor to shoreline erosion. At location 1 SLR may actually account for 67 percent of the erosion that occurred, at locations 2 and 3 all the erosion that occurred may be due to SLR, and at location 4 the growth of the area has been limited by around 67 percent.

Overall the shoreline has been eroding based on the 42 years of imagery data examined. The Bruun model indicates some of the erosions (67 to 100 percent) measured from the imagery can be attributed to sea level rise. It would also indicate that short term erosions due to extreme events are not the key drivers of erosion but the rise rising sea levels.

Table 5-50 Comparison of long-term erosion trends for Old Harbour Bay beaches to the estimates of erosion due to sea level rise using Bruun Model.

Beach	1	2	3	4
Profile	1	2	3	4
Chainage	0+250	0+550	0+750	1+600
Long term erosion (m) (42 years)				
Brune	25.03	16.42	21.40	42.32
Historical	37.55	11.77	17.38	-20.49
Difference (m)	12.52	-4.65	-4.02	-62.81
Difference (%)	67%	140%	123%	-67%

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.

5.2.5.2 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 5-51 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 analysed along the 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.

5.2.6 Seismicity and Earthquakes

Evidence of fault movements affecting the White Limestone bedrock (five million years and older) in the Old Harbour Bay region is provided by data from water supply wells and geophysical studies (Fernandez, 1983), confirmed from numerous surface outcrops throughout the island. Although no younger rocks outcrop in the immediate vicinity of the site, in other parts of the island rocks of the Coastal Group (130,000 to 3 million years old) are warped and/or faulted (Horsfield 1973). As noted above, faulting affecting more recent unconsolidated or semi-consolidated sediments may frequently be difficult to identify, and is not evident in the field at Old Harbour Bay. Fault displacements measured on rocks as young as 130,000 years old, together with continuing seismic events in present times indicates that Jamaica is in a seismically active part of the North Caribbean Plate boundary zone. Figure 5-101, a map showing the relative frequency of seismic events in different parts of Jamaica, indicates that between 5 and 9 events greater than intensity MM VI on the Mercalli scale occur per century.

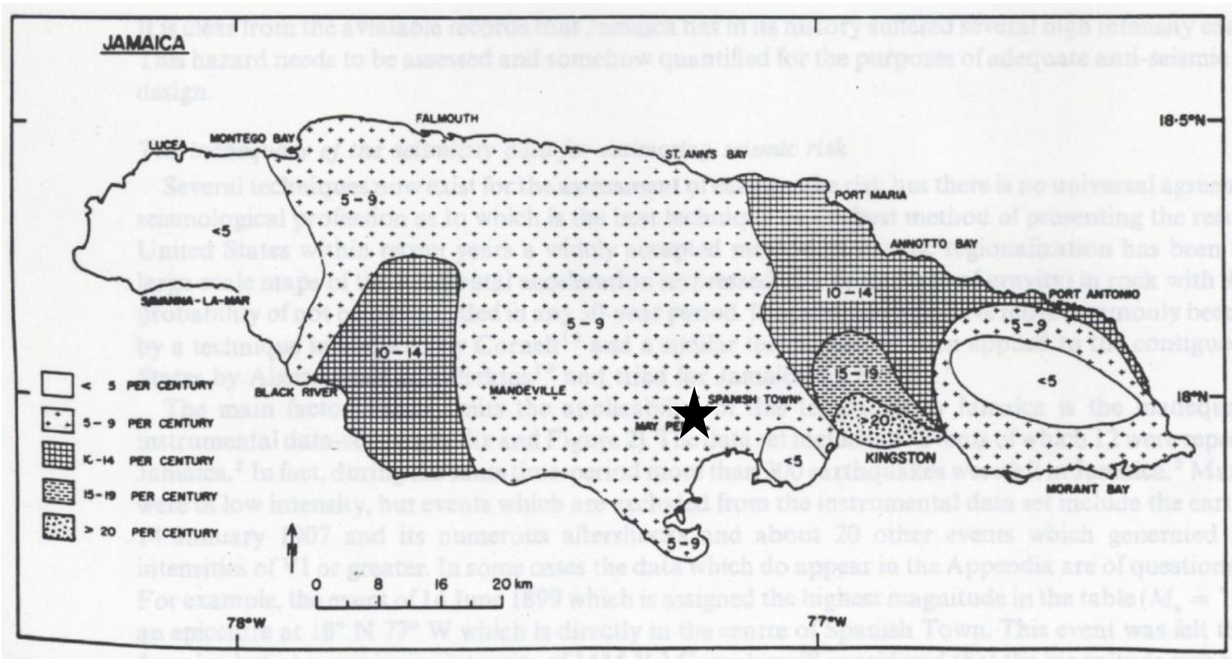


Figure 5-101 - Map showing number of times per century that intensities of MM VI or greater have been reported, 1880-1960 (from Shepherd & Aspinall, 1980). Black star is JPS 190 MW site

Figure 5-102 shows the probability of incidence of horizontal ground accelerations with a 10% probability of exceedence in fifty years in different areas of Jamaica (Shepherd et al. 1999). The Old Harbour Bay area (starred) has a 10% probability of experiencing accelerations of about 260 gals (26% g) per fifty years. The intensity of seismic shaking depends largely on the quality and thickness of the unconsolidated or semi-consolidated sediments overlying the bedrock. Shallow (less than 50 m) thicknesses transmit short period motions to best effect. Longer period motions are transmitted most effectively by thicknesses up to about 100 m (Aspinall & Shepherd, 1978). Thicknesses of semi-consolidated sediments exceeding 100 m tend to suppress the periods of engineering interest (CDMP 2001 Kingston study).

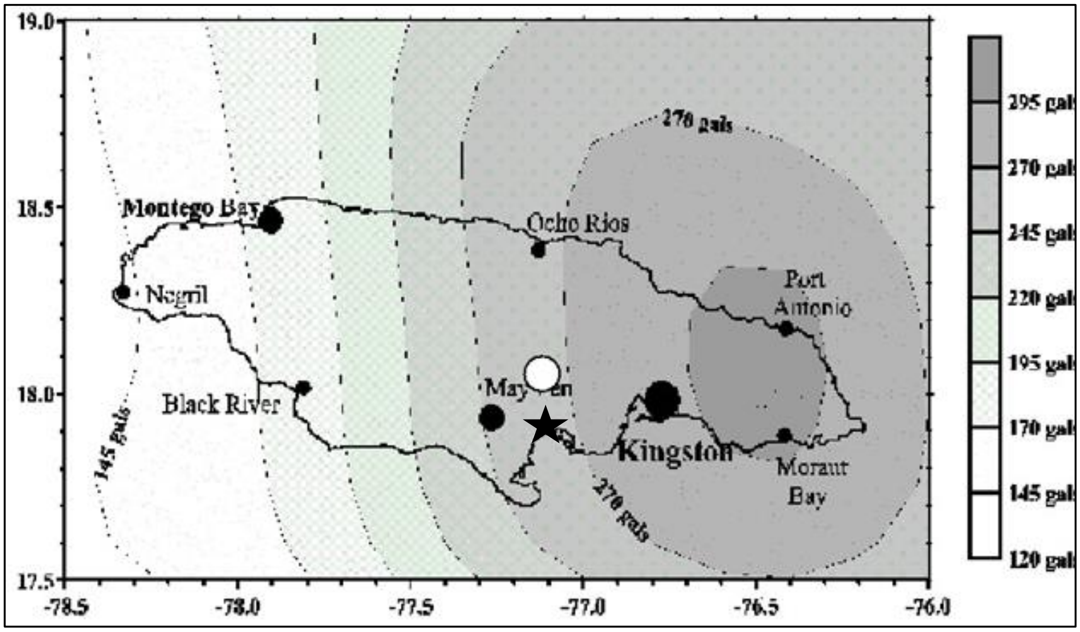


Figure 5-102 - Horizontal ground acceleration with 10% probability of exceedence in fifty years (Shepherd et al. 1999 in CDMP 2001), Contour interval is 25 gals (2.5%g). Modified from CDMP 2001. Black star is JPS 190 MW site

As described in the “Liquefaction Potential Analysis” report by Earth Systems Engineering, Ltd., the project site is in a historically active seismic area and the soils types in the vicinity of the proposed marine structures are subject to potential liquefaction in the sandy lenses of the upper 5 to 10 meters caused by seismic distress.

5.2.7 Tsunami

Although tsunami (seismic sea waves) are rare for Jamaica, there are a number of records of their occurrence along the coast (Ahmad, 1998). A tsunami event of the magnitude already recorded for the Caribbean (A.M. Scheffers at www.sthjournal.org/shelf2.pdf), and for the ‘worst case scenario’ resulting from a submarine eruption of Kick ‘em Jenny volcano (Smith and Shepherd, 1993) would be hazardous for the site. Historical records for Jamaica indicate that the highest inundation elevation ever reported for the Jamaican south coast was 2.2 m at Port Royal (NOAA/NGDC, 2012). A similar event at Old Harbour would immerse some two fifths of the area of interest and most of the site of the proposed power station.

5.3 BIOLOGICAL

5.3.1 Overview

Previous studies of the proposed project area/impact area/ area of influence have also been included as part of this report. According to the Portland Bight Sustainable Development Area Management Plan (C-CAM, 1999), the development site falls within the Portland Bight Protected Area (PBPA). 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). 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; namely, Hellshire Hills, Brazilletto Mountains, Portland Ridge and Kemps Hill. These localities 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-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).

A few mangrove species were found along an adjacent, earthen drainage canal, but no true wetland occurs on the property. The marine environment was also heavily degraded with some patches of seagrass in the nearshore environment. The coral community consists of a few random colonies occurring in the back reef, a few along a rubble crest and along the forereef. Most of the structure and rugosity of the comes from a large rubble area, held together with seagrass, sponges and other fouling and encrusting organisms and not the typical reef crest composed of hard corals, fire coral and some soft corals.

5.3.2 Portland Bight Protected Area

Jamaica currently lacks a comprehensive system of classification of protected areas. This reflects the ad hoc growth of the system under at least five Acts, each of which contains provisions that are relevant to protected area classifications. The four main governmental agencies whose legislation defines protected areas are:

- Department of Forestry
- Fisheries Department
- National Environment and Planning Agency

The following definitions are used as guidelines for the currently designated protected areas.

- According to Article 2 of the Biodiversity Convention, "Protected area" means “a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives”

- A more detailed description is given by the IUCN definition: "An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and natural and associated cultural resources, and managed through legal or other effective means."

The Portland Bight is one of three of these protected areas and represents Jamaica's largest and most dynamic protected area.

The project site is located in the Portland Bight Protected Area (PBPA), at 1,876.2 km^2 (724.4 $miles^2$) or 187,615 ha the PBPA is by far the largest protected area in Jamaica. Its land area [519.8 km^2 (200.7 $miles^2$) or 51,975 ha] is 4.7% of the island of Jamaica, and its marine area [1,356.4 km^2 (523.7 $miles^2$) or 135,640 ha] is a significant part of Jamaica's shallow shelf. In comparison, the land area of the PBPA is a bit larger than the area of the Blue Mountain/John Crow Mountain National Park [488.4 km^2 (188.6 $miles^2$) or 48,835 ha], and larger than each of the independent nation states of Barbados, Grenada (and its outer islands), Antigua & Barbuda and St. Vincent & the Grenadines.

More than half of the land area of the PBPA is in its natural state, in dry limestone forests [210.3 km^2 (81.2 $miles^2$) or 21,025 ha] and wetlands [82.0 km^2 (31.7 $miles^2$) or 8,200 ha]. The rest is cultivated in sugar cane, or is used for human settlement. About 50,000 persons live within the boundaries of the PBPA in some forty-four (44) residential communities.

Of the approx. 16,000 fishers in Jamaica, about 4,000 (approximately 25%) are based in the coastal communities of the PBPA, the highest concentration in Jamaica. The vast majority of the households in the PBPA fall at or below the poverty line.

Industrial activity in the PBPA includes portions of four sugar estates (Monymusk, New Yarmouth, Bernard Lodge, and Innswood), several small farming and livestock entities, several limestone mining and sand/aggregate quarrying operations, two international shipping ports (Port Esquivel and Rocky Point), two electricity-generating plants, and a bauxite-alumina plant (ALCOA). With substantial marine and terrestrial areas, hosting industry, commerce and human settlements in close proximity to wilderness ecosystems, the PBPA is a microcosm of an island state in urgent need of sustainable development.

According to the Portland Bight Sustainable Development Area Management Plan (C-CAM, 1999), the development site falls within the industrial zone in the protected area. The proposed site is on abandoned agricultural lands with several old fish ponds, a small mangrove forest and mudflats. The overgrown vegetation, seasonal wetlands, old fish ponds, mudflats and the mangrove wetland provide a habitat for several birds' species including the migratory birds. It should be noted that there is limited literature available on the avifauna in the disturbed areas in the Portland Bight protected area. Most of the works have been done on the Cays, undisturbed dry forest and the wetland areas.

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. Several faunal species have been identified either by historical evidence or actual on site observations. This includes the Jamaican iguana, once thought to be extinct, and now was 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.

Table 5-52 - Table 5-54 below summarizes the sensitive areas/habitats, major taxonomic/sensitive faunal groups and the proposed zonation within Portland Bight as outlined in C-CAM (2007) Management Plan, The Draft Three Bays Fish Sanctuary Management Plan (2010) and those documented in the EIA.

The project area is located in an area with disturbed vegetation, giving rise to a habitat of low diversity. That is, of the species of interest identified by C-CAM, only the American Crocodile was found on site. Sensitive ecosystems or those of international significance are also not found in the project area or in the zone of influence. A limited mangrove stand is located along the banks of the Bowers Gully. A mixed seagrass bed and a poor reef community were also observed in the back reef area. These systems are within the zone of influence but can be described as currently having major anthropogenic influences. None of the habitats are expected to be negatively impacted by the project.

Table 5-52 Sensitive Areas, their locations and inclusion in Project Site and Zone of Influence

Sensitive Areas/Habitat	Location	Project Area	Zone of Influence	Impacts
RAMSAR Wetlands	The wetlands of Portland Bight received international recognition when they were designated Jamaica's 3rd RAMSAR site (i.e. Wetland of international importance) under the RAMSAR Convention for the Protection of Wetlands and Waterfowl on 2nd February 2006.	No	No	None
Dry Limestone Forest	Portland Ridge, Braziletto Mountain, Kemps Hill , Hellshire Hills	No	No	None
Forested Areas	Portland Ridge, Braziletto Mountain, Kemps Hill , Hellshire Hills	No	No	None
Seagrass Beds	Goat Islands, along sections of the Mainland, around sections of the cays	No	Yes	A mixed seagrass bed community was observed in the back reef area- within the zone of influence but can be described as currently having major anthropogenic influences.
Caves	Jackson Bay Caves, Jamaica's most extensive cave system	No	No	
Fish Sanctuaries	C-CAM No fish Zones- Galleon Harbour, Salt Harbour, Rocky Point, Three Bays, West Harbour	No	No	
Reef/Coral Areas	Fourteen (14) Coral Cays,	No	Few coral colonies in a poorly assembled reef area in-front of the project site	A poor coral reef community was observed - within the zone of influence but can be described as currently having major anthropogenic influences
Mangrove Areas	Over 30 miles of a mangroves extending from Galleon Harbour, West Harbour, Goat Islands and areas in between Pigeon Island	Yes (few Black Mangrove species located in the project area)	Few Riparian Mangroves line Bowers Gully	A limited mangrove stand is located along the banks of the Bowers Gully- within the zone of influence but can be described as currently having major anthropogenic influences

Table 5-53 Sensitive Zones, their locations and inclusion in Project Site and Zone of Influence

Biologically Sensitive Zones	Location	Project Area	Zone of Influence	Impacts
Forest Conservation Areas	Peake Bay, Hellshire Hills, Portland Ridge	No	No	None
Wetland Conservation Areas	Extensive mangroves of West Harbour, Clarendon, wetlands between the Cockpit Salt Marsh and Peake Bay, Salt Island Lagoon, Rocky Point fishing beach and Jackson's Bay, Goat islands	No	No	None
Fish Nursery Conservation Areas	Three Bays Fish Sanctuary (Fisheries Division), Galleon Harbour Fish Sanctuary, Salt Harbour (C-CAM)	No	No	None
Wildlife Reserve	Western Cays, Hellshire Hills	No	No	None
Game Reserves	Peake Bay, Cockpit Salt Marsh, including Salt Island and Long and Short Island, Amity Hall mangal, Two Goat Islands and the mangroves joining them	No	No	None

Table 5-54 Sensitive/Endangered Fauna, their locations and inclusion in Project Site and Zone of Influence

Sensitive/Endangered Fauna	Occurrence/ Location	Project Area	Zone of Influence	Impacts
American Crocodile *(Crocodylus acutus)*	Bowers River, Salt River, Cockpit River, Salt Island Creek, Bower's Gully, Breadnut Gully, Calabash Gully, Coleburn's Gully, Salt Gully, Rocky Point fishing beach and Jackson's Bay	Yes	Yes	Limited- slightly positive- afforded some protection by reduced human access to breeding areas
Hawksbill Turtle *(Eretmochelys imbricata)*	Nests on many of the Coral Cays and Parts of the Mainland	No	No	None
Green Turtle (*Chelonia mydas)*	Nests on many of the Coral Cays and Parts of the Mainland	No	No	None
West Indian Manatee *(Trichecus manatus*)	Historically observed within the Portland Bight	Historically Likely	Historically Likely	None
Magnificent Frigatebirds *(Fregata magnificens)*	Many of the Coral Cays and Parts of the Mainland (e.g. Bowers River, Salt River, Cockpit River, Salt Island Creek, Bower's Gully, Breadnut)	Yes	Yes	None- expected similarity in noise climate to the current state

Sensitive/Endangered Fauna	Occurrence/ Location	Project Area	Zone of Influence	Impacts
Brown Noddies *(Anous stolidus)*	Many of the Coral Cays and Parts of the Mainland (e.g. Bowers River, Salt River, Cockpit River, Salt Island Creek, Bower's Gully, Breadnut)	No	Insufficient Data/Literature	insufficient Data/Literature
Yellow Boa *(Epicrates subflavus)*	Hellshire Hills and Portland Ridge	No	No	
Jamaican Iguana *(Cyclura collei)*	Hellshire Hills provides the last known habitat of the recently rediscovered (1990) endemic Jamaican Iguana (*Cyclura collei*), a globally threatened species and Jamaica's largest native land animal	No	No	None
Thunder Snake *(Tropidophis sp)*	Entirely restricted to Portland Ridge	No	No	None
Blue Tailed Galliwasp *(Celestes duquesneyi)*	Entirely restricted to Portland Ridge	No	No	None
Jamaican Hutia/Coney	Hellshire Hills and Portland Ridge	No	No	None
Jamaican Skink (*Mabouya sloanii)*	Entirely restricted to Portland Ridge	No	No	None
Endemic Cave Frog (*Eleutherodactylus cavernicola*)	Portland Ridge and Jackson Bay Caves	No	No	None
Bahama Mockingbird *(Mimus gundlachii hillii)*	Hellshire Hills and Portland Ridge	No	Insufficient Data/literature	Insufficient Data/Literature
Jamaican Pauraque (*Siphonorhis americanus)*	Last seen more than 100 years ago is rumoured to persist in the Hellshire Hills	No	No	None
West Indian Whistling Duck *(Dendrocygna arborea)*	Within the Portland Bight in particular Salt Island Lagoon, Rocky Point	No	No	None
Fish-eating bat *(Noctilio leporinus)*	Jackson Bay Caves, Jamaica's most extensive cave system	No	No	None

5.3.3 Terrestrial Flora

5.3.3.1 Background and Site Description

The current survey, executed in 2014, revealed a plant community conditioned to endure continuous anthropogenic activity, prolonged drought and some minor flooding. 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. However, this sub-section will summarise the relevant findings gleaned from terrestrial surveys conducted in the Portland Bight Protected Area were between 1998 and 2012.

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 to the north of the study site is the New Harbour Housing Development, located on lands which were originally occupied by scrub savannah and abandoned pasture (ESL, 2006); 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 proposed power 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 SJPC EIA (CL Environmental, 2012) the lands could be delineated into three contiguous zones based on the community-types present. This EIA was conducted within a rainy period (May 19 & 23, 2012). 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 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 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.

5.3.3.2 Methodology

An important part of any vegetation survey is determining the most efficient way to effectively sample the plant community. Owing to the highly disturbed and open nature of the area, it was determined that the area could be effectively surveyed using a series of walk-though floral inventories, which were conducted on July 9, 2014. During these walk-throughs, the mean vegetation height as well as species composition was noted; the latter being ranked according to a DAFOR[10] scale. The sorties were concentrated within the footprint of the planned development. However, areas adjacent to the development site and to the existing power plant were also investigated – including Southern Jamaica Power Company (SJPC) delineated lands.

Additionally, information garnered from past environmental assessments in the area was used to assist the survey. In particular, the 2012 SJPC 360 MW Combined Cycle Plant EIA provided the most recent background information (Appendix 7). Virtually all plant species encountered during the field surveys were identified *in-situ* or samples collected and taken to the University of the West Indies Herbarium for later identification.

[10] DAFOR occurrence rank: a subjective scale of species occurrence within an area of study. The acronym refers to, **D**ominant, **A**bundant, **F**requent, **O**ccasional, **R**are.

5.3.3.3 Results and Discussion

Based on the sampling regime, it was felt that the results were best organised into the following sections:

1. The primary development site
2. Surrounding lands
3. Greater SJPC lands

Location for these sections may be seen Figure 5-103.

The most frequent, ecologically important and socially important floras are here presented, along with general descriptions of the area. Overall, the area appeared to be affected by high levels of anthropogenic influence due to the close proximity of a functioning power plant, human communities, scattered dwellings and subsistence agriculture. No endemic species were encountered, except that *Guiacum officinale* (Lignum Vitae) is a tree of national importance. A complete list of species encountered is presented in Appendix 7.

The Primary Development Site

The area delineated as the main development site included a section of the existing power plant that was bordered by a substantially high concrete wall. This section within the existing power plant was restricted in plant-life and diversity. The grounds were apparently kept clear and used to store waste material (as evidenced by the solid waste seen in Plate 5-4. A few stands of the grass *Cynodon dactylon* (Bermuda Grass) were the sole macrophytic representatives present (Plate 5-5)

Plate 5-4 Cleared disposal area of primary site (view towards the south-west)

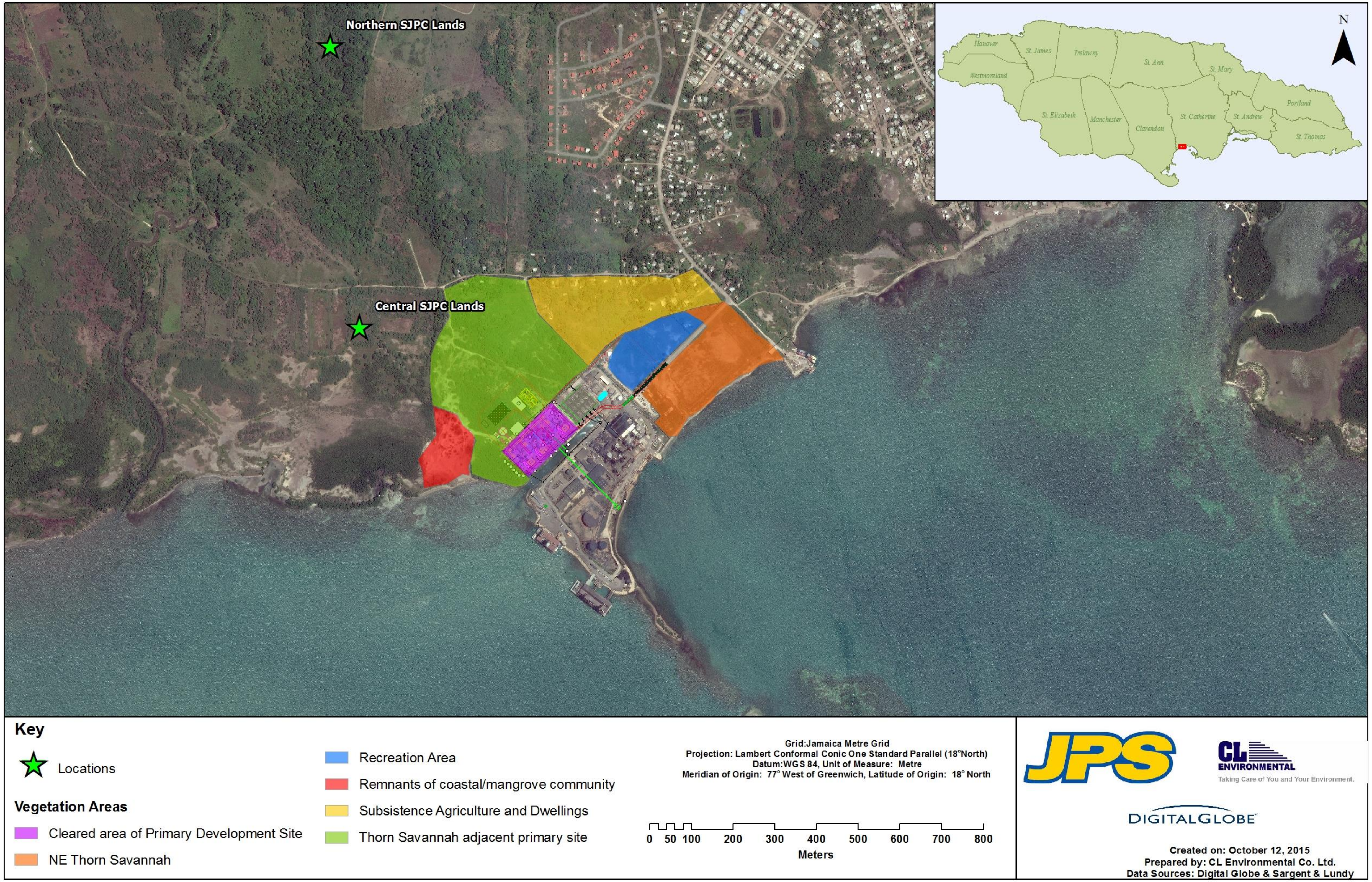


Figure 5-103 Vegetation areas

Plate 5-5 Waste area of primary site (looking north-east) bordered by clusters of *Cynodon dactylon* (Bermuda Grass) in distance

The land external to this walled area (to the northwest and southwest) was significantly richer in flora; although, also quite disturbed. Solid waste derived from the maintenance of nearby power lines was observed nearest to the plant as well as instances of charred vegetation. In several locations the ground cover appeared sparse, with the substrate being exposed regularly (Plate 5-6). This could have been exacerbated by the ongoing drought, which was at the time affecting the region. Several plant species were exhibiting signs of water stress (Plate 5-7).

Plate 5-6 Lands adjacent to primary site dominated by *Acacia tortuosa* (Wild Poponax) and with sparse ground cover provided by *Cynadon dactylon* (Bermuda Grass).

Plate 5-7 Tuft of *Sporobolus indica* undergoing drought stress

The flora was representative of a Thorn Savanna with the herbaceous component dominated by the grasses *C. dactylon* and *Sporobolus indica*. *Acacia tortuosa* (Wild Poponax) was the dominant tree constituent (Plate 5-6), while the nationally important *Guaiacum officinale* (Lignum Vitae) was the only other tree species present. Shrubby herbs, such as *Sida acuta* (Broomweed) and *Urena lobata* (Ballard Bush) were ubiquitous and the cacti *Harrisia gracilis* (Torchwood Dildo) and *Stenocereus hystrix* (Dildo Pear) were conspicuous shrubs. Herbaceous climbers were also common; namely, *Antigonon leptopus* (Coralita) and *Ipomoea* sp. The dominance of *A. Tortuosa* remained relatively constant; however, the grasses tended to give way to *S. acuta*, *Stemodia maritima*, *Gomphrena decumbens* and *G. celosioides* towards the shore and the dominant climber/runner became *Ipomoea* sp (Plate 5-8).

Plate 5-8 View of shore from lands adjacent and to the south of the primary development site

Surrounding Lands

Northeast of the existing power plant, the vegetation was a remnant of the thorn savannah, which was severely influenced by anthropogenic activity. Evidence of grazing and fire damage was present at the time of this survey.

Phanerophyte representation was very poor and was limited to a few *A. tortuosa* representatives. The grasses *C. dactylon* and *Sporobolus spp*. were quite abundant. However, as one progressed southeast, towards the shore, there was a slight change in species composition where the grasses gave way to succulent herbaceous halophytes, namely *B. maritima* (Jamaican Sappire), *Portulaca* sp. and *Sesuvium portulacastrum* (Seaside Purselane). The shrubs *Jatropha gossypifolia* (Belly-Ache Bush) and *W. indica* were common constituents.

Plate 5-9 Overview of flora located north-east of existing power plant. Note charred vegetation just above date stamp

A recreation complex, was also located to the north-east. Here, ornamental/cultivated plants such as *Nerium oleander* (Oleander), *Lantana camara* (Wild Sage), *Durata repens* (Angel's Whisper), *Ixora* sp. and *Ziziphus mauritiana* (Coolie Plum). These plants surrounded a sports field consisting mainly of mowed *C. dactylon*, *Sporobolus* spp. and *S. Portulacastrum*. *Casurina* equisetifolia (Willow), Ficus sp. and Cassia emarginata trees were also found along the perimeter (Plate 5-10).

Plate 5-10 Sports field of recreation complex ringed by tree species and occupied mainly by grasses and succulent halophytes

Greater SJPC Lands

The vegetation here was not expected to be impacted directly by the proposed development. However, it was rapidly assessed so as to provide a drought-period update the SJPC EIA of 2012. The southernmost portion of the property consisted of large areas of bare, sandy-clay soil, occupied by vegetation islands consisting mainly of *B. maritima*, *A. tortuosa* and *S. maritima*. The shoreline itself was occupied primarily by mangrove species *Rhizophora mangle* (Red Mangrove) and *Avicennia germinans* (Black Mangrove).

Plate 5-11 Southern section of Lands occupied by *Batis maritima* (foreground), *Avicennia germinans* (centre) and *Rhizophora mangle* (distance). *Acacia tortuosa* may be seen just left, almost out of frame.

The central areas were also grass dominated; in particular, with the ubiquitous *C. dactylon*. Notably absent from the area (when compared to the CL Environmental SJPC EIA, 2012) were the herbs *Eleocharis* sp. and *Typha domingensis* (Reedmace) due to the dry conditions. Subsistence agriculture was also present with cultivations of Carica papaya (Papaya), Mangifera indica, Musa sapientum (Banana) and Saccharum officinarum (Sugarcane) (Plate 5-12). A. tortuosa was the dominant tree species.

Some northern sections showed severe loss of ground cover due to clearance by fires and drought conditions (also in Plate 5-12). In other northern sections, the vegetation as described in the CL Environmental SJPC EIA (2012) remained intact, but reduced in canopy cover. Of note was the occurrence of a large clearance of vegetation to make an informal roadway (Plate 5-13). A complete list of the vegetation encountered in 2012, in this area, may be found in Appendix 7.

Plate 5-12 Section of land cleared by fire. Note cultivation of *Musa* spp. in background

Plate 5-13 Section of vegetation cleared for vehicular access

5.3.4 Fauna

5.3.4.1 Avifauna

SJPC Site Description

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.

FISH PONDS

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 were also a belt of large acacia trees along the banks of the ponds.


Plate 5-14 Images showing the old fish ponds within the project area.

MANGROVES

The mangroves were seen throughout the area for the proposed power plant. The mangrove density varied throughout the project area, where there was a large patch of dense mangroves found on the coastal sections of the property. As you move from the coast the mangroves gradually become sparse.


Plate 5-15 Representation of the mangroves located near the coast on the property.

ACACIA WOODLAND

A small patch of acacia woodland was located near the present power plant. The vegetation in the area consists of mainly acacia trees and cactus.


Plate 5-16 Small patch of dry acacia woodland.

MUDFLAT AND SALINAS

The mudflats and Salinas were located mainly on the coastal area. A few were located inland within the mangrove wetlands near the mangrove forest. The main mudflat on the property was currently inundated, which was mainly influence by the tide. Most of the other mudflats on the property were dry as a result of the drought in the area.

Plate 5-17 Main mudflat located on the property.

Methodology

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 additon, addition time were spent at the water bodies and the salinas to note the 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 and July 2014.

Results and Discussion

FISH PONDS, WETLAND, COAST AND SALINA

The old ponds, mudflats, mangrove wetland, coast and the temporary wetland within the study area is an 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 in foraing 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 weland bird numbers were low.

Mangrove wetland

A few birds were observed in the mangroves, such as the Yellow Warblers 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 timeboth survey was carried out.

Coastal birds

On the coast, birds such as the Brown Pelican, Laughing Gull and Frigate Bird were observed. The most common species 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 species (Table 5-55). In addition, during the rainy reason several areas in the Salina that 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.

Table 5-55 Wetland birds observed in the study.

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

Groupings	Proper Name	Scientific Name	Status	DAFOR	Habitat Type
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		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).

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 Morehen 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 Morehen 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 attribute 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, morehens and Coots. It should be noted that both surveys were conducted before the arrival of the migrant wetland birds from North America.

TERRESTRIAL SPECIES

Thirty one (31) terrestrial bird species were observed during the survey of the property. The bird species diversity consisted of 12 endemic birds, 16 residents, and 3 migrants. It should be noted that four of the twelve of endemic birds identified in the study are forest specialist. The dominat terrestial species in the area was the white wing dove. In addition, most of the teresrtrial birds in the study were observed in the acaica woodland. A few terrestrial birds were observed in the trees along the old fish ponds and alo in the mangrove trees.

Only a few migrant warblers were seen in the study as this was as a result of the time of the year the study was carried out before the arrival of the migrants form 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 (Downer & Sutton, 1990). Overall, the migratory birds account for a large number of Jamaica's avifauna, which is almost doubled during winter season from August to May. Both bird surveys were not conducted in the winter migratory season and the bird species present in the area can only be carried out in a survey. In addition, due to the limited size of the acacia woodland only a few bird species which are typical of dry limestone forest were observed during the study (Table 5-56). 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.

Table 5-56 Terrestrial birds observed during the survey of the property.

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

Proper Name	Code Used	Scientific Name	Status	DAFOR
Yellow Warbler	YEWA	Dendroica petechia	Resident	R
Yellow-faced Grassquit	YEFC	Tiaris olivacea	Resident	F
Zenaida Dove	ZEDO	Zenaida aurita	Resident	O

Limitations

- The study was carried out in the dry season. Fauna species composition with emphasis on birds and arthropods will change significantly in the wet season.
- The survey was conducted before the arrival of the migrants; hence the bird survey does not represent all the species which could be present in the area.

5.3.4.2 Bats (Chiroptera)

There are 27 different species of Bats found in Jamaica, some more common than others and some more easily detected. Habitat and feeding requirements vary greatly, insectivores, nectivours, frugivours, and combinations of these. There is also a fishing bat (*Noctilio leporinus*). Bats may utilize dense or cluttered forest, open spaces, forest edges, low lying vegetation or the understory for feeding and or travel and the usage of a particular area changes. Some species may roost in trees while others prefer caves, buildings and other more sheltered and humid environments. Bats utilize a diverse habitat range, even amongst species with similar feeding habits, showing deliberate niche portioning. Insect feeding bats for example may utilize open spaces, cluttered spaces or even prefer the edge of a forest and they may also hunt at different times of night.

Bats have historically been documented in the Clarendon and St Catherin area, including sections of the PBPA (Table 5-57). The proposed project site may therefore be used by a variety of bat species. Occasional flora constituents, such as columnar cacti, (*Harrisia gracilis* and *Stenocereus hystrix)* and ornamental shrubs (namely *Nerium oleanrder*) may be pollenated by bats, these have been document on or near the proposed site. It is therefore possible that nectivourous, insectivoursous and frugivours use the surrounding vegetation and land area for both hunting and travel.

Table 5-57 Historical Occurrence of Various Bat Species in the Parishes of St. Catherine and Clarendon.

Species	Feeding Habit	Historical Occurrence
Noctilio leporinus	Piscivore	Hellshire Hills Sisters Cave
Pteronotus macleayii	Insectivore	Douglas Cave Castel , S.t Clair Cave
Pteronotus parnellii	Insectivore	Hellshire Hills and two sisters cave, Douglas Cave Castel, St. Clair Cave, Jackson's Bay Cave
Pteronotus quadridens	Insectivore	Portland Point Lighthouse, St Clair Cave
Mormoops blainvillei	Insectivore	Douglas Cave Castel, River Sink Cave, St. Clair Cave, Jackson's Bay Cave, Riverhead Cave
Macrotus waterhousii jamaicensis	Insectivore	Portland Cave, Portland Cottage, Portland Ridge Cave, Portland Ridge, Portland Point, Portland Point Lighthouse, Colbeck Castel, Fort Clarence, Hellshire Hills,
Glossophaga soricina	Nectarivore	Mason River, Portland Cave, Mahoe Gardens, Portland Cottage, Portland Point, Portland Ridge, Portland Ridge Cave, Portland

Species	Feeding Habit	Historical Occurrence
		Point, Portland Point Lighthouse, Portland Cave, Riverhead Cave, River Sink and Two Sisters Cave
Monophyllus redmani redmani	Nectarivore	Douglas Cave, Mason River Research Centre, St. Clair Cave, Hellshire Hills, Jackson's Bay, Jackson's Bay Cave, Portland Cave, Skeleton Cave
Erophylla sezekorni syops	Frugivore	Kemps Hill, Portland Cave, Portland Ridge, Portland Point, Portland Point Lighthouse, Hellshire Hills, St. Clair Cave, Jackson's Bay
Phyllonycteris aphylla	Frugivore	St. Clair Cave, River Head Cave, Pedro Cave
Ariteus flavescens	Frugivore	Kemps Hill, Portland Ridge, Ferry Cave, Hellshire Hills, Riverhead Cave, Jackson's Bay, Portland Cave
Artibeus jamaicensis jamaicensis	Frugivore	Mason River Research Centre, Portland Ridge, Skeleton Cave, St Clair Cave, Ferry, Ferry Cave, Hellshire Hills, Drums Cave, Jackson's Bay, Jackson's Bay Cave, Portland Cave, Riverhead Cave, River Sink Cave
Natalus micropus micropus- (Chilonatalus micropus)	Insectivore	Jackson's Bay, St. Clair Cave,
Natalus stramineus jamaicensis	Insectivore	St Clair Cave, Portland Cave
Eptesicus fuscus (lynni)	Insectivore	Portland Point Lighthouse, Jackson's Bay, Riverhead Cave

Bat behaviour, biology and historical occurrence; Bats of Jamaica- Hugh H. Genoways, Robert J. Baker, John W. Bickham, Carlton J. Phillips Special Publication, Museum of Texas Tech University.

5.3.5 Marine Benthic Community

A detailed description of the benthic community will include previous studies along with current data. Special emphasis was placed on the recording and identification of rare, threatened, endemic, protected, endangered, and economically important species. Additionally, identification and descriptions of each marine habitat was also included.

5.3.5.1 2012 Study

Introduction

A previous benthic assessment was conducted in May 2012, the study area extended approximately 2 kilometres, from the shoreline to the reef area. Two distinct zones were identified during the survey (Figure 5-104).

- Fore Reef and Reef Crest
- Lagoon

The two distinct zones were surveyed using different methods due to both habitat types as well as environmental conditions. The results from this survey were used to guide the surveys conducted in this report. The findings below were reconfirmed in the current study.

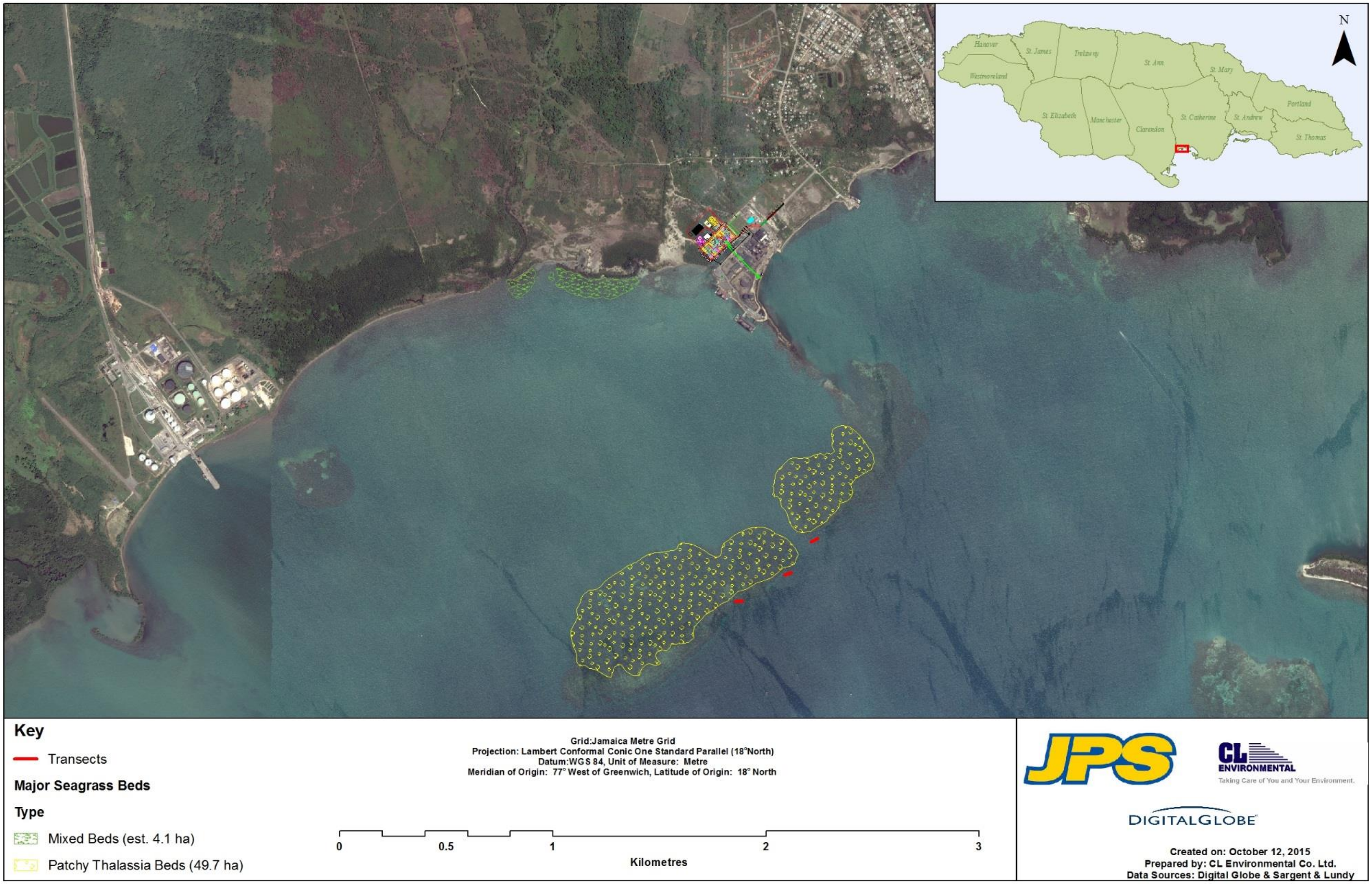


Figure 5-104 Map showing 2012 benthic study area with transect locations as well as seagrass areas

Forereef and Crest

METHOD

Using the results and data from the 2012 study of the area, several surveys and ground truthing activities 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. Several attempts were made to use a transect line survey method for both a benthic and fish assessment, however due to the extremely poor visibility, this was impossible. Various roving surveys and ground truthing exercises were conducted. Survey types included the following:

Roving SCUBA Survey

Roving SCUBA surveys were conducted. Some of these areas found seaward of the barrier (large mounds of unconsolidated material/rubble and rock held together by seagrass and various encrusting and fouling organisms) were previously surveyed. A photo inventory of sensitive species such as coral and seagrass were recorded along with general observations (Figure 5-105).

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 hazards (crocodiles). The images and video captured with the ROV were used to help describe the substrate type and conditions.

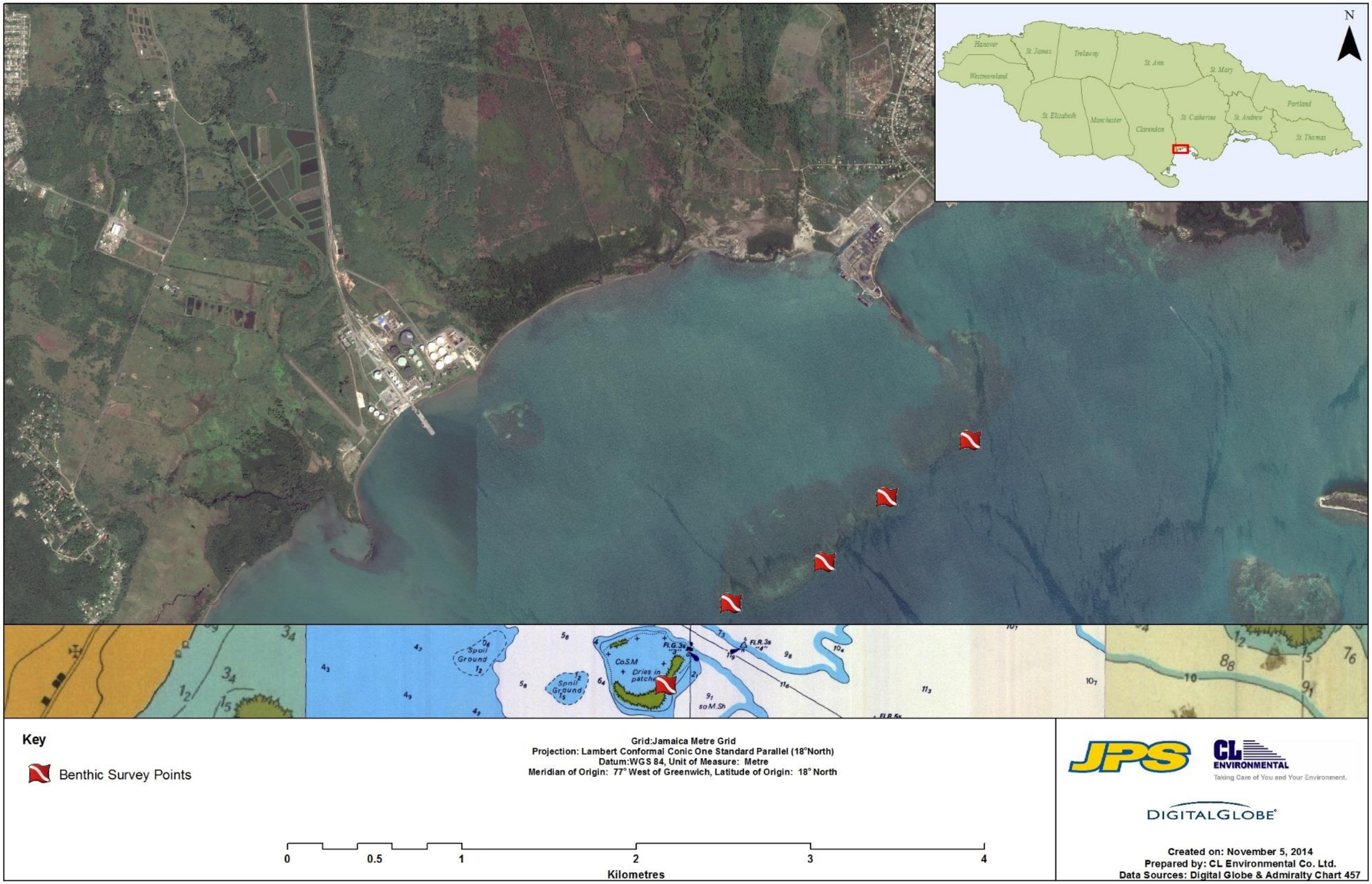


Figure 5-105 Locations of roving SCUBA surveys

RESULTS

During the 2012 study 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.

Directly in front of these patch areas 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.

This continues to be an accurate description of this area, with even fewer species observed but his may be as a result of the poor visibility.

Coral Community

A fringing reef system was reported approximately 3km from the shoreline (CLE, 2005), but no coral reef communities were observed (CLE, 2005; ESL, 2006b, CLE 2012). The area was dominated by seagrass, Thalassia testudinum, and macroalgae with mounds of coral heads and coral rubble interspersed throughout (ESL, 2006b).

The coral community occurs in an area of rubble, composed of a combination of *Acorpora cervicornis* and *Porites porites* branches dominated by algae. Some small patch reef formations (very low relief) were also observed in the area.

Much of the unconsolidated substrate is dominated by fleshy algae with the main types being *Sargassum sp., Dictyota sp., Caulerpa sp.* Calcareous algae were less dominant and included Halimeda spp. and Galaxura spp. and small amounts of turf algae; shown in Table 5-58 and Figure 5-106.

Table 5-58 Table showing Algae species and Occurrence

Algae	Class	Occurrence
Sargassum sp.	Phaeophycae	25
Caulerpa sp.	Bryopsidophyceae	10
Dictyota sp.	Phaeophycae	19
Halimeda sp.	Bryopsidophyceae	5
Galaxaura sp.	Rhodophyceae	14
Fleshy Algae		5

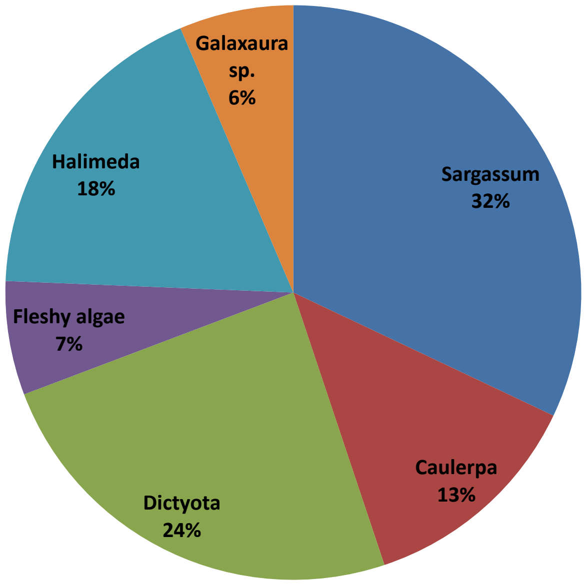


Figure 5-106 Algal Composition of the Backreef Area

Plate 5-18 - Plate 5-19 show the general reef conditions including the dominant algal species. Some sponges were also seen holding the substrate together (Plate 5-20) however the typical nuisance sponges such as the 'chicken liver' (*Chondrilla nucula)* were not observed.

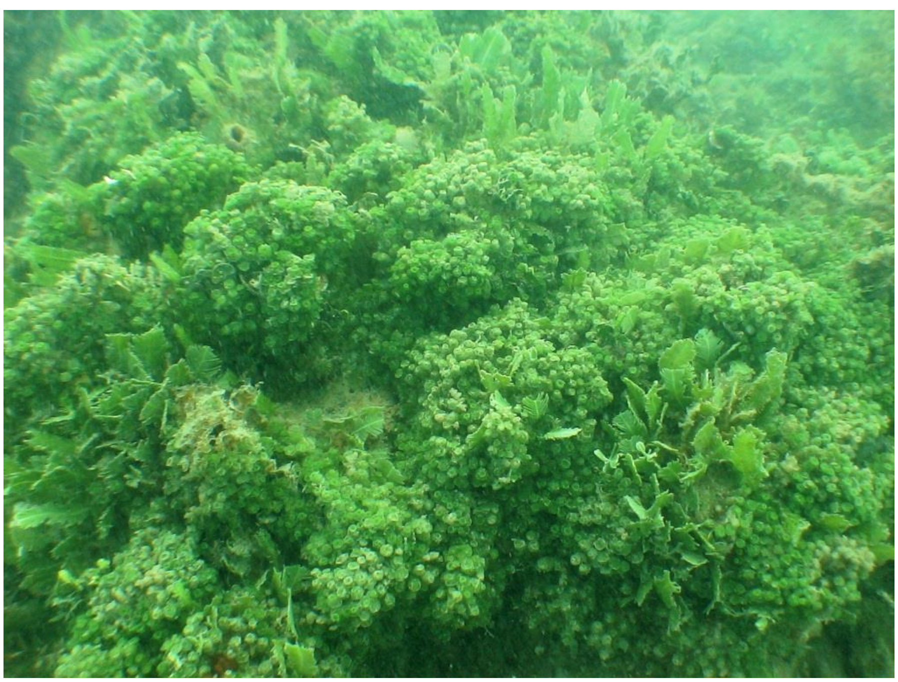


Plate 5-18 Photo showing Algae covering the substrate (*Caulerpa sp.*)

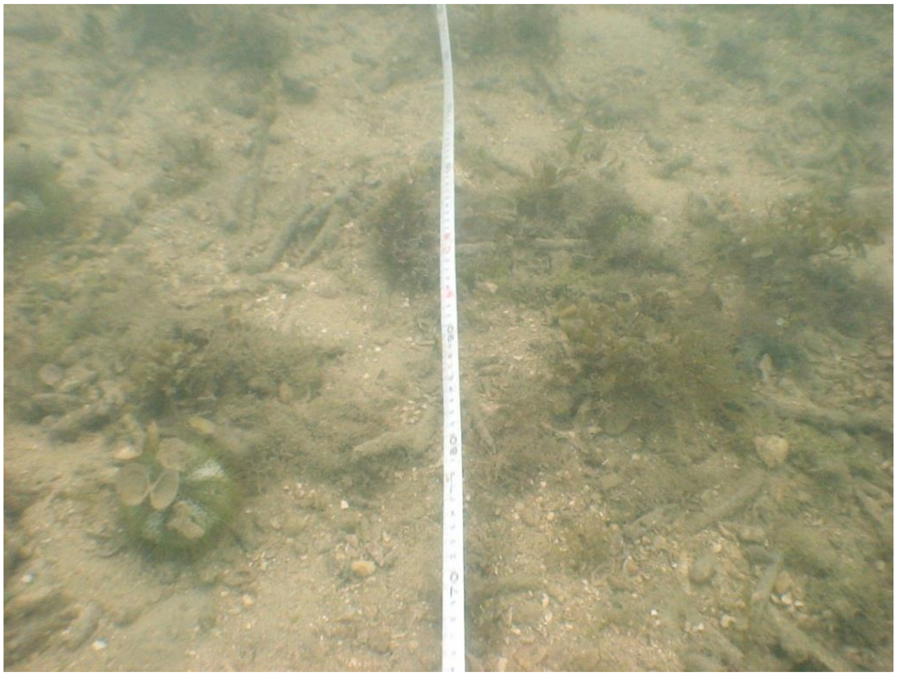


Plate 5-19 Photo showing a sandy/rubble substrate with some macro algae.

Plate 5-20 Photo sowing sponges and algae holding the substrate together

A total of seven hard coral species were observed (Table 5-59). These include *Colpophyllia natans*, *Oculia sp*., *Porites asteroides sp*.,*Stephanocenia intersepta* and *Mancinia areolata* and *Montastrea annularis* which was the largest live, hard coral colony observed in the area Gorgonians (Sea whips) along with some seagrasses (*T. testudinum*) were also observed in the backreef area (Plate 5-21 - Plate 5-25).

Table 5-59 Table showing the hard coral species observed in the area

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

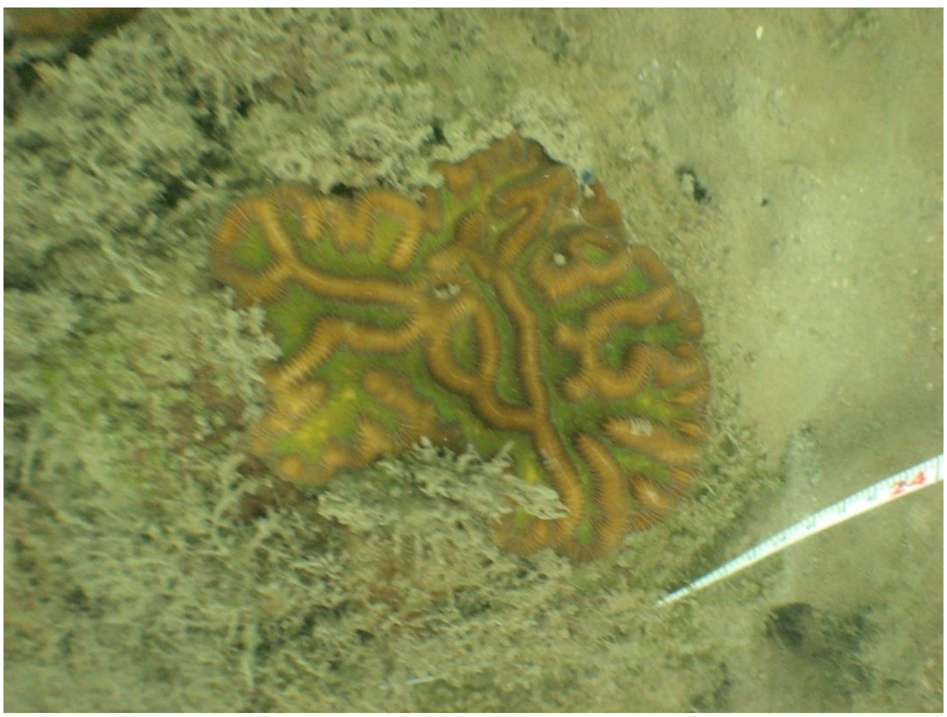


Plate 5-21 Photo showing *Colophyllia sp.*

Plate 5-22 Photo showing *Oculina sp*.

Plate 5-23 Photo showing *Porites asteroides*.

Plate 5-24 Photo showing *Stephanocenia sp*. and *Mancinia sp*.

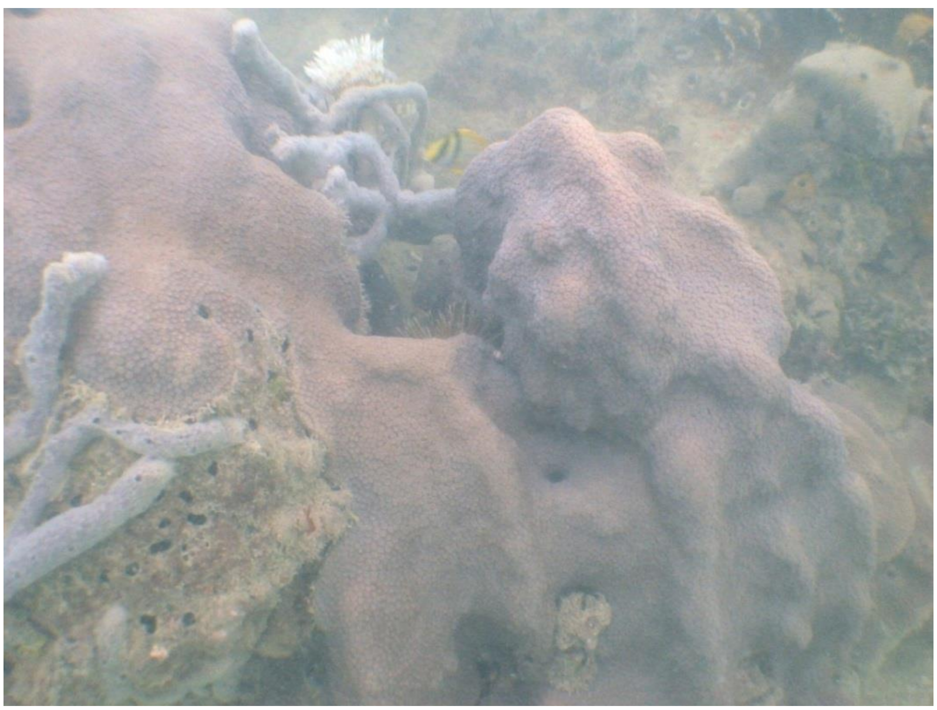


Plate 5-25 Photo showing *Montastrea annularis* colony

The sample area was found to be sufficient as shown in Figure 5-107.

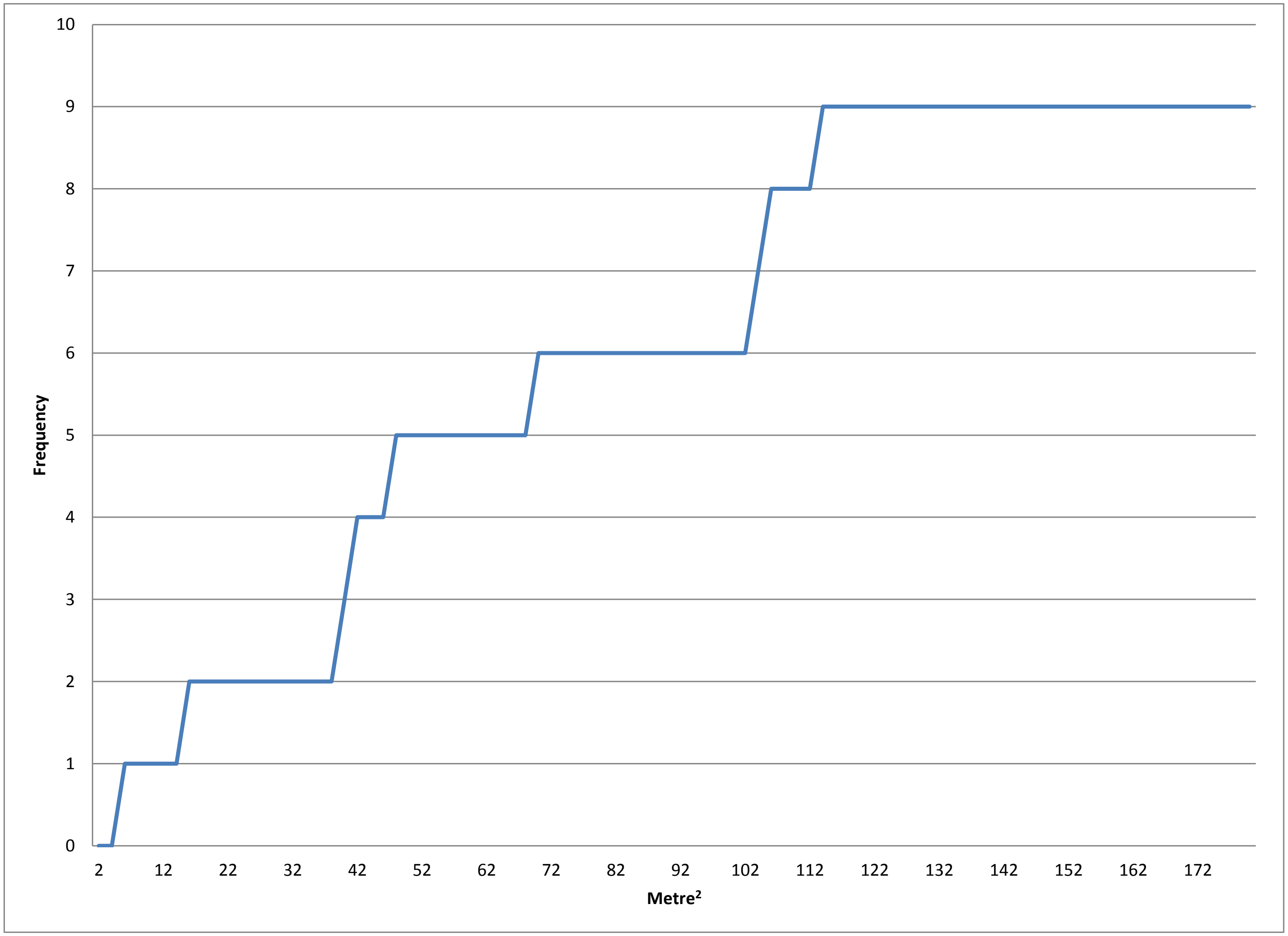


Figure 5-107 Species Area Curve for Hard Coral Species in the Study Area

The results are similar to other surveyed reefs in the area. According to the 2005 JCRMN[11] (Jamaica Coral Reef Monitoring Network) report, The Portland Bright Protected Area (PBPA) consists of a marine area (approximately 70% of the PBPA) and has widespread coral reefs associated with the 16 cays and several shoals (Linton et al., 2003). Extensive 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 *Porities 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

In 2001, a Preliminary Assessment of Nearshore Fishable Resources of Jamaica's Largest Bay, Portland Bight was conducted. Samplings of mangrove, seagrass *(Thalassia, Syringodium* and *Halodule*) and nearshore sandy habitats over 13 months in Jamaica's largest bay, which included Galleon Harbour (and its associated Fishing Sanctuary established in 2010), were conducted. A total of 98 species were found within the 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. This was confirmed with the Jaccard coefficient of similarity, with Manatee Bay and Galleon Harbour on the east side being most similar in diversity and the western sites being similar. Manatee Bay westward through to Galleon Harbour had a mean species number of 32 (±2.4) species, whereas the Cays sites had only 8 species. Sites along the east side of the Bight had relatively less diversity with 15 species being found (Aiken et al., 2002).

[11] 2005, JCRMN Report

Table 5-60 Species found at Manatee, Coquar, and Galleon Harbour 12 months apart, indicating nursery role (Aiken et al., 2002)

Species	Common Name
Anchoa lyolepis	Dusky anchovy
Archosargus rhomboilalis	Sea bream
Sparisome chrysopterum	Redtail parrot
Eucinostomus gula	Silver jenny
Selene vomer	Lookdown jack
Gerres cinereus	Yellowfin mojarra
Caranax latus	Horse-eye jack
Ocyurus chrysurus	Yellowtail snapper
Haemulon sculurus	Bluestriped grunt
Sphyraena barracuda	Great barracuda
Lutjanus apodus	Schoolmaster snapper
Odontoscion dentax	Reef croaker
Bothus lunatus	Peacock flounder
Lutjanussynargis	Lane snapper
Acanthurus chirurgus	Doctorfish
Sphoeroides spengleri	Bandtail puffer
Penaeus spp	Marine shrimp

Portland Bight has been identified as a nursery along the mangrove-seagrass interface due to the presence of juveniles at all times during a 12 month period. Galleon Harbour was identified as a Critical Habitat and as a nursery, with a special note being made of the fact that the muddy areas near Galleon Harbour had adult and juvenile marine commercial shrimp in larger numbers than elsewhere in this study (Aiken et al., 2002).

Environmental Solutions Limited reported the presence of juvenile fish at their offshore sites which comprised mainly of damselfish and parrotfish. These sites were characterized as seagrass meadows comprised solely of *Thalassia testudinum*, with interspersed macroalgae and are used for feeding, and as nursery grounds for juvenile development (ESL, 2006b).

In the present study, the reef fish diversity was also low and several small fish were observed. Table 5-61 shows the species present, the size class, developmental stage and the feeding habit. Figure 5-108 shows the trophic level distribution of the fish types observed.

Table 5-61 Table showing a summary of the fish survey

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

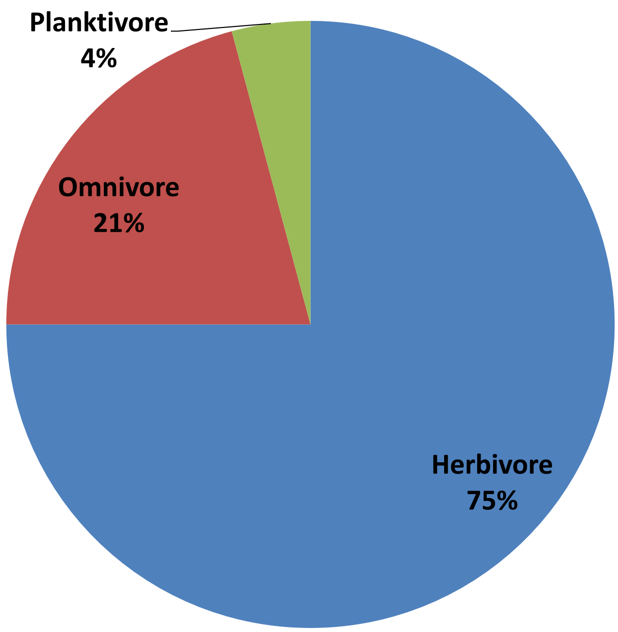


Figure 5-108 - Trophic level composition of the fish community

The numbers of fish observed were very low and most of these were small adult herbivores suggesting that the reef and surrounding areas are heavily fished and much of the nursery function of the habitat is either gone or severely reduced. Damselfish were the most abundant while surgeonfish and wrasses were the least abundant.

Invertebrate Community

Invertebrates were surveyed along with the substrate survey belt transect. Invertebrates seen in the backreef include brittle stars and star fish (*Oreaster sp.)* Plate 5-26 - Plate 5-28*),* sea cucumbers such as Donkey Dung *(Holothuria mexicana)* and sea urchins (*Echinometra sp and Lytechinus sp.).*

Table 5-62 Invertebrate frequency and classification

Invertebrates	Frequency	Characteristics	Class	Main Diet	Frequency in Thalassia dominated areas
Lytechinus sp	78	Collector Urchin	Echinoidea	Algae, Seagrass	11
Echinometra sp	65	Rock Boring Urchin	Echinoidea	Algae	3
Starfish	16	Predators	Asteroidea	Slow moving organisms	1
Sea Cucumber	4	Scavengers	Holothuroidea	Organic Debris	0
Brittle Star	1	Scavengers	Ophiuroidea	Organic Debris	0

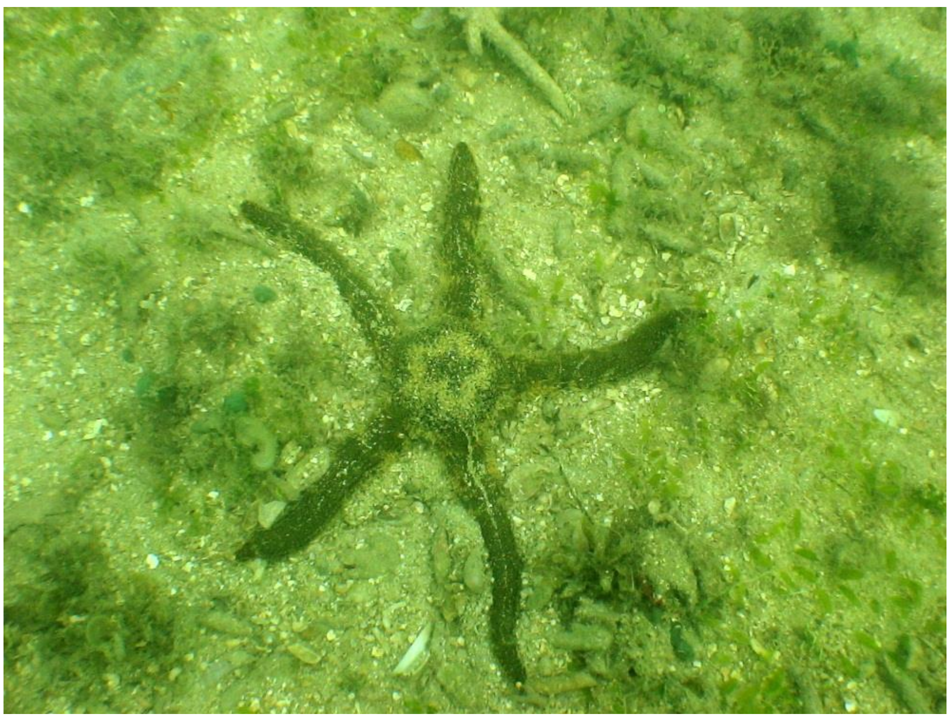


Plate 5-26 Photo showing Brittle Star

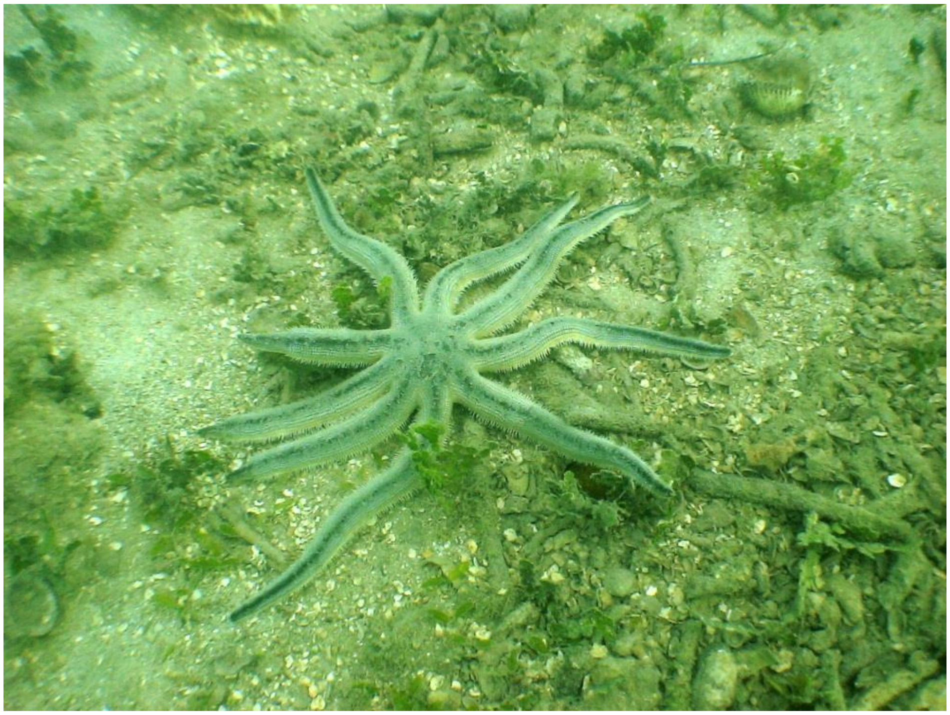


Plate 5-27 Photo showing Starfish

Plate 5-28 Photo showing Starfish

Sea urchins (*Lytechinus and Echinometra)* were the most abundant invertebrate observed (Figure 5-109), followed by starfish, sea cucumbers and brittle stars which had the lowest occurrences. No commercially important species were observed (lobster or conch) and no *Diadema antillarium* were seen in the study area. Jones (2006) reported that invertebrate diversity is generally low but parrotfish were abundant at most sites in the Reef Check surveys of 2004-2005.

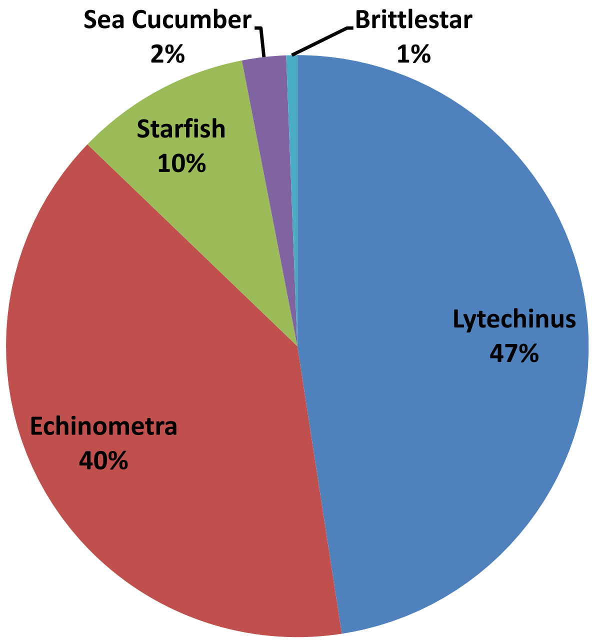


Figure 5-109 Invertebrate community composition (relative invertebrate presence along transect)

Reefs play an important structural role in shoreline protection as well as providing habitat, nursery and foraging ground for fish and many other animals. However the reef community and structure in the study area is severely affected. With low diversity in all communities (corals, fish, invertebrates), the reef has experienced a phase shift from a coral dominated community to an algal dominated one. Coral colony size was generally small with some typical backreef species present. The substrate is also largely unconsolidated, making coral recruitment very difficult. The fish and invertebrate communities have both very low population sizes along with very low diversities. The functionality of the reef system is significantly reduced and the recovery reef community would require drastic changes.

No commercially important fish or invertebrate species were observed. No invasive species were seen (*Pterois volitans/miles* - Lionfish or *Perna viridis* – Green Mussel).

Lagoon

The lagoon area lies directly behind the reef. A patchy distribution of seagrass was observed, extending towards the shoreline. This area is characterised by low visibility and soft/muddy substrate with mixed seagrass types.

METHOD

Surveys were conducted on 17 May, 2012 between 11 am and 3 pm, using a VideoRay Remote Operated Vehicle (ROV) and visual surveys. The ROV was used in the lagoon area due to the low visibility caused by siltation from the Bowers Gully and other operations in the area. This area is also known to have large crocodiles, making diving or snorkelling unsafe.

The ROV was used to estimate both the limits of the seagrass beds as well as the composition. Visual surveys were conducted along the shoreline; estimating the limits of each bed and the species composition. Anecdotal information about the location of other patches of seagrass was also used during the survey. This was useful when visual confirmation was impossible.

The ROV was allowed to sit on the bottom of the sea floor for short periods of time in-order to capture video and or images of any possible fauna in the area.

RESULTS

Seagrass Communities

The mixed bed area of seagrasses along the shoreline of the proposed site was identified with an estimated area of 4.1 hectares. In contrast, ESL found very small patches of seagrass *(Thalassia testudinum and Syringodium filiforme)*, approximately 1.5km west of the present study site. The patchy distribution of *Thalassia testudinum* seagrass immediately behind the reef area had an estimated area of 49.7 hectares.

Directly behind the reef, *T. testudinum* occurs in a patchy distribution on a rockier substrate (Plate 5-29). Moving northwest, towards the shoreline the sediment type changes becoming more muddy and silty. The mud-flat area consists of very small patches of algae but shows signs of several burrowing animals, mainly worms (Plate 5-30). It was unclear as to the full extent of the seagrass as visibility decreases significantly towards the shoreline (Plate 5-31 and Plate 5-32). Using video and images obtained from the ROV, the dominant seagrass observed appeared to be *Thalassia testudinum,* with a smaller percentage of *Syringodium filiforme* also present in the southern beds while mixed beds account for majority of the major beds (Plate 5-33) *S. filiforme* begins to dominate approaching and along the shoreline (Plate 5-34 and Plate 5-35). This poor visibility is possibly due to sediment from the fresh water tributaries along the coastline and the general high turbidity in the area due to wave action.

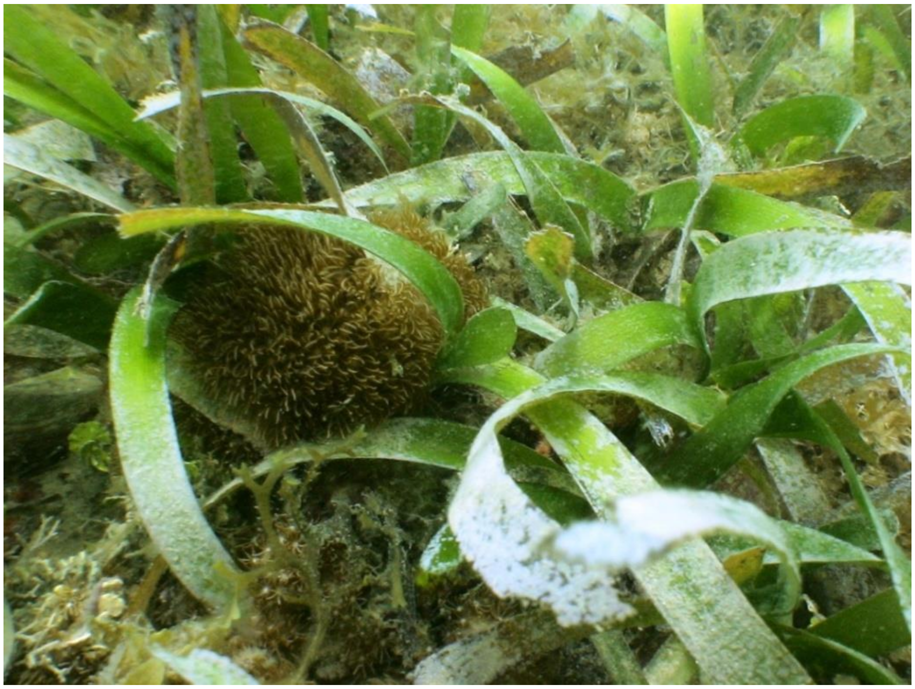


Plate 5-29 Seagrass mixed with Algae and a Soft Coral in the Lagoon

Plate 5-30 ROV Photo of muddy substrate with burrow holes made by animals in a low visibility area

Plate 5-31 ROV Photo of *T. testudinum* in a low visibility area

Plate 5-32 ROV Photo of *S. filiforne* in a low visibility area

Plate 5-33 ROV Photo of a patchy distribution *of T. testudinum and S. filiforme* in a low visibility area

Plate 5-34 Photo of a patchy distribution of *T. testudinum and S. filiforne* along the shoreline

Plate 5-35 Photo of a patchy distribution of *T. testudinum and S. filiforne* along the shoreline

Coral Community

Several coral species were noted on small patch reefs, on sandy sediments and a few in the seagrass beds. Plate 5-36 - Plate 5-40 were photographed in 2014 and show similar conditions (small colony size, low diversity and occurrence) as the 2012 survey. Coral cover in the area was extremely low. While no disease or mechanical damage was noted during the survey, anecdotal information suggests that the area was once heavily dynamited. This may account for the large patches of unconsolidated material as well as the low coral cover and lack of reef structure.

Plate 5-36 Small *P.asteroides* colony

Plate 5-37 Toppled *Millepora sp.*

Plate 5-38 Large *Diploria* colony

Plate 5-39 Large *Montastrea* colony with bleach spots and signs of mechanical damage.

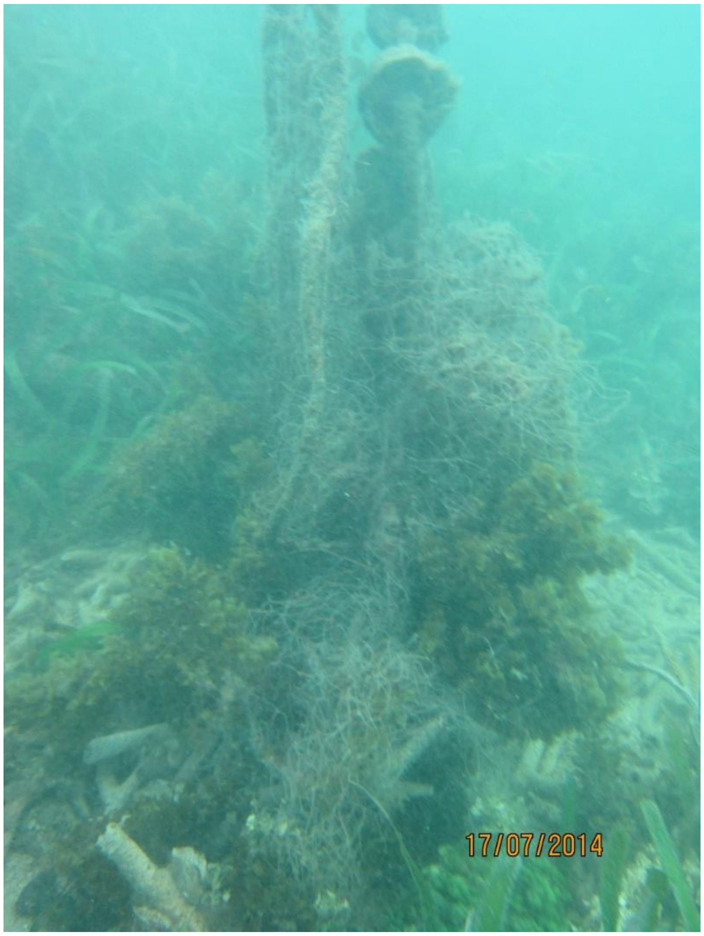


Plate 5-40 Fishnet wrapping around dead coral colony and tangled with sponges and other animals

5.3.5.2 Current Study

Based on 2012 findings, several roving surveys (of previously surveyed 2012 areas) were conducted with special emphasis on sensitive species and fish surveys in the potential areas of influence. The area has exceptionally poor visibility even with good weather conditions.

Thalassia testudinum was the dominant grass seen in all survey areas, similar to previous studies. Several algal species were also seen in dense patches in seagrass areas. Seagrass distribution remains patchy with the densest beds occurring on mounds of unconsolidated reef material/rubble. This included coral skeletons (*Porites and A. cervicornis* skeletons most likely), rock and other rubble.

These mounds of rubble act as a fringing barrier reef system and provide coastal protection to the bay. Although not a true reef system (and system under large amounts of degradation and stress), the loose material provide ecological volume for several species. Due to the intense over fishing and other harmful practices in the area (some ongoing and others restricted), none of these structures or ecosystems can function properly or to their full potential.

The benthic community also includes several invertebrate species including starfish, sea cucumbers, urchins and most notably large clumps of bivalve muscles. Although no commercially important species were seen during the survey, local fishermen have also begun harvesting sea cucumbers, which they say are harvested for export.

The Forereef and Crest

A fringing reef/ barrier reef system remains intact composed mainly of seagrass and coral skeletons with an extremely sparse coral community and large amounts of macroalgae (as with previous studies).

Seagrass beds are dominated by *Thalassia testudinum* and occur in patches, mainly on mounds of coral skeleton and rock but also in the lagoon areas towards the shoreline. Plate 5-41- Plate 5-44 show small coral colonies occurring in the seagrass beds of the reef crest.

Plate 5-41 Starfish in seagrass bed

Plate 5-42 *Solonastrea* sp. In seagrass bed

Plate 5-43 *Oculina* sp. in seagrass bed

Plate 5-44 *Diploria strigosa* in rubble/seagrass area at the base of the crest

The forereef was composed mainly of small patch reef with a sandy and silty substrate. A few larger coral colonies were seen in these area (Plate 5-45), the area has poor visibility, very few live corals were seen on each patch, instead these were dominated by macroalgae and some encrusting species (sponges and bivalves) (Plate 5-46). Some soft corals were also seen in this area (Plate 5-47).

Plate 5-45 Large *Montastrea* colony seen in front on the forereef

Plate 5-46 Encrusting bivalve

Plate 5-47 Soft Coral and Macroalgae in poor visibility

Fish Community

Fifteen (15) different taxa of fish were identified from the five survey areas. Five (5) taxa were identified from Site 1, one (1) from Site 2, three (3) from Site 3, five (5) from Site 4 and ten (10) from Site 5. Fish abundance was generally low, ranging from a maximum (24 individuals) at Site 5 to a minimum (2 individuals) at Site 2 (Table 5-63). As expected, the majority of fish observed were in the smaller size classes (≤6-10cm) with damselfish, foureye butterflyfish or surgeonfish present at most sites.

Table 5-63 Abundance of fish species at each site.

Generic name	Taxon or scientific name	No. of individuals				
		Site 1	Site 2	Site 3	Site 4	Site 5
Dusky Damselfish	*Stegastes fuscus*	-	2	1	-	3
Blue Tang	*Acanthurus coeruleus*	-	-	-	-	1
Banded Butterfly	*Chaetodon striatus*	-	-	-	-	1
Foureye Butterflyfish	*Chaetodon capistratus*	1	-	-	2	4
Grey Angelfish	*Pomacanthus arcuatus*	2	-	-	-	-

Generic name	Taxon or scientific name	No. of individuals				
		Site 1	Site 2	Site 3	Site 4	Site 5
Parrotfish	Scaridae	-	-	1	-	4
Surgeonfish	*Acanthurus bahianus*	3	-	6	2	1
Squirrelfish	Holocentridae	1	-	-	-	-
Schoolmaster Snapper	*Lutjanus apodus*	-	-	-	2	-
Yellowtail Snapper	*Ocyurus chrysurus*	-	-	-	1	-
Hogfish	*Lachnolaimus maximus*	-	-	-	1	-
Porgy	Sparidae	-	-	-	-	6
Porcupine fish	Diodontidae	-	-	-	-	2
Spotted drum	*Equentus punctatus*	-	-	-	-	1
Remora	Echeneidae	1	-	-	-	1
Total		**8**	**2**	**8**	**8**	**24**

Figure 5-110- Figure 5-113 show the size class frequency of all fish observed at each site (Site 2 had a single fish and therefore no graph was generated). Most fish fell within the 6-10 cm size range with low abundance. The lack of major grazers (larger parrot fish) and the general low abundance and diversity suggest a very poor fish community, heavily overfished and suffering from intense anthropogenic influences and pressure.

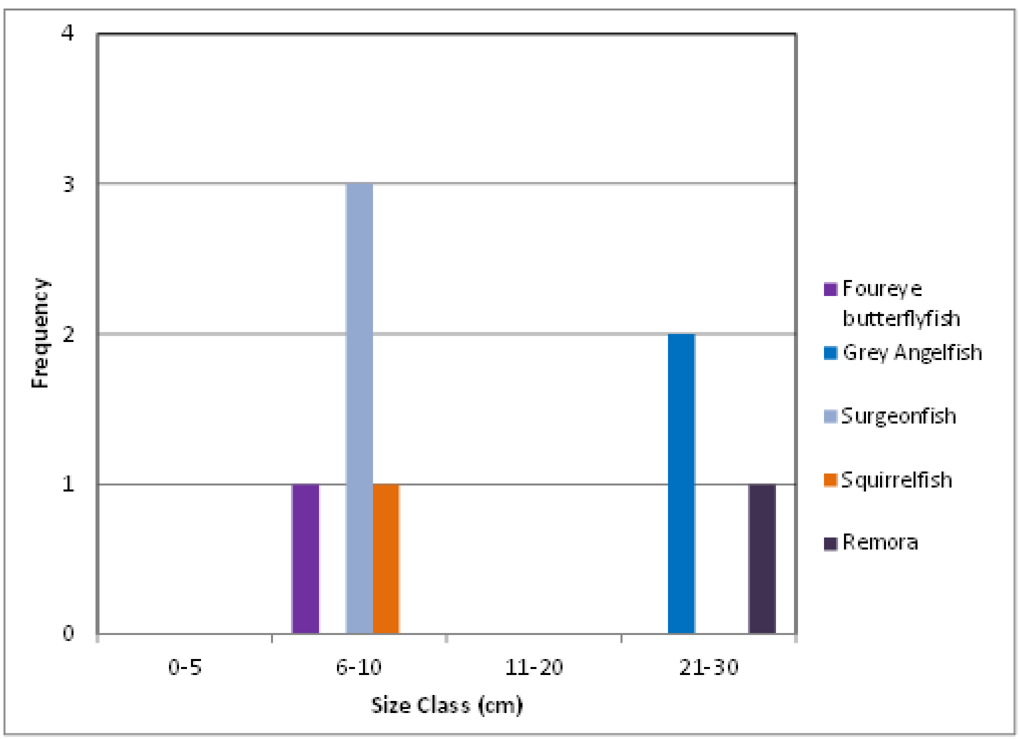


Figure 5-110 Size class and quantities of fish observed at Site 1

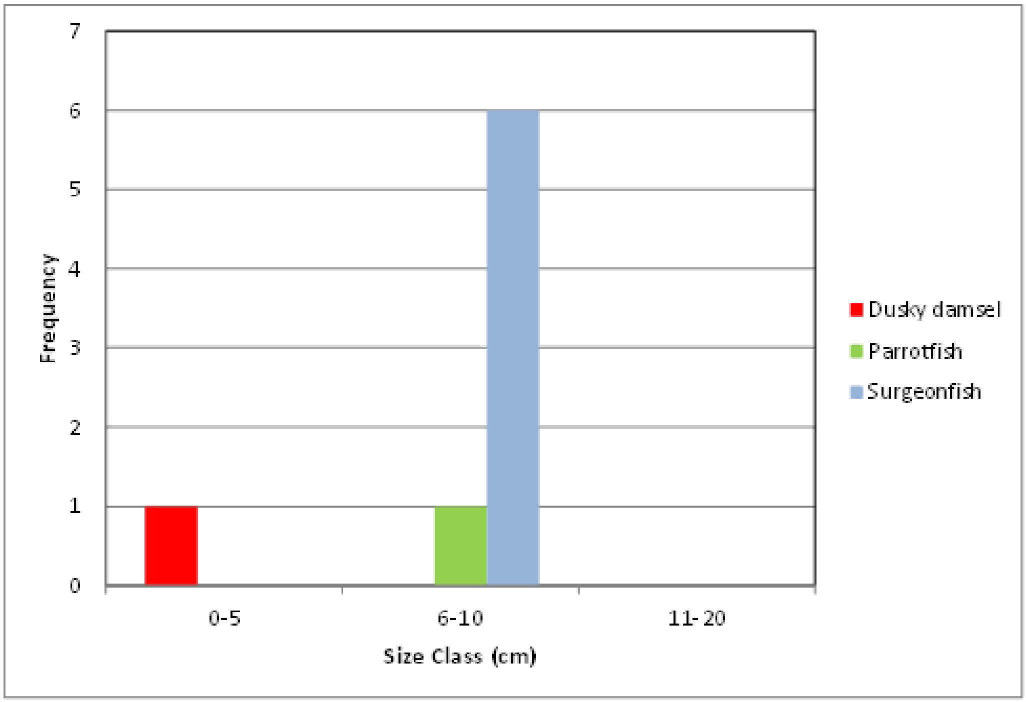


Figure 5-111 Size class and quantities of fish observed at Site 3

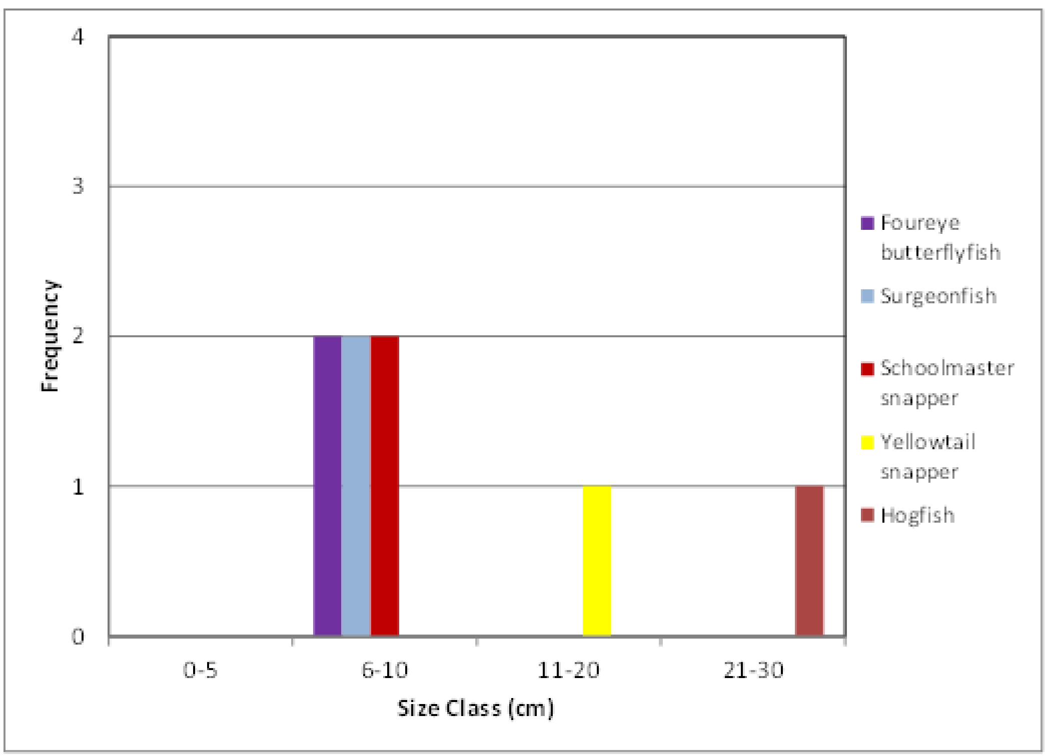


Figure 5-112 Size class and quantities of fish observed at Site 4

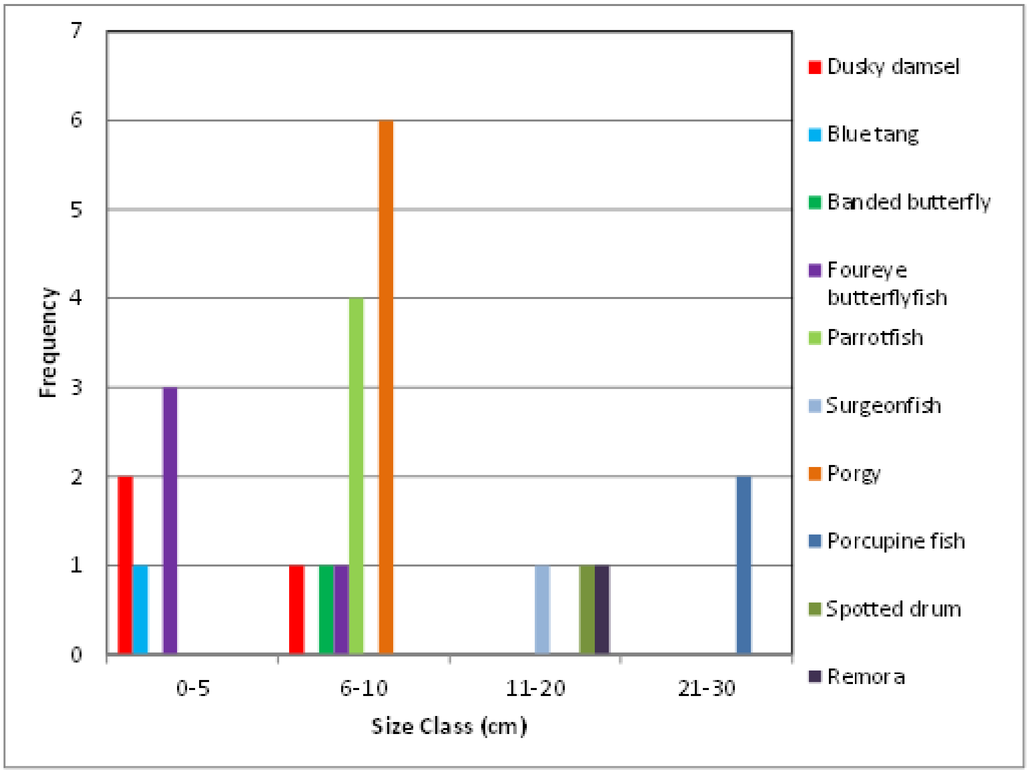


Figure 5-113 Size class and quantities of fish observed at Site 5

Portland Bight represents a unique area the proposed project areas falls within the industrial zone of the protected area. Both the terrestrial and nearby surrounding marine environment have been heavily degraded and modified. Sensitive and protected species include, some mangroves along the river bank, seagrass and a sparse coral community. Most ecosystem functions have been heavily reduced.

The dynamics of such a large area include; the industrial activities, anthropogenic pollution, a very large fishing community, the occurrence rare, endemic and protected species all combine to give Portland Bight Protected Area a unique social and environmental atmosphere. The area needs thoughtful and careful management in order to integrate further developments, environmental awareness and responsibility, rehabilitation of severely degraded areas and conservation of highly sensitive and unique ecosystems.

5.4 EXISTING POLLUTION SOURCES

5.4.1 Soil Contamination

5.4.1.1 Introduction

In February 2015, the CL Environmental conducted a site visit in order to ascertain the location of potential points of impact at the proposed site. During this visit, six main areas of interest were identified as follows (Figure 5-114):

- Presence of oily waste in one locality (1); the team was advised that this area was lined.
- One (1) storage area for resins.
- One (1) storage area for organic solvents.
- Three (3) storages areas for ash; the team was advised that two of the three areas were lined.

Upon identification of the potentially impacted areas, and, a determination of the potential contaminants, it was agreed that soil sampling would be subjectively carried out in these areas of impact, or at the nearest accessible points.

5.4.1.2 Methodology

Sampling

Soil samples were collected on May 4 and 5, 2015 from seven boring locations (Table 5-64, Figure 5-114) pre-determined based on the locations of areas thought to be potentially impacted.

Table 5-64 Borehole number and location in Jamaica Grid 2001 (JAD 2001)

BOREHOLE NUMBER	LOCATIONS	
	EASTINGS (JAD 2001)	NORTHINGS (JAD 2001)
BH 1	738507.418	638858.331
BH 2	738551.042	638849.366
BH 3	738566.489	638907.569
BH 4	738521.063	638918.850
BH 5	738545.128	638926.816
BH 6	738623.052	638963.144
BH 7	738594.671	638960.882

Drilling was done by hollow stem auger and soil samples collected at regular intervals until the maximum depth attainable was reached. Each sample collected was split in two portions. One portion was placed on ice immediately and retained for lab analysis if selected based on field readings using the Minirae 2000 Photo Ionisation Detector (PID). The second sample was analysed in the field then discarded. At least two samples per boring were retained for analysis. One being the sample at the maximum depth reached and another sample at the point of the highest PID reading.

Laboratory Analysis

Samples were analysed by Test America Laboratories in Pensacola, Florida. The parameters analysed were:

- BTEX (benzene, toluene, ethyl-benzene and total xylenes).
- MTBE (methyl-tert-butyl-ether)
- The Resource Conservation and Recovery Act (RCRA) 8 metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver).
- Iron
- Vanadium
- Total Petroleum Hydrocarbons (by Florida Residual Petroleum Organic (FL-PRO) method.

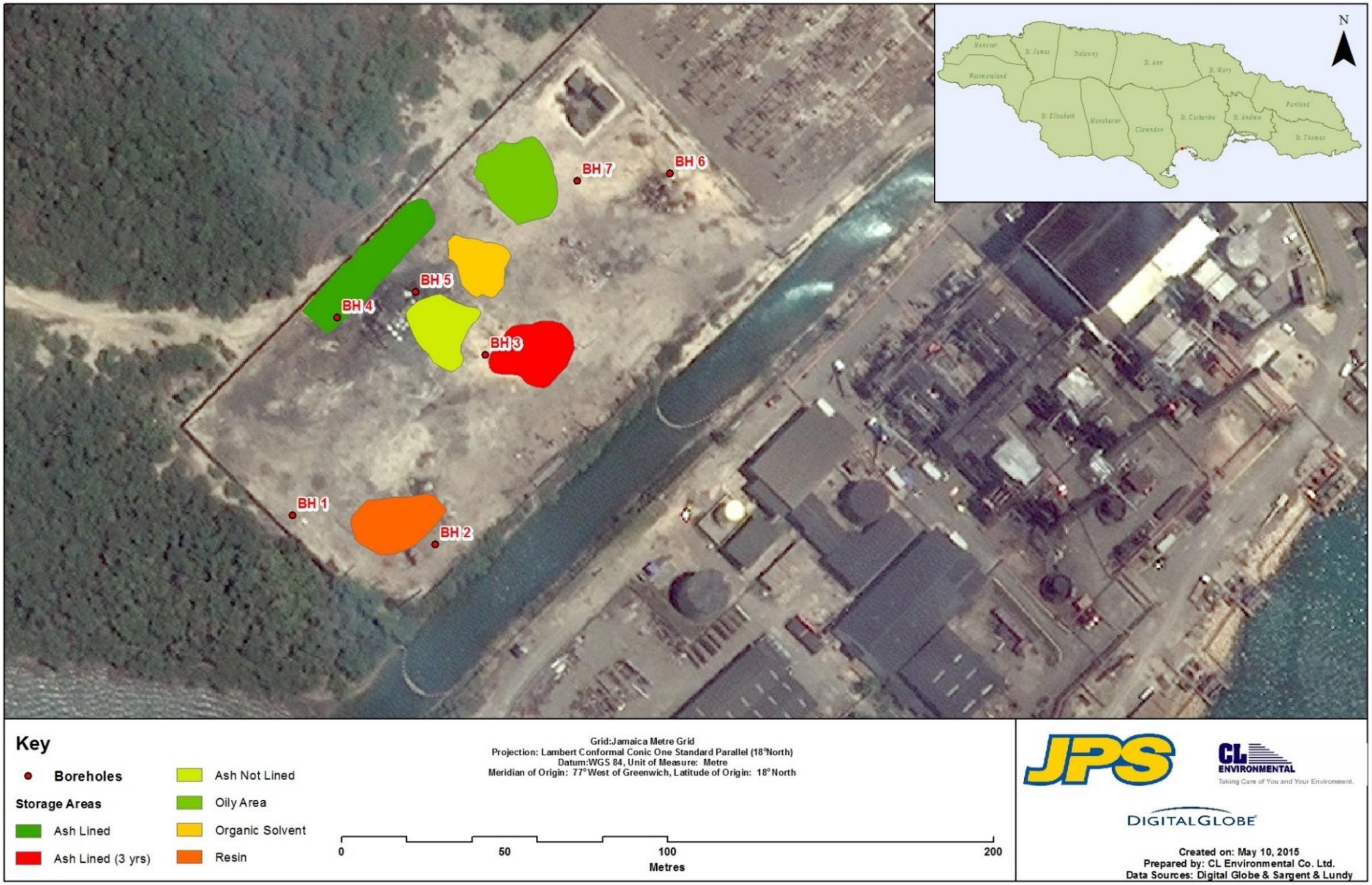


Figure 5-114 Satellite image depicting borehole locations and approximate areas of storage at the proposed 190 MW Site

Standards

The National Environment & Planning Agency (NEPA) does not have standards for all the parameters analysed, therefore the Florida Soil Cleanup Target Levels were used as a guide to ascertain potential impact levels. As shown in Table 5-65, clean up target levels vary between residential and commercial/industrial areas and are also based on the leachability of the contaminant of concern into groundwater as well as surface water (fresh or marine). Specifically considered is groundwater of low yield or poor quality.

5.4.1.3 Results and Discussion

Borehole Locations

Regarding the location of borehole locations:

- Borehole One (BH1) - this boring was located towards the western perimeter fence, approximately equidistance between the northern and southern perimeter boundaries. Information received from the JPS Co. suggested that no waste was stored in that general area.
- Borehole Two (BH2) - this boring was located within/ in close proximity to the area identified as the location where resins were stored. Due to the presence of presence of overhead high tension power lines, the location of the boring had to be shifted from that initially marked as a safety precaution. However the main resin area was sampled.
- Borehole Three (BH3) – this boring was located between two areas identified as areas where ash was stored. It was indicated that one area was lined and one area was not.
- Borehole Four (BH4) – this boring was located towards the northern perimeter fence in the vicinity of a third area identified as one where ash was previously stored. Information indicated that this area was lined.
- Borehole Five (BH5) – this boring was located within an area identified as the location where organic solvents were previously stored.
- Borehole Six (BH6) – this boring was located towards the eastern section of the site (close to the substation). This area was selected as an area thought not to be impacted, as information received suggested that no waste materials were stored in this area.
- Borehole Seven (BH7) – this boring was initially proposed to be within an area identified as a lined oil waste storage area. The area initially proposed, had to be changed as there were some changes to the landscape which restricted access. Therefore this boring was relocated on the periphery of the oil waste area, within what was considered a reasonable distance to detect impact if present and represent site conditions.

Table 5-65 Florida Soil Cleanup Target Levels for BTEX, RCRA 8 Metals and Iron, Vanadium and Nickel

	Direct Exposure		Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/ Poor Quality
	Residential	Commercial/ Industrial				
Unit:	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
Arsenic	2.1	12				
Barium	120	130000	1600			16000
Cadmium	82	1700	7.5		14	75
Chromium	210	470	38	4.2	19	380
Iron	53000					
Lead	400	1400				
Mercury	3	17	2.1	0.01	0.03	21
Nickel	340	35000	130		11	1300
Selenium	440	11000	5.2	0.5	7.4	52
Silver	410	8200	17	0.01	0.06	170
Vanadium	67	10000	980			9800
Benzene	1.2	1.7	0.007	0.5	0.5	0.07
Toluene	7500	60000	0.5	5.6	5.6	5
Ethlybenzene	1500	9200	0.6	12	12	6
Total Xylenes	130	700	0.2	3.9	3.9	2
Total Recoverable Petroleum Hydrocarbons	**460**	**2700**	**340**	**340**	**340**	**3400**

Sample Analysis

Table 5-66 presents a summary of the analytical data for soil samples.

TOTAL PETROLEUM HYDROCARBONS

Total Petroleum Hydrocarbons (TPH) were detected in samples collected from BH1, BH3, BH4 and BH7. All four of these borings were sampled at the 2.5ft depth interval, THP was detected. The National Environment & Planning Agency's standard for TPH in soil is 1000 mg/kg. All samples were below this standard and therefore complied. Concentrations were, BH1 - 2.5', 84 mg/kg, BH3 - 2.5', 53 mg/kg, BH4 - 2.5', 610 mg/kg and BH7 - 2.5' 95 mg/kg.

Both BH1 and BH4 confirmed TPH at the 7.5 feet depth interval and had concentrations of 55 mg/kg and 140 mg/kg respectively. No petroleum hydrocarbons were detected in the BH3 - 5' sample or the BH7 - 7.5' sample.

Petroleum hydrocarbons were not detected in the samples collected for BH2, BH5 and BH6.

A review of the concentrations related to leachability based on groundwater criteria and marine surface water criteria (Table 2), suggests that concentrations of 55 mg/kg and 140 mg/kg at 7.5 feet, which are below the 340 mg/kg cleanup level, should not result in petroleum hydrocarbons leaching into groundwater or marine surface water.

Petroleum hydrocarbons were detected in the C_{10}-C_{28} and C_{28}-C_{40}, carbon ranges which encompass diesel fuel, Bunker C Oil and Heavy fuel oils. No hydrocarbons in the gasoline range of C_8-C_{10} were detected.

BTEX

No components of BTEX (benzene, toluene, ethylbenzene, total xylenes) were detected in the fourteen samples submitted for analysis.

METHYL-TERT-BUTYL-ETHER

No MTBE (methyl-tert-butyl-ether) was detected in the fourteen samples submitted for analysis

8 RCRA METALS

The eight Resource Conservation and Recovery Act (RCRA) metals being reported on were selenium, silver, mercury, lead, chromium, cadmium, barium and arsenic. These will be reported on as individual parameters.

SELENIUM

Selenium was not detected in any of the samples submitted for analysis.

SILVER

Silver was not detected in any of the samples submitted for analysis.

MERCURY

The Florida Soil Cleanup Target Levels for Mercury is 17mg/kg specifically for Direct Exposure in Commercial/Industrial areas. Nine of the fourteen samples analysed confirmed the presence of mercury. Concentrations ranged between 0.017 mg/kg and 0.23 mg/kg. By comparison with the 17 mg/kg standard, the fourteen samples confirming the presence of mercury were found to be compliant with the standard. Mercury was detected in both samples for BH1, BH5 and BH7.

For boreholes BH3, BH4 and BH6 no mercury was detected in the upper level samples; 2.5', 2.5' and 5' respectively for BH3, BH4 and BH6. Mercury was detected only in the samples at furthest depth at 5', 7.5' and 7.5' for BH3, BH4 and BH6 respectively

Considering the elevated groundwater levels at the site the cleanup level for leachability based on groundwater criteria was considered. This standard is 2.1 mg/kg. When data were compared with this standard, it was revealed that samples were also compliant.

Mercury was not detected in the samples collected for BH2.

LEAD

The Florida Soil Cleanup Target Levels for Lead is 1400mg/kg specifically for Direct Exposure in Commercial/Industrial areas. All fourteen samples analysed confirmed the presence of Lead. Concentrations ranged between 2.1mg/kg and 18 mg/kg. Data revealed that samples collected at the furthest depths reached ranged between 12 mg/kg and 14 mg/kg.

With the exception of BH7 - 2.5' which had a concentration of 18 mg/kg the samples collected closer to surface had lower concentrations of Lead (ranging between 2.1 mg/kg and 13 mg/kg) when compared with the samples collected at furthest depths reached.

BH7 - 2.5' has the highest recorded concentration (18 mg/kg) and BH3 - 2.5' had the lowest recorded concentration (2.1 mg/kg).

The concentrations of lead in all borehole samples were compliant with the standard.

CHROMIUM

The Florida Soil Cleanup Target Levels for Chromium is 470 mg/kg, specifically for Direct Exposure in Commercial/Industrial areas. Chromium was detected in all fourteen samples submitted for analysis. Concentrations ranged between 3.3 mg/kg and 20 mg/kg and did not exceed the standard of 470 mg/kg.

Groundwater measurements recorded suggested that groundwater levels at the site are elevated, consequently the standard relating to leachability based on groundwater criteria was considered. This standard is 210 mg/kg. A comparison of the data and the groundwater leachability standard, also revealed that samples did not exceed that standard.

With the exception of BH7 - 2.5', for each boring the higher chromium concentration was recorded at the furthest depths sampled.

BH2 samples had comparable chromium concentrations at 11 mg/kg and 12 mg/kg at 2.5' and 5' respectively. BH5 at similar depths of 2.5' and 5’ also had values which were comparable at 8.7 mg/kg and 9.0 mg/kg.

CADMIUM

The Florida Soil Cleanup Target Levels for Cadmium is 1700 mg/kg, specifically for Direct Exposure in Commercial/Industrial areas. Cadmium was detected in only one of the fourteen samples submitted for analysis. BH7 - 2.5' had a concentration of 0.84 mg/kg and was found to comply with the standard.

By comparison with the standard of leachability based on groundwater criteria, 7.5mg/kg, the BH7 - 2.5' sample was found to be compliant.

BARIUM

The Florida Soil Cleanup Target Levels for Barium is 130,000 mg/kg, specifically for Direct Exposure in Commercial/Industrial areas. The presence of barium was confirmed in all fourteen sample analysed. Concentrations ranged between 20 mg/kg and 350 mg/kg and were found to be compliant with the soil cleanup target level.

With the exception of BH2, which had the same barium concentration at the 2.5' and 5' depths (130 mg/kg), all other borings had lower barium concentrations closer to the surface.

Leachability based on groundwater criteria for barium is 1600 mg/kg. This standard was considered as it was realised that groundwater levels at the site are elevated. Comparison with this standards indicated that the samples analysed were compliant with this standard.

ARSENIC

The Florida Soil Cleanup Target Levels for Arsenic is 12 mg/kg, specifically for Direct Exposure in Commercial/Industrial areas. Arsenic was detected in all fourteen samples analysed. Concentrations detected ranged between 3.8 mg/kg and 19 mg/kg. BH6 - 5' had a concentration of 12 mg/kg, and BH7 - 2.5' had a concentration of 19 mg/kg. Comparison with the standard revealed that BH7 - 2.5' was non- complaint as it exceeded the standard, while BH6 - 5' was at the limit of the standard.

Regarding BH7, arsenic concentrations changed from 19 mg/kg at 2.5' to 5.0 mg/kg at 7.5'. BH6 arsenic concentrations changed from 12 mg/kg at 5' to 5.2 mg/kg at 7.5'.

Both BH3 and BH5 were sampled at the 2.5' and 5' depths. A review of the analytical data revealed that arsenic concentrations increased with depth for these borings only. For the other borings BH1, BH2, BH4, BH6 and BH7 higher arsenic concentrations were detected closer to surface.

With the exception of BH6 - 5' and BH7 - 2.5' arsenic concentrations were below 10 mg/kg.

IRON

The Florida Soil Cleanup Target Levels for Iron is 53,000 mg/kg, specifically for Direct Exposure in residential areas (Table 2). The presence of Iron was confirmed in all fourteen samples. Concentrations detected ranged between 5,900 mg/kg and 41,000 mg/kg. A review of the data revealed that the higher concentrations of Iron for each boring was at the furthest depth sampled and lower concentrations closer to surface. The lowest concentration of Iron in soil recorded was 5,900 for BH3 - 2.5', while the highest concentration recorded was 41,000 mg/kg for BH2 - 5'.

While values of 29,000 mg/kg to 41,000 mg.kg may seem elevated, it should be noted that "Iron is the most abundant element in soils, ranging from 7,000 mg/kg to 500,000 mg/kg, with a mean concentration of 38,000 mg/kg (3.8%) in soils, (Lindsay 1979)" (*as reported in The Handbook of Soil Science; Summer, Malcolm E.; 1999)*. This suggests therefore that the values recorded are within what is considered normal.

NICKEL

The Florida Soil Cleanup Target Levels for Nickel is 35,000 mg/kg, specifically for Direct Exposure in Commercial/Industrial areas. The cleanup level relating to leachability based on groundwater criteria is 130 mg/kg and that relating to leachability based on marine surface water criteria is 11 mg/kg. Nickel was detected in all fourteen samples submitted for analysis. Concentrations ranged between 5.8 mg/kg and 740 mg/kg.

By comparison with the target levels for commercial/industrial areas, all samples would have been found to be compliant with the Nickel standard of 35,000 mg/kg. However, as was observed groundwater levels are elevated and the site is within close proximity to the coastline. As a result the target level of 130 mg/kg relating to leachability based on groundwater criteria was also considered. A comparison of the analytical data with the groundwater criteria revealed that the BH7 - 2.5' sample was non-compliant with the standard as concentration was 740 mg/kg.

Natural concentrations of Nickel in soil vary, with the commonly accepted value of 100 mg Ni/kg of soil being the maximum permissible level (*Soil Quality, Sustainable Agriculture and Environmental Security in Central and Eastern Europe; Wilson, Michael; Maliszewska-Kordybach, B. 2012).*

Speciation of Nickel in Natural and Contaminated Soils. Potentiality of Phytoremediation (Barbafieri, M.; Lubrano, L.; Petruzelli, G.) in Conference Proceedings Contaminated Soil '98, *Vol 2; Sixth International FZK/TNK Conference Consoil '98* reports that in Italy Nickel is present in very high concentrations also in natural soils (over 300 mg/kg).

Literature suggests that there is variability in natural Nickel concentrations in soil with concentrations of 300 mg/kg being considered natural. It may be inferred that Nickel concentrations detected below 300 mg/kg or the groundwater leachability criteria of 130 mg/kg may be naturally occurring and not necessarily indicative of impact to soil. The recorded concentration of 740 mg/kg for BH7 however, may be indicative of impact to soil, as this value was significantly higher than the other recorded concentrations which ranged between 5.6 mg/kg and 57 mg/kg, however this cannot be categorically stated.

It should be noted that while BH7 - 2.5' was 740 mg/kg for Nickel, the 7.5' sample was 17 mg/kg. Other boreholes showing a decrease in Nickel concentrations with increasing depth were BH2 and BH3.

BH1, BH4, BH5 and BH6 all showed increases in concentration with increasing depth.

VANADIUM

The Florida Soil Cleanup Target Levels for Vanadium is 10,000 mg/kg, specifically for Direct Exposure in Commercial/Industrial areas. Leachability based on groundwater criteria is 980 mg/kg. Vanadium was detected in all fourteen samples analysed.

By comparison with the 10,000 mg/kg standard, all samples complied as concentrations ranged between 62 mg/kg and 3,500 mg/kg. When compared with the groundwater leachability criteria, at least one sample from all borings except BH6 exceeded this standard. BH 6 had concentrations of 62 mg/kg and 160 mg/kg

BH1, BH2 and BH4 were observed to have exceeded the groundwater leachability standard at 2.5', however complied at depths of 7.5', 5' and 7.5’ for BH1, BH2 and BH4 respectively. BH7 was also observed to have exceeded the standard at 2.5'; while concentrations decreased at 7.5' the result of 1,100 mg/kg was still not compliant.

BH3 and BH5 exceeded the leachability standard, at both depths sampled however it was observed that concentrations were higher at depth. In the case of BH3 concentrations changed from 1000 mg/kg to 2900 mg/kg and for BH5 concentrations changed from 1600 mg/kg to 2300 mg/kg.

Table 5-66 Summary of Results for Soil Samples Collected at the Proposed JPS 190 MW Site May 4 and 5, 2015

	BH1 -2.5'	BH1 - 7.5'	BH2 -2.5'	BH2 - 5'	BH3 - 2.5'	BH3 - 5'	BH4 - 2.5'	BH4 - 7.5'	BH5 - 2.5'	BH5 - 5'	BH6 - 5'	BH6 7.5'	BH7 - 2.5'	BH7 - 7.5'	Standard
C8 - C40	84	55	ND	ND	53	ND	610	140	ND	ND	ND	ND	95	ND	1000[2]
C8 - C10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
C10 - C28	43	21	ND	ND	23	ND	250	76	ND	ND	ND	ND	41	ND	
C28 - C40	52	41	ND	ND	36	ND	450	81	ND	ND	ND	ND	69	ND	
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.7[1]
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	60000[1]
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9200[1]
Total Xylenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	700[1]
BTEX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Methyl-tert-butyl ether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Arsenic	7.7	6.7	7.9	3.8	5.9	8.6	7.0	5.5	6.0	7.3	12	5.2	19	5.0	12[1]
Barium	46	150	130	130	20	260	51	190	330	350	35	290	100	200	130000[1]
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.84	ND	1700[1]
Chromium	6.7	14	11	12	3.3	10	7.3	15	8.7	9.0	7.4	11	20	9.3	470[1]
Iron	19000	36000	25000	41000	5900	35000	15000	36000	37000	38000	17000	38000	29000	35000	53000[1]
Lead	5.3	13	7.4	12	2.1	13	4.9	13	13	14	5.8	12	18	13	1400[1]
Mercury	0.023	0.037	ND	ND	ND	0.020	ND	0.088	0.018	0.025	ND	0.025	0.23	0.017	17[1]
Nickel	8.6	57	12	8.2	17	9.9	10	44	10	13	5.8	10	740	17	35000[1]
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11000[1]
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8200[1]
Vanadium	1200	590	1200	210	1000	2900	1500	390	1600	2300	62	160	3500	1100	10000[1]

[1] *Florida Soil Cleanup Target Levels - http://www.dep.state.fl.us/waste/quick_topics/rules/documents/62-777/62-777_TableII_SoilCTLs.pdf*

[2] *National Environment & Planning Agency - Interim Standards for Petroleum in Groundwater and Soil*

5.4.1.4 Conclusions

- Samples analysed for petroleum hydrocarbons were found to be compliant with the NEPA 1000 mg/kg standard. Highest petroleum concentrations were recorded at the BH4 sample point with the 2.5' sample having the higher concentration of 610 mg/kg. The Florida Soil Cleanup Target Level leachability standard with respect to groundwater criteria is 340 mg/kg. With reference to this standard, it was realised that the BH4 - 2.5' standard was non-compliant. Specifically relating to BH4 groundwater was measured at approximately 3.5 feet below ground. It is recommended that in an effort to address issues of contamination and mitigate against the possibility of having contaminants leach into groundwater, remedial action be undertaken as soon as possible. It is anticipated that as part of site preparation for the construction of the 190 MW power plant, land preparation of some sort will be undertaken. It is recommended that impacted soil in the vicinity of BH4 be excavated to a depth of 3.0 feet, minimum, (not to reach groundwater), providing that excavated soil can be safely disposed of. Should soil excavation and proper disposal not be an option, in-situ remediation is recommended. Note however that in-situ remediation, while considered cost-effective, is a medium term action, which may impact on overall project timelines.
- No benzene, toluene, ethylbenzene, total xylenes (BTEX) or methyl-tert-butyl-ether (MTBE) were detected in any of the fourteen samples analysed.
- Metals including the RCRA metals occur naturally in soil. Therefore it was expected that metals would have been detected in soil. Seven of the RCRA metals were all observed to be within cleanup target levels for all sample points. Arsenic was found to exceed the cleanup target level at BH 7. For BH 6 Arsenic was at the target level of 12 mg/kg. Providing there is an approved facility to accept impacted soils it is recommended that soils be excavated from the BH 7 and BH 6 areas.
- Based on leachability standards (980 Mg/kg) Vanadium was found to be non-compliant. However in the absence of data characterising the naturally occurring metal concentrations for the Old Harbour Bay area, it cannot be categorically stated that these values indicate soil contamination as they may well be within what is normal.
- Regarding Nickel, literature suggests that concentrations vary in soils. The highest concentration of 740 mg/kg recorded by comparison with the results of the samples suggests that there may be impact at the BH7 sample point; however impact does not persist beyond 7.5 feet. Groundwater level was recorded at approximately 7 feet below ground. It is recommended that soils in the vicinity of BH 7 be excavated to a depth not to reach groundwater in an effort to remediate by means of excavation, providing there is an approved facility that can receive impacted soils.
- As it relates to concentrations of Iron recorded; while values of 29,000 mg/kg to 41,000 mg.kg may seem elevated, it should be noted that "Iron is the most abundant element in soils, ranging from 7,000 mg/kg to 500,000 mg/kg, with a mean concentration of 38,000 mg/kg (3.8%) in soils, (Lindsay 1979)" (*as reported in The Handbook of Soil Science; Summer, Malcolm E.; 1999)*. This suggests therefore that the values recorded are within what is considered normal and does not necessarily indicate soil contamination.

5.4.2 Cooling Water Discharge

The marine area in proximity to the proposed JPS power plant is used for cooling water discharge by the existing JPS Old Harbour Power Plant and the JEP Doctor Birds 1 and 2 Power Barges. These three sources represents potential thermal pollution to the marine environment.

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 in improving 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 proposed new power plant will however, result in the cooling water discharge becoming compliant.

The JEP barges cooling water discharges since there commissioning have been compliant with the World Bank guidelines, however, at times they are non-compliant with the NEPA standard at certain depths (most times at the surface).

5.4.3 Runoff from the Bowers Gully

Bower's Gully, which is located west along 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 5-48) (C. L. Environmental Co. Ltd. 2012). During heavy rains the water becomes very turbid owing to sediment resuspension.

The sediments that the Bowers Gully also influence silting in the bay, evidenced by the increased maintenance dredging frequency of the Windalco Port Esquivel facility.

Plate 5-48 Photograph showing general conditions of Bowers Gully

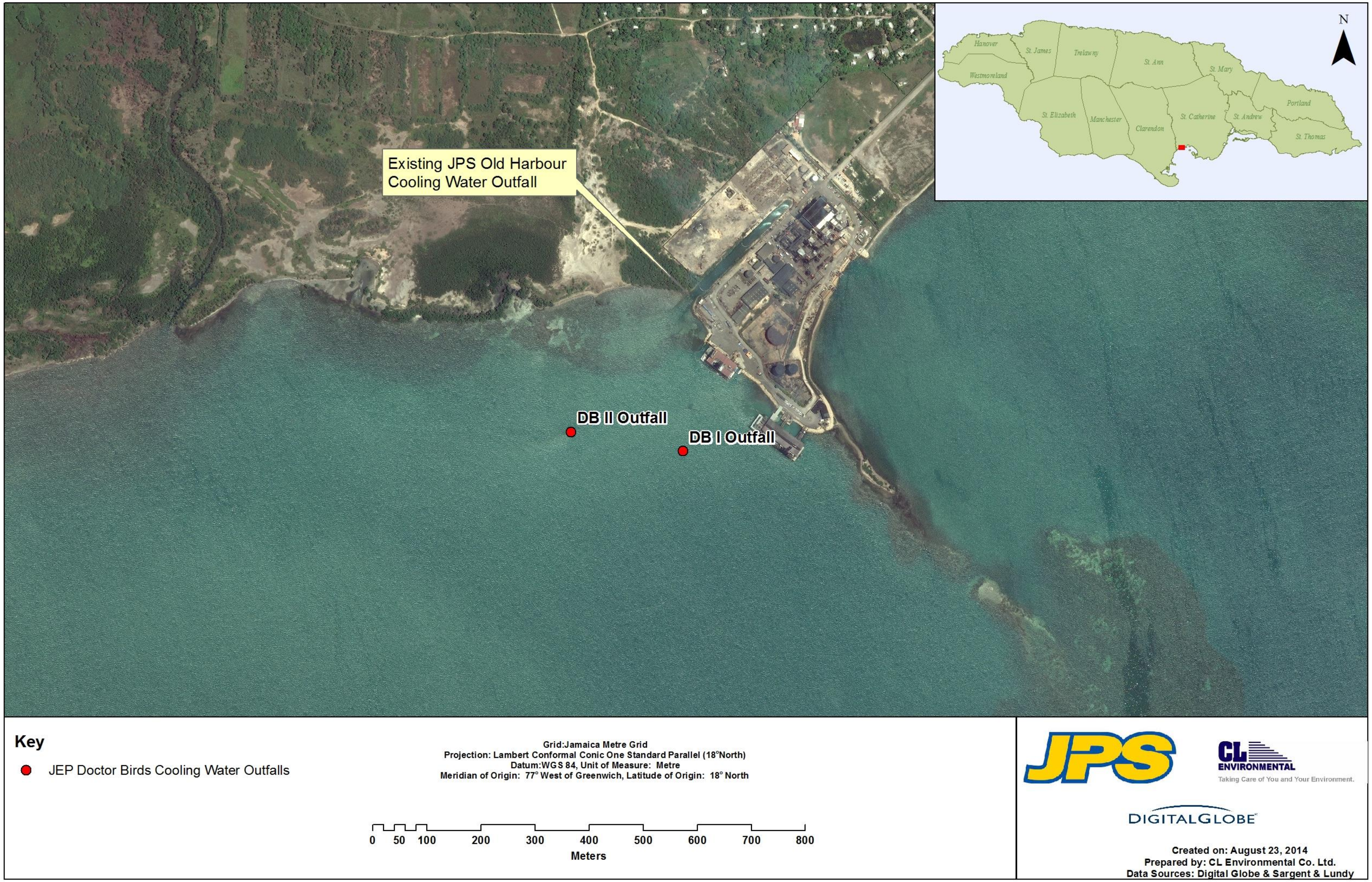


Figure 5-115 Map depicted JPS and JEP Doctor Birds cooling water discharges

5.5 HERITAGE

The Jamaica National Heritage Trust (JNHT) conducted an Archaeological Impact Assessment (AIA) on the site of the proposed South Jamaica Power Company Limited (SJPC) 360MW Power Plant. The field survey was conducted over a 2 day period, May 16 and 17, 2012.

Historically, the area contains historic and archaeological sites dating back to Jamaica's first known inhabitants (The Taíno) 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.

Currently the sections slated for development are in ruinate with charcoal burning occurring and presently the waste storage area for the existing JPS Old Harbour Bay power plant.

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 shards, both Spanish and English bricks and concrete troughs associated with cattle rearing were found to the immediate east and west of the site. Detailed results of the assessment may be found in the Archaeological Impact Assessment report submitted in conjunction with the EIA for the South Jamaica Power Company Limited (SJPC) 360MW Power Plant.

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) was 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 the SIA as well. For the purposes of this project, the SIA was demarcated as two (2) kilometres from the proposed development area. As seen in Figure 5-116, the SIA is located in Old Harbour Bay, in the parish of St. Catherine. 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 settlements of Port Esquivel, Brampton Farm and Lloyd's Pen surround the demarcated SIA.

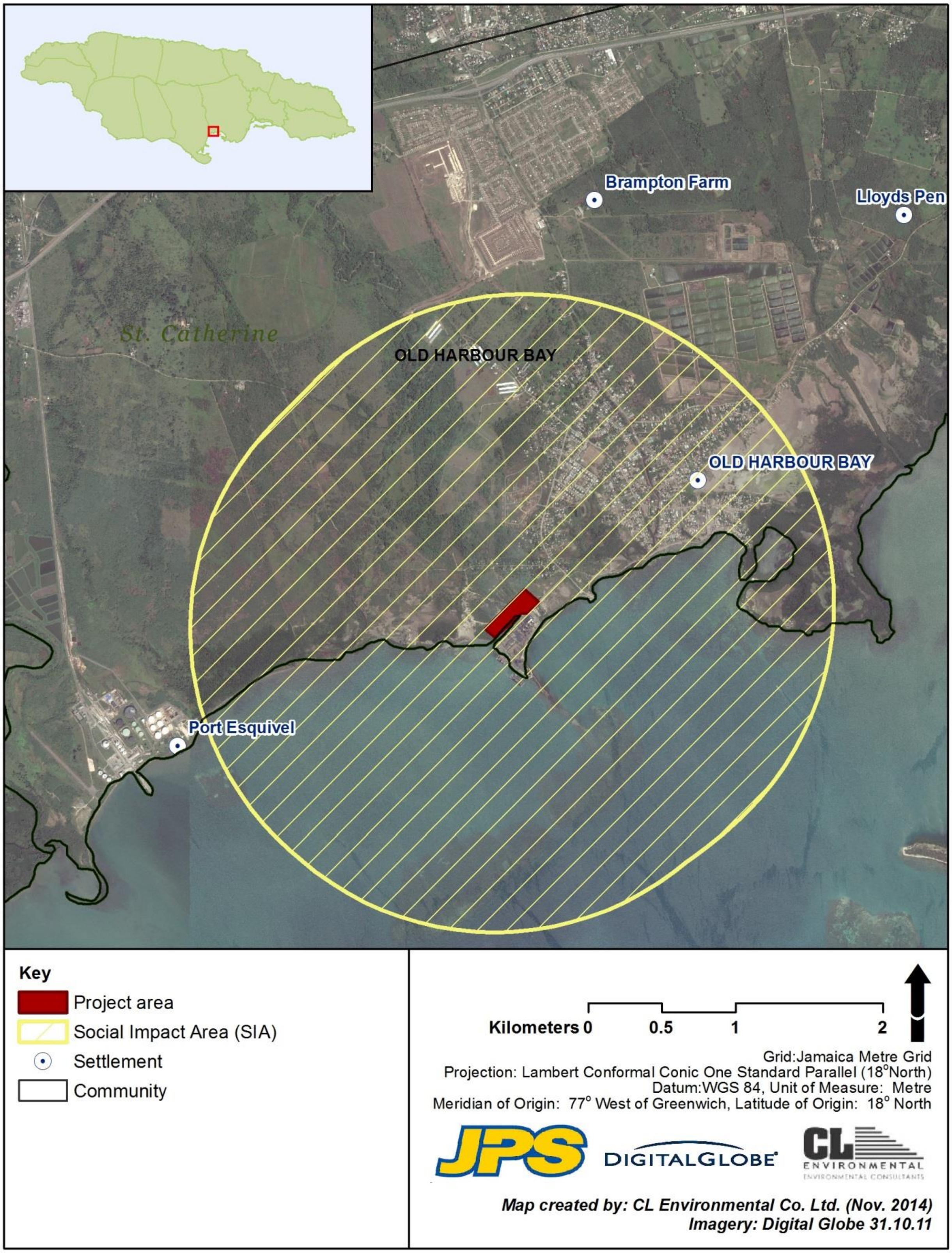


Figure 5-116 Map showing the Social Impact Area (SIA)

Demographic Analyses and Census Database

Population data were extracted from the STATIN 2011 Population Census database for the SIA by enumeration district. This was undertaken using Geographic Information Systems (GIS) methodologies, which were also used to derive visual representations of the data. 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).

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 Mona GeoInformatics Institute. Additional data were also gleaned from the 1984 national topographic maps (metric series) and satellite imagery available for the project.

5.6.1.2 Demography

Population Growth Rate

The total population within the SIA in 2011 was approximately 5,026 persons (STATIN 2011 Population Census). Examination of the 2001 population data showed that there were approximately 5,601 persons within the 2 km radius of the proposed development area in 2001. From this population, and that calculated for the year 2011 (5,026 persons), it was estimated that the actual growth within the SIA between 2001 and 2011 was approximately -1.08% per annum. Based on this growth rate, at the time of this study (2014), the population was approximately 4,866 persons and is expected to reach 3,712 persons over the next twenty five years if the current population growth rate remains the same. The annual SIA growth rate of -1.08% differs greatly from the regional rate of 0.72%

for St. Catherine (2001-2011)[12]; at the regional rate, the population within the SIA is estimated at 5,136 persons in 2014 and 6,145 persons in 2039.

Age & Sex Ratio

Table 5-67 shows the percentage composition of each age category of the population. This is compared on a national, regional and local (SIA) level. Percentage age for the 0-14 years age cohort is highest in the SIA (28.1%), when compared to the regional and national figures of 26.1%. Elderly persons aged 65 years and greater make up 5.5% of the SIA population; this is lower than both the national figure (8.1%) and the St. Catherine figure of 7.0%. Within the SIA, the 15-64 years age category accounted for 66.4% and can therefore be considered a working age population. This SIA percentage was slightly lower than that for the nation (65.9%), and comparable to the parish of St. Catherine (66.9%) (Table 5-67). A Social Development Commission (SDC) Community Profile for the community of Old Harbour Bay in 2007 indicated the population can be considered as a working age population with 63% of the community's population being between the ages of 15-64 years; this is similar to the 2011 Census data presented here.

Table 5-67 Age categories as percentage of the population for the year 2011

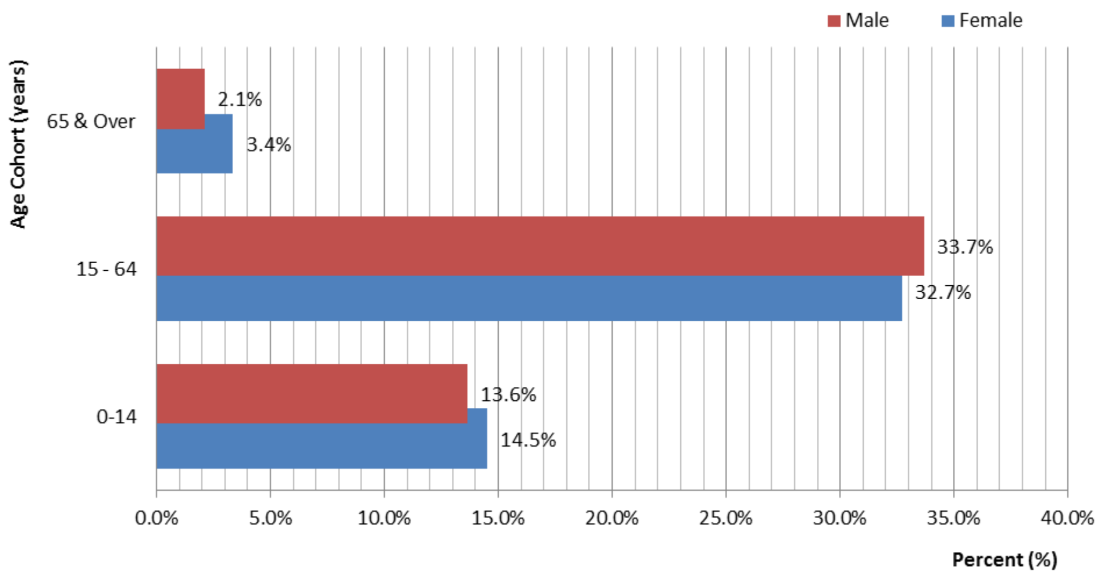
Source: STATIN Population Census 2011

Age Categories	Jamaica	St. Catherine	SIA
0-14	26.1%	26.1%	28.1%
15 - 64	65.9%	66.9%	66.4%
65 & Over	8.1%	7.0%	5.5%

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, approximately 7.4% comprised the young category and as mentioned previously, 5.5% make up the 65 years and older category.

As seen in Figure 5-117, Census 2011 data indicated that there were approximately 1.0% more males within the 15-64 years; however there were 1.3% and 0.9% more females in the 65 & over and 0-14 years cohorts respectively. Sex ratio for all age cohorts within the SIA was calculated to be 97.7 males per one hundred females. This is comparable to the 2007 SDC Profile of Old Harbour Bay that stated that there were more females (53.9%) than males (46.1%) in the population.

[12] http://statinja.gov.jm/Census/Census2011/Census%202011%20data%20from%20website.pdf

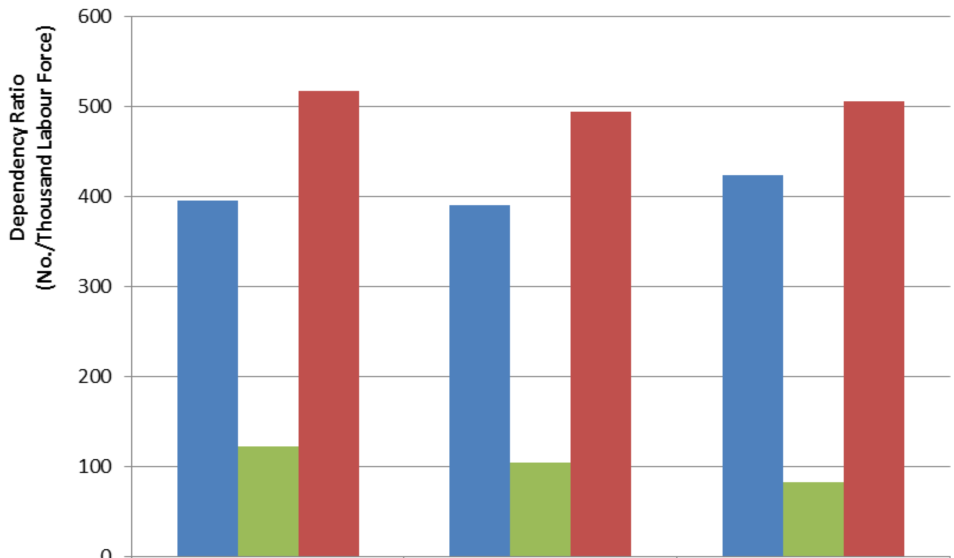


Source data: STATIN Population Census 2011

Figure 5-117 Male and female percentage population by age category for the SIA in 2011

Dependency Ratios

The child dependency ratio for the SIA in 2011 was 424.0 per 1000 persons of labour force age; old age dependency ratio stood at 82.4 per 1000 persons of labour force age; and societal dependency ratio of 506.4 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. Comparisons of the child dependency ratios at varying extents indicate that the child dependency ratio for the study area (SIA) was higher than the national and regional figures of 395.4 and 390.8 respectively (Figure 5-118).



	Jamaica	St. Catherine	SIA
Child Dependency	395.4	390.8	424.0
Old Age Dependency	122.4	104.0	82.4
Societal Dependency	517.8	494.8	506.4

Source: STATIN Population Census 2011

Figure 5-118 Comparison of dependency ratios for the year 2011

Population Density

The land area within the SIA was calculated to be approximately 7.6 km^2. With a population of 5,026 persons in 2011, the overall population density is estimated at 663.9 persons/km^2. This population density is considerably higher than the regional level (433.6 persons/km^2), as well as the national density of 245.5 persons/km^2 (Table 5-68). As seen in Figure 5-119, the population is not evenly distributed within the SIA; fewer persons live in the western and northern EDs within the SIA.

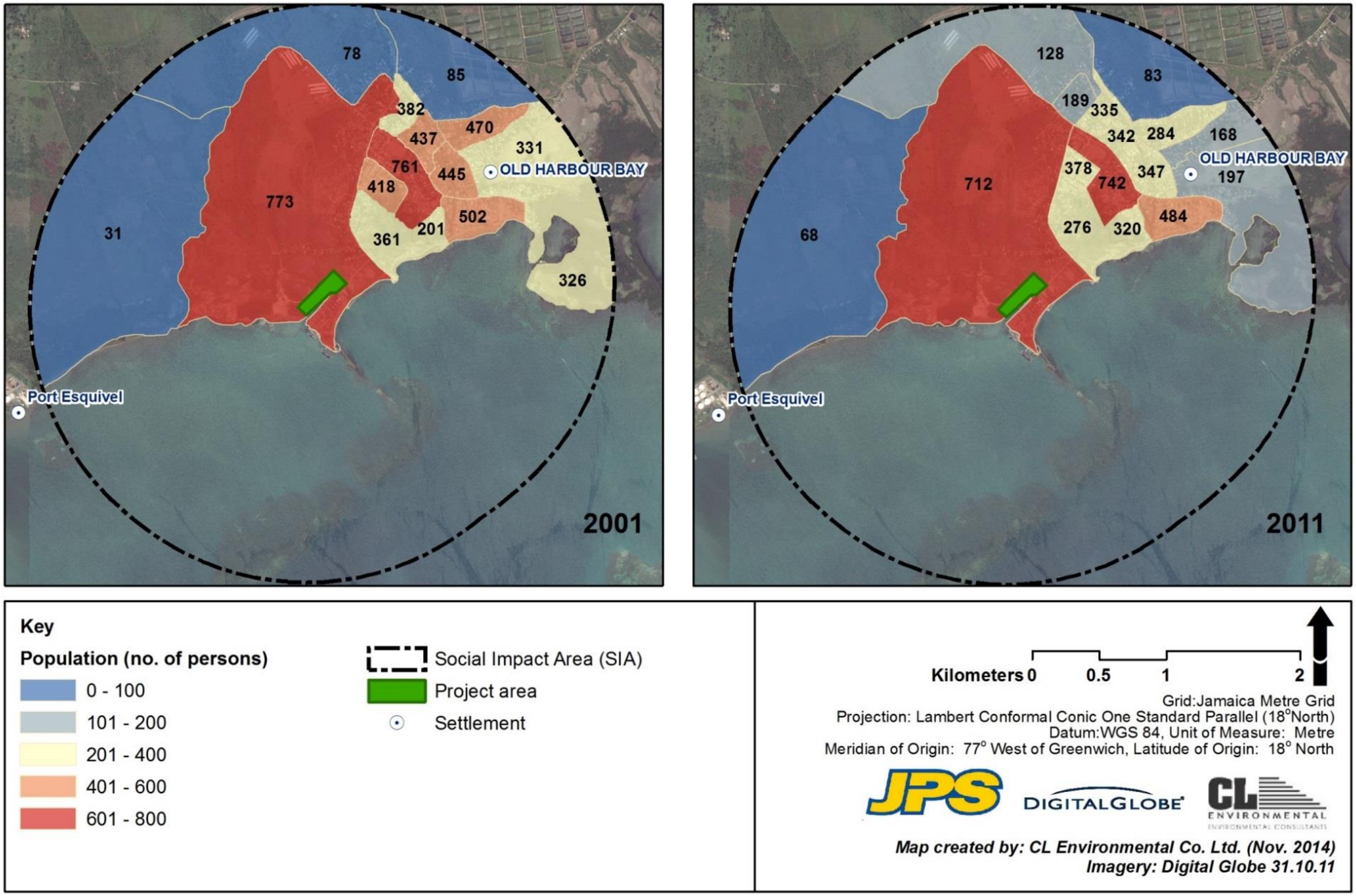
Table 5-68 Comparison of population densities for the year 2011

Source: STATIN Population Census 2011

Category	Jamaica	St. Catherine	SIA
Land Area (km^2)	10,991.0	1,190.6	7.6
Population	2,697,983	516,218	5,026
Population Density	245.5	433.6	663.9

Population Growth Areas

Figure 5-119 depicts the population within each enumeration district (ED) for the years 2001 and 2011. Total SIA population decreased from 5,601 persons to 5,026 persons within this ten year timeframe. An increase in population is observed for three EDS - two located to the west and north of the SIA, and another located 700 metres northeast of the project area. Population decreases are noticeable in all other EDs within the SIA.



Data source: STATIN Population Census 2011 and 2001

Figure 5-119 SIA 2001 and 2011 population data represented in enumeration districts

Migration Patterns

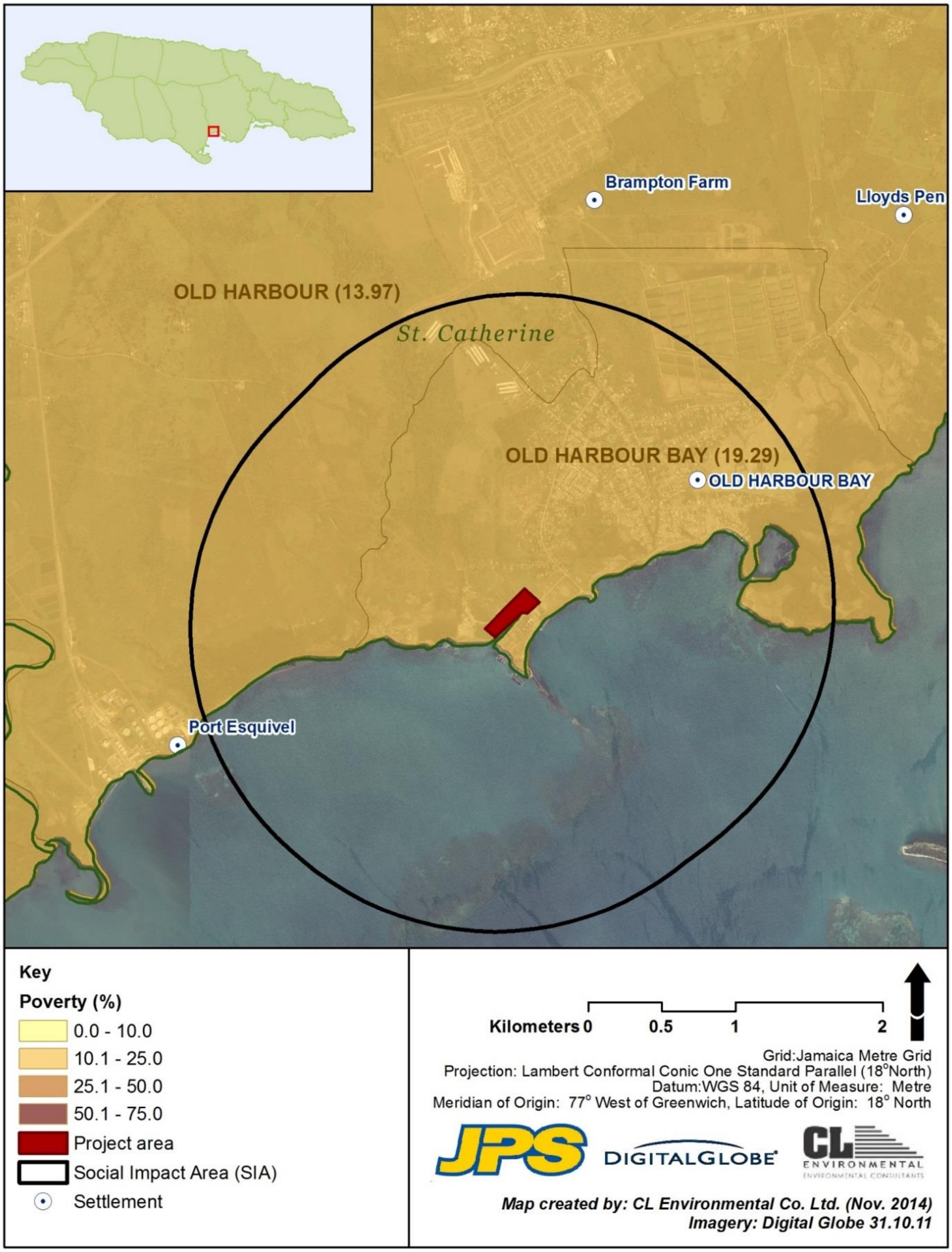
Migration is quite uncommon in the Community, as most residents (88.6%) have lived in the Community for 10 or more years (SDC 2007).

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 5-120, 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 5-120 Proportion of persons in poverty in each community

5.6.1.4 Education

The educational attainment of persons in 2011 for the national, regional and SIA extents are represented in Table 5-69. When educational attainment within the SIA is calculated as a percentage, it becomes evident that there is a propensity towards the attainment of a primary and secondary school education. Approximately half of the SIA population (50.7%) attained a secondary school education, followed by 33.6% attaining a primary education. Secondary educational attainment is higher than the Jamaica and St. Catherine figures (45.7% and 44.7% respectively). There are lower percentages of those attaining a university or other tertiary level in the SIA (6.2%) when compared to the national combined total of 9.9% for Jamaica and 12.7% for St. Catherine. Statistics for pre-primary and no education are comparable amongst all extents examined.

Table 5-69 Population 3 years old and over by highest level of educational attainment as a percentage, for the year 2011

Source: STATIN Population Census 2001

	Jamaica	St. Catherine	SIA
No Schooling	0.7%	0.6%	0.5%
Pre Primary	4.8%	4.9%	5.0%
Primary	34.4%	32.0%	33.6%
Secondary	45.7%	44.7%	50.7%
University	4.7%	5.9%	1.9%
Other Tertiary	5.2%	6.8%	4.3%
Other	0.5%	0.7%	0.4%
Not Stated	4.0%	4.4%	3.6%

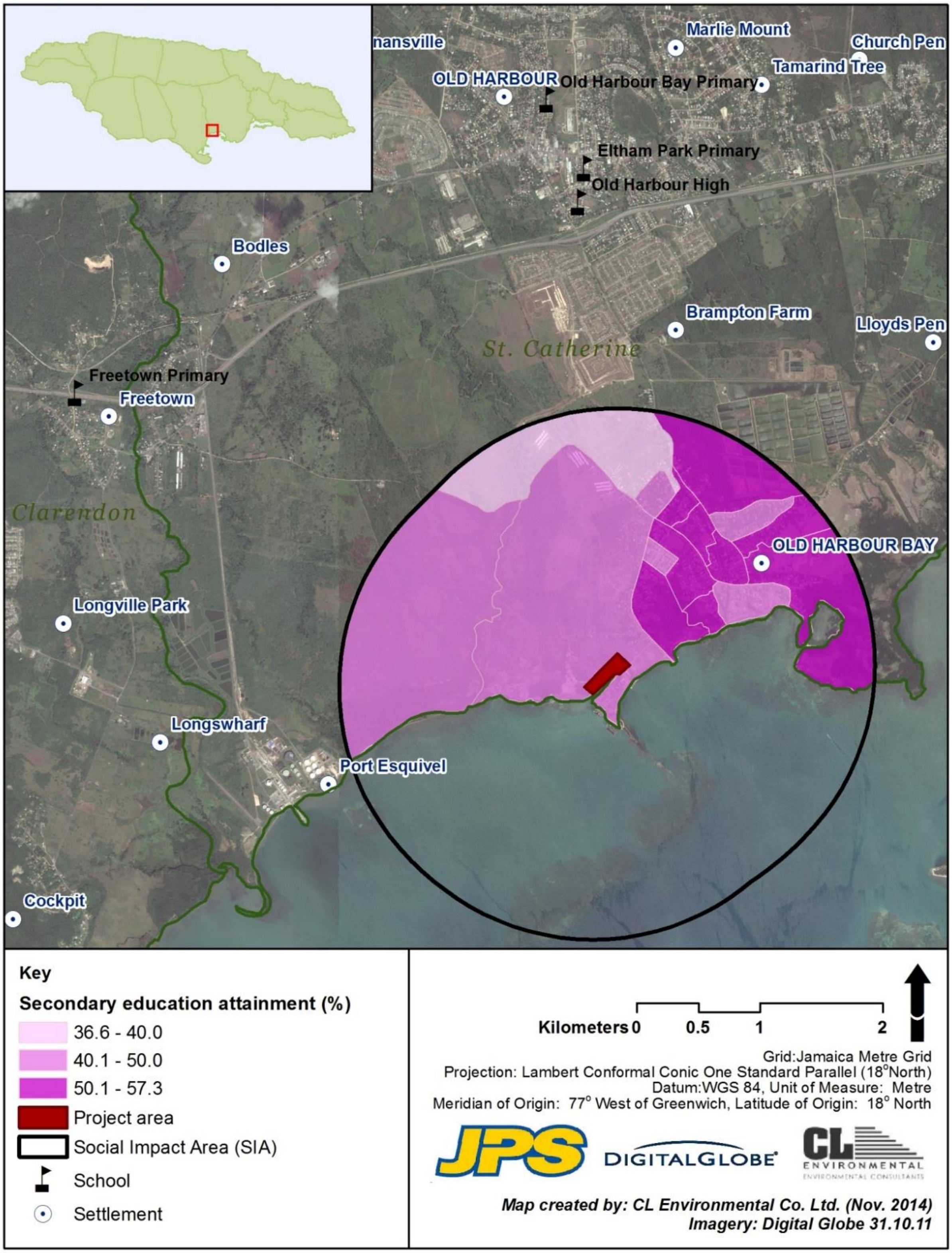
The relatively high proportion of the population in proximity to the project location attaining a secondary education, as well as tertiary education suggests that the labour pool is relatively educated, and as such, there should be no problem in obtaining non-technical workers from the community. This is shown in Figure 5-121, which also depicts the location of schools in proximity to the proposed location. No schools are found within the 2 km buffer SIA; the closest schools in proximity to the proposed location are situated north of the project area - approximately 3.7 km (Old Harbour High), 3.9 km (Eltham Park Primary) and 4.5 km north (Old Harbour High), as well as 4.9 km northwest (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 (51.2%). 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 5-70).

Table 5-70 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
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



Source: Education (STATIN Population Census 2011), Schools (MGI)

Figure 5-121 Percentage population attaining a secondary education within the SIA

5.6.1.5 Employment

Information presented below is primarily taken from the SDC 2007 Community Profile for the Old Harbour Bay Community.

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).

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 5-71). However a large amount of persons (35.2%) reported having no source of income (SDC 2007).

Table 5-71 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 5-72). 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 5-72 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

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 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 5-73).

Table 5-73 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 the 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 5-74).

Table 5-74 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).

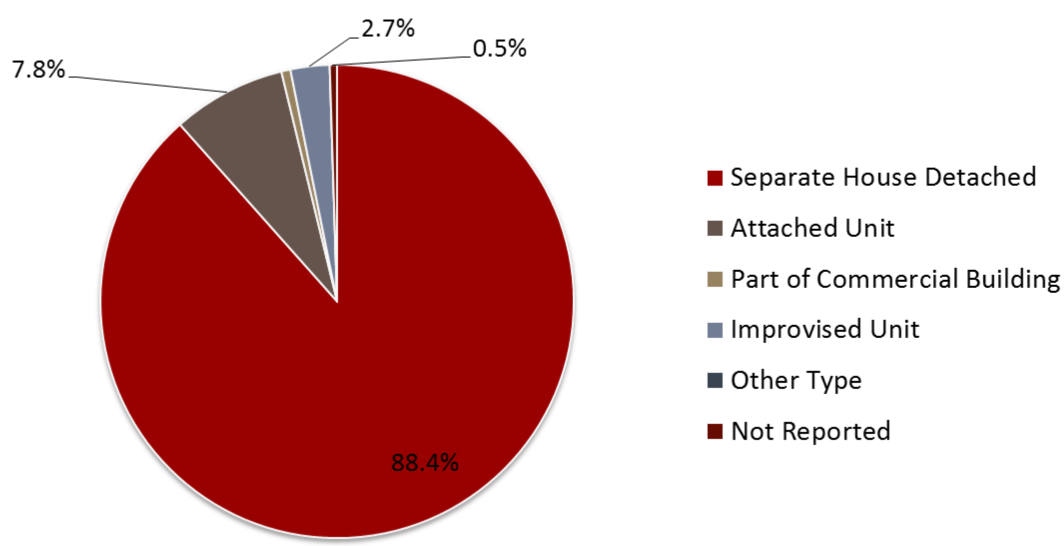
5.6.1.6 Housing

Housing Unit Type

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 1,447 housing units within the SIA in 2011. Approximately 88.4% of the housing units in the SIA were of the separate detached type, 7.8% were attached, 0.6% were a part of a commercial building, 2.7% were improvised units and 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

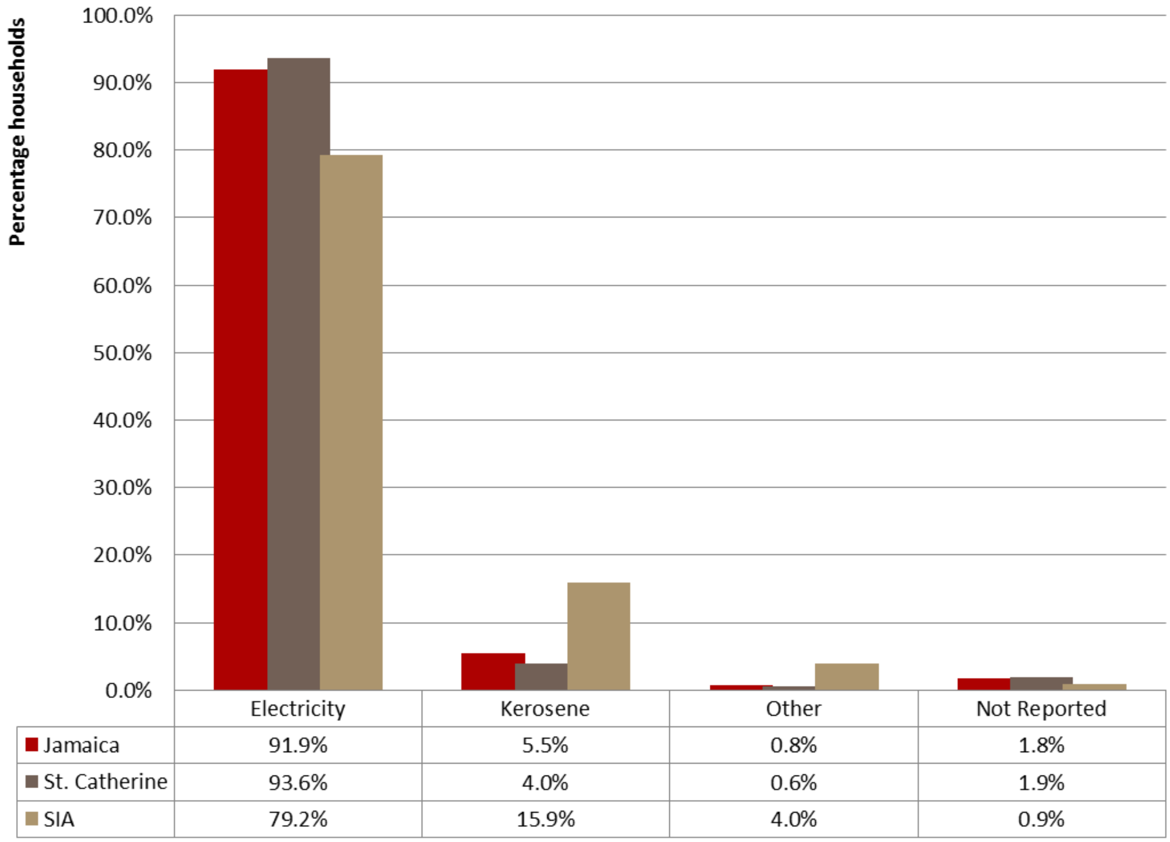
Terminal is part of the wider Old Harbour Bay community, which was originally known as Burkesfield. The name Terminal came into existence due to the construction of the Marine Terminal by the United States Marine Corps. The topography is generally flat and is characterized by ponds and swamps. This informal 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 statistics 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.

5.6.1.7 Infrastructure

Lighting

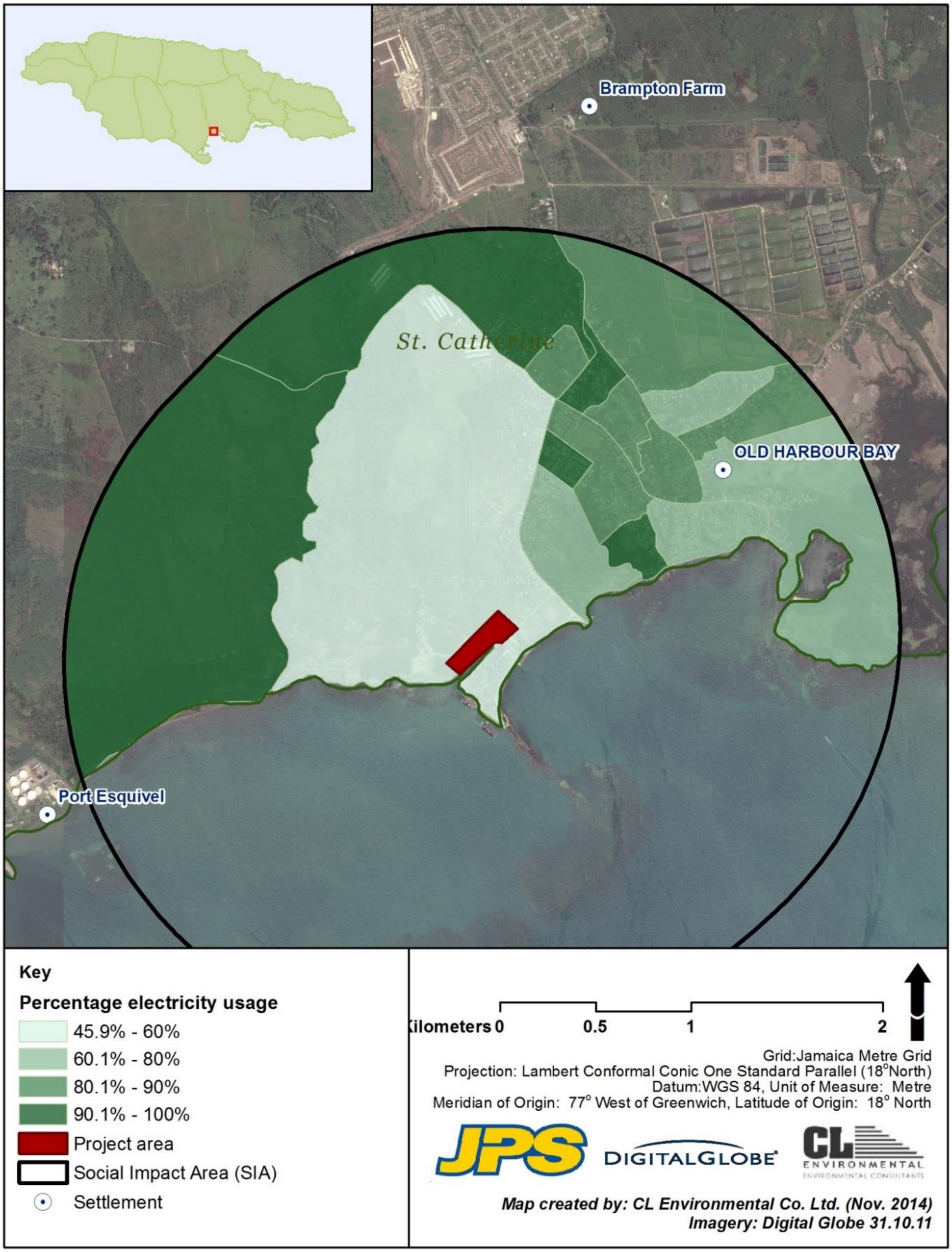
The percentage of households using electricity as their main means of lighting in the SIA (79.2%) was lowest amongst all extents (Figure 5-123). Data for the parish and national extents showed that less than 6% of households utilise kerosene; however within the SIA, 15.9% of households utilise this source of lighting. Other means of lighting was highest in the SIA (4.0%). Figure 5-123 details the percentage of households using a particular category of lighting and Figure 5-124 depicts the percentage households in the SIA using electricity.



	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	79.2%	15.9%	4.0%	0.9%

Source: STATIN Population Census 2011

Figure 5-123 Percentage households by source of lighting



Source: STATIN Population Census 2011

Figure 5-124 Percentage dwelling with electricity 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. Eighty nine percent (89.0%) of the households within the SIA received their domestic water supply from a public source, this is higher than the national and parish levels (75.5% and 82.2% respectively). About 5.7% of the households in the SIA received water from private sources, 3.9% from other sources, 0.3% from trucked water and 1.1% not reported.

Table 5-75 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%	42.6%
	Piped in Yard	16.5%	16.1%	41.3%
	Stand Pipe	7.1%	1.8%	0.6%
	Catchment	2.2%	0.9%	4.6%
Private Source	Into Dwelling	6.4%	4.4%	3.5%
	Catchment	9.8%	3.6%	2.2%
	Spring/ River	3.0%	3.1%	0.0%
	Trucked Water/Water Truck	2.1%	3.7%	0.3%
	Other	1.8%	1.6%	3.9%
	Not Reported	1.3%	1.2%	1.1%

Water demand for the SIA in 2014 is estimated to be 1,105,165.9 litres/day (~291,954.0 gals/day) and is expected to decrease to 843,069.4 litres/day (~222,715.4 gals/day) over the next twenty five years based on population growth rates calculated previously.

Wastewater Generation and Disposal

It is estimated that approximately 884,132.7 litres/day (~233,563.2 gals/day) of wastewater is generated within the study area (for 2014) and is expected to decrease to 674,455.6 litres/day (~178,172.3 gals/day) over the next twenty five years based on calculated growth rates. Census 2011 data for wastewater disposal methods was not available. 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 as multiple responses were allowed). 15.7% of the households shared toilet facilities. On average these facilities were shared with approximately four other families.

Solid Waste Generation and Disposal

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 islands waste. Solid waste collection for commercial and industrial facilities is done by arrangements by these entities with private contractors. It is estimated that at the time of this study (2014), approximately 7,188.39 kg (~7.2 tonnes) of solid waste was being generated in the SIA.

5.6.1.8 Communication and Social Services

Telecommunication

The parish of St. Catherine and the study area are served with landlines provided by LIME Jamaica Limited (formerly Cable and Wireless). Wireless communication is provided by Digicel Jamaica Limited and LIME; a network to support internet connectivity is also provided by LIME and Flow.

Post Offices

Post offices are not found within the demarcated SIA; that found 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.

5.6.1.9 Health and Emergency Services

Health Centres

One health centres exist 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 5-125, (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.[13] 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

[13] http://www.wrha.gov.jm/content/wrha_profile.html

(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.[14] 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 is 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. [15]

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 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. The Spanish Town Hospital currently has a total bed capacity of 600, staff complement of 320 and annual patient load of 160,000[16].

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 5-125). 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

[14] http://www.serha.gov.jm/HospitalClassification.aspx

[15] http://www.srha.gov.jm/(S(cjpesv45wp1hxh45tmztaw55)A(LWGTf5TRzQEkAAAAYmExZGEyNTMtOTQ1MS00Y2E5LWExN2MtOTg5MDc0MzMzNzZiZBmNPbLEvZ8olv4EJ8HqK7ztlLQ1))/Facilities/MPH.aspx

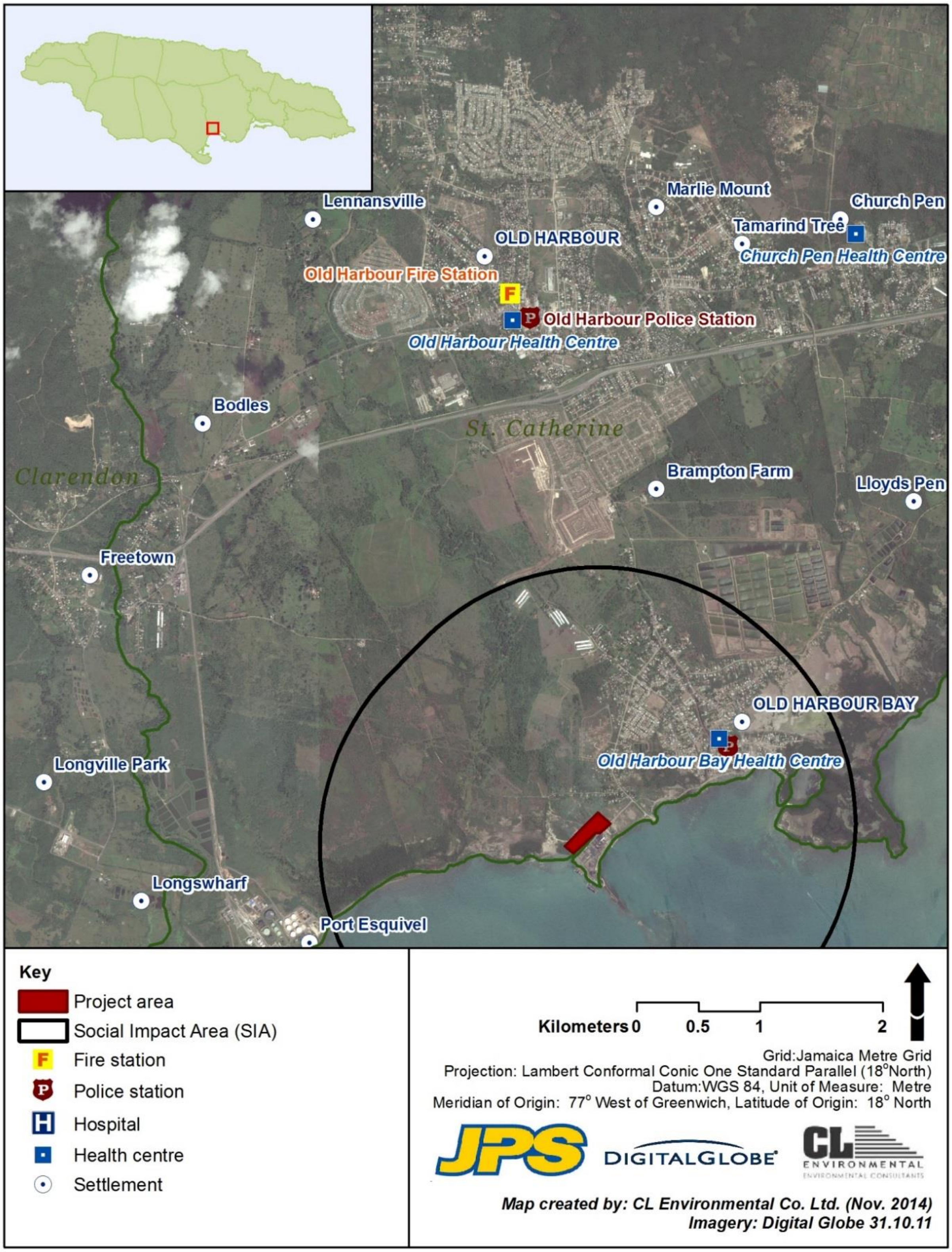
[16] http://www.serha.gov.jm/SpanishTown.aspx

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. [17] 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.

[17] http://www.jfb.gov.jm/structure.html



Data source: Mona GeoInformatics Institute

Figure 5-125 Health and emergency services located in and around the SIA

5.6.1.10 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 average daily aircraft movement is 67. 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 5-126. Roads within the social impact area are in various states of repairs. Access to the 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 taxis, 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).

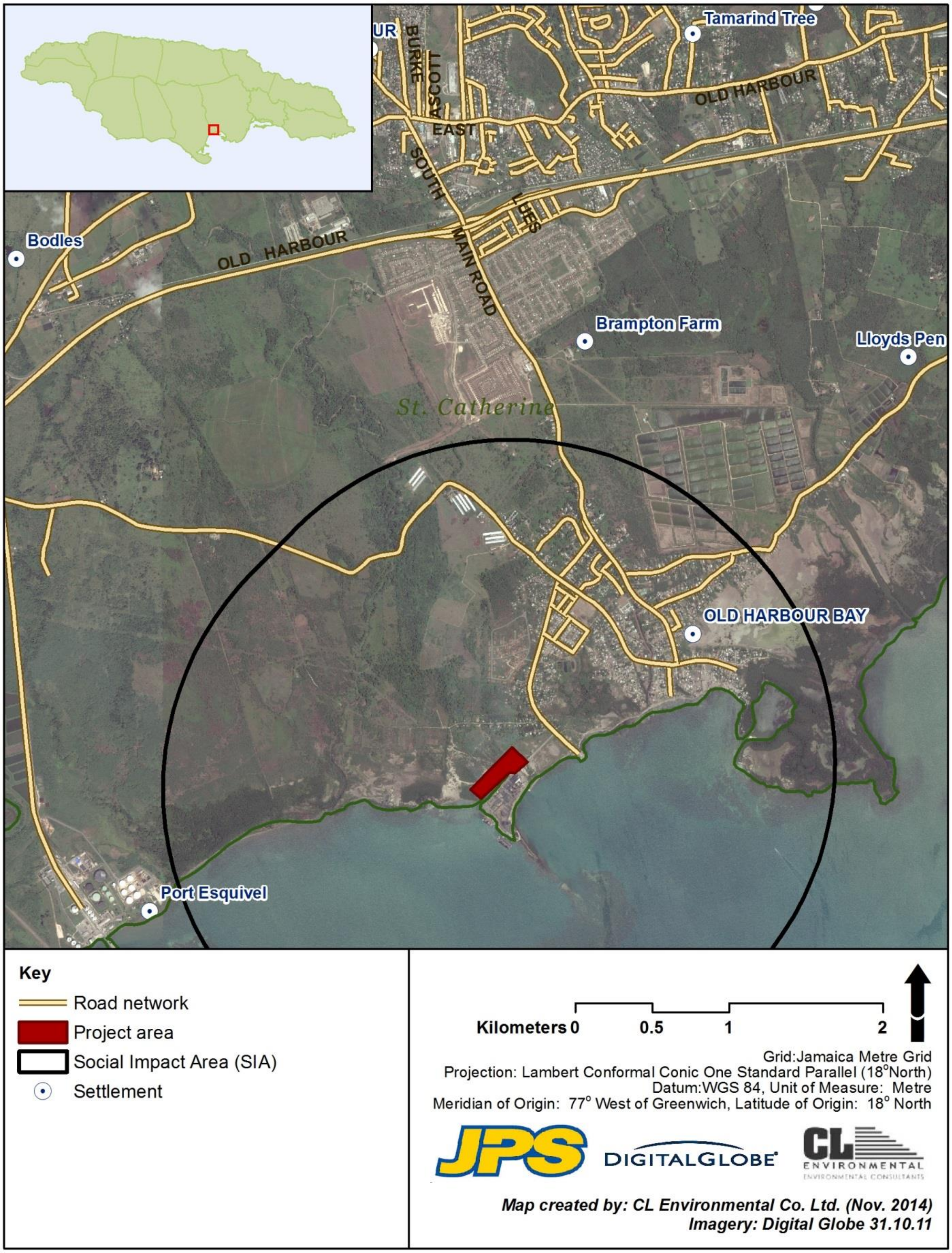


Figure 5-126 Road network and infrastructure located in the SIA

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 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. 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. *(Source: Jamaica National Heritage Trust Archaeological Impact Assessment for the JPS 360MW Plant).*

Existing Land Use

The proposed site is adjacent to JPS' existing 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 proposed site of the new power plant is on the storage area for the existing Old Harbour 220 MW plant and LNG storage and vaporization facility. An air quality monitoring station and well water transfer pipes exist on the property, and the Parish Council roadway runs through the site.

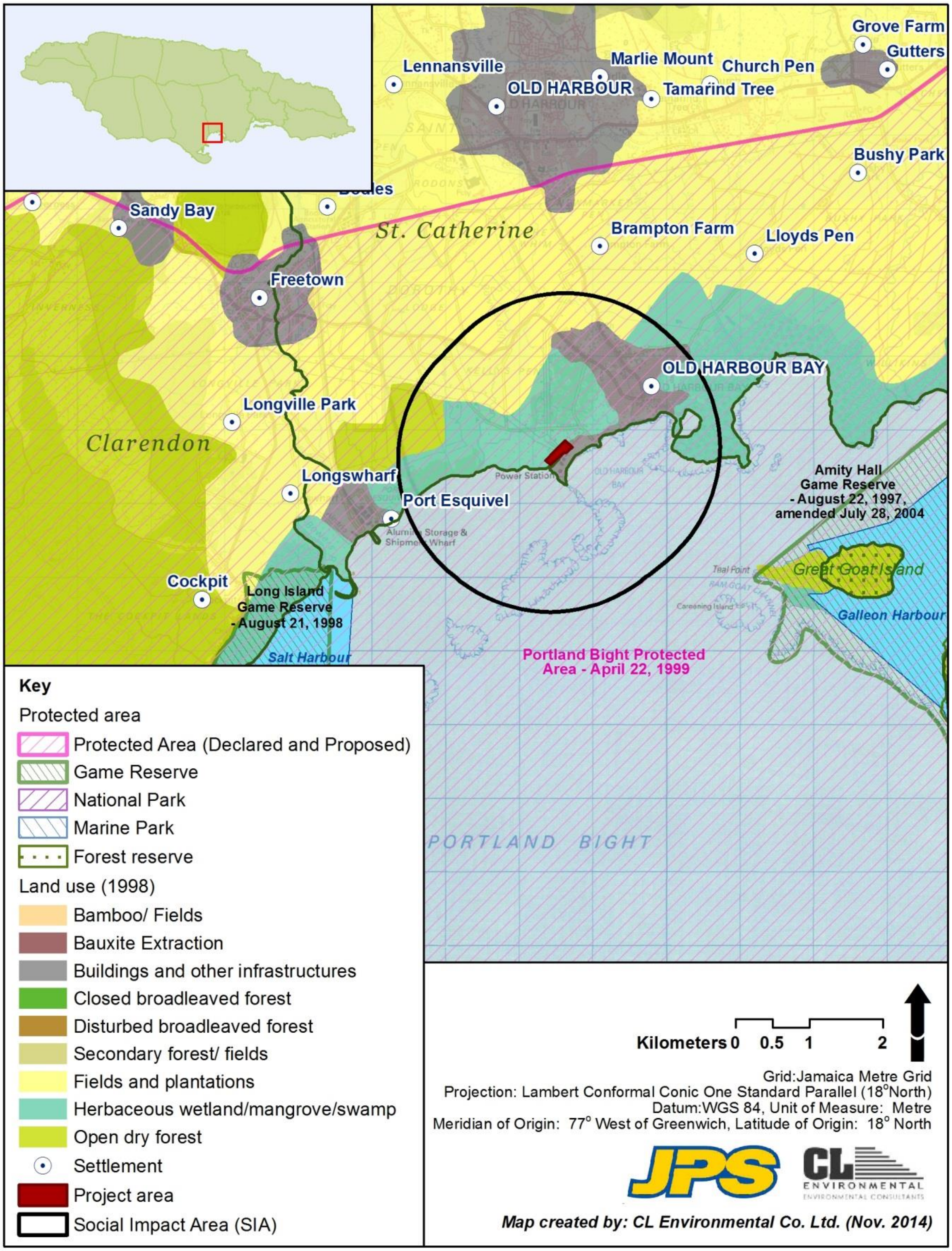
Existing land use in the study area is agricultural, commercial, industrial, residential, educational and recreational (Figure 5-127). Other uses include a cemetery (Old Harbour Bay Cemetery), telecommunication modules and cellular towers, an airstrip and informal solid waste disposal. Agricultural facilities 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. For transportation purposes, there is the Highway 2000 east-west link which runs through the SIA.

Future Land Use

Proposed land use on the site was previously described in section 4.0. 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



Data source: Land use (Forestry Department, 1998) and protected areas (NEPA and MGI)

Figure 5-127 Land use and protected areas within the SIA

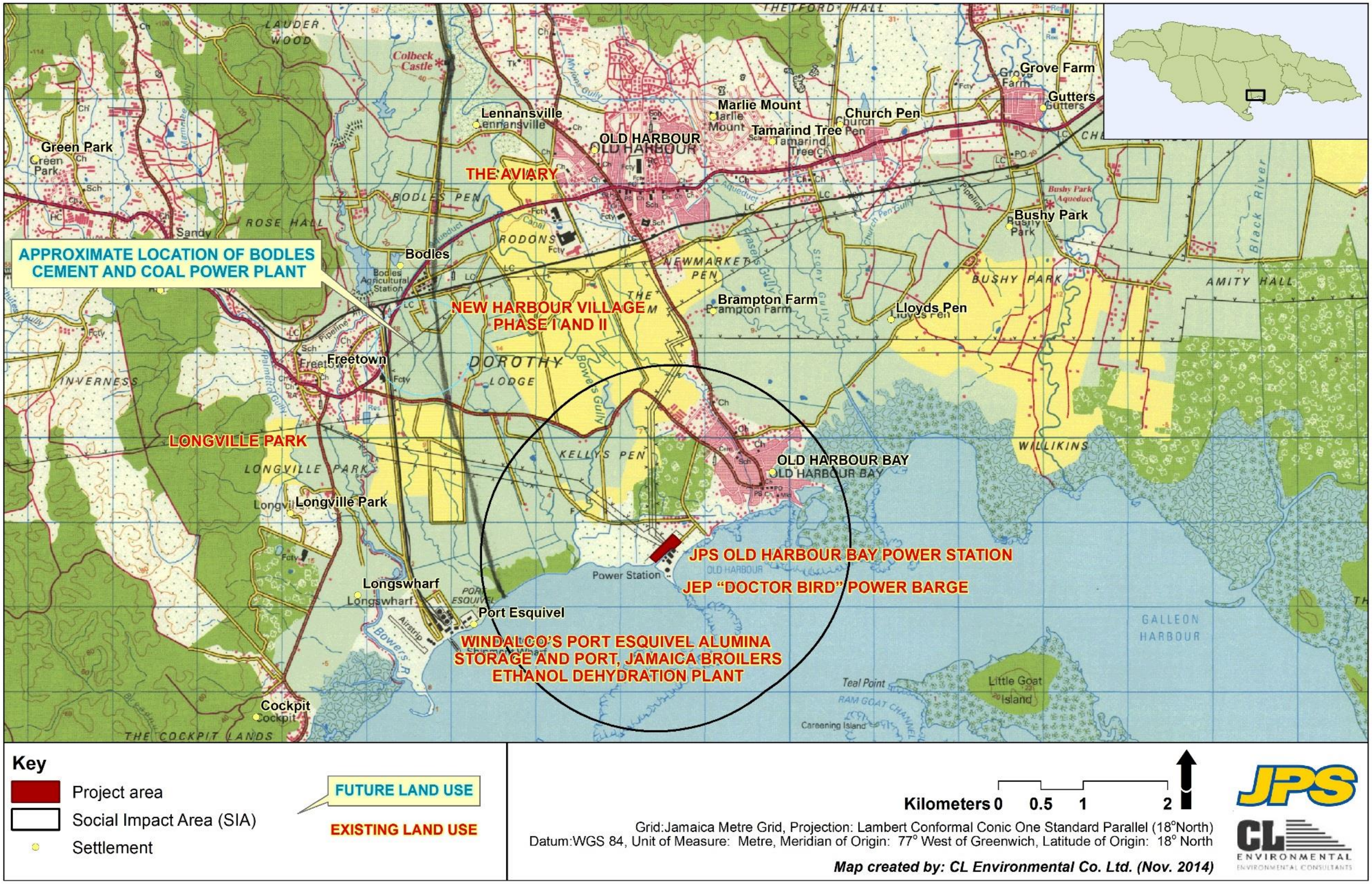


Figure 5-128 Existing and future land use

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 exist 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. The proposed Project area is bounded by Special Fishery Conservation Areas (SFCA). SFCAs are no-fishing zones reserved for the reproduction of fish populations; thus, any fishing activities would be limited to areas offshore and outside the Bay. 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.[18] 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 three 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.

[18] http://www.ccam.org.jm

5.6.2.3 Zoning

As seen in Figure 5-129, the SIA falls within the St Catherine Coastal Development Order boundary. 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 however falls within an area zoned for "heavy industry".

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. The proposed development along with proposed landscaping will improve the visual impact of the site.

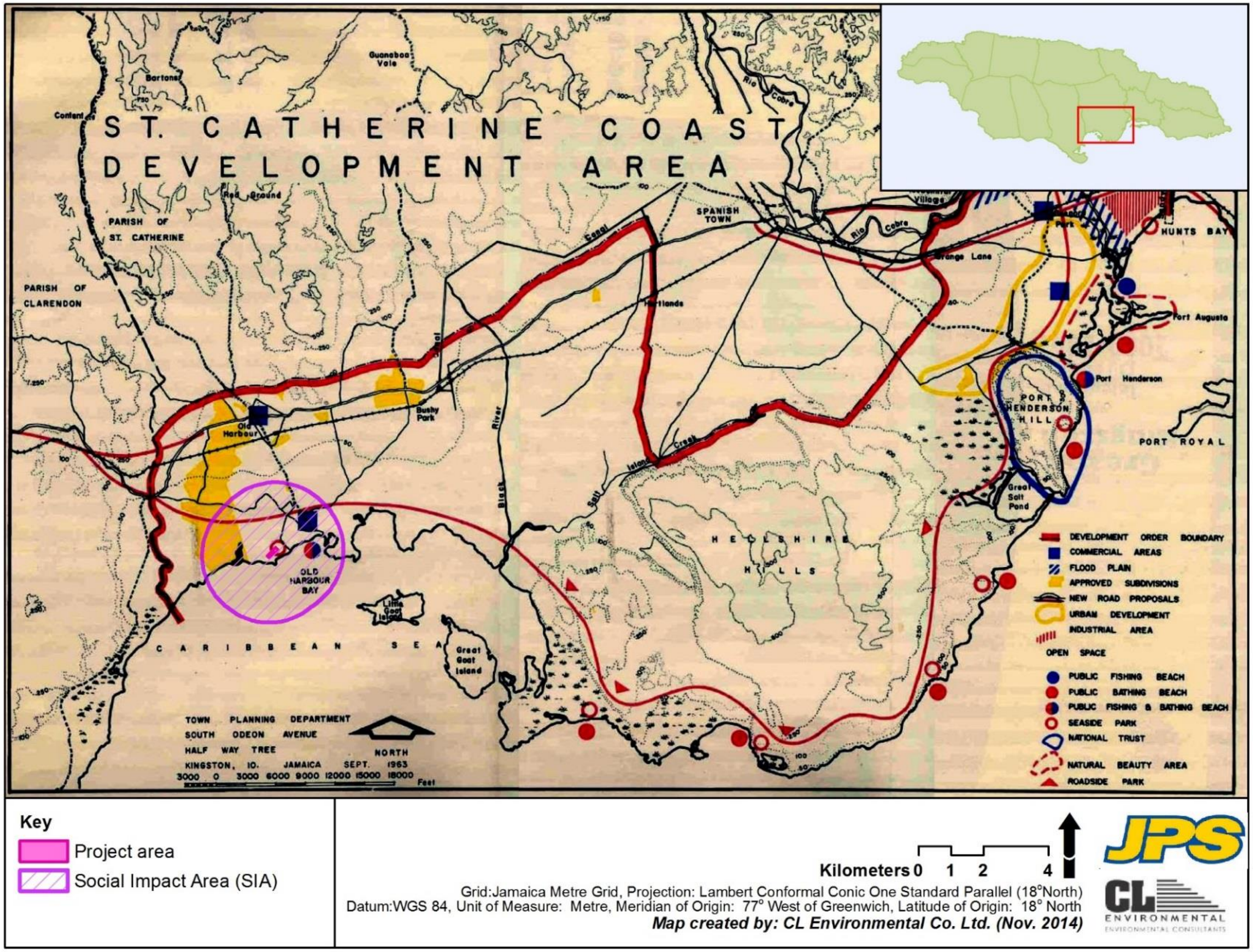


Figure 5-129 St Catherine Coastal Development Order map

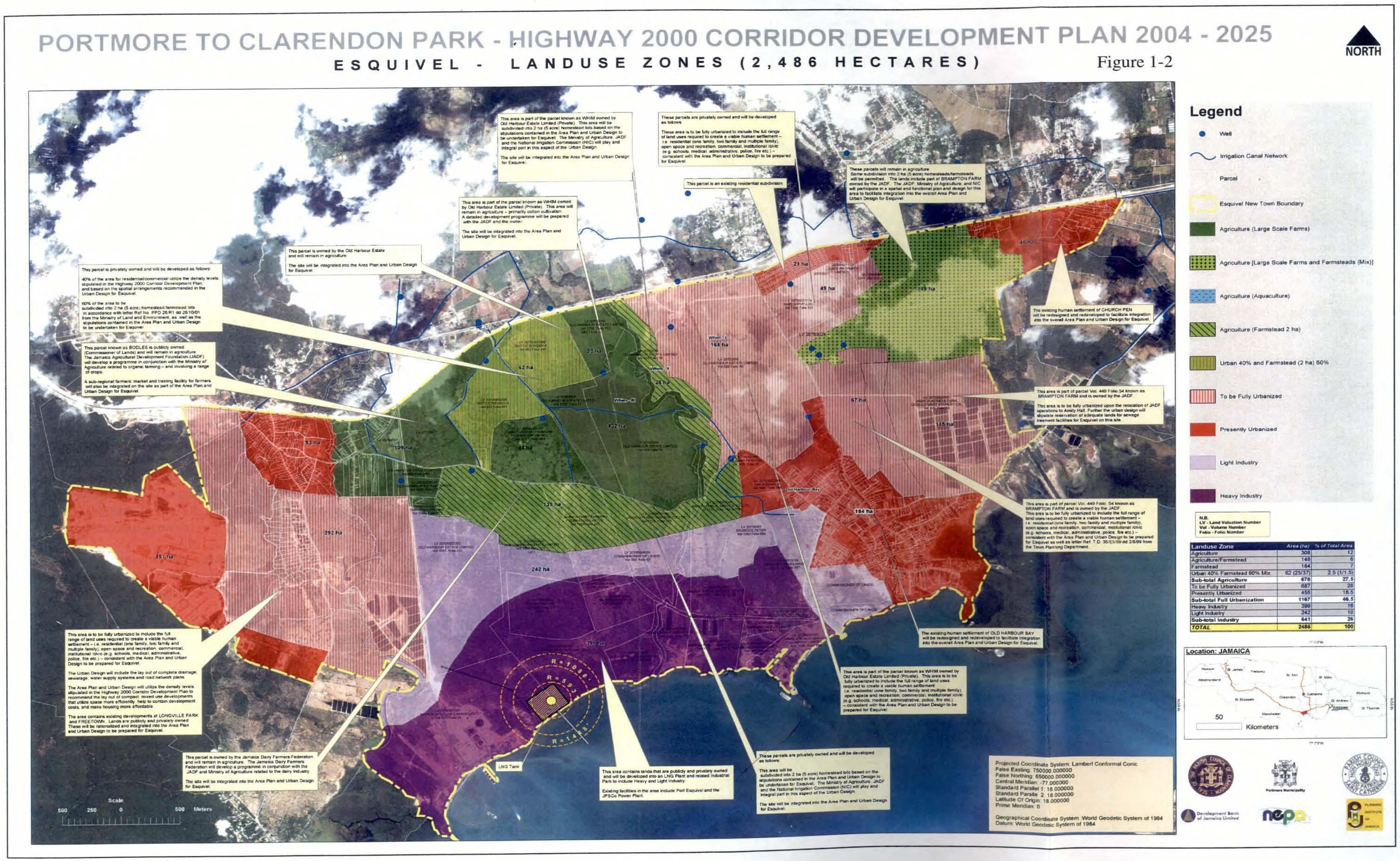


Figure 5-130 - Map showing Land Use of Highway 2000 Corridor Development (Portmore to Clarendon Park)

6.0 PUBLIC PARTICIPATION AND CONSULTATION

This section outlines the stakeholder consultation programme for this EIA process and summarizes the key stakeholder issues arising to date.

6.1 STAKEHOLDER CONSULTATION PROGRAMME

Stakeholder consultation during the course of this EIA includes the following mechanisms.

1. Perception Surveys:
   a. Conducted within 11 communities two (2) kilometres of the proposed development area (Blackwood Gardens, Settlement, Kelly Pen, Cross Roads, Dagger Bay, Station Lane, Bay Bottom, Burkesfield Meadows, Main Street Old Harbour Bay, Buddho and Terminal/ Terminal Road). The questionnaire (Appendix 8) administered addressed the following major issues:
      - General acceptability of the proposed project by community-based stakeholders.
      - Fears and expectations about the specific project, including any anticipated social conflict and crime.
      - Perceptions and attitudes of the community.
      - General health, safety and environmental concerns related to the project
   b. Aimed at fisher folk at the Old Harbour Bay Fishing Beach in an attempt to gather the opinions of fishers within a two (2) kilometre radius of the proposed development area.

2. Other Stakeholders:
   a. Water Resources Authority (WRA),
   b. St Catherine Parish Council
   c. National Works Agency (NWA)
   d. National Road Operating and Constructing Company (NROCC)
   e. Jamaica National Heritage Trust (JNHT)

3. Public Presentation:
   a. A public presentation outlining the project, environmental impacts, and proposed mitigations main findings of the EIA will be held at a community-based meeting. The meeting will be held in conformance with the NEPA Guidelines for Conducting Public Presentations. The key points are:

i. The Public Meeting shall not be held less than 21 days after the EIA is made available for public review; and
ii. The public has one (1) month after the public meeting to submit written responses/comments.

b. The continued availability of all EIA documentation for public review until a decision is made in respect of the development application. This includes:
   i. The approved Terms of Reference (appended in the EIA),
   ii. The EIA inclusive of all supporting technical appendices; and
   iii. The verbatim minutes of the Public Meeting (including the register of attendance).

6.2 PERCEPTION SURVEY

6.2.1 Community

6.2.1.1 Introduction

On October 16 and 17, 2014 Eighty One (81) community questionnaires were administered (Appendix 8) within a two kilometre radius of the area proposed for the construction of the Jamaica Public Service Company's 190 Megawatt Combined Cycle Power Plant. The majority of the respondents (61.7%) were male and 38.3% were female. Of the Eighty One (81) respondents age cohort distribution was as follows; 4.9% were under 20 years of age, 19.8% were 20-29 years , 18.5% were aged 30-39 years, 18.5 % were aged 40-49 years, 27.2% were aged 50-59 years and 11.1% were older than sixty-five years of age.

Eleven communities were visited. These communities were Blackwood Gardens, Settlement, Kelly Pen, Cross Roads, Dagger Bay, Station Lane, Bay Bottom, Burkesfield Meadows, Main Street Old Harbour Bay, Buddho and Terminal/ Terminal Road.

6.2.1.2 Results and Findings

Of the residents interviewed 17.3% indicated that they were fishers and 7.4% indicated they were fish vendors. Approximately seventeen percent (17.3%) of respondents also indicated that someone in their household was a fisher, 18.5% indicated that someone in their household was a fish vendor, with 70.4% of respondents interviewed were head of their household.

Approximately ninety-eight percent (97.5%) of all respondents were aware that the Jamaica Public Service Company (JPS) operates the power plant in Old Harbour Bay. Ninety-Three percent (92.6%) of respondents were aware that JPS uses fuel oil in the production of electricity. As it related to awareness of the Office of Utilities Regulation's (OUR) revocation of the license issued to Energy World International (EWI); fifty-three percent (53.1%) of respondents indicated awareness while 44.4% were not aware of the OUR's revoking the EWI's license. Regarding respondents' awareness of plans by the Jamaica Public Service Company to construct a 180-200 MW (Megawatt) combined cycle power plant on property at the existing Old Harbour facility; 37% of respondents were aware of this proposal while

63% were unaware. While it cannot be statistically represented, it was realised that some respondents indicating awareness of the project were still thinking of the previously proposed 360 MW project and not this current 180- 200 MW project.

In general, interviewees' response while indicating some awareness of the projects details were not conclusive to confirm that their details were factual. Regarding project concerns, 30.9% of interviewees indicated that they had concerns about the project, 60.5% indicated they had no concerns and 8.6% were uncertain.

As it related to how the project may affect individuals' lives, interviewees indicated no effect as well as positive and negative impacts; some respondents indicated that they were not sure. Where positive impact was mentioned (30.9%), interviewees were anticipating job creation, employment opportunities and the expectation that electricity bills would be reduced upon the introduction of a natural gas plant. Where negative impact was mentioned (16%), some of the interviewees concerns' were related to possible health implications such as respiratory distress, elevated noise levels, pollution, vibrations, and soot emissions which damage food crops. A Health Impact Study was conducted for the previously proposed SJPC 360 MW power plant which highlighted some of these perceived issues, which upon investigation indicated that most persons within the area were not being affected. In fact, the perceived health impacts that are being postulated were not proven as similar populations in a different are of Jamaica had similar incidents when compared with those living in proximity to the power plants.

Approximately ninety six percent (96.3%) of interviewees, when asked if they depended on the proposed site for business, farming or residence indicated they did not. The remaining 3.7% indicated that they depended on the land. However when interviewed, it was realised that respondents may have been referring to JPS owned lands outside the existing perimeter fence of the power plant.

Regarding interviewees knowing of anyone who depended on the lands of the proposed site for business farming or residence 4.9% indicated that they knew someone, while 95.1% indicated they did not know of anyone. Again it was realised that respondents may have been referring to lands owned by JPS which falls outside the existing perimeter fence of the plant.

Approximately thirty one percent (30.9%) of respondents indicated that they had problems with domestic water supply. Problems stated were low water pressure, no water and mention of suspended particulates, primarily in the water some communities receive from JPS. While conducting the interviews, it was realised that the Old Harbour Bay residents receive water from the National Water Commission and the Jamaica Public Service Company. It was confirmed that residents of Terminal and Burkesfield Meadows, receive water from the JPS water line.

Approximately forty three percent (43.2%) of respondents indicated that their community was affected by flooding. Affected communities were Main Street Old Harbour Bay, Station Lane, Bay Bottom, Blackwood Gardens, Buddho, Dagger Bay and Terminal. Of the respondents (56.8%) indicating that their communities were not affected by flooding, identified the communities of Cross Roads, Burkesfield Meadows, Kelly Pen and Settlement

Regarding whether the proposed site was affected by flooding, 6.2% of respondents indicated that the proposed site was affected while the others (93.8%) indicated that it was not. Approximately ninety nine percent (98.8%) of respondents indicated that the site was not affected by frequent fires.

When questioned, 43.2% of those interviewed indicated that they were affected by storm surge or sea level rise. When asked if the proposed site was affected by storm surge or sea level rise, 6.2% of respondents stated that the site was affected, while the balance (93.8%) indicated that the proposed site was not affected by storm surge or sea level rise.

As it related to respondents awareness of recreational facilities in or nearby their community, 76.5% stated that they were aware. On the issue of historic sites and/or cultural areas in or nearby their community 27.2% stated that they knew of such an area or site. Regarding the presence of nature reserves, 50.6% respondents indicated that they knew of a reserve in or nearby their community. Those aware of a recreational facility mentioned mainly the Blackwood Gardens Community Centre. Goat Island was named as both a historic site and nature reserve. The Anglican Church at the Old Harbour Bay Square was also named as a historic site.

In general, respondents were aware of the Jamaica Public Service Company and a proposal to construct a new power plant. However respondents not aware of the details associated with the plant and in some instances thought the project was that proposed in years past, and had concerns related to experiences they have had in the past.

Percentages presented for community respondents are for the total number of respondents.

Please see Appendix 9 for detailed results of the perception survey by community.

6.2.2 Fisherfolk

6.2.2.1 Introduction

On October 16 and 17, 2012, twenty (20) questionnaires specifically aimed at fisher folk were administered at the Old Harbour Bay Fishing Beach, in an attempt to gather the opinions of fishers within a two kilometre radius of the area proposed for the construction the Jamaica Public Service Company's 190 Megawatt Combined Cycle Power Plant. Forty percent (40%) of the respondents were female and 60% were male.

During this exercise respondents were somewhat reluctant to provide answers and either declined giving a response or gave vague non-specific answers. Although interviewed at the Old Harbour Bay Fishing beach, respondents were from the communities of Old Harbour Bay, Settlement, Buddho, Blackwood Gardens, Dagger Bay, Bay Bottom, Station Lane, Burkesfield Meadows and Main Street Old Harbour Bay specifically the Panton Town and Nurain/Noreign Avenue areas.

6.2.2.2 Results and Findings

Of the Twenty (20) respondents age cohort distribution was as follows; 0.0% were under 20 years of age, 5.0% were 20-29 years , 5.0% were age 30-39 years, 40.0 % were age 40-49 years, 35.0% were age 50-59 years and 10.0% were older than sixty-five years of age while 5% of respondents did not state their age.

More than half of respondents (55.0%) indicated they were fishers (fishermen/women) while 45.0% of indicated they were fish vendors. Forty percent (40.0%) of respondents indicated that in addition to them another person in the household was a fisher. Approximately a third (30.0%) of respondents indicated that in addition to them another person in the household was a fish vendor.

None of the interviewees indicated they were fishing or selling fish for up to five years; 10.0% six to eleven years; 10.0% twelve to seventeen years; 5.0% eighteen to twenty-four years; 5.0% twenty five to thirty years and 40.0% for over thirty years. Approximately a third (30%) on those interviewed did not state how long they had fished or sold fish. Respondents indicating they were fish vendors indicated that they sold fish at the Old Harbour Bay Fishing Beach.

Of the respondents indicating that they fished, 14.3% did not specify what was used. Approximately seven percent (7.1%) indicated that they used lines, 14.3% indicated they uses the spear; 28.6% used only the net, 14.3% used only the fish pot, 14.3% used both the net and fish pot. 7.1% indicated they used mesh wire for fishing.

Approximately twenty nine percent (28.6%) of fishers indicated that they fished only in the Old Harbour Bay area, 7.1% of fishers fished in both the Old Harbour Bay area and Rocky Point; 7.1% fished in both the Old Harbour Bay area and Pedro Cay, 14.3% fished only in Pedro Cay. Approximately twenty nine percent (28.6%) indicated that they fished far out to sea but did not specify an exact location, 7.1% indicated they fished in the Pedro and Morant Cays and 7.1% of respondents did not specify where they fished.

Approximately seventy nine percent (78.6%) of the respondents used canoes with engines for fishing, no fisher used canoes without an engine for fishing. Of the respondents having canoes with an engine, 78.6% used one engine and 7.1% used 2 engines. Approximately seventy nine percent (78.6%) used 40 horsepower (hp) engines, 7.1% used 50hp engines; 14.3% did not respond. Approximately fourteen percent (14.3%) of interviewees did not indicate what type of vessel they used for fishing, while 7.1% indicated that a large boat was used, but fishing was not by net.

On the issue of how many persons worked on fishing canoes/vessels, two persons worked on 21.4% of vessels, three persons worked on 57.1% of vessels and forty-four to forty-seven persons worked on 7.1% of vessels and 14.3% of interviewees did not offer a response.

Regarding the frequency of fishing and selling of fish, fishers indicated that they fished mainly twice or three times per week. Fishers indicating that they fished once per week also indicated that they remained at sea for an extended period before returning to Old Harbour Bay. The type of fish caught as reported by fishers included, doctor fish, parrot, snapper, sprat, angel, grunt, jack, turbit and welshman. Some fishers stated that they caught “reef fish” which they explained encompassed the varying species of fish they catch.

Concerning the pound catch of fish, fishers indicated that they caught total weights ranging from three pounds to four hundred pounds. In the case of large vessels, the pound catch estimated was four thousand. The main reported weight varied from approximately three pounds per day to eighty pounds per day. Respondents indicating heavier pound catch, were those who spent multiple days at sea and returning to shore with between three and five hundred pounds of fish. Interviewees were not able to state the weight per species of fish they caught.

On the matter of average weekly income from fish sales, no respondent reported an income of less than $1,000.00 per week or an income of between $1,000.00 and $2,000.00 per week; 5.0% indicated an income of $2,000.00 to $4,000.00 per week. 20.0% indicated income ranging between $4,000.00 and $6,000.00. 10.0% of interviewees stated that an income of between $6,000.00 and $8,000.00 was generated, while 40.0% indicated that average weekly income was more than $8000.00 per week. 15.0% of respondents did not offer a response.

Relating to the changes in the pound catch/sale/yield over time, 70% of respondents who offered a response indicated a decrease. 5.0% indicated an increase and 5.0% indicated no change. 20% of interviewees did not offer a response.

Regarding changes in the size and types of fish caught or sold 35.0% of interviewees indicated that they did not observe a change while 30.0% indicated they observed a decrease. 10.0% of respondents stated that there was an increase in the size and types of fish caught or sold, 20.0% of respondents offered no response while 5.0% stated that they have observed "unusual fish". Migration of new fish species, climate change, an increase in the number of vendors and a decrease in the amount of fish, damage to the reef caused by the power station and the presence of dolphins were stated as contributing factors to the fluctuations in fish earning and fish catch.

Eighty five percent of all respondents were aware that the Jamaica Public Service Company (JPS) operates the power plant in Old Harbour Bay, 5.0% were not aware, while 10.0% did not offer a response.

Ninety percent of respondents were aware that JPS uses fuel oil in the production of electricity while 10.0% did not offer a response. As it related to awareness of the Office of Utilities Regulation's (OUR) revocation of the license issued to Energy World International (EWI), only 35.0% of respondents were aware. More than halve (55.0%) of respondents were not aware of the OUR’s revocation; 10.0% did not offer a response. Regarding respondents’ awareness of plans by the Jamaica Public Service Company to construct a 180-200 MW (Megawatt) combined cycle power plant on property at the existing Old Harbour facility; it was observed that 45.0% of respondents were aware of this proposal and 45.0% of respondents were not aware and 10.0% of interviewees did not offer a response.

On the issue of project concerns, 20.0% of all respondents expressed concern, 60.0% did not express concern and 10.0% of respondents were uncertain if they had any concerns and 10.0% offered no response. Interviewees expressing concern were concerned about the availability of possible work opportunities for the youth, noise emissions from the JPS Plant and pollution of the reef.

Fifteen percent of respondents anticipated a positive impact on their lives as a spin off from the project; 25.0% of respondents were unsure of any impact on their lives, 30.0% of respondents indicated that they did not expect the project to affect their lives in any way while 15.0% of respondents expected a negative impact. Fifteen percent of respondents offered no response. Interviewees anticipating a negative impact on their lives anticipated a reduction in the yield of fish. Interviewees also expected their health to be negatively affected and noise levels to increase. It was also highlighted that there is an "acid smell" in the air which blows from the plant over sea and affects the fishers, it was expected that this would get worse with the introduction of a new power plant.

A positive impact on individuals' lives was anticipated as cheaper electricity cost was expected as a spin-off of the project. It was also expected that more jobs would be created and the project was seen as a good development which is needed for the community.

Seventy five percent of respondents indicated that they did not depend on the proposed site for any type business/fishing/residence, 15.0% indicated that they depended on the proposed site and specified fishing and small farming, whilst 10.0% did not offer a response.

Seventy percent of respondents indicated that they did not know of anyone who depended on the proposed site for any type business/fishing/residence, 20.0% indicated that they knew of someone who depended on the proposed site and specified fishing and small farming, whilst 10.0% did not offer a response.

In general, it was realised that males tended towards fishing at sea and women sold fish. Some of those who fished, travelled distances in excess of 75 miles and sometimes stayed at sea for days before returning to shore. Fishing vessels were mainly single engine canoes with an engine size of 40 Hp.

While it could not have been statistically represented, it was learnt that from the perspective of the fish vendor, the season when fish sales are high is at times when fish is scarce and in high demand. Fishermen indicated that their pound catch is highest at "fall o' year". While the exact period for fall o' year could not be stipulated, it was gleaned that this period occurs between August and December when there is good weather if no hurricanes affect the area.

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[19]:

- **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 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 area; 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 an EIA. 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, into 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.

[19] Taken from - Ogola, P. F. A. 2007. Environmental Impact Assessment General Procedures, presented at Short Course II on Surface Exploration for Geothermal Resources, organized by UNU-GTP and KenGen, at Lake Naivasha, Kenya, 2-17 November, 2007

- Uncertainty in prediction due to lack of accurate data or complex systems. 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 in the social surveys; and
- Discussions held among the EIA Study team.

Table 7-1 shows the impact assessment criteria for the various potential impacts.

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

Table 7-2 Impact matrix for site preparation and construction phase

	RECEPTOR	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
			DIRECT	INDIRECT	POS	NONE	NEG				
Physical	Water Column	Increased turbidity and TSS from runoff	X				X	1	1	1	-1
	Hydrology and Run Off	N/A									
	Airshed	Reduced Air quality and Noise Pollution	X				X	1	1	1	-1
Biological	Fish	N/A									
	Marine invertebrates	N/A									
	Terrestrial Invertebrates	Displacement and loss of habitat	X				X	1	1	1	-1
	Reptiles (Marine Turtles, Crocodiles)	Displacement, loss of habitat and disruption of nesting	X				X	1	1	1	-1
	Avifauna	Displacement and loss of habitat	X				X	1	1	1	-1
	Reefs	Increased turbidity and other pollutants from runoff		X			X	1	1	2	-1.3
	Seagrass	Increased turbidity and other pollutants from runoff		X			X	1	1	2	-1.3
	Salina Vegetation	Species loss	X				X	1	1	1	-1
	Mangroves	Species loss	X				X	1	1	1	-1
Heritage	Heritage	Destruction of artefacts	X				X	1	1	1	-1
Human/ Social	Traffic	Increased traffic congestion	X				X	1	1	1	-1
	Existing natural and social environment	Increased solid waste generation	X				X	1	1	1	-1
		Increased wastewater generation	X				X	1	1	1	-1
		Increased accidental potential of labourers	X				X	1	1	1	-1
		Increased noise and dust exposure of labourers	X				X	1	1	1	-1
		Increased water usage	X				X	1	1	1	-1
	Labour Force/Local Economy	Increased employment	X		X			1	1	2	1.33

Table 7-3 Impact matrix for operational phase

ACTIVITY/HAZARD	RECEPTOR	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
			DIRECT	INDIRECT	POS	NONE	NEG				
Fire	**Biological**										
	Fish/Marine Mammals	Species loss	X				X	1	3	1	1.67
	Meiofauna and Bottom dwellers	N/a	X				X	1	3	1	1.67
	Reptiles	Species loss	X				X	1	3	1	1.67
	Seagrass	Species loss	X				X	1	3	1	1.67
	Reef	Species loss	X				X	1	3	1	1.67
	Terrestrial Flora and Fauna	Species loss	X				X	1	3	1	1.67
	Physical										
	Water Quality	N/a									
	Air Shed	N/a									
	Socioeconomic										
	Local Population	Injury from thermal radiation and vapour dispersion (if ignited)	X				X	1	3	2	2
	Occupational										
	Plant Employees	Injury and/or death from thermal radiation and vapour dispersion (if ignited)	X				X	1	3	2	2
Water Usage and Wastewater Generation	Water Resources	Increased water usage	X				X	1	1	1	1
	Sewage and Wastewater	Increased wastewater generation	X				X	1	1	1	1
	Surface Water Quality	Increased temperature from cooling water discharge	X				X	1	1	1	1
		Increased chemical wastewater	X				X	1	1	1	1
	Ground Water Quality	N/A				X					
	Potable Water Quality	N/A				X					
Hazardous and Non-Hazardous Waste	**Biological**										
	Fish/Marine Mammals	Habitat destruction/loss	X				X	1	2	1	1.33
	Reptiles	Habitat destruction/loss	X				X	1	2	1	1.33
	Seagrass	Habitat destruction/loss	X				X	1	2	1	1.33
	Reef	Habitat destruction/loss	X				X	1	2	1	1.33
	Terrestrial Flora and Fauna	Habitat destruction/loss	X				X	1	2	1	1.33
	Physical										
	Surface Water Quality	Increased hydrocarbons in water in the event of oil/fuel spills	X				X	1	2	2	1.67
	Ground Water Quality	Increased hydrocarbons in water in the event of oil/fuel spills	X				X	1	2	2	1.67
	Potable Water Quality	Increased hydrocarbons in water in the event of oil/fuel spills	X				X	1	2	2	1.67
	Socioeconomic										
	Local Population	Aesthetically unappealing	X				X	1	1	1	1
	Occupational										
	Plant Employees	Aesthetically unappealing	X				X	1	1	1	1
Air Emissions	**Physical**										
	Air Shed	Reduced NOx, SO_2, CO and CO_2.	X		X			3	2	2	2.3
		Reduced greenhouse gas emissions	X		X			3	3	2	2.67
	Socioeconomic										

ACTIVITY/HAZARD	RECEPTOR	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
			DIRECT	INDIRECT	POS	NONE	NEG				
	Local Population	Acute respiratory ailments	X				X	2	1	1	1.33
	Occupational										
	Plant Employees	Acute/chronic respiratory ailments	X				X	2	1	1	1.33
Noise and Vibration	**Biological**										
	Fish/Marine Mammals	Disturbance of sensitive species	X				X	1	1	1	1
	Meiofauna and bottom dwellers	Disturbance of sensitive species	X				X	1	1	1	1
	Reptiles	Disturbance of sensitive species	X				X	1	1	1	1
	Seagrass	N/a									
	Reef	N/a									
	Terrestrial Flora and Fauna	Disturbance of sensitive bird species	X				X	1	1	1	1
	Physical										
	Water Quality	N/a									
	Air Shed	Noise pollution	X				X	1	1	1	1
	Socioeconomic										
	Local Population	Disturbance from noise and vibration	X				X	1	1	1	1
	Occupational										
	Plant Employees	Acute/chronic hearing problems (PPE recommended), vibration nuisance	X				X	3	1	1	1.67
Natural Disasters	**Biological**										
	Fish/Marine Mammals	Habitat destruction/loss, species loss	X				X	2	3	1	2
	Meiofauna and bottom dwellers	Habitat destruction/loss, species loss	X				X	2	3	1	2
	Reptiles	Habitat destruction/loss, species loss	X				X	2	3	1	2
	Seagrass	Habitat destruction/loss, species loss	X				X	2	3	1	2
	Reef	Habitat destruction/loss, species loss	X				X	2	3	1	2
	Terrestrial Flora and Fauna	Habitat destruction/loss, species loss	X				X	2	3	1	2
	Physical										
	Surface Water Quality	Increased hydrocarbons from fuel oil spill and other pollutants	X				X	2	3	1	2
	Ground Water Quality	Increased hydrocarbons from fuel oil spill and other pollutants	X				X	2	3	1	2
	Potable Water Quality	N/A									
	Socioeconomic										
	Local Population	Serious injury or death	X				X	2	3	1	2
	Occupational										
	Ship Employees	Serious injury or death	X				X	2	3	1	2
Employment	**Socioeconomic**										
	Labour Force/Local Population	Increased jobs/employment	X		X			3	3	3	3
		Economic growth nationally	X		X			3	3	3	3
		Increased worker productivity	X		X			3	3	3	3
Electricity Costs	**Socioeconomic**										
	Local Population	Stable electricity supply and lower electricity costs	X		X			3	3	3	3
Traffic	**Socioeconomic**										
	Local/Community roads	No net increase in traffic	X			X					

7.1 SITE PREPARATION AND CONSTRUCTION

7.1.1 Physical

7.1.1.1 Land Impacts

Noise Pollution

HEAVY EQUIPMENT

Site clearance for the proposed development necessitates the use of heavy equipment to carry out the job. Equipment to be used include bulldozers, backhoes etc. They possess the potential to have 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. The 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 7-4.

Table 7-4 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 Federal Highway Administration (FHWA) Roadway Construction Noise Model (RCNM) version 1.1 was used to predict noise levels from construction activities on the proposed power plant site at the nearest residential receptor. This receptor is located at Terminal Lane and is situated approximately 231.2m from the site. A total of 12 pieces of equipment were used to analyse a worst case scenario (all equipment being used at the same time) and at the closest point to the receptor (231.2m) and no shielding of the equipment.

The results of the model indicate that the overall Leq will be 71.6 dBA which would exceed the NEPA standards for daytime (55 dBA) and night time (50 dBA). The model also predicted a Lmax of 77.6 dBA which the highest noise level expected during a measurement period or a noise event (Table 7-6).

ACCESS ROAD

During the site clearance and construction phases of the Proposed Project, an access road will be built to the site which will facilitate the movement of heavy vehicles and equipment. It is anticipated that during the site filling phase is when the highest daily volume of vehicular traffic will occur. It is anticipated that during this phase approximately 70 truck trips per day to carry fill material to the site. SoundPlan 7.3 model was used to determine the potential noise impact to the community for this activity (worst case scenario). A speed limit of 30 km/h for the trucks was used in the model.

The predicted noise along Old Harbour Main Road, Terminal Road and the Access Road are reported in Table 7-5. Sixteen locations (receivers) were assessed (two sensitive receptors – church & school) of which eight were found to be in exceedance of the NEPA daytime noise standard. The day time noise standard was used as the trucking will be done during day time hours.

Table 7-5 Predicted noise levels along Old Harbour Bay Main Road, Terminal Road and Access Road from approximately 70 truck trips per day

RECEIVER	PREDICTED NOISE (dBA)	NEPA DAY TIME NOISE STD (dBA)
House 1 OHB Main Road	53.2	55
House 2 OHB Main Road	**62.9**	55
House 2 Terminal Road	50.7	55
House 3 Terminal Road	**63.0**	55
House 5 Blackwood Gardens	**58.7**	55
House 6 Terminal Road	**59.4**	55
House 7 Terminal Road	**61.7**	55
House 8 Terminal Road	**59.4**	55
House 9 Burkesfield Meadow	46.1	55
House 10 Burkesfield Meadow	43.7	55
House 11 Terminal Road	**60.8**	55
House 12 Terminal Road	**57.8**	55
New Harbour Phase 1	51.5	55
New Harbour Village Phase 2	51.8	55
Blackwood Gardens Basic School	40.6	45
Mount Refuge Baptized Church	51.8	55

Table 7-6 RCNM worst case scenario noise level prediction of the construction noise on the proposed JPS 190MW power plant site

			Roadway Construction Noise Model (RCNM),Version 1.1												
Report date:	12/17/2014														
Case Description:	JPS1														
				---- Receptor #1 ----											
		Baselines (dBA)													
Description	Land Use	Daytime	Evening	Night											
Nearest Structure Terminal Lane	Residential	61.4	61.4	59.9											
				Equipment											
				Spec	Actual	Receptor	Estimated								
		Impact		Lmax	Lmax	Distance	Shielding								
Description		Device	Usage(%)	(dBA)	(dBA)	(meters)	(dBA)								
Dump Truck		No	40		76.5	231.2	0								
Concrete Mixer Truck		No	40		78.8	231.2	0								
Jackhammer		Yes	20		88.9	231.2	0								
Dozer		No	40		81.7	231.2	0								
Paver		No	50		77.2	231.2	0								
Generator		No	50		80.6	231.2	0								
Compressor (air)		No	40		77.7	231.2	0								
Impact Pile Driver		Yes	20		101.3	231.2	0								
Pumps		No	50		80.9	231.2	0								
Pneumatic Tools		No	50		85.2	231.2	0								
Backhoe		No	40		77.6	231.2	0								
Excavator		No	40		80.7	231.2	0								
				Results											
		Calculated (dBA)			**Noise Limits (dBA)**						**Noise Limit Exceedance (dBA)**				
				Day		**Evening**		**Night**		**Day**		**Evening**		**Night**	
Equipment		***Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Dump Truck		52.8	48.9	55	N/A	55	N/A	50	N/A	None	N/A	None	N/A	2.8	N/A
Concrete Mixer Truck		55.2	51.2	55	N/A	55	N/A	50	N/A	0.2	N/A	0.2	N/A	5.2	N/A
Jackhammer		65.3	58.3	55	N/A	55	N/A	50	N/A	10.3	N/A	10.3	N/A	15.3	N/A
Dozer		58	54.1	55	N/A	55	N/A	50	N/A	3	N/A	3	N/A	8	N/A
Paver		53.6	50.6	55	N/A	55	N/A	50	N/A	None	N/A	None	N/A	3.6	N/A
Generator		57	54	55	N/A	55	N/A	50	N/A	2	N/A	2	N/A	7	N/A
Compressor (air)		54	50.1	55	N/A	55	N/A	50	N/A	None	N/A	None	N/A	4	N/A
Impact Pile Driver		77.6	70.7	55	N/A	55	N/A	50	N/A	22.6	N/A	22.6	N/A	27.6	N/A
Pumps		57.3	54.3	55	N/A	55	N/A	50	N/A	2.3	N/A	2.3	N/A	7.3	N/A
Pneumatic Tools		61.6	58.5	55	N/A	55	N/A	50	N/A	6.6	N/A	6.6	N/A	11.6	N/A
Backhoe		53.9	50	55	N/A	55	N/A	50	N/A	None	N/A	None	N/A	3.9	N/A
Excavator		57.1	53.1	55	N/A	55	N/A	50	N/A	2.1	N/A	2.1	N/A	7.1	N/A
	Total	77.6	71.6	55	N/A	55	N/A	50	N/A	22.6	N/A	22.6	N/A	27.6	N/A
		*Calculated Lmax is the Loudest value.													

The NEPA day time noise limit (55 dBA) along the access road was depicted in Figure 7-1.

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

vi. Use equipment that has low noise emissions as stated by the manufacturers.
vii. Use equipment that is properly fitted with noise reduction devices such as mufflers.
viii. 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.
ix. 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.
x. 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 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.

The avifauna will be marginally affected by changes in the noise environment; the community dynamics and population have already been shaped by elevated noise levels in the project area and zone of influence. Therefore, no mitigation is required.

Vibration

Construction activities often generate vibration complaints. This may be as a result of interfering with persons 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.

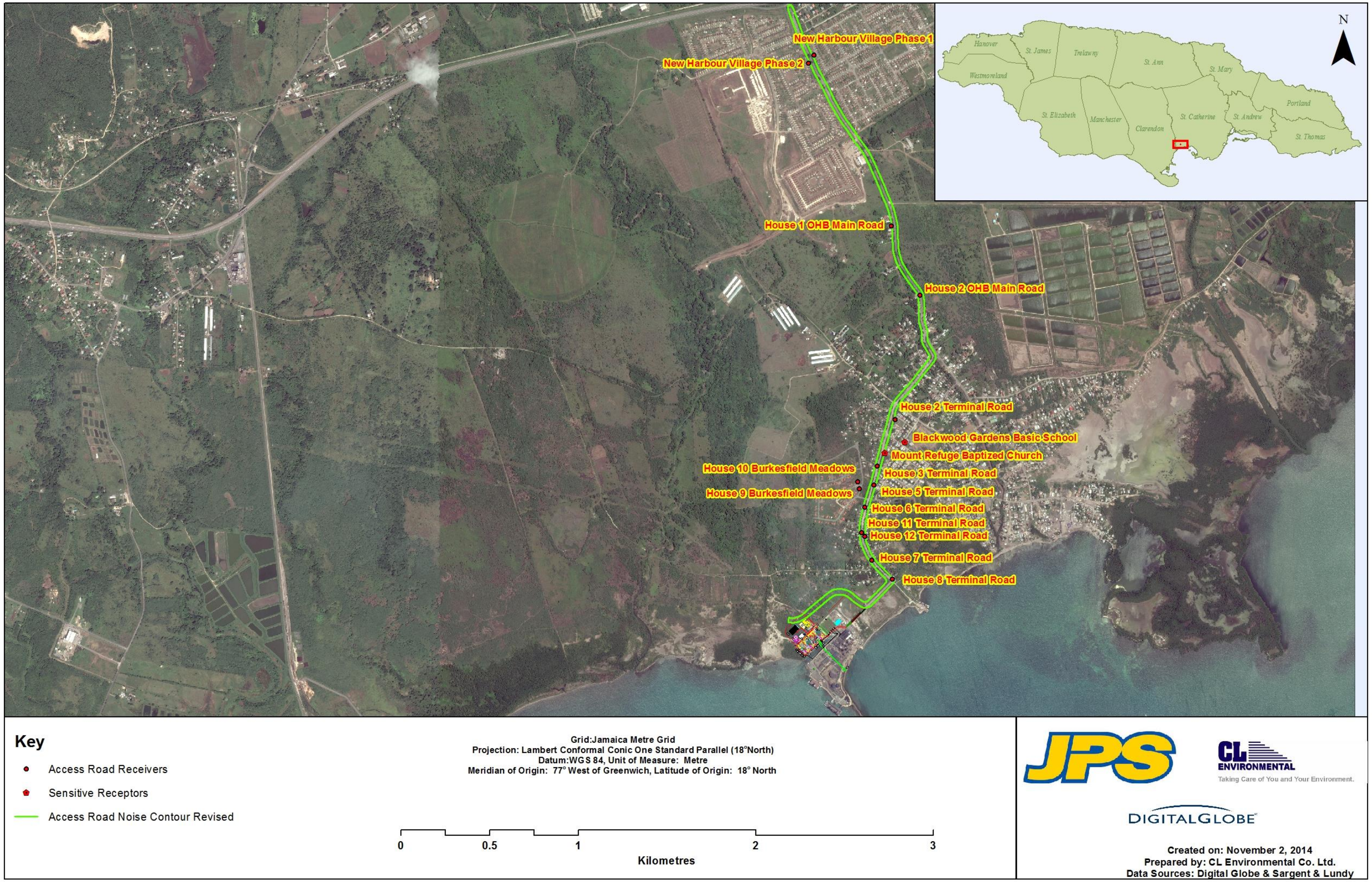


Figure 7-1 Map showing the 55 dBA noise contour along the access road noise and modelled noise receivers

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 PPV less than approximately 3.048 mms-1 (0.12 inches per second), the potential for architectural damage due to vibration is unlikely. 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 $L_v^{\dagger}$ 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 residential receptor to the JPS 190MW is approximately 760.56 feet (231.82 m).

The vibration impact was predicted on the closest receptors with the use of ten (10) pieces of construction equipment (Table 7-11).

Table 7-11 Predicted vibration levels at the closest residential receptor to the JPS 190MW Power Plant in PPV in/sec and PPV mm/sec in brackets

EQUIPMENT	RECEPTOR VIBRATION
Pile Driver (Impact)	0.009 (0.23)
Vibratory Roller	0.0013 (0.03)
Large Bulldozer	0.00053 (0.013)
Loaded Truck	0.00045 (0.0114)
Jack Hammer	0.00021 (0.0053)
Back Hoe	0.0012 (0.030)
Dump Truck	0.0011 (0.0279)
Frontend Loader	0.0012 (0.030)
Grader	0.0012 (0.030)
Paver	0.0011 (0.0279)

Comparing these level with the British Standard from a human standpoint, most equipment used would result in no vibration being perceived except with pile driving which might just be perceptible.

From a building standpoint, the vibration levels predicted will have no effect residential buildings within proximity of the JPS 190MW Power Plant project.

RECOMMENDED MITIGATION

d. Sequence of operations:
    iii. Phase demolition, earth-moving and ground-impacting operations so as not to occur in the same time period. Unlike noise, the total vibration level produced could be significantly less when each vibration source operates separately.
    iv. Avoid night time activities. People are more aware of vibration in their homes during the night time hours.
e. Alternative construction methods:

iv. Avoid impact pile-driving where possible in vibration-sensitive areas. Drilled piles or the use of a sonic or vibratory pile driver causes lower vibration levels where the geological conditions permit their use.
v. Select demolition methods not involving impact, where possible.
vi. Avoid vibratory rollers near sensitive areas.

f. Have regular meetings or devise a communication strategy to inform the residents of construction activities.

Solid Waste Generation

During the construction phase of the proposed project, 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.)
iv. Earth materials from grading, roadway construction 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 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.

Storage of Raw Material and Equipment

Any raw materials used in construction 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 reduced speed near the construction site.
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.

7.1.1.2 Water Impacts

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

ii. 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.
iii. Showers should be provided for the workers.

7.1.1.3 Air Impacts

Site preparation 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.

RECOMMENDED MITIGATION

v. Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.

vi. Minimize cleared areas to those that are needed to be used.
vii. Cover or wet construction materials such as marl to prevent a dust nuisance.
viii. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.

7.1.2 Biological

7.1.2.1 Habitat Fragmentation

Habitat fragmentation is the process whereby a large, continuous area of habitat is both reduced in area and divided into two or more fragments by roads, fields, towns and many other human constructs (Primack, 2006). These fragments are often isolated from each other by a highly modified or degraded landscape and their edges experience an altered set of microclimate conditions called “edge effect”. Edge effect refers to the variation in the observed microenvironment at the fragment edge. Differences in microclimate factors such as light, temperature, wind and humidity may each significantly impact species composition and vigour within the fragment.

Fragmentation normally occurs during circumstances of severe habitat loss where, for example, large areas of natural vegetation may be cleared for agricultural, residential or industrial developments such as this. The development may reduce the passive movement of spores and seeds across a landscape as well as restrict the movement of animal species that often act as pollen and seed vectors. Fragmentation may also lead to increased vulnerability of the fragment to invasion by exotic and native pest species as well as diseases.

The effects of habitat fragmentation, however, are expected to be minimal negative since the study site and surrounding areas were already degraded and the species composition limited by current land use practices (e.g. logging, burning and livestock grazing). Although planned access roads and fencing may limit the movement of animal vectors, the grasses and some of the common herbs present are wind propagated.

The marine environment also appears to be heavily degraded and may also experience some habitat fragmentation as a result of the lying of various pipelines. However the impacts of these activities is expected to be minimal.

RECOMMENDED MITIGATION

iii. Limit rights-of-passage to areas already showing noticeable signs of habitat degradation. For example areas with open fields and pastureland.
iv. Develop thorough procedures for the proper disposal of solid waste as well as hazardous and flammable materials. Restrict their disposal into surrounding locales.

7.1.2.2 Flora

The vegetation present within the study area exhibited high levels of anthropogenic influence, which was evidenced by the secondary community observed. The study has shown that the planned development of a power plant would not result in the inadvertent removal of endemic, endangered, threatened or rare species; however, the National Flower *Guiacum officinale* occurs on the site. Effects on the flora, especially during the construction phase, may vary.

RECOMMENDED MITIGATION

i. None required

Accidental or Intentional Removal of Important Plant Species or Communities

Over 52 plant species were encountered. This moderate species richness is possibly due to the mixture of vegetation types present and the then prevailing drought. Although none were endemic, endangered, threatened or rare, the diversity of the area is important. Therefore, minimising the negative impact on the flora during the construction phase of the development is also important.

- Mangroves are very important land stabilisers in a wetland community and help to provide conditions necessary for other plant species to become established. They are also important because they may be used as a habitat for faunal species.
- The Guango/Bastard Cedar stand in the greater SJPC lands provided a microhabitat for several plant and fungal species not common to the surrounding vegetation. Based on their basal diameter it may be estimated that several of the trees were quite old (a tree-core analysis would be necessary to determine their actual age). The herb, *Rivina humilis* (Bloodberry) frequently occurred here and is known to have tremendous potential for medicinal remedies.

RECOMMENDED MITIGATION

vii. The removal of vegetation should be strictly limited to the development site.
viii. Altering the orientation or placement of the development's footprint should be considered in more densely vegetated or otherwise sensitive communities mentioned above are not or minimally disturbed.
ix. A proper plan should be developed concerning transportation routes and storage for equipment and material.
x. The proposed post construction or operation road network should be kept simple as well as be used throughout the preparation and construction phases of the project.
xi. Proper planning regarding access points to the construction site should be established.
xii. A buffer area should be established and maintained between the project area and the surrounding vegetation.

Increased Soil/Substrate Erosion and Flooding

The potential for land erosion and flooding is greatly increased as a result of vegetation removal. A plant's roots act as a mesh within the substrate increasing its cohesiveness and improving drainage.

Areas where bare ground is exposed tend to erode faster than areas inhabited by plants as they help percolate rainwater into the substrate below. There was evidence on site that some soil compaction and erosion was occurring due primarily to the degraded nature of the community. As such any further vegetation removal would intensify these impacts.

RECOMMENDED MITIGATION

iv. If possible, trees with trunks of DBH 20 cm and greater should be left intact.
v. Remove trees only as would be necessary. A tree removal protocol should be developed for site preparation prior to project initiation.
vi. Prepare vegetation restoration plan to be implemented once construction is complete.

Storage and Transportation of Raw Materials

Plant growth and health can be significantly affected by dust, grime and toxic emissions. Leaching from storage areas can disturb the pH balance in the soil and result in plant loss.

RECOMMENDED MITIGATION

iii. A central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of paints and chemicals into the sediment.
iv. In terms of transporting equipment, the paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.

Impact on Biodiversity/Ecosystem Functions

In terms of the impact on vegetation, the least affected area would be the primary development lands. Here the community was the least rich in species; canopy cover was sparse; and the vegetation indicative of an open, secondary successional, xerophytic community. Occasional flora constituents, such as columnar cacti, (*Harrisia gracilis* and *Stenocereus hystrix*) and ornamental shrubs (namely *Nerium oleanrder*) may be pollenated by bats.

The SJPC lands which surround the project area (and should have the least direct impact) had the highest diversity but was dominated by *Samanea saman* (Guango) and *Guazuma ulmifolia* (Bastard Cedar) trees. In 2012 the Guango/Bastard Cedar stand was a closed community with limited light permeating through to the forest floor in some sections. As a result, the shrub component of this stand was quite poor; however, the ground and epiphytic constituents were well represented. In rainy periods, herbs, such as *Achyranthes indica* (Devil's Horse-whip) and *Ravina humilis*, were very common as these species were adapted to the low-light conditions.

Fruit trees of the Anacardiaceae family, namely *Mangifera indica* (Mango) and *Anacardium occidentale* (Cashew) and Caricaceae (*Carica papaya*) have been known to be frequented by fruit bat species. However, these trees were limited to domestic cultivation away from the primary development lands and should not be severely impacted by the development.

RECOMMENDED MITIGATION

See mitigations stated for the unintentional removal of important species above.

7.1.2.3 Fauna

Overall, the proposed development will have an impact on the fauna on the property with special emphasis on the birds, as a result of the modification or removal of some of their habitat such as the mudflats, mangrove forest and the old fish ponds. However during the survey no animals with special conservation status were encountered on the property. Specific potential impacts are listed below.

- The study was not conducted at the time when the migrant warblers are present. The migrant warblers are known to utilize mangrove forests and acacia woodlands which are present in the project area. However, none of the migrant warblers have any special conservation status in Jamaica. The removal of vegetation will result in the loss of habitat for the migrant warblers.
- During the clearing of the property, there is an increased probability of human and crocodile interaction which increases the risk of people hunting the crocodiles or poaching the eggs because they are in high demand.
- The clearing of the property will remove seasonal flooding of the artificial fish ponds, mangroves, woodland and mudflats which will have an impact on the avifauna and the terrestrial and amphibious invertebrates.

RECOMMENDED MITIGATION

- Planting of trees on the property will increase avifauna and terrestrial invertebrates' number.
- The re-vegetation of the site will not have a significant impact on the crocodile population. However the vegetation can help hide the juvenile crocodiles from predators.
- A winter bird survey should be a part of the monitoring plan for the project.
- The removal of the vegetation will change the bird species composition in the area. In order to reduce the negative impact of the development, trees can be planted which could attract a number of birds.

7.1.2.4 Benthic Communities

Fish

Runoff and or siltation as a result land based activities may result in reduced water quality resulting in the temporary displacement of some fish species in the area of influence. The excess sedimentation can also result in the clogging of fish gills.

RECOMMENDED MITIGATION

See Mitigation - Sediment Barriers and Silt Screens

Reptiles- Sea Turtles and Crocodiles and Mammals- Dolphins

Land based activities may disrupt nesting activities for turtles and crocodiles and temporarily displace these animals.

RECOMMENDED MITIGATION

Sensitisation and education of all construction personnel about all marine fauna (reptiles and mammals) and birds must be undertaken prior to any major works. This should include, but not limited to; proper procedures in the event of an accident/entanglement/interaction; protocol if a nest is discovered. The use of a spotter may also be necessary in-order to prevent incidents.

Where possible, all work activities should be conducted outside of crocodile and turtle nesting seasons.

Reefs

Nearby and surrounding reef systems may be exposed to high levels of sediment as a result of the construction activities. The sedimentation of these sensitive ecosystems may result in the smothering of sessile organisms, in particular coral colonies and sponges.

RECOMMENDED MITIGATION

- Sediment barriers/silt and retention ponds are recommended See Recommended
- Special care should be taken in the placement of these screens around these systems.
- Contractors should be responsible for ensuring that only the approved areas identified are used thus minimising the possible damage to any nearby reefs. .

Seagrass

Run-off and excess sedimentation may impact nearby seagrass beds.

RECOMMENDED MITIGATION

- Construct berms around the construction site
- Sediment barriers/silt screens are recommended.

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.

7.1.3 Heritage

If significant artefacts are present in any of these proposed project areas, site clearance has the potential to negatively affect the archaeological heritage of the area.

RECOMMENDED MITIGATION

i. During site clearance, JNHT should be present in order to undertake further archaeological evaluations and ascertain the magnitude of Taíno sites, if any.
ii. Ensure the preservation of the historic and cultural sites.
iii. Monitoring should be conducted during clearing and excavation stages in areas where historic artefacts were discovered.

iv. The recording of impacted structures should be undertaken prior to destruction.

7.1.4 Human/Social

7.1.4.1 Employment

There is the potential for increased employment during the pre-clearance and construction phases. It is anticipated that approximately 70 persons will be employed directly during the site clearance and an average of 200 persons to a maximum of 400 -450 persons at the peak during construction. Approximately 70% of the work force will be obtained from local labour. In addition it is anticipated that approximately 1,140 and 1,520 – 1,710 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.

7.1.4.2 Traffic Management (Commuters and Pedestrians)

The construction process may necessitate the re-routing of some vehicular and pedestrian traffic and introducing traffic delays thereby increasing in travel time. Any re-routing of vehicular traffic has the potential to lead to increase fares. Increased accident potential from additional trucks traversing the main roads is also a possibility.

Negative impacts on traffic are expected during the construction stages, and these include:

- Disruptions in traffic.
- Reduced level of service due to increased large/construction vehicle on the roads.

Wear and tear on roads from loaded trucks transporting material and/or construction debris is also a cause for concern.

RECOMMENDED MITIGATION

During the site preparation and construction phases, the following should be enforced:

vi. Trucks should operate ideally during off peak hours.
vii. Loading of trucks as per NWA axel load guidelines.
viii. Traffic diversion routes must be identified and constructed as necessary.
ix. Adequate caution signage as per NWA guidelines and the use of flagmen where necessary.
x. Trucks must be properly covered and loaded so as to not let loose material fall during transport.

7.1.4.3 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.

7.1.4.4 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

Hydrology and Runoff

As mentioned previously in section 5.1.6 Hydrology and Runoff, runoff was estimated for both existing (predevelopment) and post development scenarios. The post development scenario for the site considered climate change impacts.

The flows from this area will increase from 15 to 22 percent for the 10 to 100 year event due to the increased impermeable areas after the construction of the power plant.

Table 7-12 Comparison of predevelopment and post development future flows from the JPS site

Storm	Predevelopment runoff (m^3/s)	Future Flows (m^3/s)	Increases
Ivan	4.3		
Gustav	0.8		
10yr	2.2	2.69	22%
50yr	3.1	3.56	15%
100yr	3.4	3.92	15%

RECOMMENDED MITIGATION

iii. In order to minimize quantity of waste water, rain water from clean areas such as roads, paved areas free from contamination and buildings, etc. will be collected through open ditches (and/or) road side gutters. Collected rainwater will be routed to the holding area before being re-routed to the sea. This will allow for sediments to fall out before discharge to the sea. The recommended volume for the holding area should contain the first flush or ½ inch of rainfall before it discharges to the sea.

iv. Oily water on the site will generally originate from two area, plant floor and car park area. Floor water will originate from a number of activities; these will include wash down operations, maintenance operations, and spills during loading. Oily water in car park area may be as a result of spills from delivery trucks or any other vehicles undergoing mechanical problem or maintenance. Floor water will be directed to floor drains which will terminate at oil water separators. Similarly car park runoff will be directed to storm drains which will terminate in oil water separators as well. Class 1 separators are recommended for both circumstances given the bay is an environmentally sensitive area.

Noise

The predicted noise from the proposed power plant was determined by using SoundPlan version 7.3. The noise spectrum for both the Steam Turbine Generators and the Gas Turbine Generators and other major equipment provided by the manufacturer was used to calibrate the model. Once the model was calibrated then structures such as the auxiliary buildings, tank farm, ground and other buildings within the area were added.

The noise impact from the proposed plant at the fence line (industrial), institutional (schools) and residential location were assessed and reported in Table 7-13 and depicted in Figure 7-2 and Figure 7-3.

COMPARISON WITH NEPA GUIDELINES

Stations 3 and 5 will be non-compliant with the NEPA day time standard when winds from the south were taken into consideration and Stations 2, 3 and 5 non-compliant with the NEPA night – time standard with or without considerations of wind. It is should be noted that only Station 5 was offsite the JPS compound.

COMPARISON WITH WORLD BANK GUIDELINES

Stations 2, 3 and 5 will be non-compliant with the World Bank day time guidelines, this with or without influences of the south wind, except for Station 5, where exceedance occurred only with the wind. Stations 2, 3, 5 and 6 non-compliant with the night-time guidelines with or without wind considerations.

Table 7-13 Comparison of anticipated noise readings with NEPA and World Bank guidelines

STATION			DAY TIME (7 am. – 10 pm.) (dBA)					NIGHT TIME (10 pm. – 7 am.) (dBA)				
No.	LOCATION	CATEGORY	BASELINE	PREDICTED NOISE FROM 190MW PLANT (GP)	PREDICTED NOISE FROM 190MW PLANT (CONCAWE)	NEPA STD.	WORLD BANK GUIDELINE	BASELINE	PREDICTED NOISE FROM 190MW PLANT (GP)	PREDICTED NOISE FROM 190MW PLANT (CONCAWE)	NEPA STD.	WORLD BANK GUIDELINE
1	North-Western Property Boundary	Industrial	66.9	64.9	68.1	75	70	59.6	64.9	68.1	70	70
2	South-Western Property Boundary	Industrial	62.4	71.9	74.7	75	70	56.5	71.9	74.7	70	70
3	South-Eastern Property Boundary	Industrial	64.0	74.9	77.5	75	70	58.0	74.9	77.5	70	70
4	North-Eastern Property Boundary	Industrial	62.9	64.7	67.1	75	70	59.8	64.7	67.1	70	70
5	Informal Settlement	Residential	61.4[20]	54.1	57.0	55	55	59.9	54.1	57.0	50	45
6	Blackwood Gardens	Residential	52.2[21]	46.5	48.6	55	55	46.9	46.5	48.6	50	45
7	Old Harbour Bay Police Station	Residential	56.2[22]	37.4	38.9	55	55	52.7	37.4	38.9	50	45
8	New Harbour Village Phase II	Residential	43.1	35.7	36.6	55	55	41.9	35.7	36.6	50	45
9	Longville Park Housing Scheme	Residential	51.7[23]	27.4	21.6	55	55	49.9	27.4	21.6	50	45
10	New Harbour Village Phase I	Residential	60.6[24]	31.1	31.0	55	55	56.3	31.1	31.0	50	45
11	JPS Guard House	Industrial	61.4[25]	56.8	60.0	75	70	54.9	56.8	60.0	70	70

NB: Numbers in red indicate non-compliance with both NEPA and World Bank guidelines and blue indicate non-compliance with World Bank guideline.

[20] Average of noise data from 2007 – 2012 (Campbell 2014), Jamaica Energy Partners Annual Noise Assessment (2013 and 2014) and current measurements
[21] Average of noise datd from Jamaica Public Service Noise Assessments (2010, 2011 and 2013), South Jamaica Public Company EIA (2012) and current measurements
[22] 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
[23] One of noise measurements conducted for the South Jamaica Public Company EIA (2012)
[24] 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)
[25] One of noise measurements conducted for the South Jamaica Public Company EIA (2012)

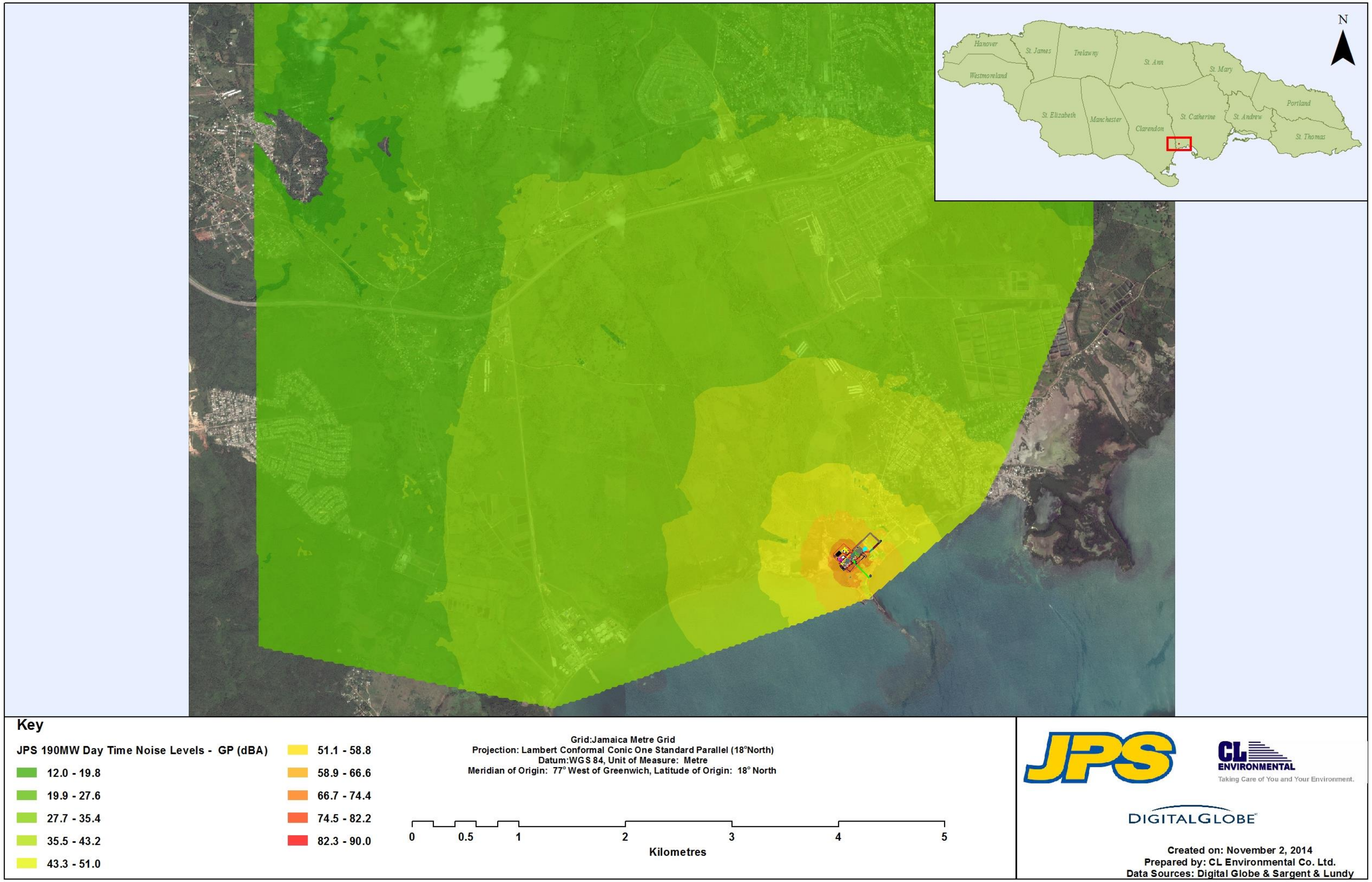


Figure 7-2 Predicted day time noise level of the proposed 190 MW LNG power plant (General Prediction model)

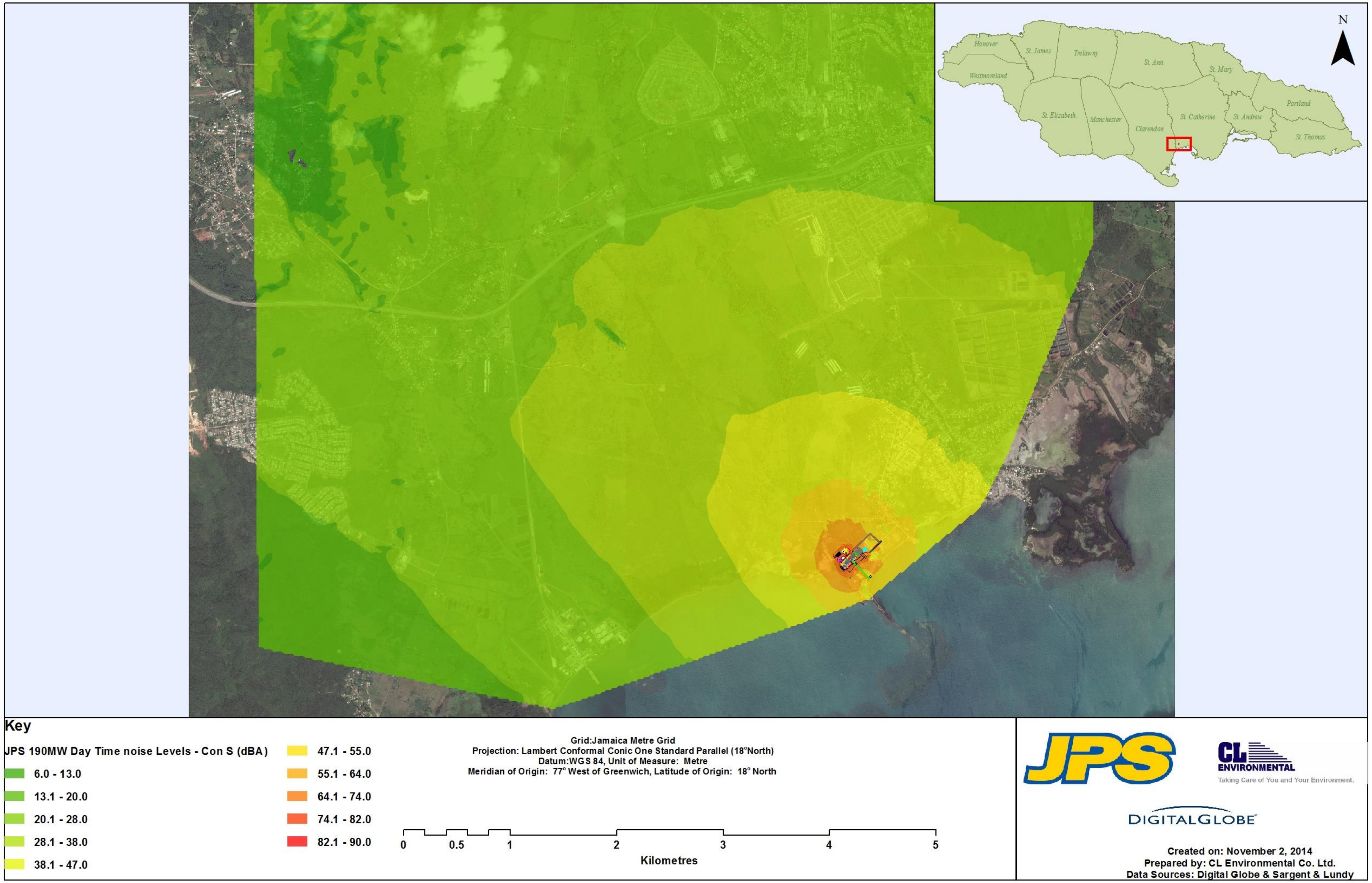


Figure 7-3 Predicted night time noise level of the proposed 190 MW LNG power plant (Concawe model - winds from the south)

Although the locations at which noise levels were taken during the conduct of the EIA were compliant with the NEPA and World Bank guidelines, there were areas in proximity to the proposed Plant where the noise generated by the Plant would be non-compliant. This assessment was done using the night time noise limit of 50 dBA, since once the night time noise limits are met then automatically the day time night standard would be met. This coupled with the fact that persons will be more sensitive to night time noise.

Based on this, a 50 dBA noise limit was predicted using the noise model. This identified the following two areas to be non-compliant with the 50 dBA limit. These are: Sections of Terminal Lane and Sections of Terminal Road and are illustrated in Figure 7-4.

COMMUNITY NOISE EQUIVALENT LEVEL (CNEL)

CNEL is equivalent to the European Standard of Day Evening Night Levels (L_{den}). It is a 24-hour equivalent continuous level in dBA where 5 dBA is added to evening noise levels from 7:00 p.m. to 10:00 p.m. and 10 dBA is added to night-time noise levels from 10:00 p.m. to 7:00 a.m. It can give an indication of the likelihood of community complaints about a noise source. At a guideline CNEL level of 65 dBA it is expected that will be sporadic complaints from the community.

The calculated 65 dBA CNEL limit lines were calculated for the JPS 190MW operating alone using the General Prediction and Concawe (wind from the south) models and are illustrated in Figure 7-5. The results indicate that there should be no complaints from the community as it relates to the operation of the JPS 190MW power plant alone.

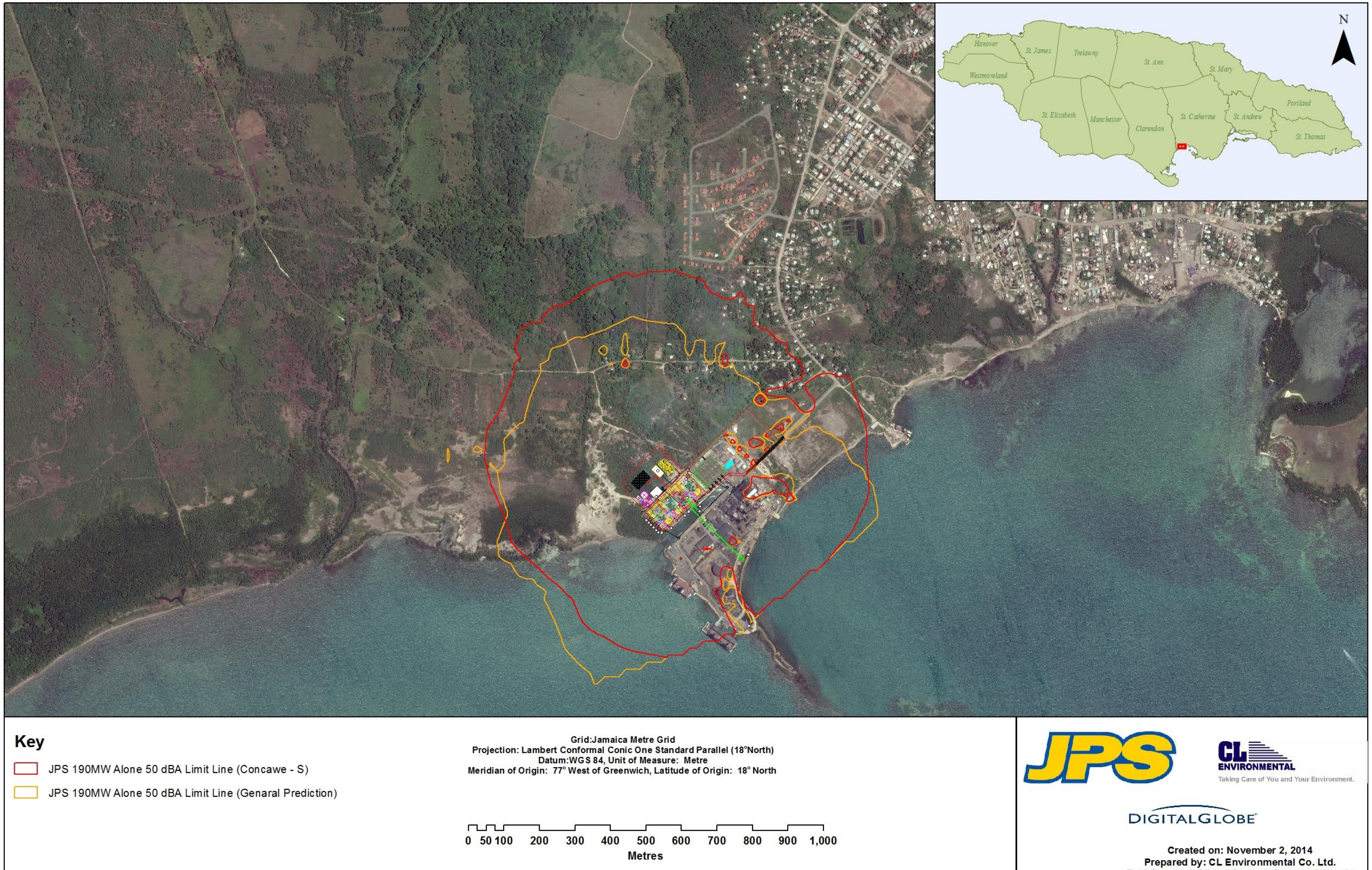


Figure 7-4 The NEPA 50 dBA (night time) limit lines using the General Prediction and Concawe (winds from the south) models

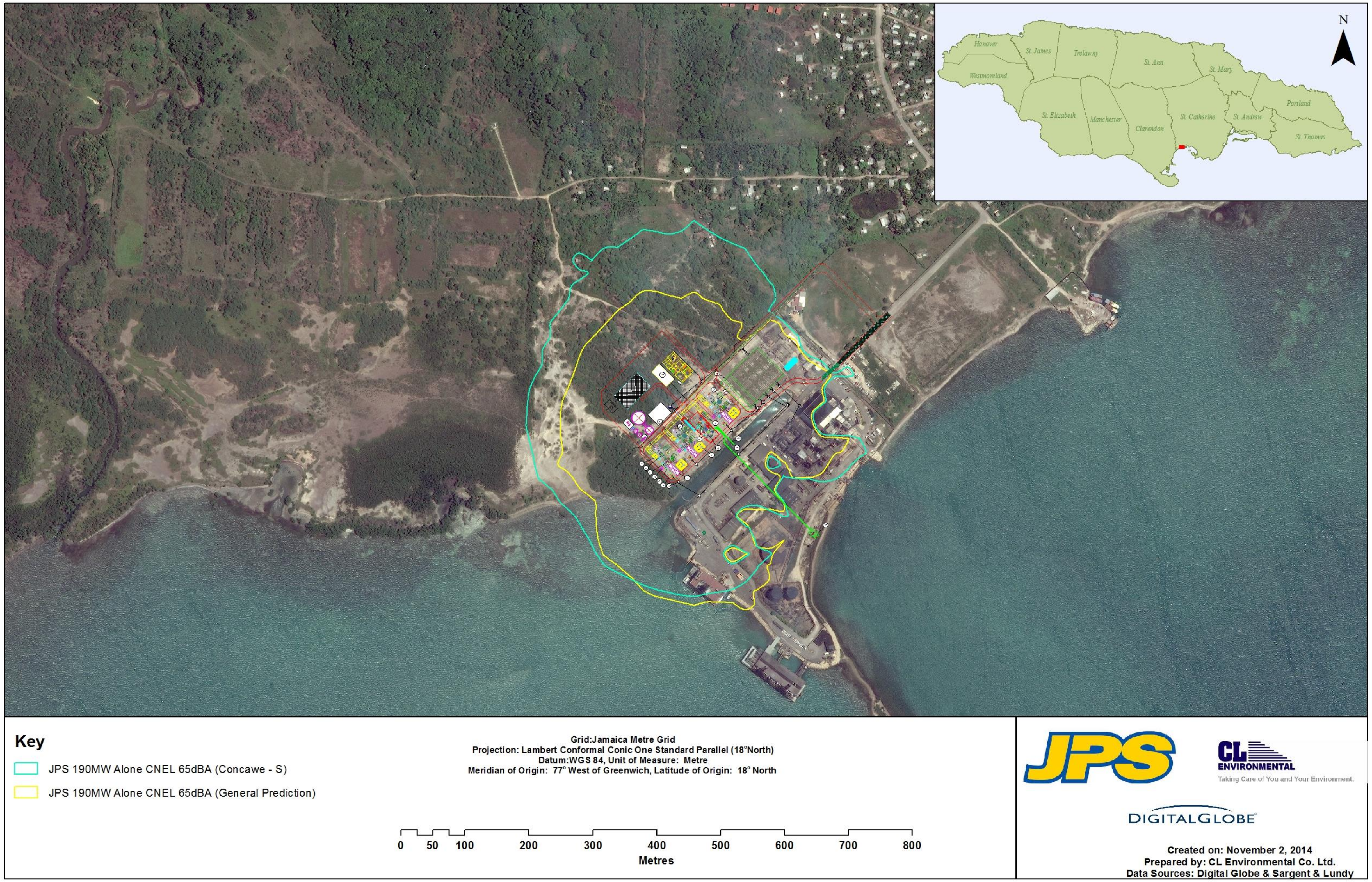


Figure 7-5 Community Noise Equivalent Levels (CNEL) 65 dBA limit lines for General Prediction and Concawe (winds from the south) models

SENSITIVE RECEPTORS

Sensitive receptors (schools, churches and clinics) within 6 km were mapped. Note that this list is not intended to be exhaustive. The noise attributed to the operation of the JPS 190MW power plant 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).

Schools

A total of twelve schools were investigated (Table 7-14). When the General Prediction model was used to predict the noise levels when the JPS 190MW power plant was operating alone, the stations generally exhibited the inverse law, which is the decrease in noise with increasing distance. The noise levels ranged from a low of 25.7 dBA (Old Harbour Primary) to a high of 39.2 dBA (Blackwood Gardens Basic School). When modelled with the Concawe model with the wind blowing from the south (worst case scenario) the noise levels at the schools ranged from a low of 21.2 dBA (Longville Park Early Childhood Centre) to a high of 41.1 dBA (Blackwood Gardens Basic School). The noise levels however did not exhibit the inverse law.

The predicted noise levels from the JPS 190MW plant operating alone noise levels at the schools were all compliant with both the NEPA daytime standard and the World Bank guideline when both the General Prediction and concawe models were used.

Table 7-14 Schools listed in order of increasing distance (m) from the proposed JPS 190MW power plant with the predicted noise from JPS 190MW power plant operating alone

SCHOOLS	DISTANCE FROM DOCTOR BIRD POWER FACILITY (m)	LAeq (16)		NEPA STD	WORLD BANK GUIDELINE
		JPS 190 MW	CONCAWE S – JPS 190 MW		
Blackwood Gardens Basic School	1143.7	39.2	41.1	45	55
Children First Basic	1235.0	39.1	40.4	45	55
Old Harbour Bay Primary	1330.1	37.7	38.4	45	55
Baptist Early Childhood Centre	1353.3	38.1	39.2	45	55
St. Wade Basic School	1415.0	37.4	38.9	45	55
Old Harbour High School	3795.6	28.6	27.5	45	55
Portmore Community College (Old Harbour)	4149.2	27.7	26.4	45	55
Freetown Primary	4409.1	26.9	26.2	45	55
Monsignor Colin Bryan Preparatory	4597.5	27.1	25.9	45	55
Longville Park Early Childhood Centre	4609.3	26.5	21.2	45	55
Old Harbour Early Childhood Institution	5009.3	26.0	24.3	45	55
Old Harbour Primary	5091.8	25.7	23.8	45	55

Churches

Predicted noise levels at eighteen churches were scrutinized (Table 7-15). The noise levels at the churches did not exhibit the inverse law regardless if the General Prediction model or the Concawe model were used to predict the noise levels. When the General Prediction model was used the noise levels ranged from 26.0 dBA (Old Harbour Baptist) to 40.3 dBA (Mount Refuge Fire Baptize Holiness). When the Concawe model was used the noise levels ranged from 21.3 dBA (Longville Park Church) to 42.1 dBA (Mount Refuge Fire Baptize Holiness).

With the exception of the predicted noise at Mount Refuge Fire Baptize Holiness when JPS 190MW and JEP Doctor Birds I and II are operational (Concawe), all other predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guideline when both the General Prediction and concawe models were used (Table 7-15).

Table 7-15 List of churches in order of increasing distances (m) from the proposed JPS 190 power plant with the predicted noise from JPS 190MW power plant operating alone

CHURCHES	DISTANCE FROM DOCTOR BIRD POWER FACILITY (m)	LAeq (16)		NEPA STD	WORLD BANK GUIDELINE
		GP JPS 190 MW	CONCAWE S – JPS 190 MW		
Mount Refuge Fire Baptize Holiness	1038.5	40.3	42.1	55	55
Unnamed Church	1353.0	38.1	39.7	55	55
St Phillips Anglican	1370.9	38.1	39.3	55	55
Refuge Temple Old Harbour Bay	1454.2	37.1	38.4	55	55
Old Harbour Bay Baptist	1499.4	36.8	37.4	55	55
Old Harbour Bay SDA	1564.9	35.9	37.0	55	55
Faith Bible Baptist Church	1792.3	35.4	36.2	55	55
Old Harbour Evangelistic Centre	3471.4	28.8	28.5	55	55
Church of Our Lord Apostolic Faith	3868.2	28.5	27.4	55	55
Jehovah Witness	3948.2	28.3	27.2	55	55
Hebron Gospel Hall	4120.0	27.9	26.6	55	55
Old Harbour SDA	4185.9	27.8	26.3	55	55
Holy Ghost Ministries Inc.	4312.6	37.4	26.0	55	55
Church of the Holy Trinity	4347.4	27.4	25.9	55	55
St. Michael & St. George Anglican	4421.3	26.9	26.2	55	55
Longville Park Church	4611.7	26.3	21.3	55	55
St Dorothy's Anglican Church	4992.7	26.7	24.3	55	55
Old Harbour Baptist	5061.7	26.0	24.2	55	55

Clinics

The noise levels at two clinics were examined (Table 7-16) when the JPS 190MW power plant was operating alone. The results indicated that noise at both clinics complied with the inverse law when either General Prediction or Concawe models were used. The noise levels when the General Prediction model was used varied from 27.0 dBA (Old Harbour Health Centre) and 35.1 dBA (Bay View Medical Centre) and when Concawe model was used 25.5 dBA (Old Harbour Health Centre) and 37.0 dBA (Bay View Medical Centre).

All predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guideline whether the General Prediction and Concawe models were used (Table 7-16).

Table 7-16 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 power plant operating alone

CLINICS	DISTANCE FROM DOCTOR BIRD POWER FACILITY (m)	LAeq (16)		NEPA STD	WORLD BANK GUIDELINE
		GP JPS 190 MW	CONCAWE S – JPS 190 MW		
Bay View Medical Centre	1669.2	35.1	37.0	55	55
Old Harbour Health Centre	4479.2	27.0	25.5	55	55

RECOMMENDED MITIGATION

No mitigation is required.

Vibration

The operation of the power plant has the potential to create vibration that may cause a nuisance to both employees and residents alike.

RECOMMENDED MITIGATION

v. Ensure that the equipment are placed on the manufacturer's recommended dampening system.
vi. Monitor the following:
    a. Speed (RPM) and Power (MW)
    b. Bearing vibration: seismic, shaft rider, or shaft x-and-y proximity probes (as applicable)
    c. Journal bearing and thrust bearing metal temperature
vii. Install the continuous monitoring system for GE steam turbines - The Turbine Supervisory Instrumentation (TSI) System. This monitoring includes the typical radial displacement vibration and axial position measurements used for GE steam turbines.
viii. Vibration-monitoring capability and evaluation is one of the most important portions of the TSI system for trending and predicting changes in turbine health and thermodynamic performance. Overall, vibration monitoring provides the means to track the following types of problems:
    a. Bearing problems
        i. A change in vibration level or erratic vibration reading can be indicative of a wiped bearing and scored journal, as can an increase in bearing metal or oil drain temperature.
    b. Rotating parts-related problems

    i. Any circumferential variation in weight in the rotating parts will result in an unbalance, which will be reflected in the vibration level at the bearings. This includes problems such as: loss of bucket covers, or loss of part or all of a bucket. Step changes in vibration level may be indicative of this condition in many cases.

c. Bowed rotors
    i. Rubbing of steam path components due to insufficient clearance, created by mis-assembly or mis-operation can create a bow due to uneven heating or cooling of the rotor surfaces. This shift in centre of rotation further compounds the rub and increases distortion.
    ii. Packing, spill strips and bucket covers are the most frequently damaged parts in a bowed rotor event, but permanently bowed rotors may also occur if the localized heating or cooling is sufficient to change material properties of the rotor body.
    iii. A bow in the rotor (of even a few mils) may cause a shift in the axis of rotation sufficient to produce a change in vibration level at the bearings. In the low-pressure element of the unit, which contains longer buckets, severe mechanical damage can be caused by water induction and this may be reflected by a change in the vibration level at the bearings. Where applicable, water detection thermocouples can be used to better identify if there is a water induction problem and to help identify the source of the water.

Traffic

There is little potential for an increase in overall traffic as it is expected that there will be the closure of the JPSCo Old Harbour plant, with the opening of the 190 MW plant. Therefore, it is expected that the traffic that now goes to this plant will be diverted to the 190 MW LNG plant thus no net increase.

RECOMMENDED MITIGATION

No mitigation is required.

7.2.1.2 Water Impacts

Pollution of Water Resources

HAZARDOUS AND NON-HAZARDOUS WASTE

Non-hazardous and hazardous wastes include general solid waste, waste oils, oil contaminated rags, hydraulic fluids, used batteries, empty paint cans, waste chemicals and used chemical containers, oily sludge from oil water separators and scrap metals among others. These have the possibility of polluting nearby surface water bodies as a result of improper disposal practices.

RECOMMENDED MITIGATION

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

NATURAL DISASTERS

With any natural disaster comes the possibility of fuel/oil spill as a result of storage tank or pipeline damage. This may affect nearby surface water bodies and/or groundwater.

RECOMMENDED MITIGATION

Each storage tank should be surrounded by a bund which is designed to contain at least 110% of the storage tank capacity.

The tanks should also be designed for the seismic rating of the region and the tank profile should 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.

Oily Water Management

Oily water on the site will generally originate from two areas, plant floor and the car park area. Floor water will originate from a number of activities; these will include wash down operations, maintenance operations, and spills during loading. Oily water in the car park area may be as a result of spills from delivery trucks or any other vehicles undergoing mechanical problem or maintenance.

RECOMMENDED MITIGATION

ii. Direct rainfall into the areas or floor washing water will be led to an oil separator by gravity and connected to the industrial waste piping network. The Oil removal system receives oil-contaminated water from all over the plant. Oil removed from the Oil/water separator will be stored within the separator for periodic removal and off-site disposal.

Sewage and Wastewater Management

Water for plant and sanitary processes will be obtained from a well source. The wastewater produced from the power plant operations will include wastes from the following sources:

- RO plant reject water (brine)
- Demineralization waste water
- Filter backwash water
- Cooling tower

RECOMMENDED MITIGATION

All wastewater from the plant will be collected in a concrete tank and pre-treated to a satisfactory level and routed through a holding area to make it fully compliant with NEPA effluent quality standards before being re-routed back to the flume. The effluent quality will also be monitored by a continuous monitoring system. Sewage effluent from various buildings will be piped to the central sewage treatment plant. Waste water meeting the designated standards (Table 7-17) will be discharged into the holding pond. Those not meeting the standards will be treated to reflect the following:

Table 7-17 NEPA wastewater standard targets

Parameter	Treated waste water quality
pH	6.5~8.5
Oil & Grease (mg/l)	<10
BOD5 (mg/l)	<30
COD (mg/l)	<100
TSS (mg/l)	Max. 150, Monthly Avg.: <50

Chemically contaminated waste will be isolated by spill wall, dike, pit, trench, etc. Waste, if not biodegradable, will be treated separately and removed for disposal.

Commonly used chemicals on the plant are:

1. Phosphates
2. Oxygen scavenger
3. Amine
4. Sulphuric acid

Cooling Water Management

The cooling water from the plant will be discharged from the plant at a rate of 282,812 GPM and at a higher temperature than that of the seawater. The background or ambient temperature of seawater was measured at 30.71 degrees Celsius on average whereas the discharge from the plant will be at 35.5 degrees Celsius.

The region of water body which undergoes changes in temperature due to heated water discharge is termed as the thermal plume. This begins at the hot water outlet and extends in horizontal and vertical directions. The behaviour of thermal plume is influenced by many parameters such as the flow rate and temperature difference at the outlet and its characteristics, flow dynamics of receiving water body, relative locations of intake and outfall, withdrawal velocity, type of structure and the meteorological conditions. The thermal plume can be broadly divided into two zones: namely near field and far field. Near field is the zone adjacent to the discharge point.

In order to predict the behaviour of the plume in terms of its movement and temperature, scaled and calibrated numerical models are generally employed. The nearfield and far field modelling are generally separated to because of scaling differences. Nearfield models simulate the behaviour of the Gully in the vicinity of the discharge point.

Hydrodynamic Modelling (Thermal Dispersion)

DESIGN APPROACH AND STANDARDS

The performance of the outfall is characterized by its ability to meet NEPA guidelines for trade effluent discharge. The guideline for thermal discharge states that temperature increases of up to 2°C above ambient is allowed at the point of discharge. The World Bank guidelines dictate that within the mixing zone a temperature rise of 3°C is allowable, and where the mixing zone distance is not specified a distance or 100m. The start of the discharge should be considered as the point where the river meets the sea, the standards should therefore be met at or before 100m away from that point.

It is envisaged the cooling water will be discharged to the northeast corner of flume which will in turn discharge to the Bay. This will negate the need for nearfield modelling as the flume is a small channel that guides the flow to the Bay. As the heated water travels from the discharge point (in the flume), it is anticipated that some negligible amounts of heat will be lost by evaporation and radiation. On entering the Bay the heated water will spread out over the surface of the sea under the influence of buoyancy, momentum and shear stresses between the two layers. The water will be vertically stratified with the hot water forming a plume on the surface of the cooler sea water. This plume will be convected up and down the coast by the currents whilst being gradually dispersed by vertical and horizontal mixing. The temperature concentration will thus reduce and the edge of the plume will become indistinct. The degree of mixing occurring will be a function of the variability of the velocity, which in turn will depend upon tidal and wind conditions as well as local bathymetry (Ackers, 1980).

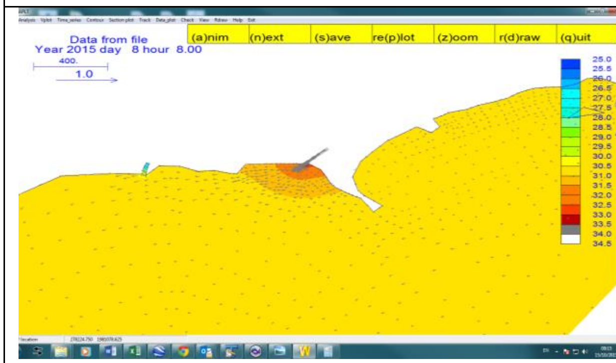
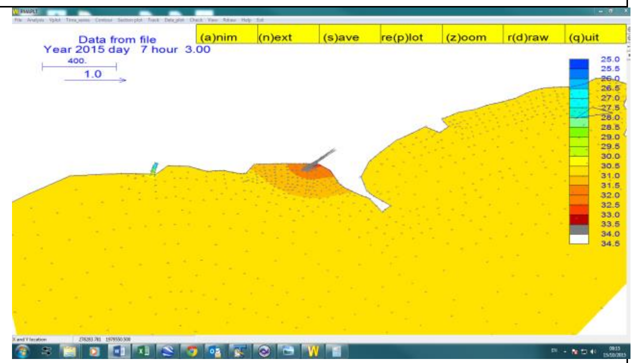
The modelling approach was to use the calibrated finite element hydrodynamic model to simulate the dispersion and mixing of the plume; applying the flows to the surface layer as a point source within northeast corner of the thermal flume.

FAR-FIELD THERMAL DISPERSION MODELLING RESULTS OF PROPOSED DISCHARGE CONDITIONS

Slow Wind Conditions

During average wind conditions the temperature of the cooling water will fall to between 32.5 °C and 31.5 °C, a maximum of 1.8 degrees above the ambient temperature of 30.7°C well within the mixing zone (or 100m radius). The cooling process will take longer as the movement of currents driven by wind are slower and facilitates less mixing. This will cause a noticeable area of slightly elevated temperature, which will have further temperature decreases down to background temperatures at or before the 100m from the discharge point. See Table 7-18.

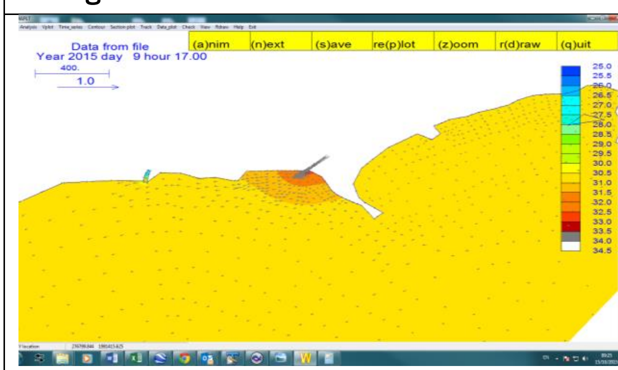
Table 7-18 Falling Tide and Rising Tide – Slow Wind Conditions

<table>
<tr><th>Falling Tide</th><th>Rising Tide</th></tr>
<tr><td>
</td>
<td>
</td></tr>
</table>

Average Conditions

During average wind conditions the temperature of the cooling water will fall to between 32.5 °C and 31.5 °C, a maximum of 1.8 degrees above the ambient temperature of 30.7°C well within the mixing zone (or 100m radius). The cooling process will take a shorter time than for slow wind conditions as the movement of currents driven by wind are faster and facilitates more mixing and a relatively smaller plume, which will have further temperature decreases down to background temperatures just outside of the 100m limit. See Table 7-19.

Table 7-19 Falling Tide and Rising Tide - Average Wind Conditions

<table>
<tr><th>Falling Tide</th><th>Rising Tide</th></tr>
<tr><td>
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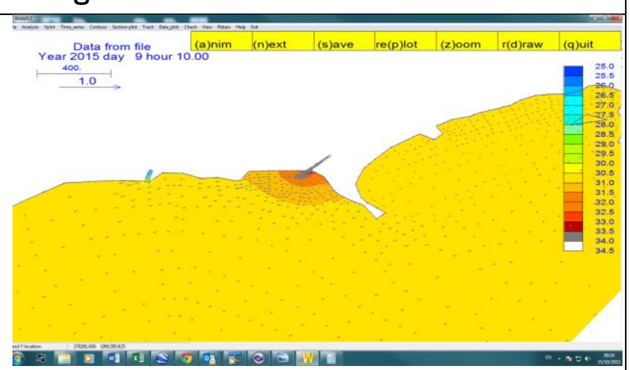
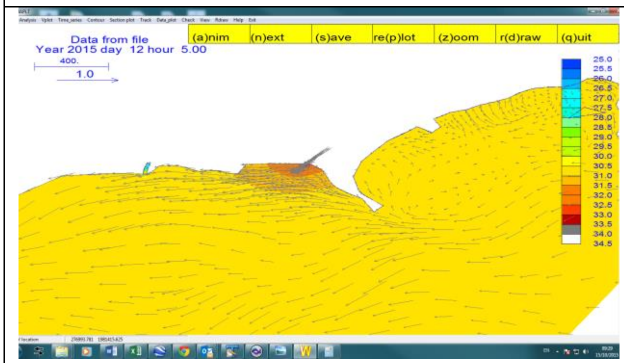
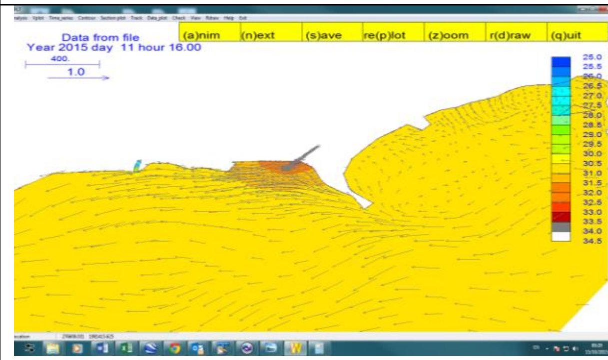
<td>
</td></tr>
</table>

Fast Wind Conditions

During fast wind conditions the temperature of the cooling water will fall to between 32.5 °C and 31.5 °C, a maximum of 1.8 degrees above the ambient temperature of 30.7°C well within the mixing zone (or 100m radius). The cooling process will be shorter than for average conditions as the movement of currents driven by wind are very fast and facilitates good mixing. This will cause a fairly small area of slightly elevated temperature within the mixing zone, which will have further temperature decreases down to background temperatures just outside of 100m limit. See Table 7-20.

Table 7-20 Falling Tide and Rising Tide - Fast Wind Conditions

Falling Tide	Rising Tide
	

RECOMMENDED MITIGATION

None Required. Having a small area of elevated temperature is unavoidable. It is within the limits set by the Regulatory agencies and thus will not require any mitigation at this time.

7.2.1.3 Air Impacts

Air Dispersion Modelling

An air dispersion modelling analysis was undertaken to determine the impact of the air pollutants from the proposed facility on the ambient air quality (Appendix 10). A determination was 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 (SO2), total suspended particulates (TSP), particulate matter less than ten microns (PM10) or nitrogen dioxide (NO2) is greater than an annual average of 21 μg/m3 or a 24-hour average concentration of 80 μg/m3; or
b) The increment in the predicted average concentration of CO is greater than 500 μg/m3 as a 8-hour average or 2000 μg/m3 as a 1-hour average

Additionally, the cumulative air quality impact of all active operating sources within the project area (including the proposed power plant) will be determined.

PROCESS DESCRIPTION AND AIR POLLUTANT SOURCES

Unit Operations of Proposed Facility

The Old Harbour 190 MW Gas-Fired Combined Cycle Power Plant will consist of three (3) blocks. Each block consists of 3x3x1 configuration, (three combustion turbine generators, three heat recovery steam generators (HRSGs) and one steam turbine generator) and is a multi-shaft design for gas turbine and steam turbine generators. The combustion turbines will be dual fuel capable, with LNG as the primary fuel. The exhaust gas from the gas turbine is led to the associated HRSG for generating the steam which in turn will be fed to a common steam turbine generator. The HRSGs will be dual pressure, non-reheat type, with duct burners, in order to obtain optimum exhaust gas energy utilization based on thermo-economic considerations.

The plant is designed for both base load and cycling duty (two shift operation) in order to be able to comply with all instructions from the system load dispatcher. The plant will operate with a 98% average annual equivalent availability factor (EAF) for the life time of the plant. This reliability is based on the inherent reliability of the Original Equipment Manufacturer (OEM) turbine packages, the unique features of the OEM gas turbines that allow for optimum maintenance schedules, a robust balance of plant (BOP) design, all coupled with competent operations and maintenance staff that will be provided. In addition, the company intends to enter into a long term service agreement (LTSA) with the OEM for scheduled maintenance on the gas turbines. This will ensure that maintenance is done in accordance with OEM requirements, with genuine OEM parts and service, and in an expeditious manner.

A metering system is used in order to measure net energy output from the plant, and to monitor and co-ordinate operation of the facility. The location of the metering system will be in a 138 kV substation control building, and potential transformers for the metering system will be located on the 138 kV side of each generator transformer feeders in the 138 kV switchyard to measure net electrical energy outputs. In order to meet the NOx emission requirement, a diluent injection system will be used at each gas turbine generator. Additionally, continuous emissions monitoring (CEM) ports will be provided for the measurement of air emission levels in the exhaust stack of each HRSG.

Potential Air Emissions

The air pollutants of concern to be discharged into the ambient air from the proposed power plant will be TSP, NOx, SO_2, CO and various priority air pollutants. These priority air pollutants include acetaldehyde, acrolein, benzene, formaldehyde and xylenes.

MODELLING APPROACH

The assessment methodology for the air dispersion modelling 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, 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 **A**MS/**E**PA **R**egulatory **Mod**el (AERMOD) was specially designed to support the EPA's regulatory modelling programs. AERMOD is a regulatory steady-state plume modelling 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 modelling air quality impacts of pollution sources, making it a popular choice among the modelling community for a variety of applications. Some of the modelling capabilities of AERMOD include the following:

- The model may be used to analyse 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 pre-processing 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 modelling the effects of settling and removal (through dry and wet deposition) of large particulates and for modelling 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 modelling 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 7-21 shows the source information data determined for the proposed power plant, while Table 7-22 displays the emission rates for criteria and priority air pollutants that were calculated based on the use of a fuel heat consumption rate of 1.383×10^9 kJ/h and USEPA emission factors for Stationary Gas Turbines.

Source information data for the main operating air pollution sources in the air shed – namely the Best Dressed Feed Mill, JPS existing power plant and JEP power plant are shown in Table 7-23, while those for the alumina handling activities at Port Esquivel are displayed in Table 7-24. Table 7-25 and Table 7-26 highlight the available emission rates for the main operating air pollution sources in the air shed. These data were obtained from the Air Dispersion Modelling Report for the Best Dressed Feed Mill, dated August 2014.

Table 7-21 Source information data for the proposed 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

Note that the Bypass stacks were not modelled because the HSRG stacks have lower exit gas velocities and temperatures that would result in lower exhaust plume heights and higher ambient impacts

Table 7-22 Air pollutant emission rates for the proposed power plant using Natural Gas

Source ID	PM, g/s	SO_2, 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

Table 7-23 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	JEP Existing Barge - 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
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 Modelling Report for Best Dressed Feed Mill, St. Catherine, Jamaica, 2014

Table 7-24 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	274006.38	1979786	3	4.572	65.98	60.99		
HDRSTRLD	AREA	Loading of Hydrate to storage	274006.38	1979786	3	4.572	65.98	60.99		
HDRSTR2	AREA	Hydrate Storage	274035.18	1979775	3	15.24	34.25	35.54		
RLCRUNL	VOLUME	Unloading of alumina from railcars	274001.69	1979713	3	31.5	20.66		4.80465	3.4186
TRNSF1	VOLUME	Transfer station	274070.86	1979608	3	31.5	2.5		0.5814	7.3256
TSL05	VOLUME	Storage Silo #5	274010.77	1979573	3	52	33.8		7.86047	7.3256
TSL01	VOLUME	Silo #1	274092.14	1979580	3	52	17.53		4.07674	7.3256
TSL02	VOLUME	Silo #2	274105.92	1979559	3	52	17.53		4.07674	7.3256
TSL03	VOLUME	Silo #3	274119.06	1979538	2.41	52	17.53		4.07674	7.3256
TSL04	VOLUME	Silo #4	274135.96	1979514	2	52	17.53		4.07674	7.3256
SHPLDR	VOLUME	Ship Loader	274240.82	1979345	0	11.1	24.41		5.67674	4.6512
TRHSE	VOLUME	Transfer House	274178.84	1979465	2	47.7	20.66		4.80465	4.186

Source: Air Dispersion Modelling Report for Best Dressed Feed Mill, St. Catherine, Jamaica, 2014

Table 7-25 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	7.8	122.7	210	10.2
JEP1_6	JEP Existing Barge - 6 Generators	7.44	118.4	226.8	10.8
JEP1_7	JEP Existing Barge - DG7	1.24	19.7	37.8	1.8
JEP1_8	JEP Existing Barge - DG8	1.24	19.7	37.8	1.8
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	0.014	0.07	0.448	0.119
FEEDB1	BDFM Boiler 1	0.0413	2.13	0.408	0.00331
FEEDB2	BDFM Boiler 2	0.00853	0.199	0.14	0.0103
GRAIN	BDFM Grain Receiving	0.416	0	0	0
MILL	BDFM Mills	2.3	0	0	0
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 Modelling Report for Best Dressed Feed Mill, St. Catherine, Jamaica, 2014

Table 7-26 Available priority air pollutant emission rates for nearby sources

Pollutants, g/s	FEEDE	FEEDB1	FEEDB2
Acetaldehyde	1.3E-05		
Acrolein	4.07E-06		
Benzene	4.01E-06	5.25E-07	9.44E-07
Formaldehyde	6.1E-04	8.1E-05	2.12E-04
Xylenes	9.98E-05		

Comparison of Proposed Emission Rates with Emission Standards

Table 7-27 highlights the emission standards to be applied to the proposed power plant and these standards are based on the NRCA (Air Quality) Regulations, 2006. The table also shows the emission rates derived for the facility based on the conversion of the USEPA emission factors (with units of lb/MMBtu) to ng/J. It should be noted that the derived emission rates in Table 7-27 revealed one exceedence – NOx. The NOx emission rate is design technology based (diluent injection) and will require certain design changes in order to ensure the achievement of compliance with the standard.

Table 7-27 Emission rate comparison with emission standards

Facility	Pollutant	Emission Standard, ng/J	Emission Factor, lb/MMBtu	Emission Rate, ng/J
New Fuel Combustion - Gas Fired 29-73 MW	NOx	40	6.6×10^{-3}	55.9
	CO	125	1.3×10^{-1}	12.9
	PM	13	3.0×10^{-2}	2.84

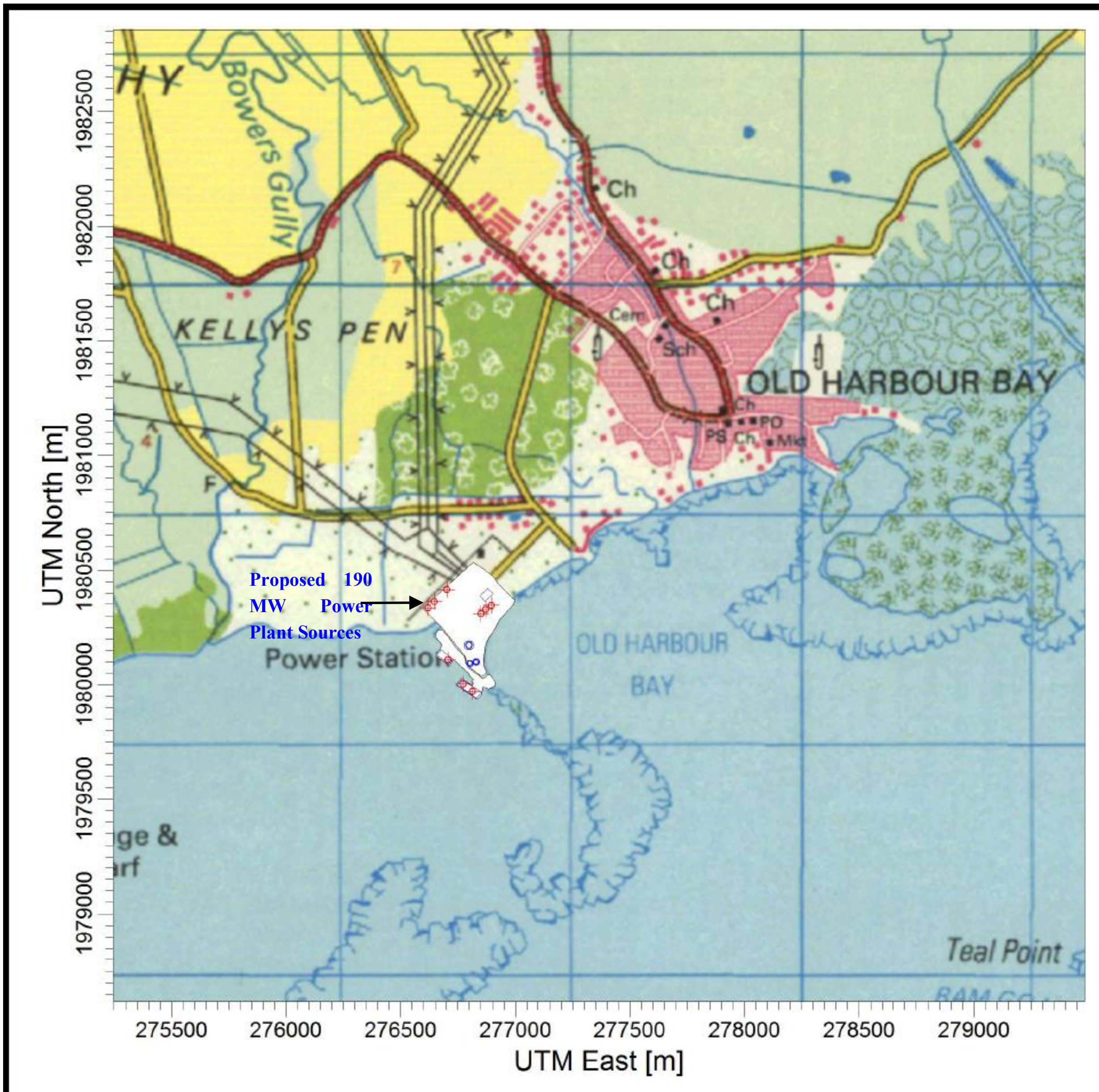
Building Downwash Effects

Buildings located close to point sources (see Figure 7-6) 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 modelling.

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 modelling, 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



COMMENTS:	SOURCES:	COMPANY NAME:	
Circular Structures	27	AIR QUALITY CONSULTANTS LIMITED	
Rectangular Structure	RECEPTORS: 5316	MODELER:	
Stacks		SCALE: 1:27,000 (0 — 1 km)	
			PROJECT NO.:

Figure 7-6 Proposed point sources and main buildings

There are a number of buildings nearby the point sources that were identified in the modelling project and these are sufficiently close to cause wake effects for the plumes. The dimensions of the various buildings (and process vessels) 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 7-28 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 7-28 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
MS1	45.00	0.00	64.00	65.00
MS2	45.00	0.00	64.00	65.00
MS3	45.00	0.00	64.00	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 modelled data set for years 2009 through 2013 with the centre point for the modelling site being main stack #2 with UTM coordinates 276647 in the east and 1980363 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 surface parameters within a 3 km radius around the centre of the modelling domain that were applied to the AERMET processor are listed in Table 7-29.

Table 7-29 Surface Parameters for AERMET Processor

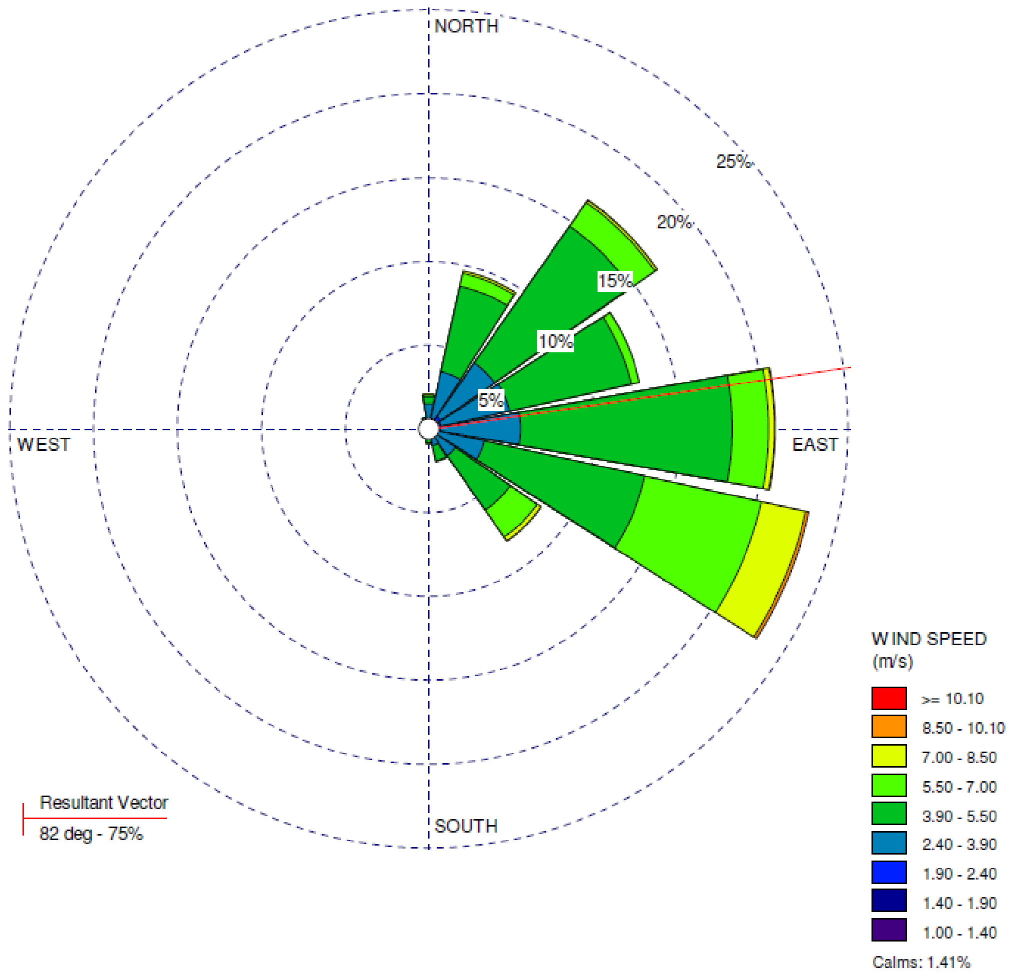
Sector (angle from north)	Land Use	Albedo	Bowen Ratio	Surface Roughness
0 – 90°	Cultivated land	0.28	0.75	0.0725
90 – 225°	Water	0.14	0.45	0.0001
225 – 360°	Cultivated land	0.28	0.75	0.0725

The 2009-2013 meteorological pre-processed data was used to determine its corresponding Wind Rose plot (see Figure 7-7). The Wind rose show that the most predominant wind direction blows from the east-southeast, with the secondary wind direction being from the east. This means that the emissions plume will be dispersed mainly in the west-north-westerly direction, and secondarily in the western direction from the proposed plant site.

Model Domain, Receptor Network and Terrain Considerations

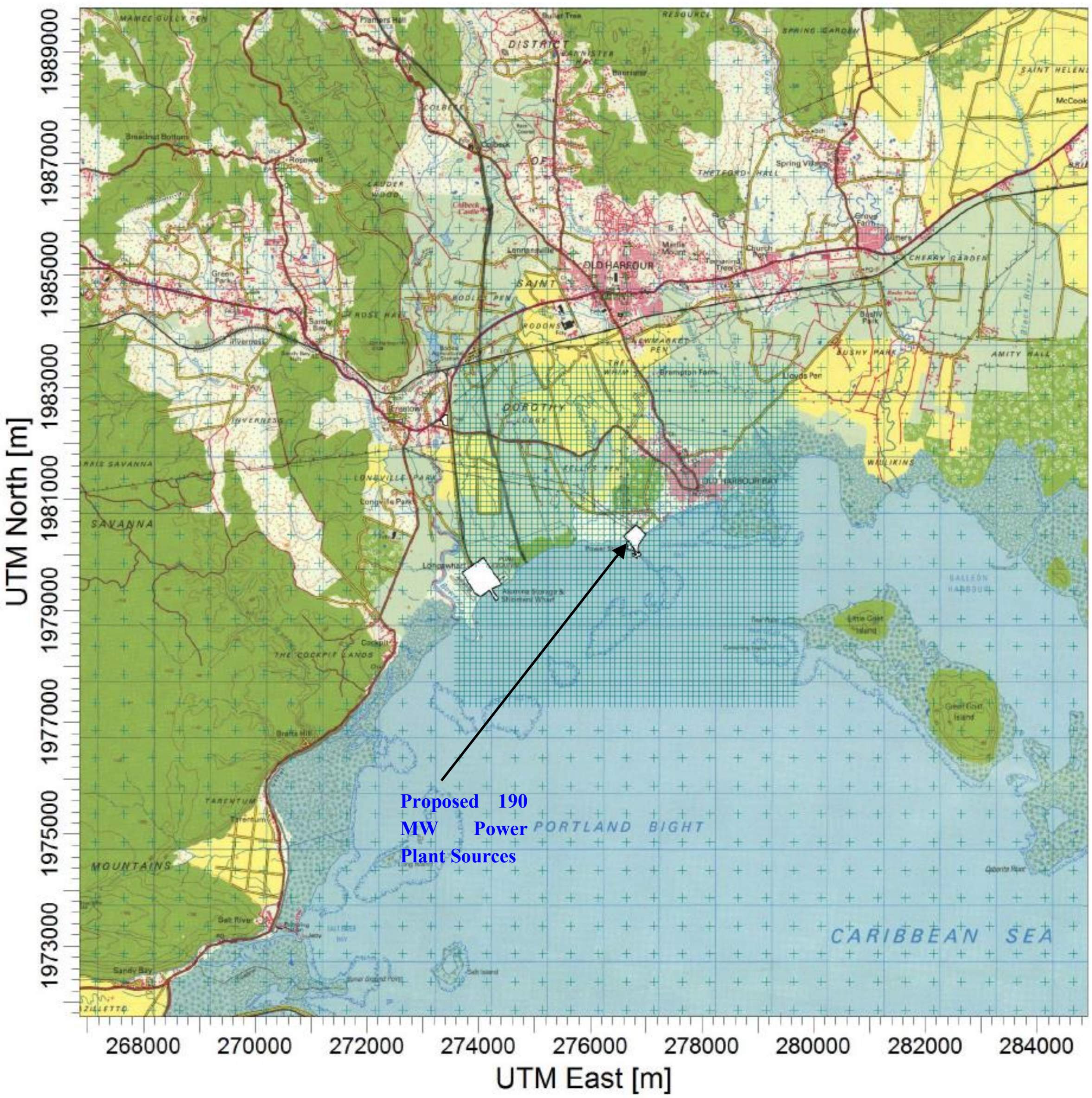
The selected model domain was 20 km in both the east-west and north-south directions, with the centre of the domain being Main Stack #2, with coordinates 276,647 m UTME and 1,980,363 m UTMN. Figure 7-8 shows the model domain that was utilized in the project, including the receptor grid and the plant boundaries. The model domain is overlain on a Jamaica Metric Grid 1:50,000 topographic map.

WIND ROSE PLOT:	DISPLAY:
Wind Rose Plot	**Wind Speed** **Direction (blowing from)**



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	Start Date: 01/01/2009 - 00:00 **End Date: 31/12/2013 - 23:00**	**Air Quality Consultants Limited**	
		MODELER: **Stephen Haughton**	
	CALM WINDS: **1.41%**	TOTAL COUNT: **43824 hrs.**	
	AVG. WIND SPEED: **4.39 m/s**		PROJECT NO.:

Figure 7-7 Wind rose plot for 009-2013 pre-processed met data



COMMENTS:	SOURCES:	COMPANY NAME:	
✦ **Receptors**	27	**AIR QUALITY CONSULTANTS LIMITED**	
	RECEPTORS: **5316**	MODELER:	
		SCALE: 1:115,000 (0 – 4 km)	
			PROJECT NO.:

Figure 7-8 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 Main Stack #2. Certain special receptor locations were also defined, including schools, church buildings, postal agencies, health centres, post offices, police stations and a courthouse.

A total of 5,316 receptors were considered. 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 44 special receptors that include schools, church buildings, postal agencies, health centres, post offices, police stations, a courthouse and air quality monitoring stations (Table 7-30).

Table 7-30 Special receptors

Description	X Coordinate, m	Y Coordinate, m	Elevation, m
Freetown Postal Agency	272484	1982422	22.15
Freetown Church	272459	1982476	24.53
Freetown Church	272397	1982529	25.2
Freetown Primary School	272492	1982820	26.93
Freetown Church	273122	1982894	20.47
Freetown Church	272695	1982517	15.32
Sandy Bay Church	270905	1984336	47.17
Green Park Health Centre	269678	1984465	40.83
Green Park Church	269919	1984552	41.81
Green Park Primary & Junior High School	269956	1984693	42.9
Green Park Church	269861	1985136	53.71
Green Park Church	269889	1985700	62.7
Lancasters Church	267755	1985199	77.47
Lancasters Church	266052	1985000	93.4
Cross Primary & Junior High School	266046	1985479	93
Palmer's Cross Postal Agency	266015	1985541	93
Palmer's Cross Church	266008	1985703	93.01
Palmer's Cross Church	265567	1985858	96.09
Palmer's Cross Church	265437	1985970	94.1
Palmer's Cross Church	265897	1986610	97.84
Palmer's Cross Church	265990	1986865	97.17
Palmer's Cross Church	266469	1986878	96.45
Hazard Primary School	263553	1986859	78.37
Trenton School	263528	1986915	77.13
Staines Preparatory School	270509	1986927	108.87

Description	X Coordinate, m	Y Coordinate, m	Elevation, m
Rosewell Postal Agency	270472	1986865	110.21
Rosewell Church	270584	1986567	95.9
Old Harbour Church	275706	1985398	37.93
Old Harbour Church	275532	1985125	35.23
Old Harbour Church	275681	1984920	32
Old Harbour Church	276042	1985007	31
Old Harbour Church	276123	1984808	29.24
Old Harbour Church	276266	1984590	29.87
Old Harbour Courthouse	276297	1984677	30
Old Harbour Post Office	276377	1984690	30
Old Harbour Police Station	276421	1984677	28.97
Old Harbour Church	276533	1984658	27.06
Old Harbour Bay Primary School	276663	1984621	24.9
Old Harbour High School	276595	1984323	25.25
Old Harbour Health Centre	276639	1984976	27.96
Monsignor Colin Bryan School	276701	1985522	32
Old Harbour Primary School	277925	1985386	44.2
Lauderwood Air Quality Station	272095	1986049	132.97
Longville Park Air Quality Station	270754	1981594	70.75

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 modelling 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, about 25% (less than the 50% threshold) of the 3 km radius area around the project site matches the urban zones of I1, I2, C1, and R2 (see Table 7-31). The majority of the area was cultivated land and sea, and hence the rural option was selected.

Table 7-31 Land use categories

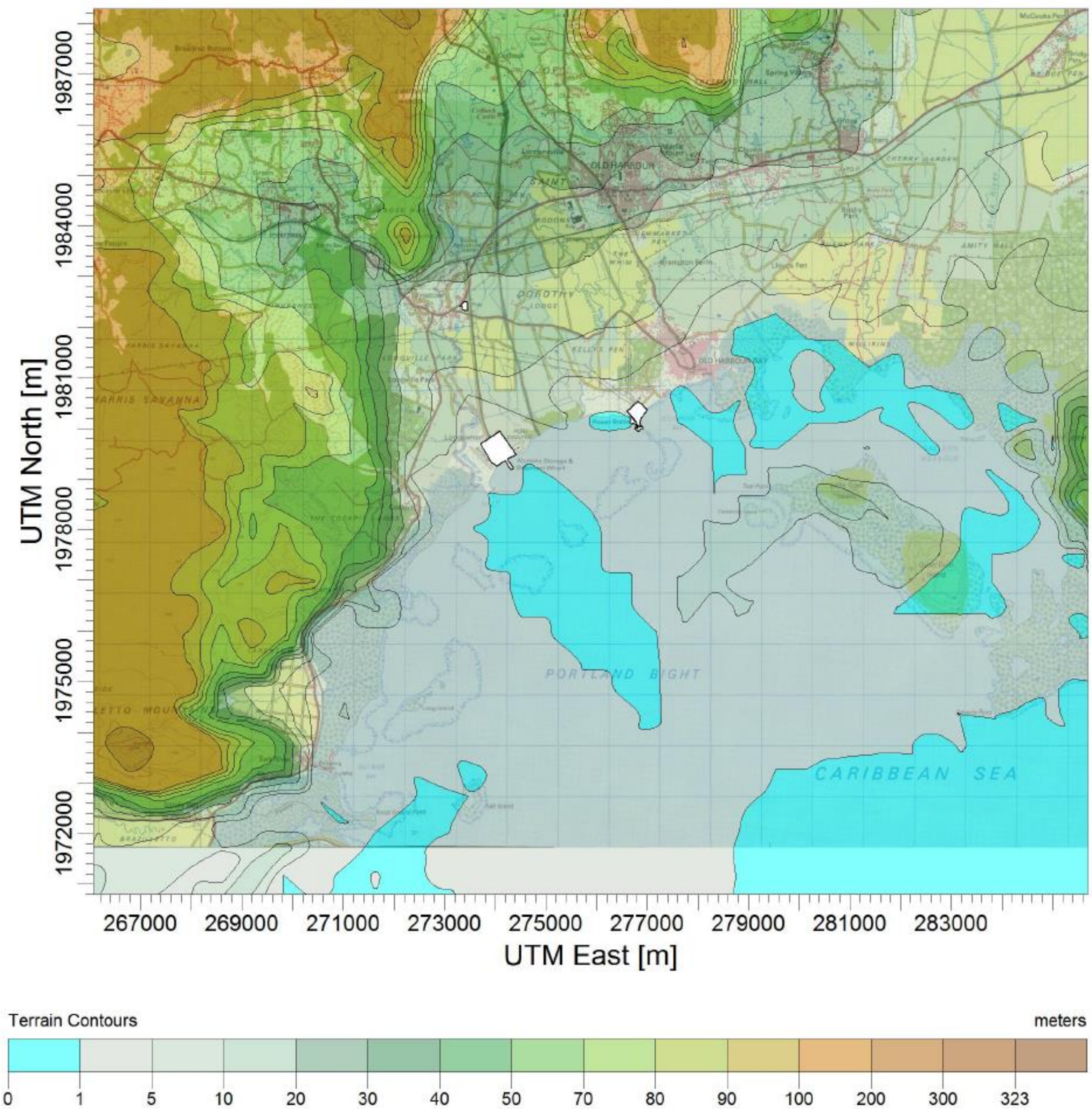
Auer Land Use Categories I1, I2, C1, & R2 (Auer 1978)

Type	Use and Structure	Vegetation
I1	Heavy Industrial Major chemical, steel and fabrication industries; generally 3-5 story buildings, flat roofs	Grass and tree growth extremely rare; <5% vegetation
I2	Light-moderate industrial Rail yards, truck depots, warehouses, industrial parks, minor fabrications; generally 1-3 story buildings, flat roofs	Very limited grass, trees almost totally absent; <5% vegetation
C1	Commercial Office and apartment buildings, hotels;>10 story heights, flat roofs	Limited grass and trees; <15% vegetation
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 made and obtained as Digital Elevation Maps derived by the Mona Informatix Limited's personnel. 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 7-9). 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 modelling analysis.

PROJECT TITLE:
Terrain Data



COMMENTS:	SOURCES: 27	COMPANY NAME: **AIR QUALITY CONSULTANTS LIMITED**	
	RECEPTORS: **5316**	MODELER:	
		SCALE: 1:125,000 (0 – 5 km)	
			PROJECT NO.:

Figure 7-9 Terrain data for the project area

MODEL RESULTS AND IMPACTS

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 Main Stack #2, and the necessary input files created, model predictions were made for the pollutants SO_2, NO_x, TSP, 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 power plant's air pollutant sources alone, as well as the 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-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 7-32 summarizes the maximum predicted concentrations for the proposed LNG-fired power plant 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 when combusting LNG (the primary fuel), 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.

Figure 7-10 through Figure 7-19 show the pollutant contour plot-files for TSP, NO_x, CO and PM_{10} for the proposed power plant when combusting LNG. 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.

Table 7-32 Model results for the proposed power plant using LNG

Pollutant	Avg. Period	Background (µg/m³)	Significant Impact Concentration (µg/m³)	Jamaican NAAQS (µg/m³)	Proposed 190MW Power Plant Sources		
					Max Conc (µg/m³)	UTME (m)	UTMN (m)
TSP	24-hr	14	80	150	5.3	270147	1981363
	Annual	20	21	60	0.64	275947	1980663
NO_2	1-hr	0	N/A	400	158.2	277147	1987363
	24-hr	0	80	N/A	26.9	276247	1978963
	Annual	0	21	100	9.5	275947	1980663
SO_2	1-hr	0	N/A	700	32.3	277147	1987363
	24-hr	0	80	280	2.7	270147	1981363
	Annual	0	21	60	0.3	275947	1980663
CO	1-hr	0	2000	40000	285.5	277147	1987363

Pollutant	Avg. Period	Background (μg/m³)	Significant Impact Concentration (μg/m³)	Jamaican NAAQS (μg/m³)	Proposed 190MW Power Plant Sources		
					Max Conc (μg/m³)	UTME (m)	UTMN (m)
	8-hr	0	500	10000	65.6	268647	1981363
Acetaldehyde	1-hr	0	N/A	1250	0.38	277147	1987363
	24-hr	0	N/A	500	0.03	270147	1981363
Acrolein	1-hr	0	N/A	58.75	0.06101	277147	1987363
	24-hr	0	N/A	23.5	0.00512	270147	1981363
Benzene	Annual	0	N/A	1	0.00116	275947	1980663
Formaldehyde	1-hr	0	N/A	162.5	6.7	277147	1987363
	24-hr	0	N/A	65	0.6	270147	1981363
Xylenes	1-hr	0	N/A	5750	0.6	277147	1987363
	24-hr	0	N/A	2300	0.05	270147	1981363

SUMMARY AND CONCLUSIONS

The following conclusions may be made as a result of the conduct of the air dispersion modelling analyses for the proposed LNG-fired power plant:

- The emission rates derived from the use of emission factors for each combustion turbine burning LNG, comply with the CO and PM emission standards, but exceeded the NO_x standards. It was deduced that in order to achieve compliance with the NO_x emission standard, certain changes with the design of the diluent injection technology to be employed for NOx reduction will have to be made.
- The model predictions for the LNG-fired proposed power plant revealed compliance with the CO, TSP, NO_2 and SO_2 ambient air quality standards and the priority air pollutant guideline concentrations for the requisite averaging periods. The incremental impact of the criteria air pollutants were also less than the established values that would have created a significant air quality impact.
- Based on the modelling results, the replacement of the existing JPS oil-fired power plant with the proposed LNG-fired power plant would cause a marked improvement to the prevailing SO_2 ambient air quality concentration within the air shed, while its impact on the prevailing TSP, CO and NOx concentrations will only have marginal improvement.
- Since the proposed LNG fired power plant sources demonstrated compliance with the ambient air quality standards and the guideline concentrations, as well as with the significant impact incremental values, it is envisaged that approval will be granted for the establishment of the facility. Nevertheless, it is anticipated that certain changes would need to be done for each combustion turbine's NOx emissions to achieve compliance with the NOx emission standard for a 40 MW capacity LNG-fired unit.

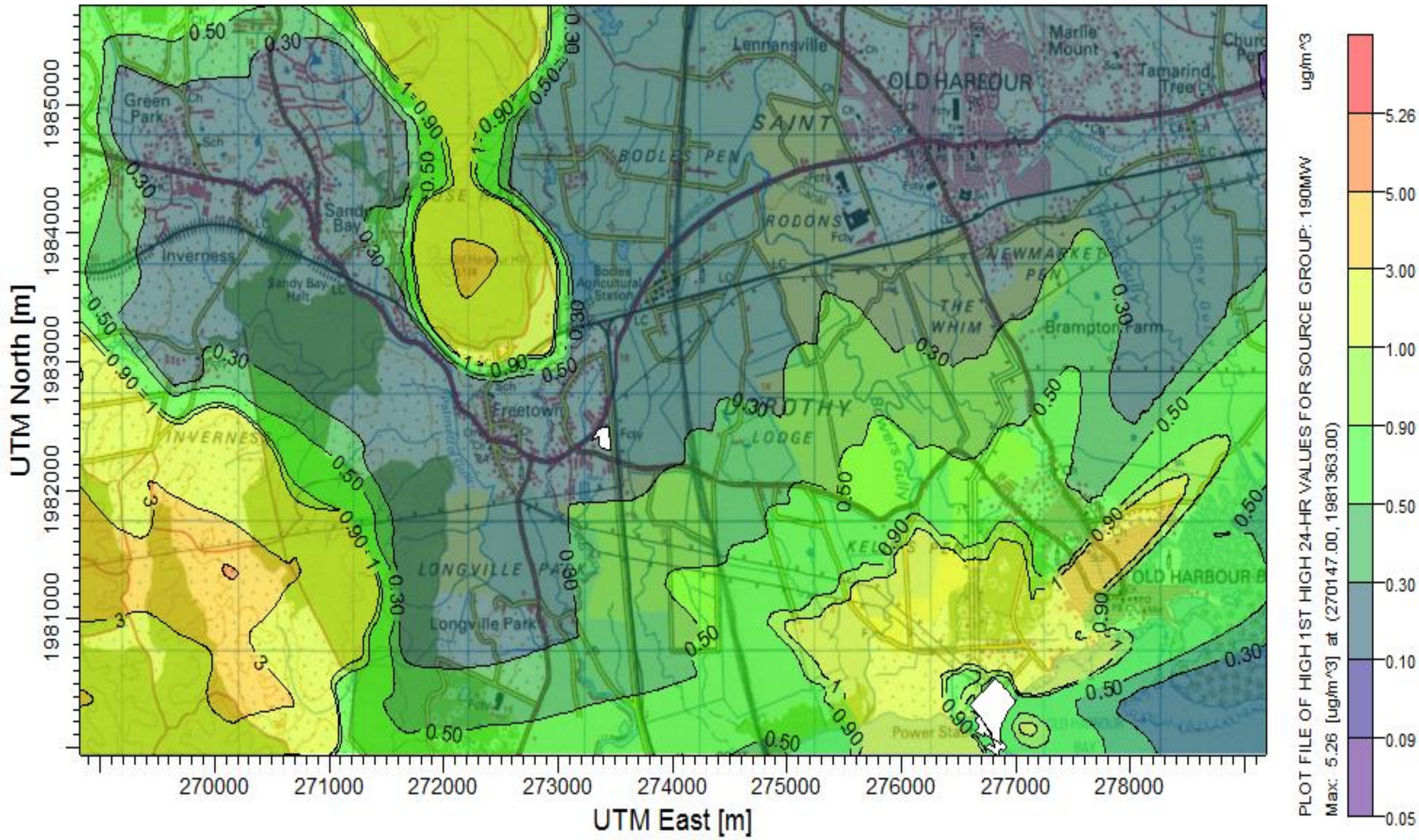


Figure 7-10 Predicted 24h TSP concentrations – proposed LNG Power Plant only

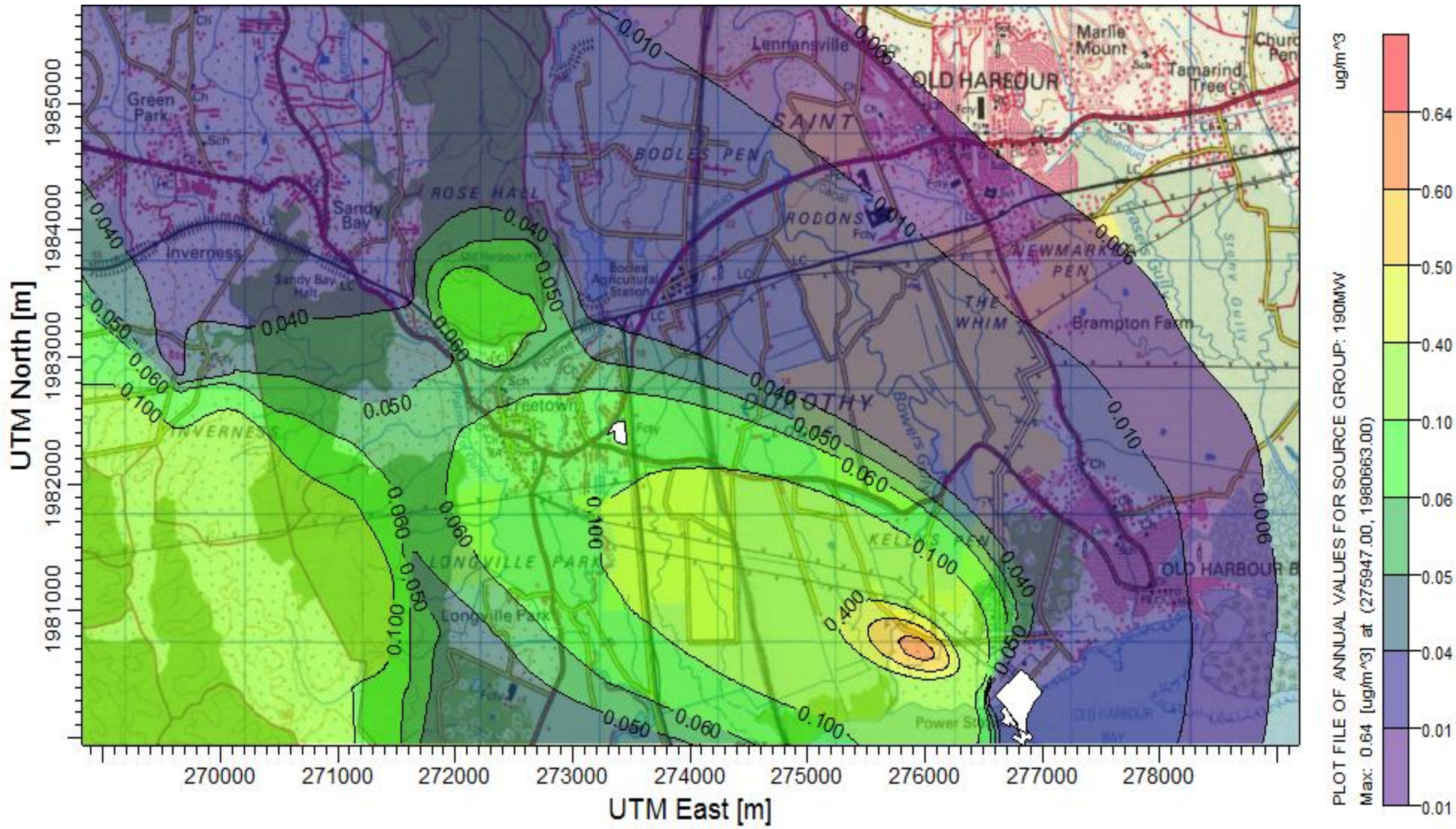


Figure 7-11 Predicted annual TSP concentrations – proposed LNG Power Plant only

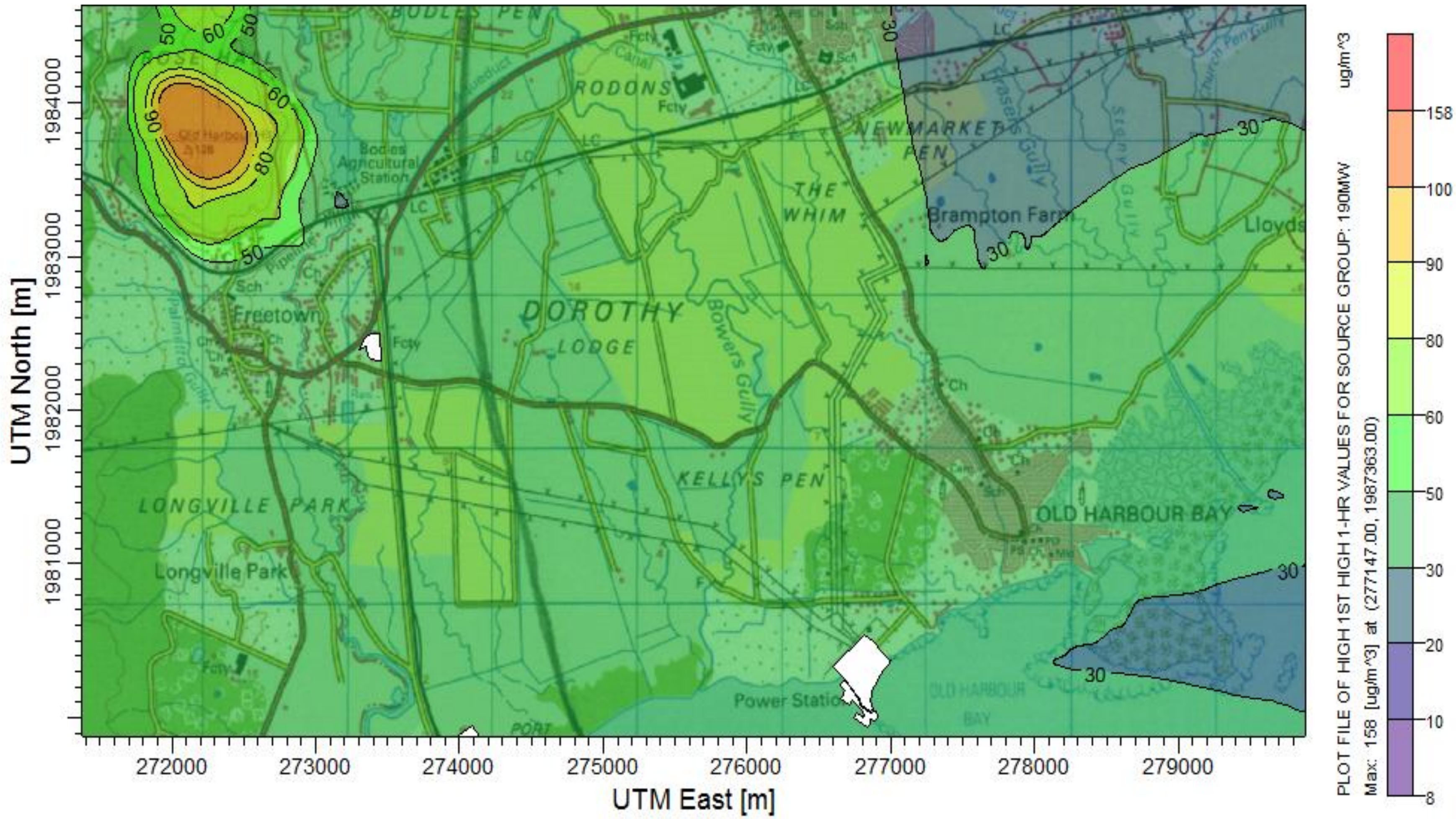


Figure 7-12 Predicted 1h NO_2 concentrations – proposed LNG Power Plant only

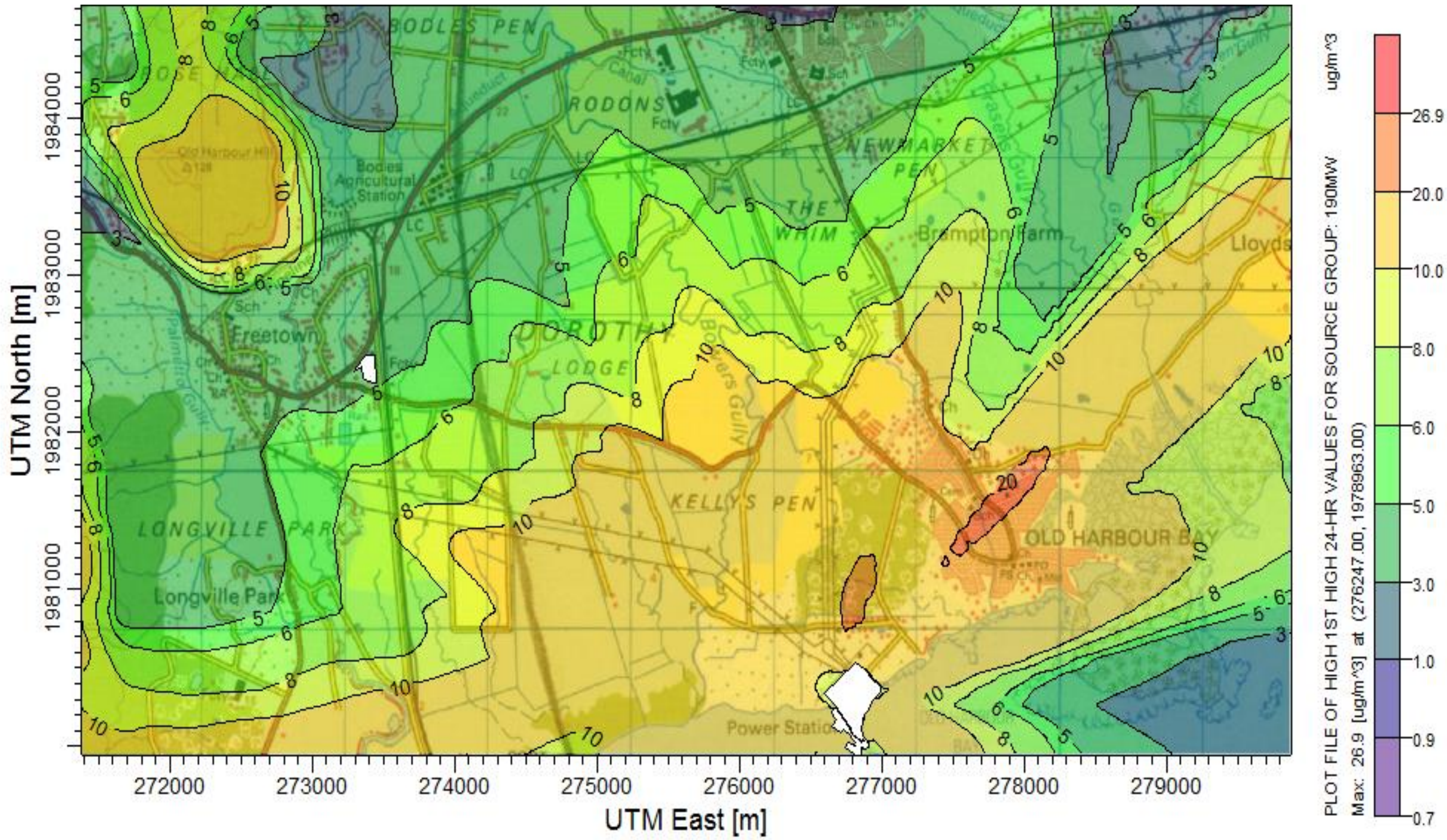


Figure 7-13 Predicted 24h NO_2 concentrations – proposed LNG Power Plant only

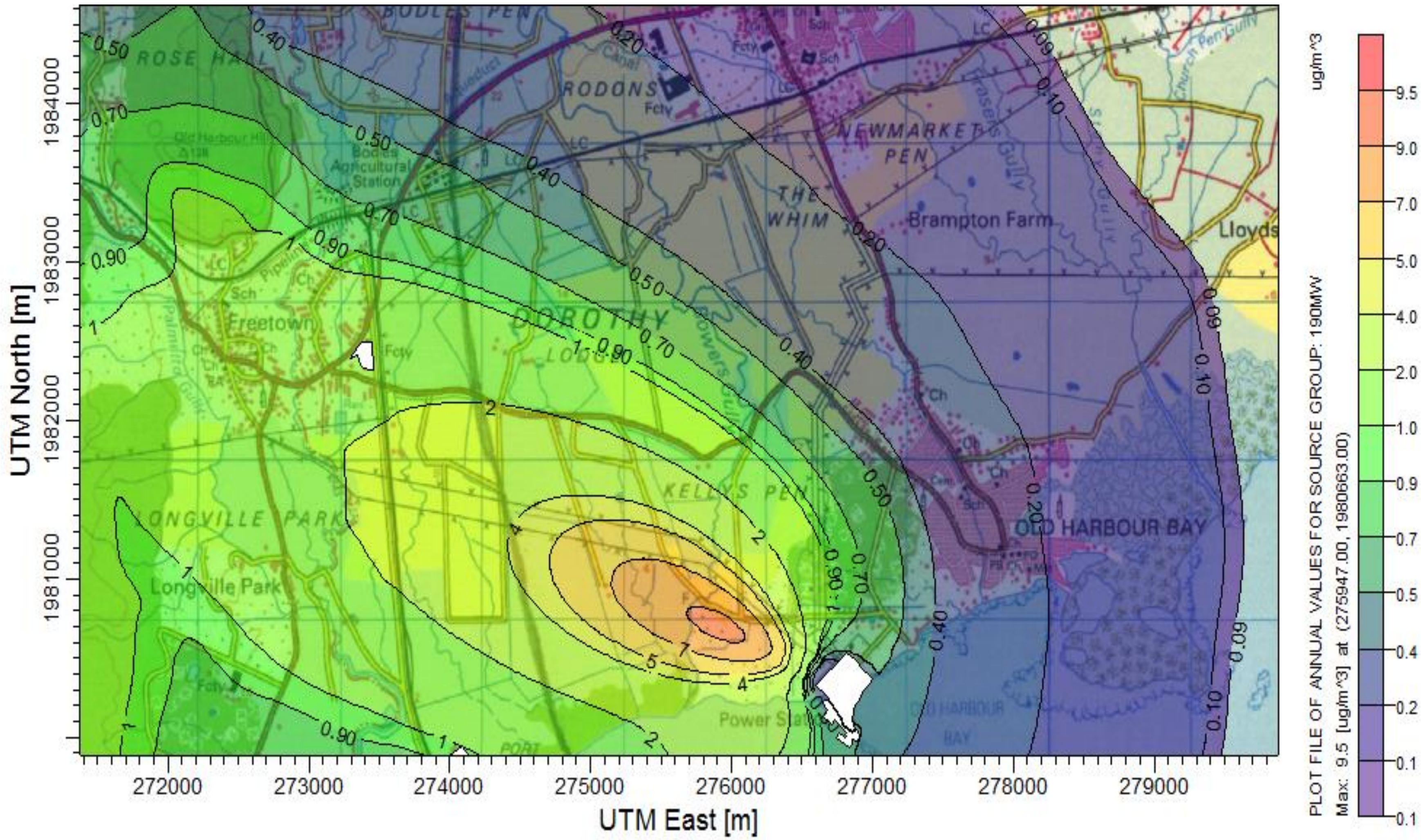


Figure 7-14 Predicted annual NO_2 concentrations – proposed LNG Power Plant only

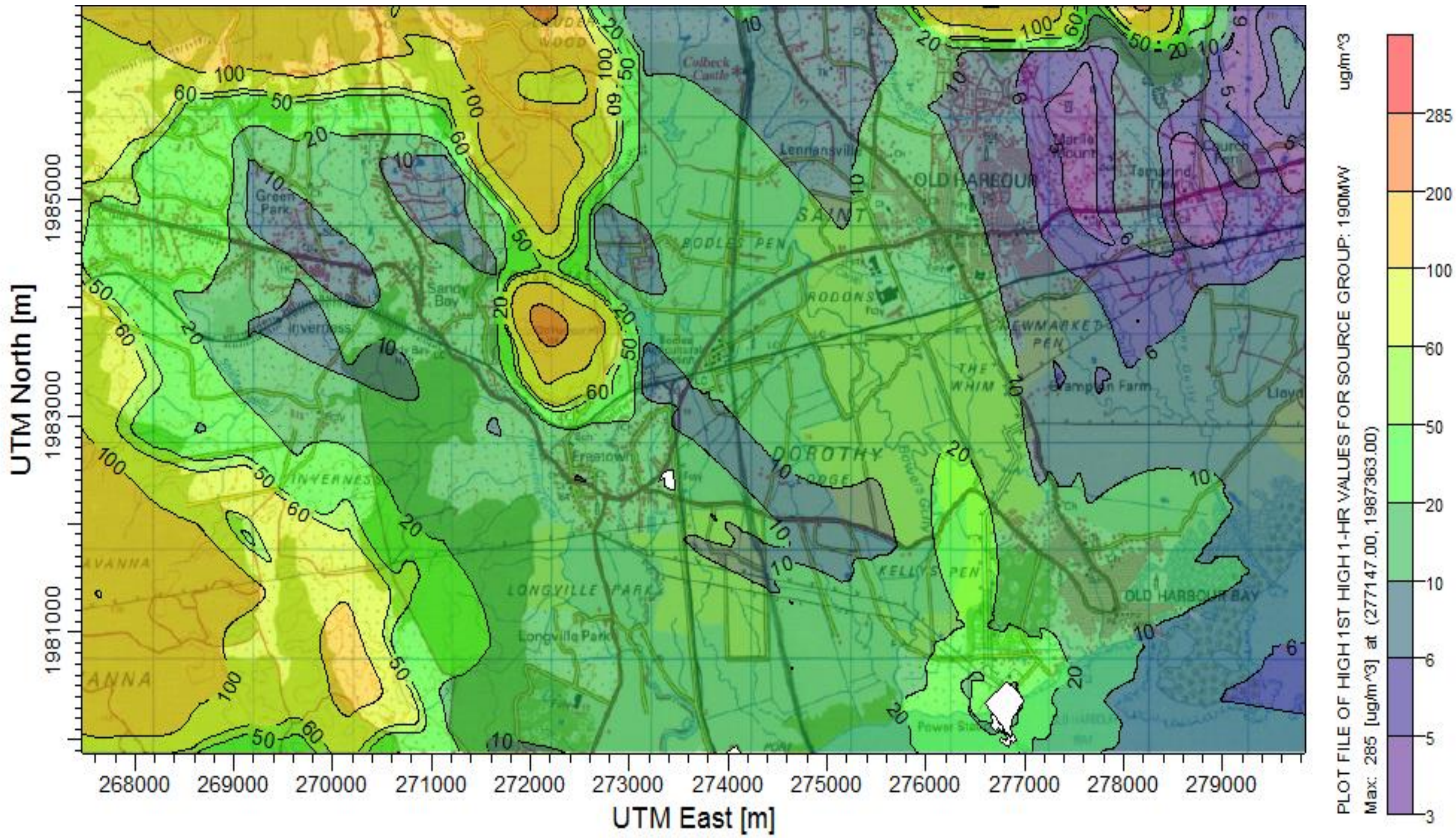


Figure 7-15 Predicted 1h CO concentrations – proposed LNG Power Plant only

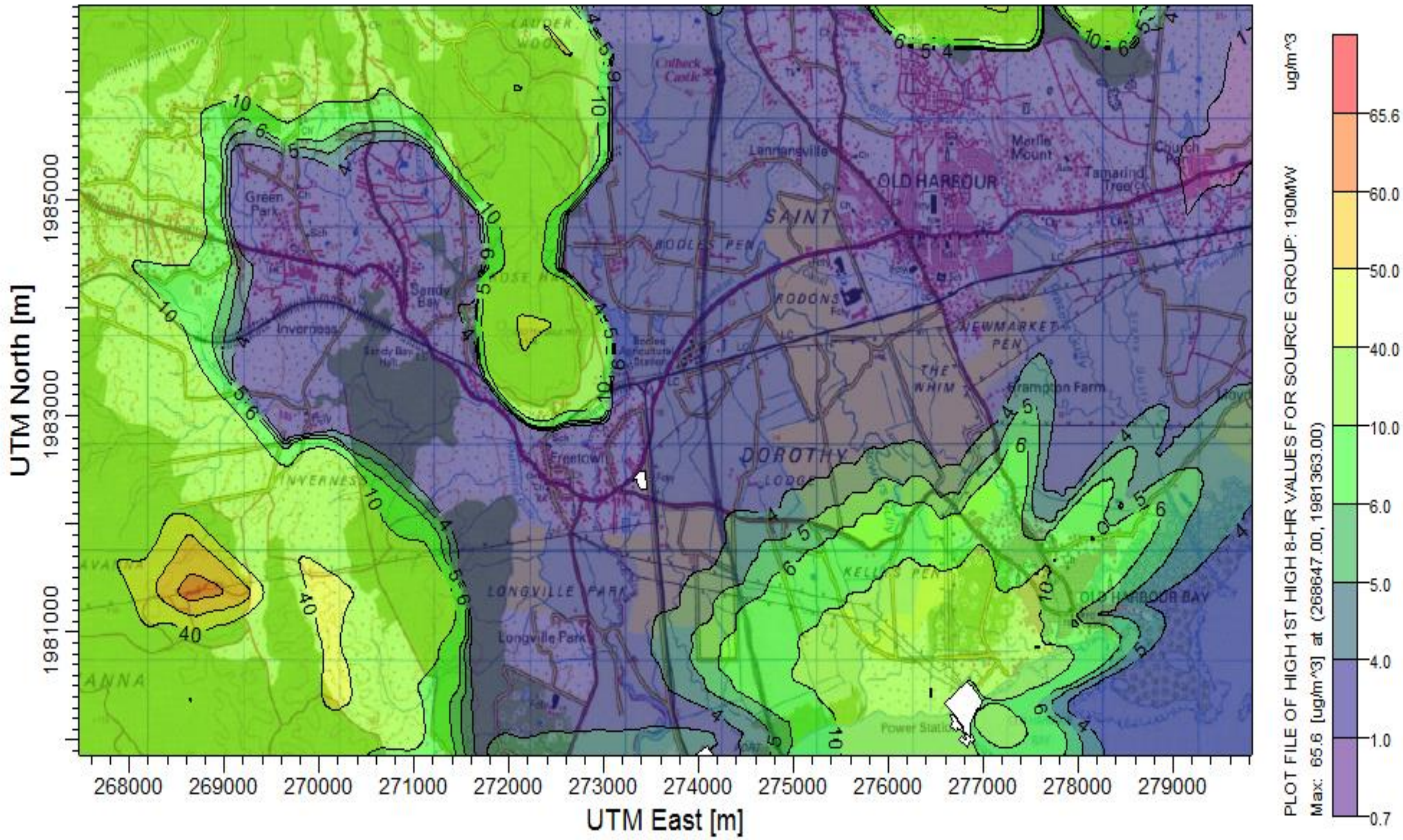


Figure 7-16 Predicted 8h CO concentrations – proposed LNG Power Plant only

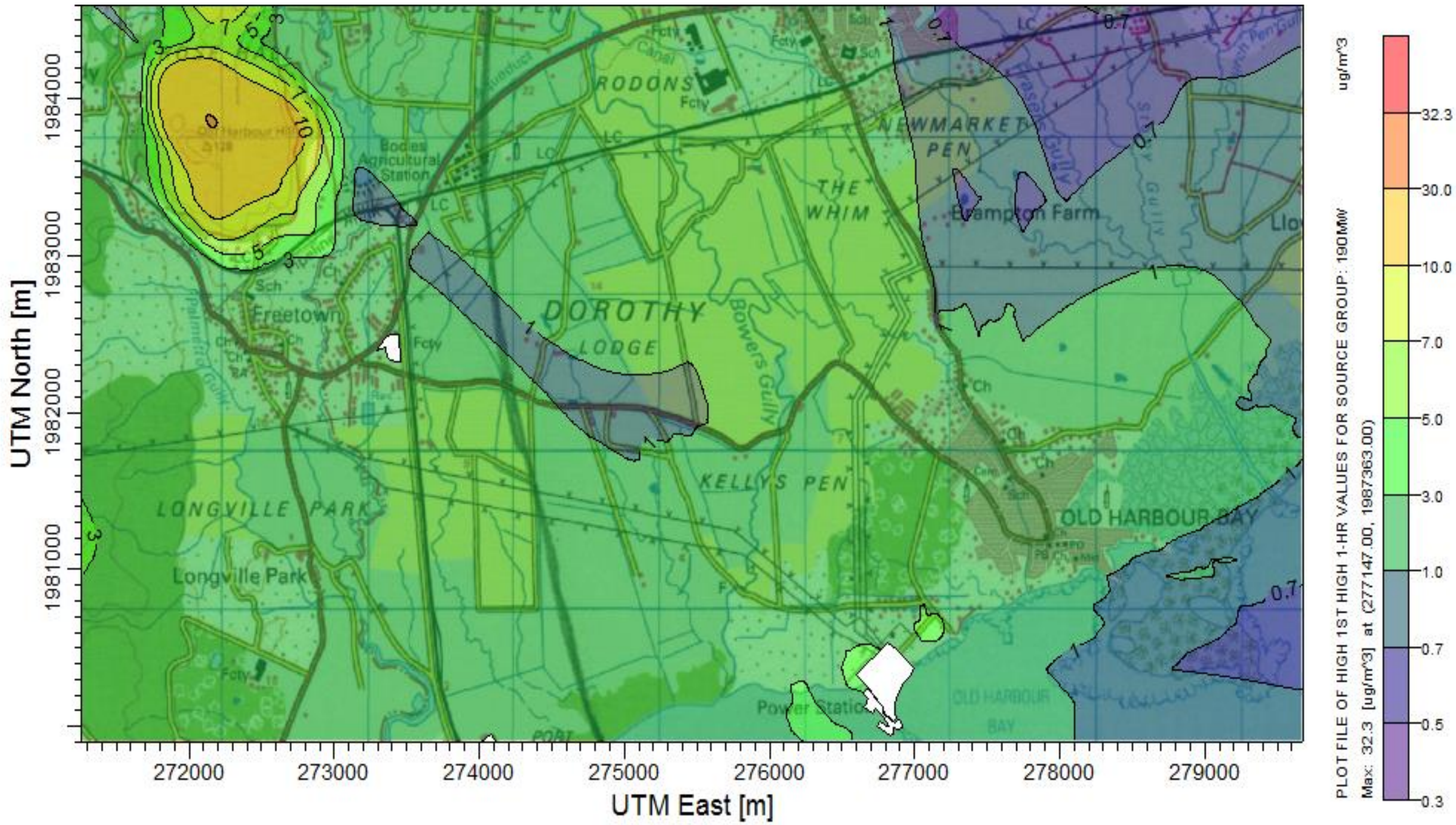


Figure 7-17 Predicted 1h SO_2 concentrations – proposed LNG Power Plant only

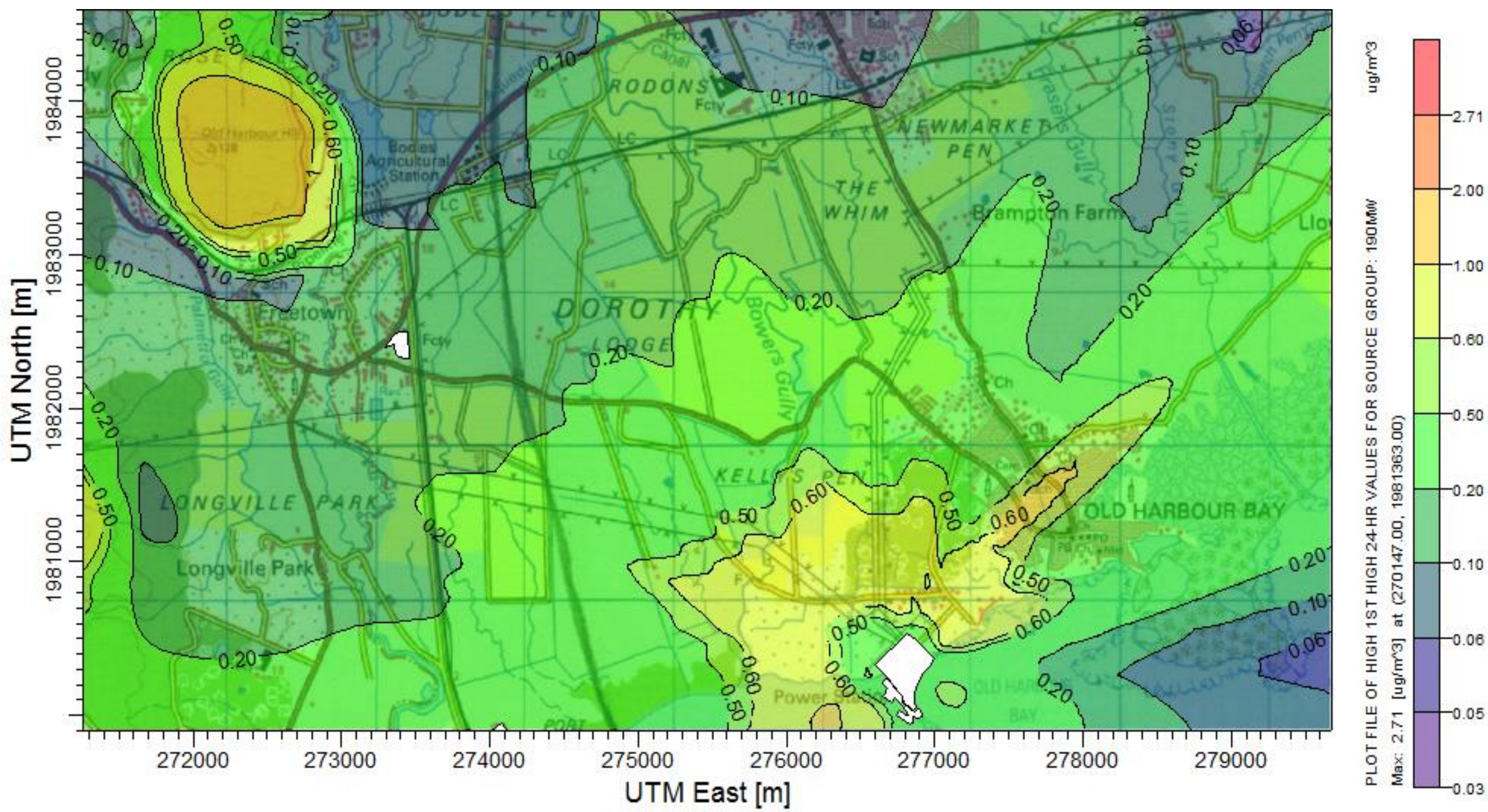


Figure 7-18 Predicted 24h SO_2 concentrations – proposed LNG Power Plant only

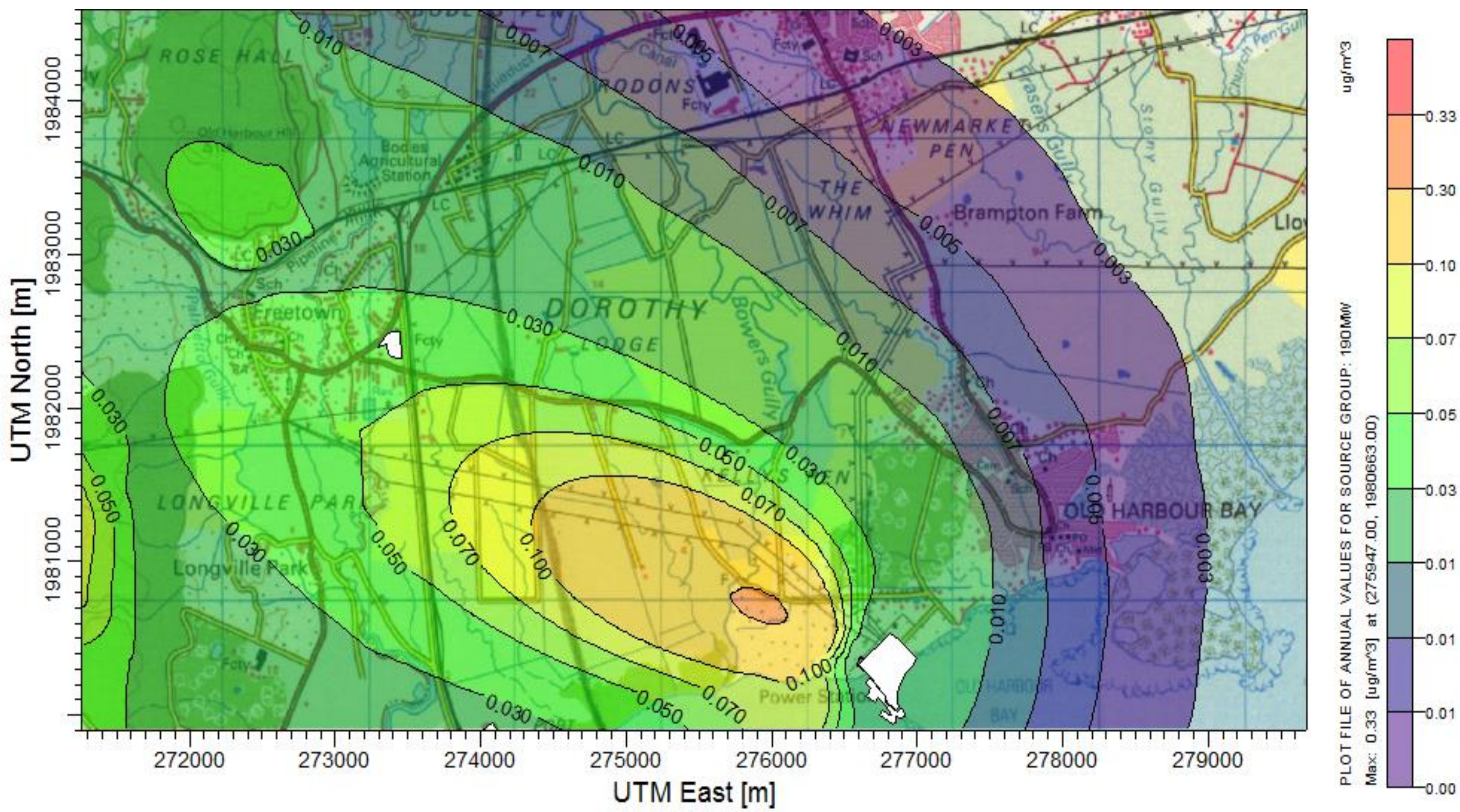


Figure 7-19 Predicted annual SO_2 concentrations – proposed LNG Power Plant only

Greenhouse Gas Emissions

GREENHOUSE GAS (GHG) EMISSIONS FOR 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 7-33):

Table 7-33 Greenhouse Gas 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
	N_2O	0.53	0.0000636	19.5
	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.*

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 10^9 kJ/h for the LNG to be used, the following emission rates were calculated (Table 7-34):

Table 7-34 Greenhouse Gas Emission rates for LNG Facility

Facility	Pollutant	Emission Factor, lb/MMBtu	Facility Emission Rate, tonne/y
LNG-Fired Combustion Turbine	CO_2	110	5.73E+05
	N_2O	0.003	1.56E+01
	CH_4	0.0086	4.48E+01

**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.*

7.2.2 Natural Hazards

7.2.2.1 Hurricane Waves, Tsunami and Storm Surge

For hurricane wind generated waves from deepwater, the largest predicted wave heights to reach the shoreline were generated from the SE and S directions ranging from 1.5 to 2 m for the 100 year return period; while for the 50 year return period wave heights of up to 1.5m was noticed reaching the shoreline. The site is 0.5m to 2.0m above msl and as such impacts from hurricane waves should be considered. Although tsunami (seismic sea waves) are rare for Jamaica, historical records for Jamaica indicate that the highest inundation elevation ever reported for the Jamaican south coast was 2.2 m at Port Royal (NOAA/NGDC, 2012). A similar event at Old Harbour would immerse some two fifths of the area of interest and most of the site of the proposed power station. In addition, storm surge analysis indicated that the entire project site is susceptible to flooding as a result of the 50 year storm surge. Given the hurricane wave models, historical tsunami evaluation and storm surge inundation modelling, coastal inundation has the potential to affect the project area.

RECOMMENDED MITIGATION

i. All new structures should be built to withstand hurricane, storm surge, tsunami and associated inundation impacts and other mitigative steps taken to protect the proposed project from these hazards should be taken.
ii. Ensure hurricanes and tsunamis are included the emergency response plan.

7.2.2.2 Earthquakes and Liquefaction

The Old Harbour Bay area has a 10% probability of experiencing accelerations of about 260 gals (26% g) per fifty years. As described in the "Liquefaction Potential Analysis" report by Earth Systems Engineering, Ltd., the project site is in a historically active seismic area and the soils types in the vicinity of the proposed marine structures are subject to potential liquefaction in the sandy lenses of the upper 5 to 10 meters caused by seismic distress.

RECOMMENDED MITIGATION

i. Detailed design of the marine structures and the subsea pipeline must take into consideration both the forces induced by design seismic events and the potential for liquefaction in the upper 5 to 10 meters of soil during these event. The "Liquefaction Potential Analysis" report as well as all other governing codes should be used for the detailed design of the marine structures and the subsea pipeline.
ii. Ensure earthquakes and liquefaction are included the emergency response plan.

7.2.2.3 Long Term Sea Level Rise

Projected increases in global and Caribbean mean sea level by 2100 relative to the 1980-1999 is 0.37m[26] ($\pm$ 0.5 m relative to global mean) and this is equivalent to 3.7 mm/yr.

RECOMMENDED MITIGATION

i. Attention should be paid to the likely changes in sea-level during the design life (and beyond) of the plant.

7.2.2.4 Coastal Erosion

Model results (section 5.2.5.2) show that the shoreline is stable for the 50 year and 100 year wave conditions. Historical data shows the shoreline has been eroding over the years. Even though it have moved in response to short term events, the long term process is significantly more dominant. An erosion model based on SLR indicates most of the erosion could be as a result of long term SLR.

RECOMMENDED MITIGATION

Minimize erosion where possible through hard and soft engineering solutions. Minimum floor levels and setbacks must be observed as per the NWA guidelines.

[26] IPCC 2007

7.2.3 Manmade Hazards

The following outlines various manmade hazards and mitigation measures:

- Fire is one of the major and most common risks. This can result from incidences such as transformer failure and gas and steam turbine malfunctions.
- Correct operation and monitoring of machines is critical. Attention should be paid to all steps in operation, including start up and pre-start checks.
- Improperly controlled maintenance activities can lead to problems. The use of correct components and properly designed spare parts are of equal importance during maintenance activities and manufacturer's guidelines should be properly adhered to. Cleanliness is important in preventing damage to machine blading, as debris or foreign objects left following maintenance activities can get drawn into the turbine can be dangerous and cause damages.
- Quality assurance of component parts and materials is extremely important as gas turbines operate at high speed with high operating temperatures and pressures, and low tolerances between blades and veins. Failure of a relatively minor component within the machine can cause extensive damage.
- Use of proper fuel is very critical. Fuel quality is of importance as rogue chemicals can cause deposits, erosion or corrosion of machine internals leading to long-term damage. Fuel pulsations as a result of varying fuel quality or irregular supply systems can cause vibration in combustion systems and turbine areas leading to mechanical damage that is exacerbated as it is exposed to high temperatures and further operation.

7.2.4 Biological

7.2.4.1 Habitat Fragmentation and Disturbance/Displacement

Seagrass beds occur in distinct patches and form part of the reef crest and should as a result experience little or no fragmentation. The potential pipeline are unlikely to cause any habitat fragmentation. Most mobile invertebrates (meiofauna) should only be temporarily affected/displaced. Fish, larvae, eggs and other plankton and sessile species should also only be temporarily affected. Although turtles are unlikely to use the area (due to larger amounts of activity and noise) for foraging and nesting, if present in the area, should also only experience minimal disturbance and displacement.

7.2.5 Human/Social

7.2.5.1 Solid Waste

Domestic waste from operations will be generated on the power plant site.

RECOMMENDED MITIGATION

Provision of solid waste storage bins and skips. Contracting a private contractor to collect solid waste in a timely fashion to prevent a build-up. Ensure that the solid waste collected is disposed in an approved dumpsite such as the Riverton dump in Kingston.

7.2.5.2 Employment

There is the potential for increased employment during the operation phase. It is anticipated that approximately 45 persons will be employed directly. A number of indirect jobs are expected to be created this further benefitting the community.

7.2.5.3 Land Use and Zoning

Given that 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, and that it is zoned for "heavy industry" according to the Portmore to Clarendon Park Highway 2000 Corridor Development Plan 2004 – 2025, no negative impact to land use is foreseen.

7.2.5.4 Aesthetics and Landscaping

The proposed development will have little, if any, visual impact on the aesthetics of the location due to the fact that the power plant is being placed in a location that is industrial and zoned for industrial purposes.

7.2.6 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.

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. In the case of the proposed 190 MW LNG plant it will lower the amount of greenhouse gases emitted compared with the existing JPSCo Old Harbour plant. 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.

The plant will obtain water from existing wells and will not impact on the water supply the community. Wastewater collection, treatment and disposal will be done through facilities on the proposed 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. This will not impact on solid waste collection or disposal in the SIA.

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. Therefore, it will be able to deal with any eventualities as it relates to fires on the facility.

It is anticipated that with the new JPS 190MW power plant using less water, having lower air and noise emissions and being more fuel efficient coupled with the other factors listed previously, that the proposed development will not negatively impact the carrying capacity of the area.

RECOMMENDED MITIGATION

None required.

8.0 CUMULATIVE ENVIRONMENTAL IMPACTS

8.1 PHYSICAL

8.1.1 Air Dispersion and Quality

As part of the air dispersion modelling 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 power plant, and the consequent retirement of the existing oil-fired 190 MW JPS facility.

Table 8-1 shows the model results for the existing operating sources, and the future sources category, which does not include the three sources on the existing 190 oil-fired JPS power plant. The results for the existing sources revealed predicted highest concentrations that exceed the respective ambient air quality standards for TSP (24h and annual averaging periods), NO_2 (1h averaging period), and all averaging periods for SO_2. When the future sources were modelled, the results revealed similar exceedances except for 24h and annual SO_2. From these results it can be concluded that the replacement of the existing JPS oil-fired power plant with the proposed LNG-fired power plant will significantly improve the prevailing SO_2 ambient air quality concentration within the air shed, while its impact on the prevailing TSP, CO and NOx concentrations will only be marginal improvement.

Table 8-1 Cumulative impacts (with proposed power plant using LNG)

Pollutant	Avg. Period	Background (µg/m³)	NAAQS (µg/m³)	Existing Sources			Future Sources		
				Max Conc (µg/m³)	UTME (m)	UTMN (m)	Max Conc (µg/m³)	UTME (m)	UTMN (m)
TSP	24-hr	14	150	**245.9**	273350.51	1982416.59	**245.4**	273350.51	1982416.59
	Annual	20	60	**83.7**	273350.51	1982416.59	**83.1**	273350.51	1982416.59
NO_2	1-h	0	400	**841.2**	277147	1987363	**731.8**	277147	1987363
	Annual	0	100	28.9	275947	1980463	27.2	275847	1980563
SO_2	1-hr	0	700	**13374.7**	277147	1987363	**1117.8**	277147	1987363
	24-hr	0	280	**1042.2**	277147	1987363	195.2	276854.67	1980036.08
	Annual	0	60	**131.1**	276147	1980663	31.1	273298.33	1982394..39
CO	1-hr	0	40000	504.4	277147	1987363	423.3	277147	1987363
	8-hr	0	10000	103.6	273361.97	1982349.81	103.6	273361.97	1982349.81

Bold type indicate exceedences above the respective standard

8.1.2 Noise

The operation of the proposed 190 MW LNG power plant will result in an increase in the existing noise level (cumulative) (Table 8-2).

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 190 MW LNG power plant) 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.

8.1.2.1 Comparison with NEPA Guidelines

Only Stations 2, 8, 9 and 11 would comply with the NEPA day time standard and Stations 8, 9 and 11 night time guidelines when the cumulative noise levels are calculated and with or without wind influence. It is important to note, that at Stations 5, 7 and 10, the NEPA Guidelines were being exceeded at these locations prior to the addition of the proposed project whether during the day or night time.

8.1.2.2 Comparison with World Bank Guidelines

Stations 1, 2 (with wind), 3, 4, 5 (with wind) and 6 exceeded the World Bank guidelines during the day time. Stations 5 (without wind), 7 and 10 will exceed the World Bank day time guidelines when the cumulative noise levels are calculated, however, they will comply with the 3dBA rule, thus compliant with World Bank guidelines.

Only Stations 5 (no wind), 7, 8, 9 and 11 will comply with the World Bank night time guidelines when the cumulative noise levels are calculated. Only Station 11 will be compliant without applying the 3 dBA rule. The baseline noise levels at Stations 5, 7 and 10 (day time) and Stations 5, 6, 7, 9 and 10 (night time) were above the guidelines prior to the 190MW project.

Of note, the baseline noise levels at Stations 9 and 10 (day and night time) will not change as a result of the 190 MW Power Plant.

Table 8-2 Cumulative noise levels based on results of noise measurements during (7:00 hrs Friday 27th, to 7:00 hrs Monday 30th, April 2012) and historical data

STATION			DAY TIME (7 am. – 10 pm.) (dBA)							NIGHT TIME (10 pm. – 7 am.) (dBA)						
No.	LOCATION	CATEGORY	BASELINE	PREDICTED NOISE FROM JPS 190MW & DOCTOR BIRDS I & II (GP)	PREDICTED NOISE FROM JPS 190MW & DOCTOR BIRDS I & II (CONCAWE)	CUMULATIVE NOISE FROM JPS 190MW & DOCTOR BIRDS I & II (GP)	CUMULATIVE NOISE FROM JPS 190MW & DOCTOR BIRDS I & II (CONCAWE)	NEPA STD.	WORLD BANK GUIDELINE	BASELINE	PREDICTED NOISE FROM JPS 190MW & DOCTOR BIRDS I & II (GP)	PREDICTED NOISE FROM JPS 190MW & DOCTOR BIRDS I & II (CONCAWE)	CUMULATIVE NOISE FROM JPS 190MW & DOCTOR BIRDS I & II (GP)	CUMULATIVE NOISE FROM JPS 190MW & DOCTOR BIRDS I & II (CONCAWE)	NEPA STD.	WORLD BANK GUIDELINE
1	North-Western Property Boundary	Industrial	66.9	74.7	75.7	75.4	76.2	75	70	59.6	74.7	75.7	74.8	75.8	70	70
2	South-Western Property Boundary	Industrial	62.4	71.5	72.7	72.0	73.1	75	70	56.5	71.5	72.7	71.6	72.8	70	70
3	South-Eastern Property Boundary	Industrial	64.0	77.4	77.8	77.6	78.0	75	70	58.0	77.4	77.8	77.4	77.8	70	70
4	North-Eastern Property Boundary	Industrial	62.9	79.1	79.2	79.2	79.3	75	70	59.8	79.1	79.2	79.2	79.2	70	70
5	Informal Settlement	Residential	61.4[27]	60.5	64.4	64.0	66.2	55	55	59.9	60.5	64.4	63.2	65.7	50	45
6	Blackwood Gardens	Residential	52.2[28]	56.0	60.1	57.5	60.8	55	55	46.9	56.0	60.1	56.5	60.3	50	45
7	Old Harbour Bay Police Station	Residential	56.2[29]	48.9	53.2	56.9	58.0	55	55	52.7	48.9	53.2	54.2	56.0	50	45
8	New Harbour Village Phase II	Residential	43.1	43.5	47.4	46.3	48.8	55	55	41.9	43.5	47.4	45.8	48.5	50	45
9	Longville Park	Residential	51.7[30]	34.1	31.4	51.8	51.7	55	55	49.9	34.1	31.4	50.0	50.0	50	45
10	New Harbour Village Phase I	Residential	60.6[31]	41.1	41.6	60.6	60.6	55	55	56.3	41.1	41.6	56.4	56.4	50	45
11	JPS Guard House	Industrial	61.4[32]	59.1	61.8	63.4	64.6	75	70	54.9	59.1	61.8	60.5	62.6	70	70

NB: Numbers in red indicate non-compliance with both NEPA and World Bank guidelines, blue indicate non-compliance with World Bank guideline, green indicate non-compliance with NEPA guidelines but compliance with World Bank guidelines when the 3 dBA rule is applied and purple indicate compliance with NEPA guidelines and compliance with World Bank guidelines when the 3 dBA rule is applied.

[27] Average of noise data from 2007 – 2012 (Campbell 2014), Jamaica Energy Partners Annual Noise Assessment (2013 and 2014) and current measurements

[28] Average of noise datd from Jamaica Public Service Noise Assessments (2010, 2011 and 2013), South Jamaica Public Company EIA (2012) and current measurements

[29] 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

[30] One of noise measurements conducted for the South Jamaica Public Company EIA (2012)

[31] 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)

[32] One of noise measurements conducted for the South Jamaica Public Company EIA (2012)

8.1.2.3 Sensitive Receptors

Schools

When the predicted noise generated from the operation of the 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. When the General Prediction model was used the noise ranged from a low of 34.6 dBA (Longville Park Early Childhood Centre) to a high of 49.9 dBA (Blackwood Gardens Basic School) and when the Concawe model was used it ranged from a low of 32.1 dBA (Longville Park Early Childhood Centre) to a high of 54.6 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 JPS 190MW and the JEP Doctor Birds I and II plants are operational, the noise levels at five school were non-compliant with both NEPA day time standard and World Bank guideline (Table 8-3). The schools that had non-compliant noise levels were:

i. Blackwood Gardens Basic School
ii. Children First Basic
iii. Old Harbour Bay Primary
iv. Baptist Early Childhood Centre
v. St. Wade Basic School

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	DISTANCE FROM DOCTOR BIRD POWER FACILITY (m)	LAeq (16)		NEPA STD	WORLD BANK GUIDELINE
		JPS 190 MW & DOCTOR BIRDS I & II	CONCAWE S – JPS 190 MW & DOCTOR BIRDS I & II		
Blackwood Gardens Basic School	1143.7	49.9	54.6	45	55
Children First Basic	1235.0	49.8	54.2	45	55
Old Harbour Bay Primary	1330.1	48.5	53.4	45	55
Baptist Early Childhood Centre	1353.3	49.0	53.5	45	55
St. Wade Basic School	1415.0	48.0	52.9	45	55
Old Harbour High School	3795.6	37.9	37.0	45	55
Portmore Community College (Old Harbour)	4149.2	37.3	37.2	45	55
Freetown Primary	4409.1	34.8	35.6	45	55
Monsignor Colin Bryan Preparatory	4597.5	35.3	34.6	45	55
Longville Park Early Childhood Centre	4609.3	34.6	32.1	45	55
Old Harbour Early Childhood Institution	5009.3	35.3	35.3	45	55
Old Harbour Primary	5091.8	35.2	35.2	45	55

NB: Numbers in red are non-compliant with NEPA day time standard and World Bank guideline

Churches

When the noise generated from the operation of the JPS 190MW and the JEP Doctor Birds I and II were predicted by both models, the noise levels did not exhibit the inverse law. Noise levels ranged from a low of 34.6 dBA (Longville Park Church) to a high of 50.7 dBA (Mount Refuge Fire Baptize Holiness) when the General Prediction model was used. When the Concawe model was used, noise ranged from a low of 32.2 dBA (Longville Park Church) to a high of 55.5 dBA (Mount Refuge Fire Baptize Holiness) (Table 8-4).

COMPARISON WITH LOCAL STANDARD AND INTERNATIONAL GUIDELINE

With the exception of the predicted noise at Mount Refuge Fire Baptize Holiness when JPS 190MW and JEP Doctor Birds I and II are operational (Concawe), all other predicted noise levels were compliant with both the NEPA daytime standard and the World Bank guideline when both the General Prediction and concawe models were used (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	DISTANCE FROM DOCTOR BIRD POWER FACILITY (m)	LAeq (16)		NEPA STD	WORLD BANK GUIDELINE
		GP JPS 190 MW & DOCTOR BIRDS I & II	CONCAWE S – JPS 190 MW & DOCTOR BIRDS I & II		
Mount Refuge Fire Baptize Holiness	1038.5	50.7	55.5	55	55
Unnamed Church	1353.0	48.0	52.8	55	55
St Phillips Anglican	1370.9	48.8	53.4	55	55
Refuge Temple Old Harbour Bay	1454.2	47.8	52.6	55	55
Old Harbour Bay Baptist	1499.4	47.6	52.4	55	55
Old Harbour Bay SDA	1564.9	47.0	52.0	55	55
Faith Bible Baptist Church	1792.3	45.9	50.7	55	55
Old Harbour Evangelistic Centre	3471.4	39.0	39.9	55	55
Church of Our Lord Apostolic Faith	3868.2	33.8	32.8	55	55
Jehovah Witness	3948.2	37.8	36.6	55	55
Hebron Gospel Hall	4120.0	37.5	36.4	55	55
Old Harbour SDA	4185.9	37.3	37.2	55	55
Holy Ghost Ministries Inc.	4312.6	35.4	35.0	55	55
Church of the Holy Trinity	4347.4	36.9	35.7	55	55
St. Michael & St. George Anglican	4421.3	35.0	35.6	55	55
Longville Park Church	4611.7	34.6	32.2	55	55
St Dorothy's Anglican Church	4992.7	35.2	35.8	55	55
Old Harbour Baptist	5061.7	35.2	35.0	55	55

NB: Number in red is non-compliant with NEPA day time standard and World Bank guideline

Clinics

The noise levels at two clinics were examined when noise levels were predicted with JPS 190MW and JEP Doctor Birds I and II are operational. The noise levels exhibited the inverse law when either General Prediction or Concawe models were used. The noise levels when the General Prediction model was used varied from 36.5 dBA (Old Harbour Health Centre) and 46.5 dBA (Bay View Medical Centre) and when Concawe model was used 36.5 dBA (Old Harbour Health Centre) and 51.4 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 whether the General Prediction and Concawe models were used (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	DISTANCE FROM DOCTOR BIRD POWER FACILITY (m)	LAeq (16)		NEPA STD	WORLD BANK GUIDELINE
		GP JPS 190 MW & DOCTOR BIRDS I & II	CONCAWE S – JPS 190 MW & DOCTOR BIRDS I & II		
Bay View Medical Centre	1669.2	46.5	51.4	55	55
Old Harbour Health Centre	4479.2	36.5	36.5	55	55

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 both the construction and the operation phases. Even with the proper mitigative steps, short-term impacts of varying duration such as pile driving, which is a high-noise activity, will 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 high intensity but of relatively short duration.

9.1.3 Traffic

The construction of the new power plant and associated delivery vehicles may introduce traffic delays thereby increasing the travel time. Negative impacts on traffic are expected during the construction stages, including reduced level of service in the areas surrounding Old Harbour and Old Harbour Bay due to increased large/construction vehicle on the roads.

9.2 OPERATION

9.2.1 Socio-Economic

9.2.1.1 Lower Energy Costs

Electricity costs are calculated to be lower by 30% when the new LNG power plant comes on line. Therefore, there will be a high residual impact of unmet public expectation if the new plant is not operated on LNG and the concomitant lower of electricity costs.

9.2.1.2 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 JPS. The possibility also exists that there will be resentment towards JPS arising from perceptions of bias in the recruitment process.

9.2.1.3 Accidents involving community members

The possibility exists that accidents involving community members will 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 analyse 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 following alternatives have been identified. They are discussed in further detail below:

- The "No-Action" Alternative
- The proposed development as described in the EIA
- Project Site Alternatives
- Development Alternatives
- Alternative Energy Sources

10.1 THE 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. The main consideration with this alternative, is that the project goal would not be met, that is, the proposed capacity intended to replace the inefficient heavy fuel oil burning plants will not be achieved. Further, the impacts discussed previously would not occur.

In light of the existing JPS Old Harbour facility already in the vicinity, and the major infrastructure already in place, the "no action" alternative will have a minimal effect on the physical and biological environment. In terms of the socioeconomic environment, the "no-action" alternative would result in increased possibilities of power outages for residents of Jamaica, lower job and industrial productivity in the project area, limited economic improvement, and eliminate job creation opportunities nationally. It is speculative to state the response of energy producers and end users if the project objective is not met by the proposed project. However, it should be considered that this "no action" alternative may possibly lead to the investigation of other energy providing arrangements, including renewable sources or nuclear power (discussed below), or even the greater use of other fossil-fuels that are accompanied by increased environmental adverse impacts, when compared to that of natural gas.

10.2 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA

The biological, physical and socioeconomic impacts and mitigation measures for this alternative are discussed in detail throughout this report. The positive impacts have been identified in social and economic benefits for local and national individuals due to lower potential of power outages and increased job creation. However, this project also has the potential to adversely impact the air quality of the air shed surrounding the proposed development, and increase noise pollution and water pollution of the surrounding water body. These impacts will require effective mitigation.

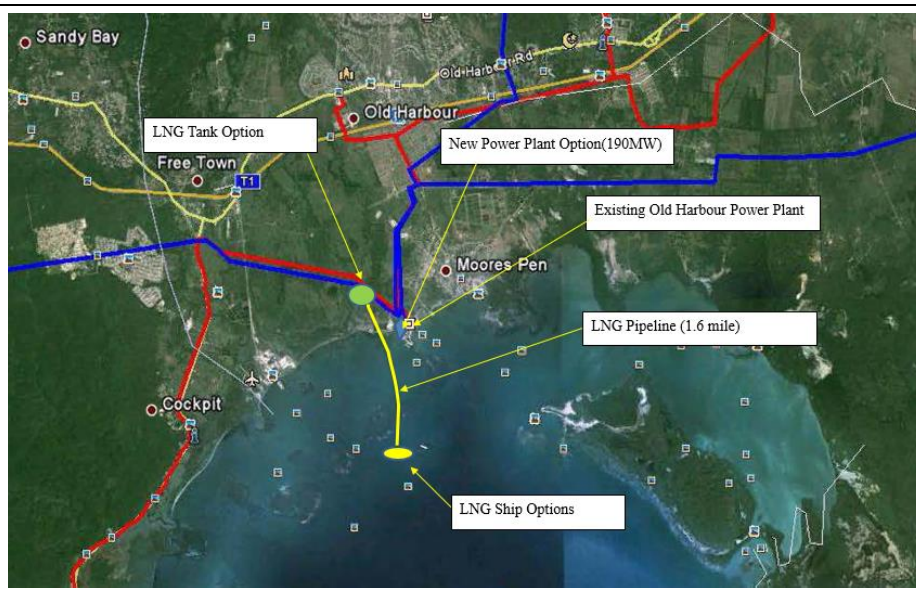
10.3 PROJECT SITE AND LAYOUT ALTERNATIVES

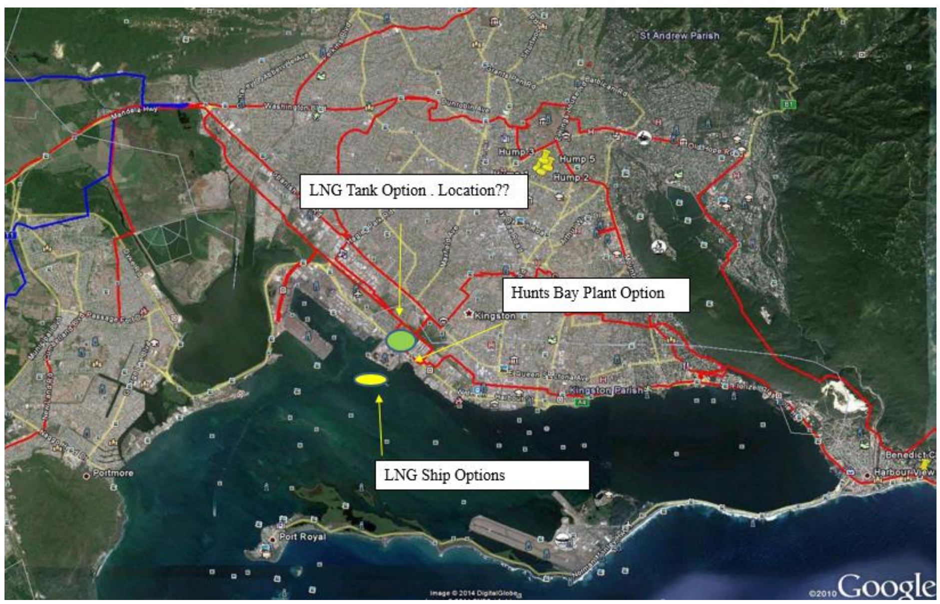
10.3.1 Site Evaluation

Three sites, namely at Old Harbour, Caymanas and Hunts Bay (Table 10-1) were evaluated based on the following criteria:

- Minimize capital and O&M Expenditure (COE impact)
    - Plant and LNG Fuel Infrastructure requirements
    - Transmission Upgrades and Expansions
- Enable speed of delivery of Project (Realisation of COE reduction)
- Network efficiency and stability

Table 10-1 Location of Old Harbour, Hunts Bay and Caymanas site options

Old Harbour	

<table>
<tr><td>Caymanas</td><td>
</td></tr>
<tr><td>Hunts Bay</td><td>
</td></tr>
</table>

The benefits of each site are described in Table 10-2 and based on the full assessment, it was concluded that the Old Harbour saved costs with the use of existing site services. In terms of overall total costs, the Old Harbour option had the lowest cost (≈ 560 million USD), followed by Hunt's Bay (≈ 600 million USD) and Caymanas (≈700 million USD). The Old Harbour site also had the shortest project timeline with a Commercial Operation Date (COD) of June 30, 2017, compared to February 28, 2018 for the remaining two options.

Table 10-2 Pros and cons of each alternative site: Old Harbour, Hunts Bay and Caymanas

	Old Harbour	Hunts Bay	Caymanas
PROS:	Interconnect with existing T&D Infrastructure	System location for Ancillary Services improves grid stability	
	System location for Ancillary Services improves grid stability		
Existing Site Services	Cooling Water Intake (reduced permit risk/cost)	Cooling Water Intake (reduced permit risk/cost)	Green field
	Rights to Ground Water (reduced permit risk/cost)	Rights to Ground Water (reduced permit risk/cost)	Re-use of grey water from Soap Berry waste water plant
	Demineralized Water system (makeup) infrastructure	Demineralized Water system (makeup) infrastructure	
	Existing Site shop, warehouse, security and land.	Existing Site shop, warehouse, security and land.	
Reliability	Seawater Cooling	Seawater Cooling	
	Interconnect OH4 Steam Turbine as Back-up for CCGT; US$2.3 Million fuel cost per annum @ 2% forced outage	Interconnect B6 Steam Turbine as Back-up for CCGT; US$2.3 Million fuel cost per annum @ 2% forced outage.	
CONS:		Would require additional ground water rights	Flight path impact to LNG carriers & LNG Tank
		Sea water Cooling impact on Kingston Harbour risky	Distance of LNG Pipeline & Infrastructure
		LNG Shipping impact on Kingston Harbour	LNG Impact in Kingston Harbour
			High operating cost of using grey water

10.3.2 Layout Alternatives

Various sections of the property were assessed as project site alternatives.

10.3.2.1 General Project Area

A rapid assessment of the general area was carried out in 2012 and 2014. The southernmost portion of the property consisted of large areas of bare, sandy-clay soil, occupied by vegetation islands while the shoreline itself had more sensitive species (*Rhizophora mangle* - Red Mangrove and *Avicennia germinans* - Black Mangrove).

10.3.2.2 Option 2

This site was located just northeast of the existing power plant. The vegetation here was a remnant of the thorn savannah, which was severely influenced by anthropogenic activity. Evidence of grazing and fire damage was present at the time of this survey.

10.3.2.3 Option 3

The site is includes a recreation complex, opposite Option 2. Here, the plant types consist mainly of ornamental/cultivated plants, which surrounded a local sports field.

10.4 DEVELOPMENT ALTERNATIVES

10.4.1 LNG Technology Options

Gas is the only fuel that accommodates renewables and LNG is believed to be a dependable, long-term, secured source in Jamaica. It is also the most attractive priced energy form, followed by ethane and propane. Various technology LNG options including technologies (turbines and reciprocating engines) and different manufacturers were evaluated. Resulting from this assessment, it was concluded that the 190 MW, 3x1 Power Island will provide the lowest system cost of energy to integrate renewable resources.

10.5 ALTERNATIVE ENERGY SOURCES

Energy alternatives theoretically can support the generation of electric power. Renewable energy resources such as solar, hydroelectric, biomass and wind, as well as more traditional forms such as coal and oil are energy alternatives discussed in subsequent sections.

10.5.1 The Proposed Development as described in the EIA but using ADO as the primary fuel

Using ADO as the primary fuel instead of LNG was investigated.

IMPACTS

- Physical: LNG produces less air emissions and pollutants than diesel oil.
- Socioeconomic: LNG is also more cost effective than ADO therefore results in cheaper costs to generate electricity with spinoff impacts to the National economy.

10.5.2 Generating the Required Power but using Nuclear Energy as an Alternative to Fossil Fuels

IMPACT

- Socioeconomic: A nuclear energy plant would result in the need for strict security and maintenance. Certain mitigation would also be required for this type of plant. For these reasons the development of such a power plant in Old Harbour is not practical at this time.

10.5.3 Generating the Required Power but using Renewable Energy Resources as an Alternative to Fossil Fuels

Wind, solar and hydro energy as renewable energy sources were also considered. Although all three are clean forms of energy there are some limitations and generally, continued resource constraints limit the full value of renewable resources.

10.5.3.1 Wind Energy

IMPACT

- Physical: Wind turbines would not be able to produce enough energy for this size of plant as the largest turbines to date are producing 3MW. This would require 120 wind turbines to generate the required power. There are two inherent problems with this; the land space required to establish these turbines and the unreliability (fluctuation) in wind doesn't make it suitable to be used for base power.

10.5.3.2 Solar Energy

IMPACT

- Physical: The acreage (land area) required for solar panels to produce the required energy makes it unsuitable for this area.

10.5.3.3 Hydroelectricity

The Government of Jamaica has embarked on a study in an effort to determine the feasibility of hydroelectric plants at five locations around the island. Additionally, the Jamaica Public Service Company Limited has enhanced and rehabilitated some of their hydroelectric plants. The largest hydroelectric plant to date in the island is the Maggotty 6.3 MW hydroelectric plant. This coupled with the fact that most of our rivers are relatively small means that the probability of producing 360 MW of base power from hydroelectricity is low.

10.5.4 Generating the Required Power but using Coal as the Fuel

Using coal as the primary fuel instead of LNG was investigated.

IMPACTS

- Physical: LNG produces less air emissions and pollutants than coal. A coal-fired plant also utilizes much more land space than a LNG plant, because of the need for a coal ash landfill area.
- Socioeconomic: LNG is more cost effective than coal therefore results in cheaper costs to generate electricity. In addition, the public sentiments toward the use of coal are unfavourable.

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 power generating capacity with reduced potential impacts which can be mitigated.

11.0 EMERGENCY PREPAREDNESS AND RESPONSE

The following points will be taken into consideration with respect to Emergency Response Planning:

- A lead person should be identified and appointed to be responsible for emergencies occurring on the site. This person should be clearly identified to the construction workers.
- The JPS construction management team should have onsite first aid kits and make arrangements for the nurse and doctor on call for the construction site.
- Make prior arrangements with health care facilities such as the Old Harbour Health Centre, Kingston Public Hospital or the Spanish Town Hospital to accommodate any eventualities.
- Arrange with health practitioners to be on call during the construction period.
- Design and implement an emergency response plan or update the existing plan to reflect the issues of the new power plant.
- Staff should be trained in Cardio Pulmonary Resuscitation (CPR).
- Coordinate with mutual aid organisations/agencies such as with the local fire brigade.
- Material Safety Data Sheets (MSDS) should be stored onsite.
- Conduct emergency response drills.

In addition, it is proposed that JPS Emergency Response Plan reflect the following issues:

- Earthquake
- Hurricane
- Flooding
- Explosion
- LNG Accidents
- Oil /Hazardous Material Spill
- Community and Outside Liaison
- Unrest and Riots
- Act of Terrorism and Armed Attack
- Bomb Threats and Acts of Sabotage
- Serious or Multiple Injury; and
- Illegal Trespassing

The plan should also include emergency call lists of persons on and offsite, building plans, site maps and evacuation routes.

The existing JPS Old Harbour Power Plant emergency response plan will be updated to reflect the new technologies.

12.0 COST BENEFIT ANALYSIS

12.1 METHODOLOGY

The UNIDO Approach for Social Cost Benefit Analysis as prescribed by United Nation Industrial Development Organization (UNIDO) was applied to a thermal coal power plant and a hydro plant hence is an appropriate methodology to be used to analyse the JPS natural gas power plant in Jamaica.

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 and 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 good and/or service 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.

UNIDO Approach is 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

12.1.1 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 profit 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 flow statement is also important here as the financial income statement only shows the annual profit and disguise investment. The net cash flow is derived from the financial income statement by standard accounting procedures and is equal to the gross cash flow (operating profit before interest and taxes plus allowances for depreciation) minus capital investments.

12.1.2 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 benefit 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 benefit in terms of these prices.

12.1.3 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:

1. Given the income distribution impact of the project what would be its effects on savings?
2. What is the value of such savings to the society?

Impact on Savings

The saving impact of a project is equal to:

$$\sum_i \triangle Y_i \times MPS_i$$

Where ΔY_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*.

12.1.4 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.

Determination of Weights: 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

12.1.5 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.

12.2 Application of UNIDO Approach to the JPS Power Plant

12.2.1 Calculation of Financial Profitability Measured at Market Prices

Table 12-1 presents the estimates of revenue collected by the project during its lifetime.

Table 12-1 Estimates of financial flows of revenue earned by the project during its lifetime

Year	Old	New	Year	Old	New	Year	Old	New
2018	213.0	128.7	2027	213.0	128.7	2036	128.7	2036
2019	213.0	128.7	2028	213.0	128.7	2037	128.7	2037
2020	213.0	128.7	2029	213.0	128.7	2031	128.7	2031
2021	213.0	128.7	2030	213.0	128.7	2032	128.7	2032
2022	213.0	128.7	2031	213.0	128.7	2033	128.7	2033
2023	213.0	128.7	2032	213.0	128.7	2044	128.7	2044
2024	213.0	128.7	2033	213.0	128.7	2045	128.7	2045
2025	213.0	128.7	2034	213.0	128.7	PV	1300	784.70
2026	213.0	128.7	2035	213.0	128.7	NPV		515.3

** Cost is measured in millions of US$ Dollars. This uses a discount rate of 16%. Assuming that the exchange rate remains stable and oil prices are the same as 2012*

The Office of Utility regulation have a rate of return of 12.5%. Given that the rate of return is guaranteed, a calculation of financial profitability is just a comparison between cost of the old plant and the new plant. The rate of return is important in calculating the reduction of final prices to the consumer. The NPV of the difference of the total fixed costs, total variable operating and maintenance, and fuel and transportation cost is US$ 515,000,000. The capital expenditure for capital, construction is US$ 219,465,000. Therefore the calculation of NPV at market prices for the Power Plant turned out to be US$ 515,000,000, therefore as per financial evaluation of the project since NPV is US$ 295,500,000, project should be under taken if financial consideration and private benefits was the only consideration.

12.2.2 Obtaining the Net Benefit of the Project Measured in Terms of Economic Prices

12.2.2.1 Identification of Economic (Social) Benefits and Costs

Social Benefits/Cost:

- The major benefit of setting up this Power Plant would be the manufacturing section which will benefit 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 benefit stated 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 to 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 a reduction in greenhouse gases hence lead to a reduction of environmental cost.
- There is the potential for increased employment during the pre-clearance and construction phases. It is anticipated that approximately 70 persons will be employed directly during the site clearance and an average of 200 persons to a maximum of 400 -450 persons at the peak during construction. Approximately 70% of the work force will be obtained from local labour. In addition it is anticipated that approximately 1,140 and 1,520 - 1,710 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 would be otherwise unemployed or under employed in the Jamaican economy.
- Revenue earned by the government in the form of taxes from the increase earnings and 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 12-2 shows the Operation and Maintenance (O&M) cost of the project in terms of shadow (economic) prices.

Table 12-2 Estimates of financial flows of operation and maintenance (O&M) expenditures in terms of Shadow Prices (During its Lifetime)

Year	Old	New	Year	Old	New	Year	Old	New
2018	210	125	2027	210	125	2036	210	125
2019	210	125	2028	210	125	2037	210	125
2020	210	125	2029	210	125	2031	210	125
2021	210	125	2030	210	125	2032	210	125
2022	210	125	2031	210	125	2033	210	125
2023	210	125	2032	210	125	2044	210	125
2024	210	125	2033	210	125	2045	210	125
2025	210	125	2034	210	125	PV	1358	808
2026	210	125	2035	210	125	NPV		550

The NPV calculation was done after doing the 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%.

12.2.2.2 Environmental Impact Comparisons - Greenhouse Gas Emissions

Greenhouse Gas (Ghg) Emissions for 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 12-3):

Table 12-3 Greenhouse Gas Emission rates for Oil-Fired Facility

Facility	Pollutant	Emission	Emission	Facility Emission
		Factor, lb/103 gal	Factor, kg/L	Rate, tonne/y
Oil-Fired	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 12-4):

Table 12-4 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.

The difference in pollutants for CO_2, N_2O, and CH_4 are; 323,260.2, -3.9, and 34.5 tonne/y respectively. Using a social of US$40 for CO_2, US$29,000 for N_2O and US$2,000 for CH_4. See Marten, Alex L., and Stephen C. Newbold (2012) for calculations. Therefore net reduction in pollutants are valued at US$13,000,000 per year with a present value of US$84,030,000 over 25 year using a discount rate of 15%.

12.2.2.3 Social Benefit from Employment

There is the potential for increased employment during the pre-clearance and construction phases. It is anticipated that approximately 70 persons will be employed directly during the site clearance and an average of 200 persons to a maximum of 400 -450 persons at the peak during construction.

Approximately 70% of the work force will be obtained from local labour. In addition it is anticipated that approximately 1,140 and 1,520 .1,710 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 underemployed in the Jamaican economy. Using the standard 1.6 multiplier for job creation the value of the employment effect is US$61,000,000. Note that 25% of the construction is labour cost and 70% of the labour will be local labour.

12.2.2.4 Benefit from Lower Electric Cost

There is an 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 in consumer prices (Table 12-5).

Table 12-5 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	35,059	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	67,057	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.

NPV of the project after Stage 2 turns out to be US$718,750,000. 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 12-6).

Table 12-6 Net Social Present Value of the project

Components	NPV (Millions US$)
(O&M) cost economic prices.	550.00
Green House Gas	84.03
Employment effect	61
Electricity cost	23.72
Total NSPV	718.75

12.2.3 Adjustment for the Impact of the Project on Savings and Investment

Following are the groups which will be benefited by the project:

- Government
- JPS
- Labour
- Consumers/producers

Table 12-7 gives the calculation of saving impact on the above mentioned stake holders.

Table 12-7 Calculation of saving impact on stakeholders

Stake holders	Net Benefit	MPS	Savings Impact
JPS	550.00	0.55	302.5
Workers	61.00	0.29	17.7
Consumers/producers	23.72	0.60	14.2
			334.4

The Net Savings Impact turns out to be US$ 334,400,000.

Calculation of Social Value of Savings 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* x *I*

= 334,400, 000 x 1:55

= 518, 354, 100

Table 12-8 gives the calculation of NPV at Stage 3

Table 12-8 Calculation of NPV at Stage 3

NPV From stage two	718.75
Net saving Impact	518.4
NPV at Stage 3	1237.15

Thus, the NPV after taking into account the savings impact turns out to be US$1,237,150,000.

12.2.4 Adjustment for the Impact of the Project on Income Distribution

Given that the consumer and workers will benefit, the impact on the income distribution is neutral. Thus, the NPV after Income Distribution Impact turns out to be US$1,237,150,000.

12.2.5 Adjustment for the Impact of the Project on Merit Goods and Demerit Goods

The adjustment factor turns out to be 1.40. This shows that social value of the project exceeds its economic value by 140%.

Calculation of Adjustment Factor and Adjusted NPV: Table 12-9 gives the Calculation of NPV at Stage 5.

Table 12-9 Calculation of NPV at Stage 5

Adjustment Factor	Unit	1.40
NPV at Stage 4	1237.15	
New NPV after Stage 5		1733.04

Thus, the final NPV of the project after application of Social Cost Benefit Analysis turns out to be US$ 1,733,040,000. Hence, the project should be undertaken as it has multiple social benefits which are reflected in the final positive NPV of the project.

12.3 CONCLUSION

The cost benefit shows that the project has a positive NPV using all recommended methodologies.

13.0 ENVIRONMENTAL MANAGEMENT AND MONITORING

13.1 MONITORING DURING SITE PREPARATION FOR THE PROPOSED POWER PLANT

- A noise survey should be undertaken to determine workers 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 $157,500**.
- Undertake daily inspections of trucks carrying solid waste generated from site clearance activities to ensure that they are not over laden as this will damage the public thoroughfare.
  Person(s) appointed by JPS 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 JPS may perform this exercise.

13.2 MONITORING DURING THE CONSTRUCTION PHASE OF THE PROPOSED POWER PLANT

- Daily inspection of the power plant construction to ensure they are 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 JPS may perform this exercise.
- Undertake monthly water quality monitoring to ensure that the construction works are not negatively impacting the marine environment quality. The parameters that should be monitored are temperature, salinity, dissolved oxygen, pH, turbidity, TDS, nitrates, phosphates, FOG, total suspended solids and faecal coliform. This is estimated to cost approximately **J$88,750** per monitoring exercise.

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.

- Monthly noise surveys should be undertaken to determine workers 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 **$157,500**.
- 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 JPS 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 thoroughfare.
  Person(s) appointed by JPS 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 JPS 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 JPS 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 JPS 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 JPS 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. The Old Harbour Bay Citizens Association could be used as the watchdog to ensure that this is achieved.
  Person(s) appointed by JPS may perform this exercise.

13.3 MONITORING DURING THE OPERATION PHASE OF THE PROPOSED POWER PLANT

- Annual noise assessments should be conducted starting with the initial commissioning of the power plant. This should be contracted out by JPS 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 JPS may perform this exercise.
- If the power plant is to be run on LNG, then no ambient air quality monitoring stations need to be set up.

13.4 REPORTING REQUIREMENTS

13.4.1 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, SJPC loading).
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.

13.4.2 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 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.
- Reports will be maintained on file at the plant for a minimum of three years.

13.4.3 Air Emissions

If the plant is to be operated on LNG then no ambient air quality stations need to be set up.

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15.0 APPENDICES

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Appendix 1 – EIA Terms of Reference

TERMS OF REFERENCE
ENVIRONMENTAL IMPACT ASSESSMENT
FOR PROPOSED OLD HARBOUR 190 MW POWER PLANT
HARBOUR BAY, ST. CATHERINE, JAMAICA

The Terms of Reference (TOR) for conducting the EIA are based on the General Guidelines for Conducting EIAs (NEPA revised 2007) for prescribed categories under the NRCA Act.

The Environmental Impact Assessment will include but not necessarily be limited to:

Cover Page

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    15.5. Data Tables
    15.6. Photographs & Maps
    15.7. Composition of the Research Team (including names, qualification and roles 15.8. Notes of Public Consultation Sessions
    15.9. Instruments used in Community Survey

Additional Requirements

The EIA study should also take into consideration the Transmission line requirements and easement and the sphere of influence of their impact on the development of adjoining/surrounding properties.

The proposed zoning of the site in the Highway 2000 corridor Portmore to Clarendon Park Development Plan must be stated and discussed.

The EIA should seek to propose mechanisms for the reduction of discharges from the plant.

To ensure that a thorough environmental impact assessment is carried out, it is expected that the following tasks be undertaken:

Task # 1 - Description of the Project

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 project

- 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 including construction of any additional power lines and high voltage transmission line and their impacts on the surroundings communities, as well as the impact of the turbines on the power supply and carbon footprint of the energy sector are to also be discussed;
- Pre-construction activities,
- Construction methods, works and duration
- Post construction plans
- 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.

- 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.

Task # 2 - Description of the Environment/Baseline Studies Data Collection and Interpretation

This section should include a detailed description of the proposed site 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

It is expected that methodologies employed to obtain baseline and other data be clearly detailed. Baseline data will include:

Physical

i.) A description of the existing soil and geology, landscape, aesthetic values and hydrology. Special emphasis should be placed on storm water run-off, drainage patterns, and aquifer characteristics. Any slope stability issues that could arise should be thoroughly explored. Any slope stability issues that could arise should be thoroughly explored.

ii.) Baseline data of ambient air parameters must be collected in an 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. 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. Data are to be collected and monitored for one wet and one dry season with at least one station in the up-wind/ non-impact/ non-polluting area (control site). Data collected should include

- nitrogen dioxide
- sulphur dioxide

Factors such as historical wind speed and direction, precipitation, relative humidity and ambient temperature data shall be assessed pre development.

iii.) Water quality of any existing wells, gullies, rivers, ponds, streams or coastal waters in the vicinity of the development. The water quality of the coastal water in the vicinity of any discharge points/sites in Old Harbour Bay and the potential cumulative impact of such discharges on the environment.
iv.) The likely constituents of any discharge.
v.) Noise levels of undeveloped site and the ambient noise in the area of influence

vi.) Sources of existing pollution and extent of contamination

The Physical Impacts should also be classified based on:

- Land Impacts
  - Onsite impacts
  - Offsite impacts
- Water Impacts
  - Pollution of water bodies
- Air Impacts
  - Changes to the micro climate of the area

Biological

Present a detailed description of the flora and fauna (terrestrial and aquatic if applicable) of the area, with special emphasis on rare, threatened, endemic, protected, endangered, and economically important species. Migratory species, biological loss and habitat loss and fragmentation due to construction and operation should also be considered and assessed.

i.) Identification and description of the different terrestrial and marine ecosystem types, the structure of these ecosystems including species dominance, dependence and diversity, habitat specificity and community structure

ii.) The description of the coastal and marine ecosystem should including but not limited to, any wetlands including mangroves, seagrass and coral community with indication of its function and value in the project area.

Socio-economic & cultural

Present and proposed land use; transportation of heavy equipment, road widening and associated traffic considerations particularly in the construction phase of the project, planned development activities; issues relating to squatting and relocation; public health and safety. The historical importance (heritage, archaeological sites and feature) and other material assets of the area should also be examined. While this analysis is being conducted, it is expected that an assessment of public perception of the proposed development be conducted. This assessment may vary with community structure and may take multiple forms such as public meetings and/or questionnaires/surveys.

i.) Availability of solid waste management facilities

Task #3 - Policy, Legislative and Regulatory Considerations

Outline the pertinent regulations and standards governing environmental quality, safety and health, protection of sensitive areas, protection of endangered species, siting and land use control at the national and local levels. The examination of the legislation should include at minimum, legislation such as the NRCA Act, the Public Health Act, the Town and Country Planning Act and the appropriate international convention/protocol/treaty where applicable.

Examine the Government National Energy Policy and renewable projects. Discuss briefly the 190 MW in relation to the National Energy Policy.

Task # 4 - Identification and Assessment/Analysis of Potential Impacts

Examine and identify the major potential environmental and public health issues of concern and indicate their relative importance to the development project. These should include the occupational exposure, health and safety measures and population exposure in the appropriate study area(s) and changes and or enhancement in emergency response plan. The identification of the major potential impacts or the ranking of the impacts should be done using an appropriate technique and the method for the ranking must be included in the EIA report.

Identify potential impacts as they relate to, (but are not restricted by) the following:

- Change in drainage patterns
- Flooding potential if necessary
- Landscape impacts of excavation, land reclamation and construction
- Loss of species and natural features
- Habitat loss and/or fragmentation
- Biodiversity/ecosystem functions including impacts on bird and bat mortality
- Air quality
- Socio-economic and cultural impacts
- Impact of flooding, excavation and construction on the historic landscape, architecture and archaeology of the site
- Potential impact of high voltage transmission lines (sphere of influence)
- Noise and vibration
- Solid waste disposal
- Soil
- Change in land use

- Visual impacts – aesthetics
- Impact on traffic associated with road widening and the transportation of heavy equipment to the site
- Impacts on aircrafts in the area
- Pollution of potable, surface or ground water should be explored to include the marine environment
- Sewage and trade effluent treatment systems and discharge. The cooling water source and implications inclusive of existing demands and any effluents that may be likely as a consequence. The cooling water discharge and its impact must also be addressed.
- Natural hazard risks – Risk assessment of the plant in relation to tsunamis, hurricanes, tropical storm, flooding must be undertaken. In light of the concentration of significant power generation capacity at Old Harbour Bay, a risk analysis of the threat to the supply of power to the national grid from the proposed plan during emergencies should be assessed. 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. Additionally, Storm surge modelling and risk analysis shall be done to assist in determining the mitigation measures necessary to protect the facility, considering sea level rise and increase in the intensity of storm events projected for the future.

Distinguish between significant positive and negative impacts, direct and indirect, long term and immediate impacts to include discussion on site restoration and residual impacts and the proposed mitigation measures. Identify avoidable as well as irreversible impacts. Cumulative impacts of this and other proposed and/or existing developments will be explored.

Characterize the extent and quality of the available data, explaining significant information deficiencies and any uncertainties associated with the predictions of impacts. A major environmental issue is determined after examining the impact (positive and negative) on the environment and having the negative impact significantly outweigh 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 will be represented in matrix form.

Task #5 - Drainage Assessment

An assessment of Storm Water Drainage should be conducted. The EIA Report will cover but not be limited to where necessary:

i.) Drainage for the site during construction to include mitigation for sedimentation to the aquatic including marine environment

ii.) Drainage for the site during operation, to include mitigation for sedimentation to the aquatic and marine environment iii.) Drainage control for crossings of rivers and/or gullies, to include impacts that drainage control features could have on aesthetics, water quality and sedimentation of rivers and/or gullies.

iv.) Storm water runoff should be assessed based on existing situation and the impact that the proposed plant is expected to have.

v.) Drainage assessment should also include impact of the development on the hydrodynamics of the general area. Of note is that the Old Harbour Bay, which is 5 kilometres from the site, is impacted by flooding.

vi.) All possible efforts should be made to retain all of the surface drainage/storm water runoff on the site. The natural drainage should not be impacted.

Task # 6 - Mitigation & Emergency Preparedness and Response

Prepare guidelines for avoiding or reducing (e.g. restoration and rehabilitation), as far as possible, any major potential impacts identified in Task # 4 due to proposed usage of the site and utilising of existing environmental attributes for optimum development. 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. In addition, the EIA should seek to propose mechanisms for the reduction of discharges from the plant. Quantify and assign financial and economic values to mitigating methods.

Indicate the emergency preparedness and response plans for dealing with risks and hazards identified at Task 4.

Task # 7 - EHS Management and Monitoring Plan

Design a plan for the management of the natural, historical and archaeological environments of the project to monitor implementation of mitigatory or compensatory measures and project impacts during construction and occupation/operation of the units/facility. Preparation of an EHS Management Plan and Historic Preservation Plan (if necessary) for the long-term operations of the site.

An outline of a monitoring programme (if necessary) 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 and report should include:

- An introduction outlining the need for a monitoring programme and the relevant specific provisions of the permit and/or licence(s) granted.
- Raw data collected
- Discussion of results with respect to the development in progress, highlighting any parameter (s) which exceeds the expected standard (s).

- The activity being monitored and the parameters chosen to effectively carry out the exercise.
- Project maintenance and decommissioning
- The methodology to be employed and the frequency of monitoring.
- The sites being monitored. These may in instances, be pre-determined by the local authority and should incorporate a control site where no impact from the development is expected.
- Frequency of reporting to NEPA
- Tables and graphs are to be used where appropriate

Task # 8 - Project Alternatives

Examine alternatives to the project or to specific aspects of the project. Include an assessment of the impacts of all the alternatives examined, including the no-action alternative. This 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. The assessment of alternatives shall include but not be limited to an examination of the physical, socio-economic and biological impacts of each alternative

Project alternatives should be discussed in the EIA

Task # 9 – Cost Benefit Analysis

Conduct a Cost Benefit Analysis of the project. A cost benefit analysis of the use-change as per the proposed project and the existing state must be included. The cost benefit analysis is to compare the annual value of lost welfare associated with impacts of the project with the net social gain from the project.

All data and survey instruments should be included in the appendices.

Task #10 - Public Participation/Consultation Programme

Conduct public presentation(s) on the findings of the EIA to inform, solicit and discuss comments from the public on the proposed development if necessary.

- Document the public participation programme for the project.
- Describe the public participation methods, timing, type of information to be provided to the public, and stakeholder target groups.
- Summarise the issues identified during the public participation process
- Discuss public input that has been incorporated into the proposed project design; and environmental management systems

Fourteen hard copies and an electronic copy of the report will be required for submission to the National Environment and Planning Agency.

Appendix 2 – NEPA Guidelines for Public Participation

NATIONAL ENVIRONMENT AND PLANNING AGENCY

NATURAL RESOURCES CONSERVATION AUTHORITY

GUIDELINES FOR CONDUCTING PUBLIC PRESENTATIONS

2007-10-25

SECTION 1: GENERAL GUIDELINES

1.1 Introduction

There are usually two forms of public involvement 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 and addendum, if any, have been prepared after the applicant has provided the information needed for adequate review by NEPA and the public.

Public involvement in the review process is in keeping with Principle 7 of the United Nations Environment Programme (UNEP) decision published as Goals and Principles of Environmental Impact Assessment [Decision 14/25 of the Governing Council of UNEP, of 17, June, 1987]

1.2 Purpose

These guidelines are prepared for the use of the developer/project proponent; the consultants involve in conducting the EIA study and prepared the EIA report and the public.

SECTION 2: SPECIFIC GUIDELINES FOR PUBLIC PRESENTATIONS

2.1 **Requirements**

Arrangements for the public presentation must be made in consultation with NEPA in respect of date, time, venue, chairperson and participants.

A permanent record of the meeting is required hence, the project proponent/consultant will submit to NEPA a copy of the verbatim report of the public presentation within seven (7) days of the date of the meeting.

2.2 Public Notification

The public must be notified at least three weeks before the date of the public presentation. The developer/consultants 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. The notice shall also be forwarded to NEPA for posting on the website. To ensure that the notice is distributed as widely as possible, other methods of notification such as community notice board, flyers, town criers etc. shall be utilized as appropriate. In addition, specific notice to relevant local NGOs and community groups should be made by the developer/consultants.

The notice 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.

The public presentation should be conducted no less than 3 weeks after the EIA has been made available to the public and no less than 3 weeks after the first notice announcing public presentation has been published by the applicant.

(A typical notice is in Appendix 1).

2. 3 Responsibility of Developer/Consultant Team

The developer/consultant is responsible for distribution of copies of the EIA Report to make them available to the public at least three weeks before the public presentation.

Copies should be placed in the Local Parish Library and the Parish Council Office as well as at the nearest NEPA Regional Office 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 presentation.

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 ***Appendix 3***.

The technical presentation by the project proponent/consultant should be simple, concise and comprehensive. The main findings of the EIA including adverse and beneficial impacts identified and analyzed should be presented.

Mitigation measures and costs associated with these measures should be presented. The presentation should inform the public on how they will get access to monitoring results during the construction and operational phases of the project, bearing in mind that the public and non-governmental groups are expected to be involved in post-approval monitoring. Graphic and pictorial documentation 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.

The project proponent/consultant will submit to NEPA a copy of the verbatim report of the public presentation within seven (7) days of the date of the meeting.

Please note that the public will be given a period of thirty (30) days after the Public Presentation to send in written comments to NEPA.

(A typical agenda for a meeting is given in Appendix 2)

APPENDIX 1

NOTIFICATION OF PUBLIC MEETING

THERE WILL BE A PUBLIC PRESENTATION ON THE ENVIRONMENT IMPACT ASSESSMENT REPORT

OF:

VENUE:

DATE:

TIME:

THE PUBLIC IS INVITED TO PARTICIPATE IN THE PRESENTATION 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
____
For further information contact:

APPENDIX 2

AGENDA

1. WELCOME AND INTRODUCTION

2. PRESENTATION OF EIA FINDINGS AND MEASURES TO MINIMIZE IMPACTS

3. QUESTION AND ANSWER SESSION

4. 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 3 - Relevant Sections of the "IFC General EHS Guidelines" and "Thermal Power: Guidelines for New Plants"

Table 1.7.1- Noise Level Guidelines[54]		
	One Hour L_{Aeq} (dBA)	
Receptor	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational[55]	55	45
Industrial; commercial	70	70

Table 2.3.1. Noise Limits for Various Working Environments		
Location /activity	Equivalent level LA_{eq},8h	Maximum LA_{max},fast
Heavy Industry (no demand for oral communication)	85 dB(A)	110 dB(A)
Light industry (decreasing demand for oral communication)	50-65 dB(A)	110 dB(A)
Open offices, control rooms, service counters or similar	45-50 dB(A)	-
Individual offices (no disturbing noise)	40-45 dB(A)	-
Classrooms, lecture halls	35-40 dB(A)	-
Hospitals	30-35 dB(A)	40 dB(A)

Table 6 (B) - Emissions Guidelines (in mg/Nm³ or as indicated) for Combustion Turbine

Note:

- Guidelines are applicable for new facilities.
- EA may justify more stringent or less stringent limits due to ambient environment, technical and economic considerations provided there is compliance with applicable ambient air quality standards and incremental impacts are minimized.
- For projects to rehabilitate existing facilities, case-by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.
- EA should demonstrate that emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards, and more stringent limits may be required.

Combustion Technology / Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO_2)		Nitrogen Oxides (NOx)	Dry Gas, Excess O_2 Content (%)
Combustion Turbine			NDA/DA		NDA/DA	
Natural Gas (all turbine types of Unit > 50MWth)	N/A	N/A	N/A	N/A	51 (25 ppm)	15%
Fuels other than Natural Gas (Unit > > 50MWth)	50	30	Use of 1% or less S fuel	Use of 0.5% or less S fuel	152 (74 ppm)[a]	15%

General notes:

- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; S = sulfur content (expressed as a percent by mass); Nm³ is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to single units; Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- If supplemental firing is used in a combined cycle gas turbine mode, the relevant guideline limits for combustion turbines should be achieved including emissions from those supplemental firing units (e.g., duct burners).
- (a) Technological differences (for example the use of Aeroderivatives) may require different emissions values which should be evaluated on a cases-by-case basis through the EA process but which should not exceed 200 mg/Nm3.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):

- Natural Gas-fired Combustion Turbine – NOx
  - Guideline limits: 51 (25 ppm)
  - EU: 50 (24 ppm), 75 (37 ppm) (if combined cycle efficiency > 55%), 50*η / 35 (where η = simple cycle efficiency)
  - US: 25 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 15 ppm (> 850 MMBtu/h (≈ 249 MWth))
  - (Note: further reduced NOx ppm in the range of 2 to 9 ppm is typically required through air permit)
- Liquid Fuel-fired Combustion Turbine – NOx
  - Guideline limits: 152 (74 ppm) – Heavy Duty Frame Turbines & LFO/HFO, 300 (146 ppm) – Aeroderivatives & HFO, 200 (97 ppm) – Aeroderivatives & LFO
  - EU: 120 (58 ppm), US: 74 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 42 ppm (> 850 MMBtu/h (≈ 249 MWth))
- Liquid Fuel-fired Combustion Turbine – SOx
  - Guideline limits: Use of 1% or less S fuel
  - EU: S content of light fuel oil used in gas turbines below 0.1% / US: S content of about 0.05% (continental area) and 0.4% (non-continental area)

Source: EU (LCP Directive 2001/80/EC October 23 2001), EU (Liquid Fuel Quality Directive 1999/32/EC, 2005/33/EC), US (NSPS for Stationary Combustion Turbines, Final Rule – July 6, 2006)

Table 7 – Typical Air Emission Monitoring Parameters / Frequency for Thermal Power Plants
(Note: Detailed monitoring programs should be determined based on EA)

Combustion Technology / Fuel	Emission Monitoring			Stack Emission Testing				Ambient Air Quality	Noise
	Particulate Matter (PM)	Sulfur Dioxide (SO_2)	Nitrogen Oxides (NOx)	PM	SO_2	NOx	Heavy Metals		
Reciprocating Engine									
Natural Gas (Plant >50 MWth to <300 MWth)	N/A	N/A	Continuous or indicative	N/A	N/A	Annual	N/A	If incremental impacts predicted by EA >/= 25 % of relevant short-term ambient air quality standards or if the plant >/= 1,200 MWth: - Monitor parameters (e.g., PM_{10}/$PM_{2.5}$/SO_2/NOx to be consistent with the relevant ambient air quality standards) by continuous ambient air quality monitoring system (typically a minimum of 2 systems to cover predicted maximum ground level concentration point / sensitive receptor / background point). If incremental impacts predicted by EA < 25% of relevant short term ambient air quality standards and if the facility < 1,200 MWth but >/= 100 MWth - Monitor parameters either by passive samplers (monthly average) or by seasonal manual sampling (e.g., 1 weeks/season) for parameters consistent with the relevant air quality standards. Effectiveness of the ambient air quality monitoring program should be reviewed regularly. It could be simplified or reduced if alternative program is developed (e.g., local government's monitoring network). Continuation of the program is recommended during the life of the project if there are sensitive receptors or if monitored levels are not far below the relevant ambient air quality standards.	If EA predicts noise levels at residential receptors or other sensitive receptors are close to the relevant ambient noise standards / guidelines, or if there are such receptors close to the plant boundary (e.g., within 100m) then, conduct ambient noise monitoring every year to three years depending on the project circumstances. Elimination of noise monitoring can be considered acceptable if a comprehensive survey showed that there are no receptors affected by the project or affected noise levels are far below the relevant ambient noise standards / guidelines.
Natural Gas (Plant >/= 300 MWth)	N/A	N/A	Continuous	N/A	N/A	Annual	N/A		
Liquid (Plant >50 MWth to <300 MWth)	Continuous or indicative	Continuous if FGD is used or monitor by S content.	Continuous or indicative	Annual					
Liquid (Plant >/=300 MWth)	Continuous or indicative		Continuous						
Biomass	Continuous or indicative	N/A	Continuous or indicative	Annual	N/A	Annual	N/A		
Combustion Turbine									
Natural Gas (all turbine types of Unit > 50MWth)	N/A	N/A	Continuous or indicative	N/A	N/A	Annual	N/A		
Fuels other than Natural Gas (Unit > 50MWth)	Continuous or indicative	Continuous if FGD is used or monitor by S content.	Continuous or indicative	Annual					
Boiler									
Natural Gas	N/A	N/A	Continuous or indicative	N/A	N/A	Annual	N/A		
				Annual	Annual	Annual	N/A		
Other Gaseous fuels	Indicative	Indicative	Continuous or indicative	Annual					
Liquid (Plant >50 MWth to <600 MWth)	Continuous or indicative	Continuous if FGD is used or monitor by S content.	Continuous or indicative						
Liquid (Plant >=600 MWth)		Continuous							
Solid (Plant >50 MWth to <600 MWth)		Continuous if FGD is used or monitor by S Content.	Continuous or indicative						
Solid (Plant >/=600 MWth)		Continuous							

Note: Continuous or indicative means "Continuously monitor emissions or continuously monitor indicative parameters". Stack emission testing is to have direct measurement of emission levels to counter check the emission monitoring system.

DECEMBER 19, 2008 23

Table 1.3.1 Indicative Values for Treated Sanitary Sewage Discharges[a]

Pollutants	Units	Guideline Value
pH	pH	6 – 9
BOD	mg/l	30
COD	mg/l	125
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Total coliform bacteria	MPN[b] / 100 ml	400[a]

Notes:
[a] Not applicable to centralized, municipal, wastewater treatment systems which are included in EHS Guidelines for Water and Sanitation.
[b] MPN = Most Probable Number

Table 5 - Effluent Guidelines
(To be applicable at relevant wastewater stream: e.g., from FGD system, wet ash transport, washing boiler / air preheater and precipitator, boiler acid washing, regeneration of demineralizers and condensate polishers, oil-separated water, site drainage, coal pile runoff, and cooling water)

Parameter	mg/L, except pH and temp
pH	6 – 9
TSS	50
Oil and grease	10
Total residual chlorine	0.2
Chromium - Total (Cr)	0.5
Copper (Cu)	0.5
Iron (Fe)	1.0
Zinc (Zn)	1.0
Lead (Pb)	0.5
Cadmium (Cd)	0.1
Mercury (Hg)	0.005
Arsenic (As)	0.5
Temperature increase by thermal discharge from cooling system	• Site specific requirement to be established by the EA. • Elevated temperature areas due to discharge of once-through cooling water (e.g., 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge point.

Note: Applicability of heavy metals should be determined in the EA. Guideline limits in the Table are from various references of effluent performance by thermal power plants.

Table 2.3.3. Minimum Limits For Workplace Illumination Intensity	
Location / Activity	**Light Intensity**
Emergency light	10 lux
Outdoor non working areas	20 lux
Simple orientation and temporary visits (machine storage, garage, warehouse)	50 lux
Workspace with occasional visual tasks only (corridors, stairways, lobby, elevator, auditorium, etc.)	100 lux
Medium precision work (simple assembly, rough machine works, welding, packing, etc.)	200 lux
Precision work (reading, moderately difficult assembly, sorting, checking, medium bench and machine works, etc.), offices.	500 lux
High precision work (difficult assembly, sewing, color inspection, fine sorting etc.)	1,000 – 3,000 lux

Table 8 - ICNIRP exposure limits for occupational exposure to electric and magnetic fields.		
Frequency	Electric Field (V/m)	Magnetic Field (µT)
50 Hz	10,000	500
60 Hz	8300	415
Source: ICNIRP (1998) : "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)		

Table 2.7.1. Summary of Recommended Personal Protective Equipment According to Hazard

Objective	Workplace Hazards	Suggested PPE
Eye and face protection	Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation.	Safety Glasses with side-shields, protective shades, etc.
Head protection	Falling objects, inadequate height clearance, and overhead power cords.	Plastic Helmets with top and side impact protection.
Hearing protection	Noise, ultra-sound.	Hearing protectors (ear plugs or ear muffs).
Foot protection	Falling or rolling objects, pointed objects. Corrosive or hot liquids.	Safety shoes and boots for protection against moving & falling objects, liquids and chemicals.
Hand protection	Hazardous materials, cuts or lacerations, vibrations, extreme temperatures.	Gloves made of rubber or synthetic materials (Neoprene), leather, steel, insulating materials, etc.
Respiratory protection	Dust, fogs, fumes, mists, gases, smokes, vapors.	Facemasks with appropriate filters for dust removal and air purification (chemicals, mists, vapors and gases). Single or multi-gas personal monitors, if available.
	Oxygen deficiency	Portable or supplied air (fixed lines). On-site rescue equipment.
Body/leg protection	Extreme temperatures, hazardous materials, biological agents, cutting and laceration.	Insulating clothing, body suits, aprons etc. of appropriate materials.

Appendix 4 – No Objection Letter (NLA)

NATIONAL LAND AGENCY
20 North Street, Kingston
Tel: (876) 750-5263/946-5263 • Fax (876) 948-9382
website: www.nla.gov.jm

Reference No.: SN/306

5th October 2015

Mr. Peter Knight
Chief Executive Officer
National Environment and Planning Agency
10 Caledonia Avenue
Kingston 5

Re: Application to Purchase Land –
Part of Bourkesfield, Old Harbour, St. Catherine

Cabinet has approved the Electricity Sector Enterprise Team (ESET), for the development of new electricity generation capacity. The Terms of Reference for the ESET include the management of the procurement process in consultation the Office of Utilities Regulation (OUR), the JPSCo and the Minister of Science, Technology, Energy and Mining.

The Commissioner of Lands is in receipt of an application from the Jamaica Public Service Company Limited (JPSCo), seeking to purchase 25.1 acres of land, part of the captioned property, owned by the Commissioner of Lands (COL), which adjoins its Old Harbour Bay Plant. This is to facilitate the construction of a new power plant.

The COL is minded to recommend the divestment of the subject property to facilitate the construction of the new Power Plant. However, this is subject to the approval of the Hon. Minister with responsibility for lands.

Yours sincerely,

fr Peter Baker
Manager, Property Services
for Commissioner of Lands

Appendix 5 - Hydrolab Calibration Certificate

HACH®
Hydromet

Certificate of Instrument Performance

Agency Name: **CL Environmental**

Certification for Job# **3073519**

Part/Model Number: MiniSonde5	Serial Number: **49186**

RECEIVED CONDITION: *(One must be checked)*	X	Within Tolerance
		Within Tolerance but Limited *(*see service report)*
		Out of Tolerance *(*see service report)*
RETURNED CONDITION: *(One must be checked)*	X	Within Tolerance
		Within Tolerance but Limited *(*see service report)*

Test Equipment Used, (ID#): ASTM – N.I.S.T traceable glass thermometer (Thermo-Fisher Scientific, Serial **1781)** and a Cole-Parmer "*PolyStat*" Constant Temperature Circulator

Environmental Conditions:

Actual Temperature	Instrument Reading	Error
10 °C	10.02°C	.02°C
20 °C	20.00°C	.00°C
30 °C	29.95°C	.05°C

Hach Company 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: [signature] Title: Instrument Service Technician

Certification Date: 08/12/2013 08/12/2013

5600 Lindbergh Drive • Loveland, CO 80538
(800) 227-4224 / FAX (970) 461-3924

Part # 19773-01
Rev. 2

Appendix 6 – Noise QC 10 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: 5507895QIG030085

Submitted By: C.L. ENVIRONMENTAL CO

22 FORT GEORGE HEIGHTS, OLD STONY HILL RD, KINGSTON 9, JAMAICA

Serial Number:	QIG030085	Date Received:	9/11/2014
Customer ID:		Date Issued:	9/17/2014
Model:	QC-10 CALIBRATOR	Valid Until:	9/17/2015
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	12/15/2013	12/15/2014
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: James Neuman 9/17/2014
JAMES NEUMAN **Service Technician**

Reviewed/Approved By: 9/17/2014
Technical Manager/Deputy

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

Appendix 7 – Flora Species

SPECIES ENCOUNTERED ON JPS AND SJPC LANDS, PRIMARILY WITHIN THE THREE PROPOSED SITES

Scientific name	Common name	Growth form	DAFOR Ranking	Location (SJPC, 1, 1+, 2, 3)[33]
Antigonon leptopus	Coralita	Climbers/Twiners	F-A	SJPC, 1+
Cissus trifoliata	Sorrel Vine		F	1+, 2
Ipomoea sp.			F	1+
Ipomoea triloba			O	1+
Passiflora maliformis	Sweet Cup		O	1+
Ricinus communis	Castor Oil Plant, Oil Nut		R	1+, 3
Urechites lutea	Nightshade, Nightsage		O	1+, 3
Batis maritima	Jamaican Sapphire	Herbs	F-A	SJPC, 2
Cynodon dactylon	Bermuda Grass, Bahama Grass		A	1, 1+, 2, 3
Euphorbia prostrata	Milkweed		F	1+
Gomphrena decumbens			F	1+, 2
Musa sapientum	Banana		R	SJPC
Oeceoclades maculata	Monk Orchid/Ground Orchid		O	SJPC
Panicum maximum	Guinea Grass		A	SJPC
Portulaca sp.	Pussley		A	2
Rhynchospora nervosa	Star Grass		F	2
Sansevieria trifasciata	Tiger Cat			SJPC
Sesuvium portulacastrum	Seaside Purslane		O	2, 3
Spilanthes urens	Pigeon Coop		O-F	1+, 2
Sporobolus indica			F	1+, 2
Sporobolus virginicus			R	2, 3
Stemodia maritima			O-F	SJPC, 1+
Allamanda cathartica	Yellow Allamanda	Shrubs	R	1+
Cajanus cajan	Gungo Peas, Pigeon Peas			SJPC
Duranata repens	Angel's Whisper		R	3
Harrisia gracilis	Torchwood Dildo		R	1+
Ixora sp.			R	3
Jatropha gossypifolia	Belly-Ache-Bush		O	2, 3
Lantana camara	White Sage, Wild Sage	Shrubs (cont'd)	R	3
Nerium oleander	Oleander		O	3

[33] SJPC = SJPC lands; 1 = primary development area; 1+ = lands adjacent the primary development area; 2 = NE lands – thorn savannah; 3 = recreation area.

Scientific name	Common name	Growth form	DAFOR Ranking	Location (SJPC, 1, 1+, 2, 3) [33]
Pluchea carolinensis	Wild Tobacco		R	1+
Stenocereus hystrix	Dildo Pear		O	1+
Abutilon sp.		Shrubby Herbs	O	3
Bambusa vulgaris	Bamboo			SJPC
Desmanthus depressus			O	1+, 2
Gynerium saggitatum	Wild Cane			SJPC
Saccharum officinarum	Sugar Cane			SJPC
Sida acuta	Broomweed		A	1+
Turnera ulmifolia	Ram-Goat Dashalong		O	1+
Urena lobata	Ballard Bush, Bur Mallow		F	1+
Waltheria indica	Rachie		F	2
Acacia tortuosa	Wild Poponax	Trees	A	1+, 2, 3
Anacardium occidentale	Cashew			SJPC
Carica papaya	Papaya			SJPC
Cassia emarginata	Senna Tree, Yellow Candle Wood		R	SJPC, 3
Casurina equisetifolia	Willow		O	3
Cocus nucifera	Coconut		R	3
Cordia alba	Duppy Cherry		R	3
Ficus sp.	Fig		R	3
Guaiacum officinale	Lignum Vitae		O	1+
Guazuma ulmifolia	Bastard Cedar		A	SJPC
Leucaena leucosephala	Lead Tree		O	SJPC, 3
Mangifera indica	Mango			SJPC
Rhizophora mangle	Red Mangrove			SJPC
Samanea saman	Guango		F	SJPC
Ziziphus mauritiana	Coolie Plum		R	3

SPECIES ENCOUNTERED ON SJPC LANDS (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

Scientific name	Common name	Growth form	DAFOR Ranking
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
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
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 8 – Perception Survey Questionnaires

JAMAICA PUBLIC SERVICE COMPANY
190 MW COMBINED CYCLE PLANT

COMMUNITY QUESTIONNAIRE

DATE:___________________ **INTERVIEWER:**______________

LOCATION:__________________

Following the revocation of the EWI licence to construct a 360 MW Power Plant, and the awarding to JPS by the Office of Utilities Regulation, The Jamaica Public Service Company (JPS) is proposing to construct a 180-200 MW (Megawatt) combined cycle power plant on the existing Old Harbour facility which has 220 MW of generation and houses major transmission and distribution operation along with a privately owned diesel power plant. The proposed location for this new power plant is on the storage area for the existing 220 MW plant. This proposed project is expected to be undertaken from 2015 to 2017 and is part of the solution to replace aged heavy fuel-oil burning plants. The proposed plant is being designed to use natural gas as the primary gas.

COHORT DESCRIPTION

1. (i) Male (ii) Female
2. Age group (i) < 20 yrs (ii) 20- 29 yrs (iii) 30-39 yrs (iv) 40-49 yrs (v) 50 – 59 yrs (vi) older than 65 yrs
3. Are you a fisher (man/woman) (i) yes (ii) no
4. Not counting you, is anyone in your household a fisher (man/woman) (i) yes (ii) no
5. Are you a fish vendor (i) yes (ii) no
6. Not counting you, is anyone in your household a fish vendor (i) yes (ii) no
7. Are you the head of your household (i) yes (ii) no

   a. **If no** who is the head of the household? (i) father (ii) mother (iii) grandparents (iv) uncle (v) aunt (vi) other______________

8. What is the age of the household head? (i) 18- 25 yrs (ii) 26-33 yrs (iii) 34-41 yrs (iv) 42 – 50 yrs (v) 51 – 60 yrs (vi) older than 60 yrs
9. What is the main employment status of the household head? (If the interviewee is not the head of the household). (i) part time, (ii) seasonal, (iii) full time, (iv) unemployed (v) retired (vi) self employed (v)other ___________
10. What is the trade of the household head? ___________________________________
11. Do you have a partner/spouse living in the same household? (i) yes (ii) no

    a. If yes what is the trade of the partner? ___________________________________

12. How many persons in the household are presently employed? ___________________
13. Are you currently (i) employed (ii) unemployed (iii) retired
14. If employed do you work (i) part time, (ii) seasonally, (iii) full time (vi) self employed (v) other ___________
15. **If employed, what do you do?** ______________________________________

    (i) casual labour (ii) semi - skilled (iii) skilled (iv) artisan (v) professional

16. Where do you work? ________________________

    How far is your work from home? (i) less than a km, (ii) 1- 5km, (iii) 6- 15km (iv) >15km.

PERCEPTION

17. Did you know that the Jamaica Public Service (JPS) owns and operates the Old Harbour Power Station in Old Harbour Bay? (i) yes; (ii) no
18. Did you know that JPS uses fuel oil in the production of electricity? (i) yes; (ii) no

    ____

19. Are you aware that the Office of Utilities Regulation revoked Energy World International's license to construct a 360 MW Power Plant ? (i) yes; (ii) no
20. Are you aware of any plans by the Jamaica Public Service Company to construct a 180-200 MW (Megawatt) combined cycle power plant on to the existing Old Harbour facility ? (i) yes; (ii) no

a. If yes what do you know? ____

____

21. Do you have any concerns about the project as proposed? (i) yes; (ii) no (iii) not sure
    b. If yes what are they? ____
22. Do you think this project will affect your life? (i) positively; (ii) negatively, (iii) not at all (iv) not sure
    c. If yes how? ____
23. Do you depend on the proposed location for any type of business/farming/ residence? (i) yes; (ii) no
    d. If yes for what purpose and how?

    ____

24. Do you know of anyone who depends on the proposed location for any type of business/farming/ residence? (i) yes; (ii) no
    e. If yes for what purpose and how?

    ____

INCOME

25. What is the average weekly income of the household head?
(i) Below $1000, (ii) $1001 - $2000, (iii) $2001 - $4000, (iv) $4000 - $6000, (v) $6001 - $8000, (vi) Over $8000

26. What is the average weekly income of the partner?
(i) Below $1000, (ii) $1001 - $2000, (iii) $2001 - $4000, (iv) $4000 - $6000, (v) $6001 - $8000, (vi) Over $8000

27. What is the average weekly income of the household? (All sources)
(i) Below $1000, (ii) $1001 - $2000, (iii) $2001 - $4000, (iv) $4000 - $6000, (v) $6001 - $8000, (vi) Over $8000

EDUCATION

28. Does anyone in your household currently attend school? f (i) yes; (ii) no
29. If yes how many persons and what are their ages? ____

Basic [ ] Primary [ ] All Age [ ] Junior High [ ] New Secondary [ ] Secondary High [ ] Comprehensive High [ ] Technical High [ ]
Vocational Agricultural [ ] Community College [ ] Teachers College [ ] University [ ] HEART [ ] Other [ ]
____

Age/ # of Persons	NAME / TYPE OF SCHOOL	DISTANCE FROM HOME (Km)

HOUSING & SOCIAL AMENITIES

30. Approximately how old is the house you are living in?

    0 - 5 yrs. [ ] 6 - 11 yrs. [ ] 12 - 17 yrs. [ ] 18 - 24 yrs. [ ] 25 - 30yrs. [ ] Over 30 yrs. [ ]

31. Is the house that you live in (i) rented (ii) owned (iii) leased (iv) other ________________
32. How long have you (household) been living here?

    0 - 5 yrs. [ ] 6 - 11 yrs. [ ] 12 - 17 yrs. [ ] 18 - 24 yrs. [ ] Over 24 yrs. [ ]

33. Number of bedrooms? __________
34. Do you know of landlines in the community? (i) Yes (ii) No
35. Do you have a telephone? (i) Yes (ii) No
    f. If yes which do you have (a) landline (b) cell phone (c) both

NATURAL HAZARDS

36. Do you have any problems with domestic/household water supply (i) yes (ii) no

a. If yes what is the problem? (i) no water at all (ii) no pipes run to the area (iii) irregular water supply (iv) low water pressure (v) other ______________________

b. If yes how do you cope with the problem (i) collect rain water (ii) buy water (iii) collect water from a spring/river (iv) water truck supplies water (v) other ______________________

c. How do you store water (i) drums and other containers (ii) underground tank (iii) aboveground tank (iv) other _______________

37. Is your community affected by flooding (i) yes; (ii) no
    d. If yes how? ____

38. Is the proposed project site affected by flooding (i) Yes (ii) No

    e. If yes how? ____

    f. How frequently does flooding occur at the proposed site? (i) once per week (ii) once per month (iii) once every 3 months (iv) once every 6 months (v) other ____________________(how often)

39. How high does the water level rise at the proposed site? (i) less than 0.3m (1ft); (ii) 0.3 – 1.0m (1– 3ft); (iii) 1.0 – 1.5m (3 – 5ft) (iv) greater than 1.5m (5ft)

40. Are there problems with frequent fires at the proposed site? (i) yes (ii) no

    g. If yes how frequently does fires occur? (i) once per week (ii) once per month (iii) once every 3 months (iv) once every 6 months (v) other ____________________(how often)

41. During past hurricanes were you affected by storm surge or sea level rise? (i) Yes (ii) No
    If yes give details____

42. During past hurricanes was the proposed site affected by storm surge or sea level rise? (i) Yes (ii) No
    If yes give details ____

SERVICES, COMMUNITY COHESIVENESS & DEVELOPMENT

43. How do you travel? (i) Bus (ii) Personal vehicle (iii) Taxi (iv) Other _________________

44. How much do you pay to travel? _____________________________________

45. Where do you normally shop for the household? _________________________

46. Where do you go to market? ______________________________________

47. Where do you go for health care when you are sick? ______________________

Over the past twelve months did you or any member of your household have frequent:
(i) bouts of diarrhoea (ii) coughing (iii) suffocating feelings (iv) congestion (v) chest pains?

If yes how often? ___________________________

48. Are there any church groups in your area? (i) Yes ___________________(ii) No

49. Are there any environmental groups in your area? (i) Yes ____________
    (ii) No

50. Are there any other organizations in your area? (i) Yes ___________________
    (ii) No

51. How active are these organizations? __________________________________

52. Are you actively involved in any of these groups? (i) Yes (ii) No (iii) Used to be
    ____

RECREATION & CONSERVATION

53. Are there any recreational facilities nearby? (i) Yes (ii) No

54. If yes, name and location of facility _______________________________________

55. Are you aware of any historic or cultural areas / sites in your community or nearby?
    (i) Yes ____ (ii) No

56. If yes, what do you know about the site? ___________________________________

57. Are you aware of any nature reserves in your community or nearby? (i) Yes (ii) No

    If yes, where is the site? ____

58. Is there anything in particular about your area that you would like to tell us?

____

____

59. Any other comments:

CONTINUE TO THESE QUESTIONS IF THE PERSON IS A FISHER OR FISH VENDOR

60. How long have you been a fisher or fish vendor?
(i) 0 - 5 yrs. (ii) 6 - 11 yrs. (iii) 12 - 17 yrs. (iv) 18 - 24 yrs. (v) 25 - 30yrs. (vi) Over 30 yrs.
61. Where do you fish? ____________________________
62. How has your pound catch/ sale/ yield changed over time? (i) increase (ii) decrease
63. Is there a time/ season when the fish catch/ sale is high? (i) yes (ii) no
    g. If yes explain ____
64. Have you noticed a change in the size and types of fish you catch or sell? (i) yes increase (ii) yes decrease (ii) no change
    h. If yes what do you think is the reason (s)? __________________________
65. Do you think that the proposed project will affect your business/ trade? (i) positively (ii) negatively (iii) not at all (iv) not sure
    i. Explain ____

Signature: ....
Interviewer

JAMAICA PUBLIC SERVICE COMPANY
360 MW COMBINED CYCLE PLANT

FISHERS QUESTIONNAIRE

DATE:___________________ **INTERVIEWER:**______________

LOCATION:__________________

Following the revocation of the EWI licence to construct a 360 MW Power Plant, and the awarding to JPS by the Office of Utilities Regulation, The Jamaica Public Service Company (JPS) is proposing to construct a 180-200 MW (Megawatt) combined cycle power plant on the existing Old Harbour facility which has 220 MW of generation and houses major transmission and distribution operation along with a privately owned diesel power plant. The proposed location for this new power plant is on the storage area for the existing 220 MW plant. This proposed project is expected to be undertaken from 2015 to 2017 and is part of the solution to replace aged heavy fuel-oil burning plants. The proposed plant is being designed to use natural gas as the primary gas

COHORT DESCRIPTION

1. (i) Male (ii) Female
2. Age group (i) < 20 yrs (ii) 20- 29 yrs (iii) 30-39 yrs (iv) 40-49 yrs (v) 50 – 59 yrs (vi) older than 65 yrs
3. Are you a fisher (man/woman) (i) yes (ii) no
4. Not counting you, is anyone else in your household a fisher (man/woman) (i) yes (ii) no
   a. If yes how many persons ______
5. Are you a fish vendor (i) yes (ii) no
6. Not counting you is anyone else in your household a fish vendor (i) yes (ii) no
   a. If yes how many persons ______
7. Are you the head of your household (i) yes (ii) no
   a. **If no** who is the head of the household? (i) father (ii) mother (iii) grandparents (iv) uncle (v) aunt (vi) other______________
8. What is the age of the household head? (i) 18- 25 yrs (ii) 26-33 yrs (iii) 34-41 yrs (iv) 42 – 50 yrs (v) 51 – 60 yrs (vi) older than 60 yrs
9. What is the main employment status of the household head? **(If the interviewee is not the head of the household)**.
   (i) part time, (ii) seasonal, (iii) full time, (iv) unemployed (v) retired (vi) self-employed (v)other ___________
10. What is the trade of the household head? ____________________________________
11. Do you have a partner/spouse living in the same household? (i) yes (ii) no
    a. If yes what is the trade of the partner? _____________________________________
12. How many persons in the household are presently employed? ____________________
13. Are you currently (i) employed (ii) unemployed (iii) retired
14. If employed do you work (i) part time, (ii) seasonally, (iii) full time (vi) self-employed (v) other ___________
15. How long have you been a fisher or fish vendor?
    (i) 0 - 5 yrs. (ii) 6 - 11 yrs. (iii) 12 - 17 yrs. (iv) 18 - 24 yrs. (v) 25 - 30yrs. (vi) Over 30 yrs.
16. Where do you sell fish? _____________________________________
17. Where do you fish? ________________________________
18. What do you use for fishing (i) line (ii) spear (iii) net (iv)fish pot (v) other ________________
19. What type of vessel do you use for fishing (i) canoe without engine (ii) canoe with engine (iii) large boat with net (trawler) (iv) other ____
    a. If your vessel has an engine how many engines does it have_________ and what is the engine size _________
20. Including you how many persons work on your vessel? ____
    ____
21. Including you does anyone else sell fish with you? (i) yes (ii) no
    a. If yes how many persons ___________________________________
22. How many times per week do you sell fish? ______________________________
23. How many times per week do you go fishing? _________________________________
24. What species/ type of fish do you catch? ____
    ____
25. How many pounds of fish do you usually catch ? ___________________________________

26. Can you give an y idea of the pound catch for fish you catch? ______________________________

____

27. How has your pound catch/ sale/ yield changed over time? (i) increase (ii) decrease (iii) no change

28. Is there a time/ season when the fish catch/ sale is high? (i) yes (ii) no

    a. If yes explain ____

29. Have you noticed a change in the size and types of fish you catch or sell? (i) yes increase (ii) yes decrease (ii) no change

    If yes what do you think is the reason (s)? ___________________________

30. What is the average weekly income of fish sales?

    (i) Below $1000, (ii) $1001 - $2000, (iii) $2001 - $4000, (iv) $4000 - $6000, (v) $6001 - $8000, (vi) Over $8000

31. Have you noticed a change in money earned from sales? (i) yes increase (ii) yes decrease (ii) no change

    If yes what do you think is the reason (s)? ___________________________

PERCEPTION

32. Did you know that the Jamaica Public Service (JPS) owns and operates the Old Harbour Power Station in Old Harbour Bay? (i) yes; (ii) no

33. Did you know that JPS uses fuel oil in the production of electricity? (i) yes; (ii) no

    ____

34. Are you aware that the Office of Utilities Regulation revoked Energy World International's license to construct a 360 MW Power Plant ? (i) yes; (ii) no

35. Are you aware of any plans by the Jamaica Public Service Company to construct a 180-200 MW (Megawatt) combined cycle power plant on to the existing Old Harbour facility ? (i) yes; (ii) no

    b. If yes what do you know? ____

    ____

36. Do you have any concerns about the project as proposed? (i) yes; (ii) no (iii) not sure

    c. If yes what are they? ____

37. Do you think this project will affect your life? (i) positively; (ii) negatively, (iii) not at all (iv) not sure

    d. If yes how? ____

38. Do you depend on the proposed location for any type of business/farming/ residence? (i) yes; (ii) no

    e. If yes for what purpose and how?

    ____

39. Do you know of anyone who depends on the proposed location for any type of business/farming/ residence? (i) yes; (ii) no

    f. If yes for what purpose and how?

    ____

40. Is there anything in particular that you would like to tell us?

____

____

Any other comments:

Signature: ....
Interviewer

Appendix 9 –Perception Survey Results by Community

BLACKWOOD GARDENS

13.6% of respondents were interviewed in the Blackwood Gardens Community. Of this, 63.6% were male and 36.4% were female. Respondents were of the age cohort 20-29 (36.4%), 30-39 (27.3%), 50-59 (9.1%) and >65 years (27.3%). No one interviewed was in the <20 and 40-49 years cohort. 90.9% of respondents stated that they were not fishers. 90.9% of respondents stated they were not fish vendors. 100% of respondents indicated that no other person in their household was a fisher, or fish vendor.

100% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, and were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 54.5% of respondents were aware of the revocation while 45.5% indicated they were not aware. 27.3% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant. Although, it could not be statistically presented, it was observed that some respondents mistook this current project proposal with that proposed previously. 72.7% of interviewees were not aware of the new proposal to construct the 180 - 200 MW plant.

On the issue of project concerns 36.4% of respondents indicated that they had concerns about the project. 63.6% of respondents indicated that they did not have any concerns related to the project. Of the 36.4% of respondents expressing concern about the project 25% were concerned about the project being safe for the area and whether benefits were to be had for the community. 25% expressed concern about possible air pollution. 25% expressed concern regarding whether or not the project would generate employment opportunities and 25% were concerned about how the plant would affect health.

36.4% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with all respondents anticipating the creation of employment opportunities. Of the 18.2% of respondents indicating a negative impact on their lives, all respondents indicated that the project would result in pollution, with 50% anticipating noise pollution and 50% anticipating air pollution which could trigger asthma. 9.1% of respondents did not anticipate an effect on their lives while 36.4% were uncertain about potential effects on their lives. 9.1% of the respondents indicated that they depended on the proposed location for business specifically stating periodic fishing while 90.9% indicated that they did not depend on the proposed location. 9.1% of respondents indicated that they knew of someone who depended on the proposed location for business, specifically for farming. 90.9% of interviewees indicated that they did not know of anyone who depended on the proposed site.

9.1% of those interviewed indicated that they had a problem with domestic water supply, with the problem being low water pressure. During the interviews process it was learnt that the Blackwood

Gardens community was supplied with water by the National Water Commission. 90.9% of respondents indicated that there was no issue with domestic water supply.

27.3% of respondents indicated that their community was affected by flooding while 72.7% stated that it was not. Regarding whether the proposed site was affected by flooding, 9.1% of respondents indicated that the proposed site was affected while 90.9% indicated the site was not. 100% of respondents indicated that the site was not affected by frequent fires.

45.5% of those interviewed indicated that they were affected by storm surge or sea level rise. Respondents indicated that there was flooding in the community and that the drains overflowed. When asked if the proposed site was affected by storm surge or sea level rise, 27.3% of respondents stated that the site was affected. 72.7% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

81.8% of respondents stated that the area had a recreational facility with all respondents naming the Blackwood Gardens Community Centre. 27.3% of respondents indicated the presence of a historic or cultural site in or nearby the area. Of the 27.3% of respondents 66.7% indicated Goat Island as a historic and cultural areas and 33.3% indicated the St. Philip's Anglican Church. 45.5% of interviewees indicated awareness of the presence of any nature reserves, with 40% of these respondents naming Goat Island, 40% naming the fish sanctuary and 20% naming Terminal.

DAGGER BAY

4.9% of respondents were interviewed in the Dagger Bay Community. Of this, 75% were male and 25% were female. Respondents were of the age cohort under 20 years of age (25%), 20-29 (25%), 30-39 (25%) and 50-59 (25%). No one interviewed was in the 40-49 years and over 65 years cohort. 75% of respondents stated that they were not fishers. 100% of respondents stated they were not fish vendors. 25% of respondents indicated that someone else in their household was a fisher while 75% indicated that no other person in their household was a fisher. 50% of respondents indicated that, not including them, someone in their household was a fish vendor.

100% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, and were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 25% of respondents were aware of the revocation while 75% indicated they were not aware. None of the respondents interviewed (100%) was aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant.

On the issue of project concerns 50% of respondents indicated that they had concerns about the project. 25% of respondents indicated that they did not have any concerns related to the project while 25% were not sure. Of the 50% of respondents expressing concern about the project 50% were concerned that the proposed plant was too close in proximity to their dwelling while the other 50%

were concerned about how long term exposure to chemicals may affect persons as well as possible sea level rise and its effects on construction.

25% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with all respondents anticipating the creation of employment opportunities. Of the 25% of respondents indicating a negative impact on their lives, all respondents indicated that it may be harmful to inhale emissions. 0.0% of respondents did not anticipate an effect on their lives while 50% were uncertain about potential effects on their lives. 100% of interviewees indicated that they did not depend on the proposed location and further indicated that they did not know of anyone who depended on the proposed site.

25% of those interviewed indicated that they had a problem with domestic water supply, with the problem being that no pipes are run in the area. 75% of respondents indicated that there was no issue with domestic water supply.

75% of respondents indicated that their community was affected by flooding while 25% stated that it was not. It was indicated that flooding in the community occurs in time of hurricane when there are heavy rains and when the tide is high. Regarding whether the proposed site was affected by flooding, 0.0% of respondents indicated that the proposed site was affected while 100% indicated the site was not. 100% of respondents indicated that the site was not affected by frequent fires.

100% of those interviewed indicated that they were affected by storm surge or sea level rise; however no details were provided. When asked if the proposed site was affected by storm surge or sea level rise, 100% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

50% of respondents stated that the area had a recreational facility. Of these respondents 50% named the Blackwood Gardens Community Centre and 50% referred to an open lot in the Dagger Bay Community. 50% of respondents indicated the presence of a historic or cultural site in or nearby the area, with all respondents stating the Goat Islands and 50% of the respondents stating that within the mangroves there still exists brick ruins; this however could not be verified. 75% of interviewees indicated awareness of the presence of any nature reserves and stated the Goat Islands and Fish Sanctuary.

STATION LANE

3.7% of respondents were interviewed in the Station Lane Community. Station Lane is also known as Old Market Street. Of this, 0.0% were male and 100% were female. Respondents were of the age cohort 20-29 (33.3%) and 30-39 (66.7%). No one interviewed was in the <20, 40-49, 50-59, and older than 65 years cohorts. 100% of respondents stated that they were not fishers. 66.7% of respondents stated they were not fish vendors while 33.3% stated that they were. 66.7% of respondents indicated another person in their household was a fisher and 33.3% indicated that no other person in their household was a fisher. 100% of respondents indicated that no other person in their household was a fish vendor.

66.7% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay while 100% stated that they were aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 33.3% of respondents were aware of the revocation while 66.7% indicated they were not aware. Of respondents interviewed no one was aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant.

On the issue of project concerns 66.7% of respondents indicated that they had concerns about the project. 33.3% of respondents indicated that they did not have any concerns related to the project. Of the 66.7% of respondents expressing concern about the project, 50% were concerned about whether employment opportunities would arise and 50% expressed concern about the community deaths being as a result of the power plant.

33.3% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with all respondents anticipating direct employment associated with new plan. 33.3% of respondents indicated that they anticipated a negative impact on their lives, with all respondents indicating health issues as a result of the new plant. 33.4% of respondents did not anticipate an effect on their lives. 100% of interviewees indicated that they did not depend or know of anyone who depended on the proposed site for any type of business, residence or farming.

100% of those interviewed indicated that they did not have a problem with domestic water supply.

100% of respondents indicated that their community was affected by flooding, with 33.3% stating that flooding occurred during times of hurricane/storms, 33.3% indicated flooding in times of very heavy rains and 33.4% did not provide details. Regarding whether the proposed site was affected by flooding, 100% of respondents indicated that the proposed site was not affected by flooding. 100% of respondents indicated that the site was not affected by frequent fires.

100% of those interviewed indicated that they were affected by storm surge or sea level rise. Flooding of homes and the community in general was the main issue reported (66.7%). 33.3% did not give details. When asked if the proposed site was affected by storm surge or sea level rise, 100% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

66.7% of respondents stated that the area had a recreational facility. Of the 66.7% indicating the presence of a recreational facility, 100% mentioned the Blackwood Gardens Community Centre. 33.3% of respondents indicated the presence of a historic or cultural site in or nearby the area, specifically naming the Church of England (Anglican Church). 66.7% of interviewees indicated awareness of the presence of any nature reserves, with respondents naming the Goat Islands (50%) and a fish sanctuary (50%). 33.3% of respondents stated that they did not know of any nature reserves, in or nearby their community.

BAY BOTTOM

9.9% of respondents were interviewed in the Bay Bottom Community. Of this, 50.0% were male and 50.0% were female. Respondents were of the age cohort under 20 years (12.5%), 20-29 (12.5%), 30-39 (12.5%), 40-49 (25%), 50-59 (25%) and >65 years (12.5%). 25% of respondents stated that they were fishers while 75% stated that they were not fishers. 100% of respondents stated they were not fish vendors. 12.5% of respondents indicated that another person in their household was a fisher while 87.5% indicated that no other person in their household was a fisher. 12.5% of respondents indicated that another person in their household was a fish vendor while 87.5% indicated that no other person in their household was a fish vendor.

100% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, and were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 50.0% of respondents were aware of the revocation while 50.0% indicated they were not aware. 50.0% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant. Although, it could not be statistically presented, it was observed that some respondents mistook this current project proposal with that proposed previously. 50.0% of interviewees were not aware of the new proposal to construct the 180 - 200 MW plant.

On the issue of project concerns 12.5% of respondents indicated that they had concerns about the project, with all respondents expressing concern about possible health effects and emissions. 75.0% of respondents indicated that they did not have any concerns related to the project. 12.5% of respondents were uncertain about whether or not they were concerned about any aspect of the project as proposed.

25% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with 50.0% of respondents anticipating the creation of employment opportunities and 50% anticipating lower electricity bills. 0.0% of respondents indicated that they expected negative impact on their lives. 37.5% of respondents did not anticipate an effect on their lives while 37.5% were uncertain about potential effects on their lives.

100% of the respondents indicated that they did not depended on the proposed location for business, farming or residence and further indicated that they did not know of anyone who depended on the proposed location for business, farming or residence.

37.5% of those interviewed indicated that they had a problem with domestic water supply, with 33.3% of interviewees stating the problem as low water pressure and 66.7% stating irregular water supply.

87.5% of respondents indicated that their community was affected by flooding further indicating that the community is flooded in times of very heavy rains occurring during rainy months where there is continuous rain for days or during hurricanes. 12.5% of individuals stated that Bay Bottom was not affected by flooding. Regarding whether the proposed site was affected by flooding, 100% indicated the site was not. 100% of respondents indicated that the site was not affected by frequent fires.

87.5% of those interviewed indicated that they were affected by storm surge or sea level rise. Respondents indicated that there was the overflowing of gullies and drains, flooding of homes and the community at large with water levels reaching between one and two metres. When asked if the proposed site was affected by storm surge or sea level rise, 12.5% of respondents stated that the site was affected, however no details were given. 87.5% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

62.5% of respondents stated that the area had a recreational facility while 37.5% indicated that Bay Bottom had no recreational facility. Of the 62.5% indicating the presence of a recreational facility, all respondents mentioned the Blackwood Gardens Community Centre. 37.5% of respondents indicated the presence of a historic or cultural site in or nearby the area. 33.3% of respondents respectively indicated Goat Island, the Church of England (Anglican Church) and the Burkesfield Area (controlled by Spaniards in the past) as historic or cultural sites. 75% of interviewees indicated awareness of the presence of any nature reserves with 25% indicating that there were not aware. Of the 75.0% indicating awareness of a nature reserve 16.7% stated Old Harbour Bay and 83.3% stated the Goat Islands, with some respondents stating the fish sanctuary and the presence of iguanas on the Goat Islands.

BURKESFIELD MEADOWS

3.7% of respondents were interviewed in the Burkesfield Meadows Community. Of this, 100% were male. Respondents were of the age cohort under 20 years (0.0%), 20-29 (0.0%), 30-39 (0.0%), 40-49 (66.7%), 50-59 (33.3%) and >65 years (0.0%). 66.7% of respondents stated that they were fishers while 33.3% stated that they were not fishers. 100% of respondents stated they were not fish vendors. 100% indicated that no other person in their household was a fisher. 33.3% of respondents indicated that another person in their household was a fish vendor while 66.7% indicated that no other person in their household was a fish vendor.

100% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, and were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation’s revocation of Energy World International's license to construct a 360MW Power Plant, 100% of respondents were aware of the revocation. 33.3% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant. 66.7% of interviewees were not aware of the new proposal to construct the 180 - 200 MW plant.

On the issue of project concerns 100% of respondents indicated that they had concerns about the project. 33.3% were concerned about whether or not the project was safe indicating that they object to the project if it is unsafe in any way. 33.3% expressed concern about noise from the JPS plant and 33.4% were concerned about smoke stack emissions as the emissions pose health issues.

33.3% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with all respondents anticipating the creation of employment opportunities which should result in a reduction in crime and idlers on the roads. 33.3% of respondents indicated that they expected negative impact on their lives, with all interviewees indicating negative impact from noise and the "acid smell" from the plant which blows towards the sea. 33.4% of respondents did not anticipate an effect on their lives while 0.0% were uncertain about potential effects on their lives.

100% of the respondents indicated that they did not depended on the proposed location for business, farming or residence and further indicated that they did not know of anyone who depended on the proposed location for business, farming or residence.

33.3% of those interviewed indicated that they had a problem with domestic water supply, with all interviewees stating the problem "green water with morass that is not fit for drinking". It should be noted that during the interview exercise it was learnt that the residents of Burkesfield Meadows are not connected to the National Water Commission's network; instead they receive water from a line run by the Jamaica Public Service. It was learnt further that JPS has advised persons connected to their line that the water is not for drinking purposes.

100% of individuals stated that Burkesfield Meadows was not affected by flooding. Regarding whether the proposed site was affected by flooding, 33.3% indicated that the site was affected by flooding in times of very heavy rains with flood water flowing from the town of Old Harbour via the Bowden Gully; while 66.7% indicated the site was not. 33.3% of interviewees stated that the proposed site was affect by frequent fires stating that in an effort to bush land; fires are set. 66.7% of respondents indicated that the site was not affected by frequent fires.

100% of those interviewed indicated that they were not affected by storm surge or sea level rise. When asked if the proposed site was affected by storm surge or sea level rise, 100% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

100% of respondents stated that the area had a recreational facility. 66.7% mentioned the Blackwood Gardens Community Centre and 33.3% mentioned a park within the Burkesfield Meadows community. 66.7% of respondents indicated the presence of a historic or cultural site in or nearby the area, with the respondents indicating Goat Islands. 100% of interviewees indicated awareness of the presence of any nature reserves. Goat Islands was again stated as a nature reserve. Welcome Beach, Port Esquivel and Galleon Harbour were also stated as nearby nature reserves.

MAIN STREET OLD HARBOUR BAY

7.4% of respondents were interviewed in the Main Street Old Harbour Bay Community. Within the Main Street Area were Panton Town, Thompson Pen and Nurain/Noreign Avenue. Of this 7.4%, 83.3% were male and 16.7% were female. Respondents were of the age cohort under 20 years (0.0%), 20-29 (0.0%), 30-39 (16.7%), 40-49 (33.3%), 50-59 (33.3%) and >65 years (16.7%). 83.3% of respondents stated that they were fishers while 16.7% stated that they were not fishers. 100% of respondents stated they were not fish vendors. 16.7% indicated that another person in their household was a fisher while 83.3% indicated that no other person in the household was a fisher. 16.7% of respondents indicated that another person in their household was a fish vendor while 83.3% indicated that no other person in their household was a fish vendor.

100% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay. 83.3% of interviewees were also aware that JPS uses fuel oil to generate electricity while 16.7% were not aware. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 33.3% of respondents were aware of the revocation the remaining 66.7% were not aware. 50% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant. 50% of interviewees were not aware of the new proposal to construct the 180 - 200 MW plant.

On the issue of project concerns 16.7% of respondents indicated that they had concerns about the project with all respondents expressing concern about how the proposed project will affect the local fishers. 83.3% of those interviewed expressed no concern.

33.3% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with 50.0% of these respondents anticipating the creation of employment opportunities for family members and 50.0% expecting a reduction in electricity rates. 16.7% of respondents indicated that they expected negative impact on their lives, with all interviewees indicating negative impact on the local fishers. 33.3% of respondents did not anticipate an effect on their lives while 16.7% were uncertain about potential effects on their lives.

83.3% of the respondents indicated that they did not depended on the proposed location for business, farming or residence and further indicated that they did not know of anyone who depended on the proposed location for business, farming or residence. 16.7% of respondents indicated that they depended on the proposed site for fishing and knew of others who also depended on the area for fishing.

16.7% of those interviewed indicated that they had a problem with domestic water supply, with all interviewees stating the problem as low water pressure.

50% of individuals stated that Main Street Old Harbour Bay was affected by flooding, with flooding occurring in times of very heavy rains and hurricane with the yard area being flooded. Regarding whether the proposed site was affected by flooding, 100% indicated the site was not. 100% of respondents indicated that the site was not affected by frequent fires.

33.3% of those interviewed indicated that they were not affected by storm surge or sea level rise while 66.7% indicated that they were affected. 25.0% of respondents did not give details, while 25.0% respectively stated that the area was flooded, hurricane Dean resulted in water levels rising 1.0 - 2.0 metres and water levels in the vicinity of the fishing beach entrance has in past times risen to more than 1.75 metres. When asked if the proposed site was affected by storm surge or sea level rise, 100% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

83.3% of respondents stated that the area had a recreational facility, with all persons naming the Blackwood Gardens Community Centre. 16.7% of respondents indicated the presence of a historic or cultural site in or nearby the area, with these respondents indicating the wharf where the East Indians landed. 66.7% of interviewees indicated awareness of the presence of any nature reserves. Goat Islands was again stated as a nature reserve. The fish sanctuary was also stated as a nearby nature reserve.

BUDDHO

7.4% of respondents were interviewed in the Buddho Community. Of this, 33.3% were male and 66.7% were female. Respondents were of the age cohort under 20 years (0.0%), 20-29 (33.3%), 30-39 (016.7%), 40-49 (16.7%), 50-59 (16.7%) and >65 years (16.7%). 16.7% of respondents stated that they were fishers while 83.3% stated that they were not fishers. 100% of respondents stated they were not fish vendors. 50% respectively indicated that another person in the household and no other person in their household was a fisher. 66.7% of respondents indicated that another person in their household was a fish vendor while 33.3% indicated that no other person in their household was a fish vendor.

100% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, and were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 50% of respondents were aware of the revocation and 50% were not aware. 16.7% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant. 83.3% of interviewees were not aware of the new proposal to construct the 180 - 200 MW plant.

On the issue of project concerns 16.7% of respondents indicated that they had concerns about the project. With these concerns relating to how the project will impact health. 83.3% of respondents did not have any concerns.

16.7% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with all respondents anticipating the creation of employment opportunities for family members. 33.3% of respondents indicated that they expected negative impact on their lives, with 50.0% of interviewees indicating negative impact from chimney noise blast which is loud and frightening and 50% indicating negative impact due to vibrations from the plant damaging homes and smoke causing asthma. 33.3% of respondents did not anticipate an effect on their lives while 16.7% were uncertain about potential effects on their lives.

100% of the respondents indicated that they did not depended on the proposed location for business, farming or residence and further indicated that they did not know of anyone who depended on the proposed location for business, farming or residence.

66.7% of those interviewed indicated that they had a problem with domestic water supply, with interviewees stating the problem as low water pressure (75%), no pipes being run in the area (25%) and irregular water supply (25%).

83.3% of individuals stated that Buddho was affected by flooding, with flooding occurring in times of very heavy rains, at which time the drains overflow. Regarding whether the proposed site was affected by flooding, 100% indicated that the site was not affected by flooding. 100% of respondents indicated that the site was not affected by frequent fires.

83.3% of those interviewed indicated that they were affected by storm surge or sea level rise. Respondents indicated that the community flooded in past hurricanes and residents had to evacuate the area. When asked if the proposed site was affected by storm surge or sea level rise, 100% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

83.3% of respondents stated that the area had a recreational facility. 60% mentioned the Blackwood Gardens Community Centre, 20% stated community centre but did not indicate if the centre had a name and 20.0% mentioned the Old Harbour Community Centre. 16.7% of respondents indicated the presence of a historic or cultural site in or nearby the area, with the respondents indicating the Church of England. 33.3% of interviewees indicated awareness of the presence of any nature reserves and named the Old Harbour Bay Fishing Port and a fish sanctuary.

TERMINAL/TERMINAL ROAD

25.9% of respondents were interviewed in the Terminal Community. Of this, 66.7% were male and 33.3% were female. Respondents were of the age cohort under 20 years (9.5%), 20-29 (19.0%), 30-39 (19.0%), 40-49 (14.3%), 50-59 (33.3%) and >65 years (4.8%). 9.5% of respondents stated that they were fishers while 90.5% stated that they were not fishers. 4.8% of respondents stated that they were fisher vendors while 95.2% of respondents stated they were not fish vendors. 14.3% of respondents indicated that another person in their household was a fisher while 85.7% indicated that no other person in their household was a fisher. 19.0% of respondents indicated that another person in their household was a fish vendor while 81.0% indicated that no other person in their household was a fish vendor.

100% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay. 90.5% of interviewees were also aware that JPS uses fuel oil to generate electricity while 9.5% were not aware. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 66.7% of respondents were aware of the revocation while 33.3% indicated they were not aware. 57.1% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant. Although, it could not be statistically presented, it was observed that some respondents mistook this current project proposal with that proposed previously. 42.9% of interviewees were not aware of the new proposal to construct the 180 - 200 MW plant.

On the issue of project concerns 19.0% of respondents indicated that they had concerns about the project. 25% of these respondents did not specify the concern; 25% were concerned about whether or not the new plant would be the same as the existing plant; 25% we concerned about the possible future health effects once the plant is operational and 25% were concerned about the possibility of being employed. 76.2% of respondents indicated that they did not have any concerns related to the project. 4.8% of respondents were uncertain about whether or not they were concerned about any aspect of the project as proposed.

38.1% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with all respondents anticipating the creation of employment opportunities. 9.5% of respondents indicated that they expected negative impact on their lives with all respondents indicating pollution, specifically noise and smoke. 28.6% of respondents did not anticipate an effect on their lives while 23.8% were uncertain about potential effects on their lives.

4.8% of the respondents indicated that they depended on the proposed location for farming, while 95.2% indicated that they did not depend on the lands for any business, farming or residence. 9.5% of interviewees indicated that they knew of someone who depended on the proposed location for farming while 90.5% of respondents indicated that they did not know of anyone who depended on the proposed location for business, farming or residence.

28.6% of those interviewed indicated that they had a problem with domestic water supply, with 16.7% of interviewees stating the problem as low water pressure, 16.3% stating no water at all and 67.0% stating irregular water supply. 71.4% of respondents indicated that they did not have any problems with domestic water supply

52.4% of respondents indicated that their community was affected by flooding. While some respondent did not provide details on flooding other respondents stated that flooding occurred in times of hurricane, times of extremely heavy rains or during flood rains. 47.6% of individuals stated that their community was not affected by flooding. Regarding whether the proposed site was affected by flooding, 14.8% indicated the site was affected while 85.7% indicated the proposed site was not. 100% of respondents indicated that the site was not affected by frequent fires.

33.3% of those interviewed indicated that they were affected by storm surge or sea level rise. Respondents who provided details on how they were affected by storm surge or sea level rise indicated that the sea has in past hurricanes deposited mud on land and that sea level changes resulted in boats being dumped on land. It was also mentioned that water comes up river and on to roadways and that shops and other buildings on the beach were destroyed. When asked if the proposed site was affected by storm surge or sea level rise, 4.8% of respondents stated that the site was affected, however no details were given. 95.2% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

90.5% of respondents stated that the area had a recreational facility while 9.5% indicated that Terminal had no recreational facility. Of the 90.5% indicating the presence of a recreational facility, 77.7% respondents mentioned the Blackwood Gardens Community Centre 22.3% of respondents named the Old Harbour Bay Community Centre. During the interview exercise, some respondents indicated that the community centre located in Blackwood Gardens was to serve the entire Old Harbour Bay area and that the centre was present before the Blackwood Gardens Housing Scheme and was originally the Old Harbour Bay Community Centre. This information however could not be verified. 28.6% of respondents indicated the presence of a historic or cultural site in or nearby the area. 16.7% of interviewees did not provide details, 16.6% of respondents indicated Goat Island, 16.7% indicated Colbeck Castle and 50% the Church of England (Anglican Church) as historic or cultural sites. 61.9% of interviewees indicated awareness of the presence of any nature reserves with 38.1% indicating that there were not aware. Of the 61.9% indicating awareness of a nature reserve 69.2% stated the Goat Islands. 7.7% stated a fish sanctuary, 7.7% stated Century Farm and 15.4% stated Terminal with some respondents (50%) stating the presence of crocodiles.

KELLY PEN

3.7% of respondents were interviewed in the Kelly Pen Community. Of this, 66.7% were male and 33.3% were female. Respondents were of the age cohort under 20 years (0.0%), 20-29 (66.7%), 30-39 (0.0%), 40-49 (0.0%), 50-59 (0.0%) and >65 years (0.0%). 100% of interviewees stated that they were not fishers or fish vendors. 100% of respondents indicated that no other person in their household was a fisher or fish vendor.

100% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay and were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 33.3% of respondents were aware of the revocation while 66.7% indicated they were not aware. 33.3% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant. Although, it could not be statistically presented, it was observed that some respondents mistook this current project proposal with that proposed previously. 66.7% of interviewees were not aware of the new proposal to construct the 180 - 200 MW plant.

On the issue of project concerns 100% of respondents indicated that they did not have concerns about the project.

33.3% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with all respondents anticipating the creation of employment opportunities. 0.0% of respondents indicated that they expected negative impact on their lives. 33.3% of respondents did not anticipate an effect on their lives while 33.4% were uncertain about potential effects on their lives.

100% indicated that they did not depend on the lands for any business, farming or residence and further indicated that they did not know of anyone who depended on the proposed location for business, farming or residence.

66.7% of those interviewed indicated that they had a problem with domestic water supply, with all interviewees stating the problem as low water pressure. 33.3% of respondents indicated that they did not have any problems with domestic water supply

100% of individuals stated that their community was not affected by flooding. Regarding whether the proposed site was affected by flooding, 100% indicated the proposed site was not. 100% of respondents indicated that the site was not affected by frequent fires.

100% of those interviewed indicated that they were not affected by storm surge or sea level rise. When asked if the proposed site was affected by storm surge or sea level rise, 100% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

66.7% of respondents stated that the area had a recreational facility with all persons naming the Blackwood Gardens Community Centre. 100% of respondents indicated that they were not aware of the presence of a historic or cultural site in or nearby the area. 100% of interviewees indicated that they were not aware of the presence of any nature reserves within or nearby their community.

SETTLEMENT

16.0% of respondents were interviewed in the Settlement Community. Of this, 61.5% were male and 38.5% were female. Respondents were of the age cohort under 20 years (0.0%), 20-29 (7.7%), 30-39 (15.4%), 40-49 (23.1%), 50-59 (38.5%) and >65 years (15.4%). 100% stated that they were not fishers. 23.1% of respondents stated that they were fisher vendors while 76.9% of respondents stated they were not fish vendors. 15.4% of respondents indicated that another person in their household was a fisher while 84.6% indicated that no other person in their household was a fisher. 15.4% of respondents indicated that another person in their household was a fish vendor while 84.6% indicated that no other person in their household was a fish vendor.

92.3% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay while 7.7% indicated that they were not aware. 84.6% of interviewees were also aware that JPS uses fuel oil to generate electricity while 15.4% were not aware. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 53.8% of respondents were aware of the revocation while 46.2% indicated they were not aware. 30.8% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant. Although, it could not be statistically presented, it was observed that some respondents mistook this current project proposal with that proposed previously. 69.2% of interviewees were not aware of the new proposal to construct the 180 - 200 MW plant.

On the issue of project concerns 46.2% of respondents indicated that they had concerns about the project. Multiple concerns were stated by some respondents. 33.3% expressed concern about possible health effects; 33.3% expressed concern about pollution of the air and sea; 16.6% were concerned about smoke emissions from chimney damaging callaloo and other crops; 16.7% of respondents were concerned about whether or not they would be employed and 16.6% were concerned about the need for compensation for Old Harbour Bay. 38.5% of respondents indicated that they did not have any concerns related to the project. 15.3% of respondents were uncertain about whether or not they were concerned about any aspect of the project as proposed.

30.8% of interviewees indicated that they expected a positive effect on their lives as a result of the project, with all respondents anticipating the creation of employment opportunities. 15.4% of respondents indicated that they expected negative impact on their lives with 50% of respondents indicating that pollution of the sea will result in a reduction in fish yield and 50% anticipating that chemicals may affect children or "poison gas" may result in loss of lives as has happened in the past. 30.7% of respondents did not anticipate an effect on their lives while 23.1% were uncertain about potential effects on their lives.

100% indicated that they did not depend on the lands for any business, farming or residence and did not know of anyone who depended on the proposed location for business, farming or residence.

30.8% of those interviewed indicated that they had a problem with domestic water supply, with all interviewees stating irregular water supply. 69.2% of respondents indicated that they did not have any problems with domestic water supply

100% of individuals stated that their community was not affected by flooding. Regarding whether the proposed site was affected by flooding. 100% indicated the proposed site was not. 100% of respondents indicated that the site was not affected by frequent fires.

100% of those interviewed indicated that they were not affected by storm surge or sea level rise. When asked if the proposed site was affected by storm surge or sea level rise, 100% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

53.3% of respondents stated that the area had a recreational facility, with all respondents naming the Blackwood Gardens Community Centre. 23.1% of respondents indicated the presence of a historic or cultural site in or nearby the area. 66.7% the Church of England (Anglican Church) and the Old Harbour Bay Primary as historic or cultural sites as cannons are present at both these sites. 15.4% of interviewees indicated awareness of the presence of any nature reserves with 50% respectively naming the Salt Gully where crocodiles are present and the fish sanctuary.

CROSS ROADS

3.7% of respondents were interviewed in the Cross Roads Community. Of this, 66.7% were male and 33.3% were female. Respondents were of the age cohort under 20 years (0.0%), 20-29 (0.0%), 30-39 (0.0%), 40-49 (33.3%), 50-59 (66.7%) and >65 years (0.0%). 100% of interviewees stated that they were not fishers or fish vendors. 33.3% of respondents indicated that another person in the household was a fisher while 66.7% indicated that no other person was a fisher. 100% of respondents indicated that no other person in their household was a fish vendor.

100% of respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay. 66.7% were aware that JPS uses fuel oil to generate electricity and 33.3% were not aware. Regarding awareness of the Office of Utilities Regulation's revocation of Energy World International's license to construct a 360MW Power Plant, 33.3% of respondents were aware of the revocation while 66.7% indicated they were not aware. 33.3% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 180-200 Megawatt combined cycle power plant on the existing JPS plant. Although, it could not be statistically presented, it was observed that some respondents mistook this current project proposal with that proposed previously. 66.7% of interviewees were not aware of the new proposal to construct the 180 - 200 MW plant.

On the issue of project concerns 33.3% of respondents indicated that they had concerns about the project and 66% indicated that were not certain. Those respondents indicating concern were specifically concerned about the possibility of employment in the area.

0.0% of interviewees indicated that they expected a positive effect on their lives as a result of the project. 33.3% of respondents indicated that they expected negative impact on their lives with all respondents indicating that the proposed project may prove to be harmful. 0.0% of respondents did not anticipate an effect on their lives while 66.7% were uncertain about potential effects on their lives.

100% indicated that they did not depend on the lands for any business, farming or residence and further indicated that they did not know of anyone who depended on the proposed location for business, farming or residence.

66.7% of those interviewed indicated that they had a problem with domestic water supply, with 50% of these interviewees stating the problem as low water pressure. 33.3% of respondents indicated that they did not have any problems with domestic water supply

100% of individuals stated that their community was not affected by flooding. Regarding whether the proposed site was affected by flooding, 100% indicated the proposed site was not. 100% of respondents indicated that the site was not affected by frequent fires.

100% of those interviewed indicated that they were not affected by storm surge or sea level rise. When asked if the proposed site was affected by storm surge or sea level rise, 100% of interviewees indicated that the proposed site was not affected by storm surge or sea level rise.

100% of respondents stated that the area had a recreational facility with 66.7% of persons naming the Blackwood Gardens Community Centre. 100% of respondents indicated that they were not aware of the presence of a historic or cultural site in or nearby the area. 100% of interviewees indicated that they were not aware of the presence of any nature reserves within or nearby their community.

Appendix 10 – Air Dispersion Modelling Met Data

Surface & Upper Air Met Data
AERMET/AERMOD
Preprocessed from MM5 Data

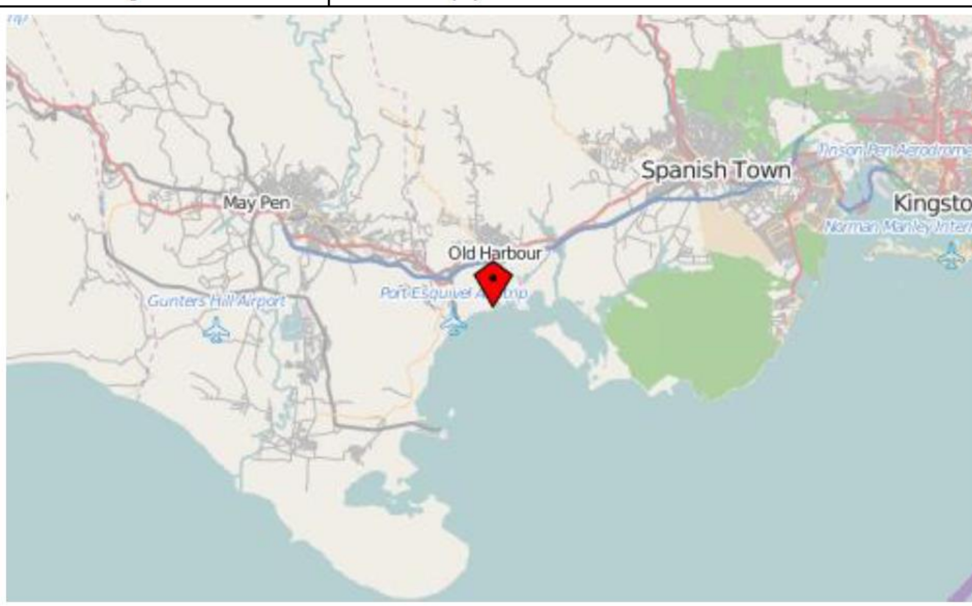
Sep 25, 2014

Met Data Order Information:

Order #:	MET145807
Ordered by:	Stephen Haughton
Company:	Air Quality Consultants Ltd.
Met Data Type:	AERMET-Ready (Surface & Upper Air Data)
Start-End Date:	Jan 01, 2009 - Dec 31, 2013
Latitude:	17.899797 N
Longitude:	77.108269 W
Datum:	WGS 84
Site Time Zone:	UTC/GMT UTC - 5 hour(s)
Closest City & Country:	Spanish Town - Jamaica

Calculated Pseudo Met Station Parameters:

Anemometer Height:	14 m
Station Base Elevation:	47 m
Upper Air Adjustment:	+5 hour(s)



MM5-Processed Grid Cell

- Grid cell centre (Lat, Lon): 17.899797 N, 77.108269 W
- Grid cell dimension: 12 km x 12 km
- Output period: Jan 01, 2009 to Dec 31, 2013
- For more information on MM5 Mesoscale Model, see link below:

  http://www.mmm.ucar.edu/mm5/mm5-home.html

Hourly Surface Met Data (*.sam)

- Format: SAMSON (surface met data for preprocessing by AERMET)
- Anemometer height: 14 meters
- Base elevation above MSL = 47 meters
- Time Zone: UTC/GMT UTC - 5 hour(s) (data reported in local time)
- Output interval: hourly
- File format description: http://www.webmet.com/MetGuide/Samson.html

Column	Parameter	Unit
6	Total cloud cover	tenths
7	Opaque cloud cover	tenths
8	Dry bulb temperature	degrees Celsius (°C)
9	Dew point temperature	degrees Celsius (°C)
10	Relative humidity	Percentage (%)
11	Station pressure	millibars (mb)
12	Wind direction	degrees (deg)
13	Wind speed	meters/second (m/s)
15	Ceiling height	meters (m) 77777 = unlimited ceiling height
21	Hourly precipitation amount	hundredths of inches

Note:

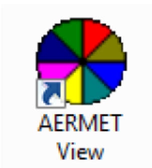
Although not necessary, if the surface file (*.SAM) is opened in a text editor (e.g., Windows NotePad), it may become apparent the file contains numerous 99999 entries in several columns. This is expected as the SAMSON format contains numerous columns which corresponds to parameters that are not used by the current version of the US EPA AERMET model. This does not affect the met data quality and is an artifact generated during MM5 processing to ensure the file is in the correct format for use in AERMET. Rest assured the data needed to support modeling in AERMET is included and not affected by the presence of columns with 99999 data flags.

Upper Air Data (*.ua)

- Format: TD-6201 – Fixed Length (upper air met data for preprocessing by AERMET)
- Data reported in Universal Time Coordinate (UTC) / GMT
- Output interval: 00Z and 12Z
- File format description: http://www.webmet.com/MetGuide/TD6200.html

AERMET View Instructions

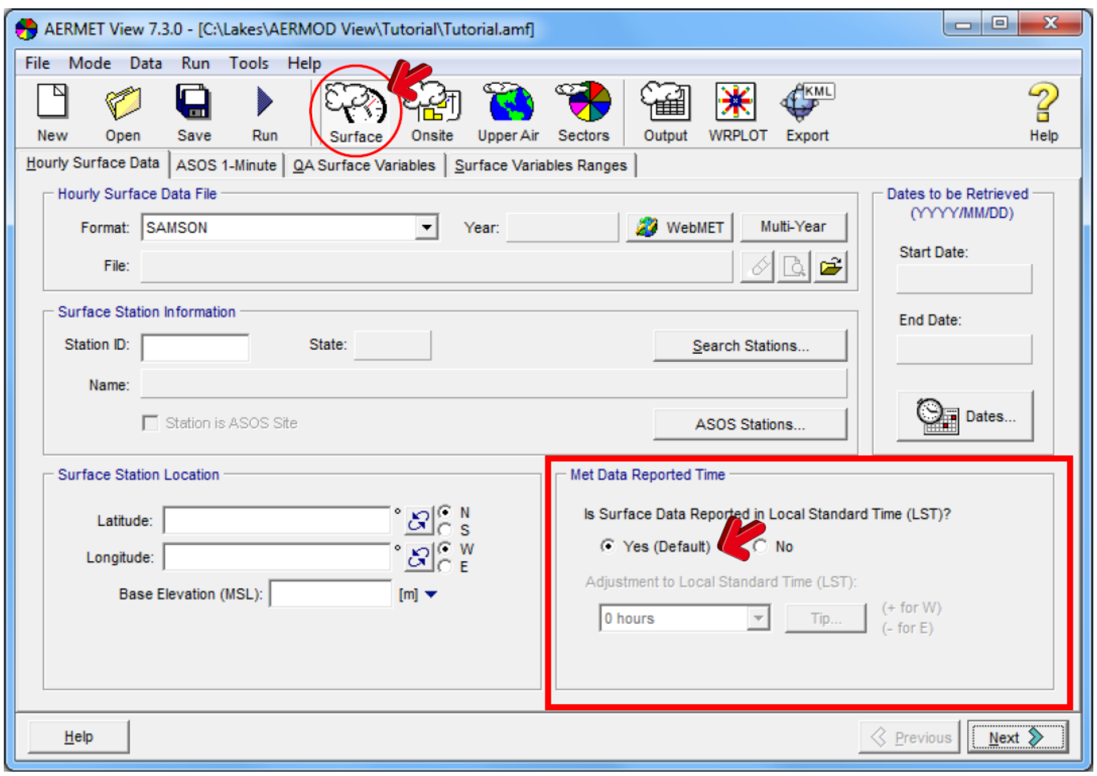
See below some tips on processing your surface (*.sam) and upper air (*.ua) met data files using **AERMET View**.



Hourly Surface Met Data

Since the surface data in SAMSON format (*.sam) is provided in local time, you must specify in AERMET View that the surface data does not need to be adjusted to local time by specifying the following:

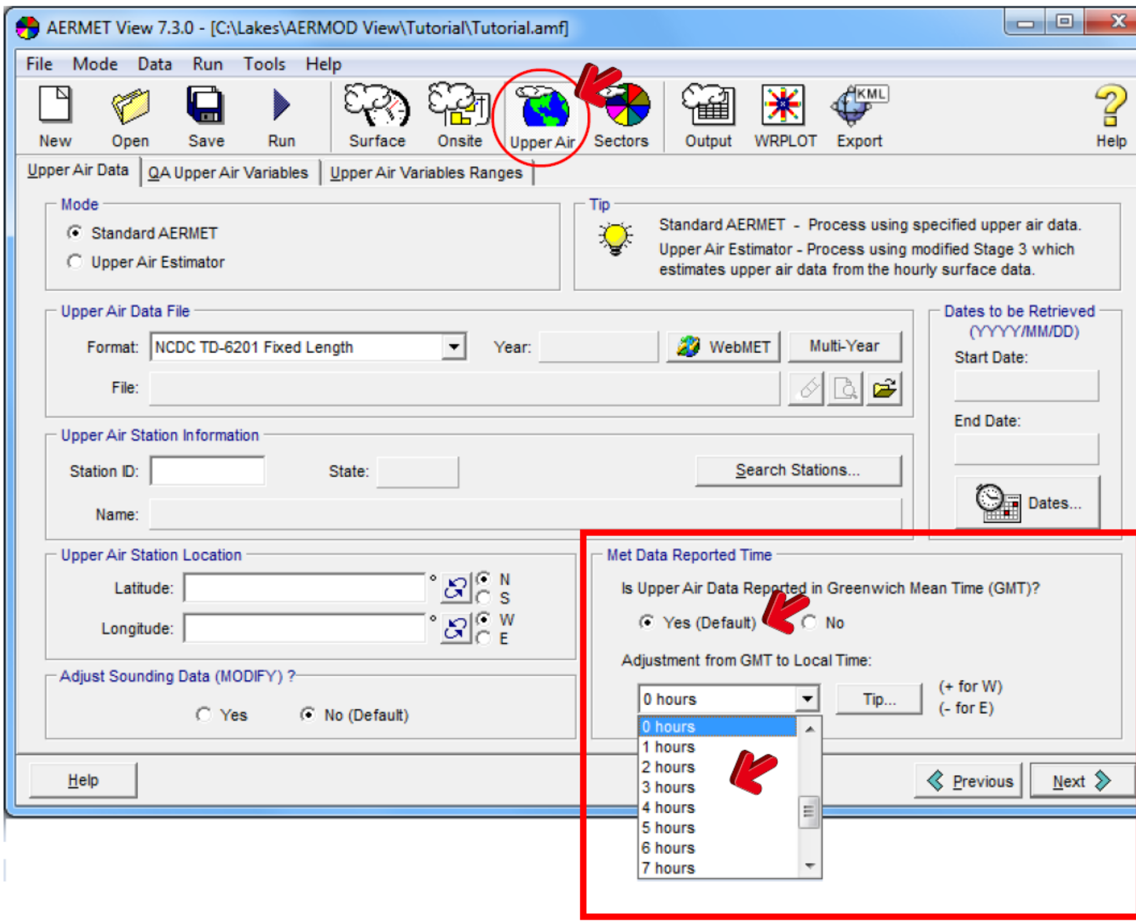
Is Surface Data Reported in Local Standard Time (LST)? Yes (Default)
Adjustment to Local Standard Time (LST): 0 hours



Upper Air Met Data

Since the Upper Air data (*.ua) is provided in UTC/GMT time then you must specify in AERMET View that the data must be adjusted to local time by specifying the following:

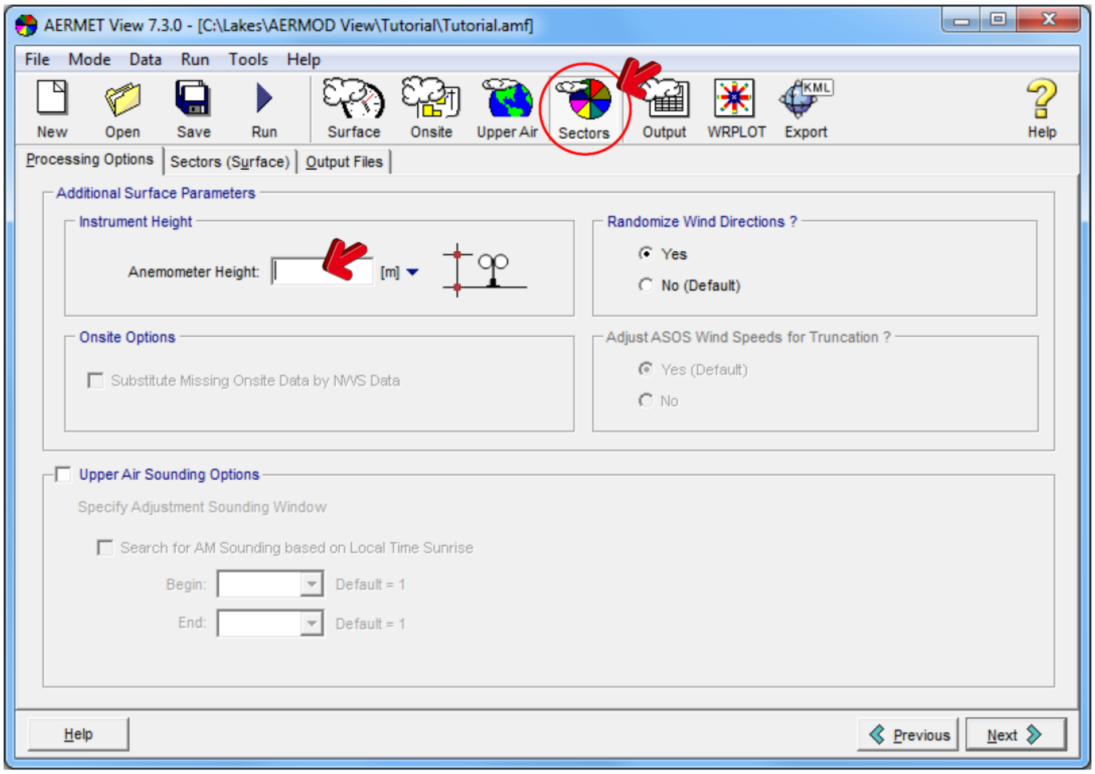
Format: NCDC TD-6201 – Fixed Length
Is Upper Air Reported in Greenwich Mean Time (GMT)? Yes
Adjustment from GMT to Local Time: +5 hour(s)



Application Site Parameters

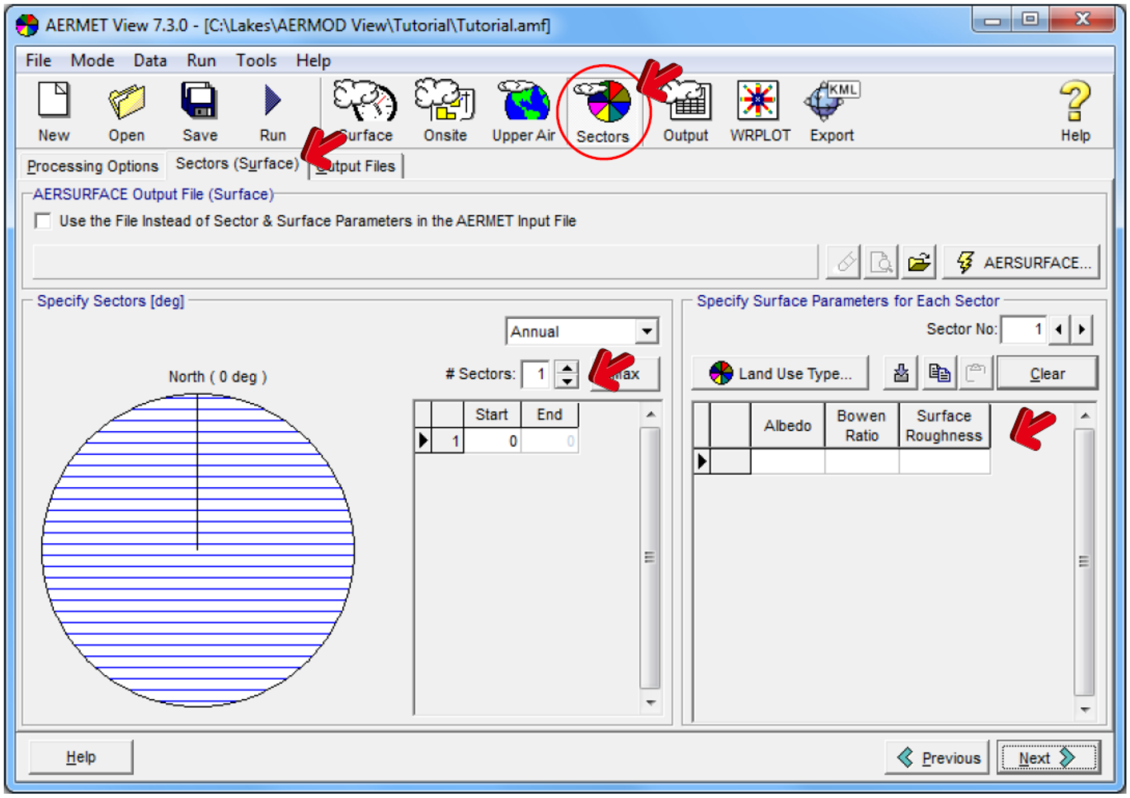
In **AERMET View**, press the **Sectors** menu toolbar button and then under the **Processing Options** tab, specify the following parameter:

Anemometer Height = 14 [m]



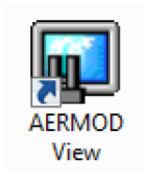
Sectors & Surface Parameters

Under the **Sectors (Surface)** tab, specify the number of sectors and the corresponding surface parameters around the facility you are modeling for.



AERMOD View Instructions

Start your **AERMOD View** project and go to the **Meteorology Pathway – Met Input Data** window.



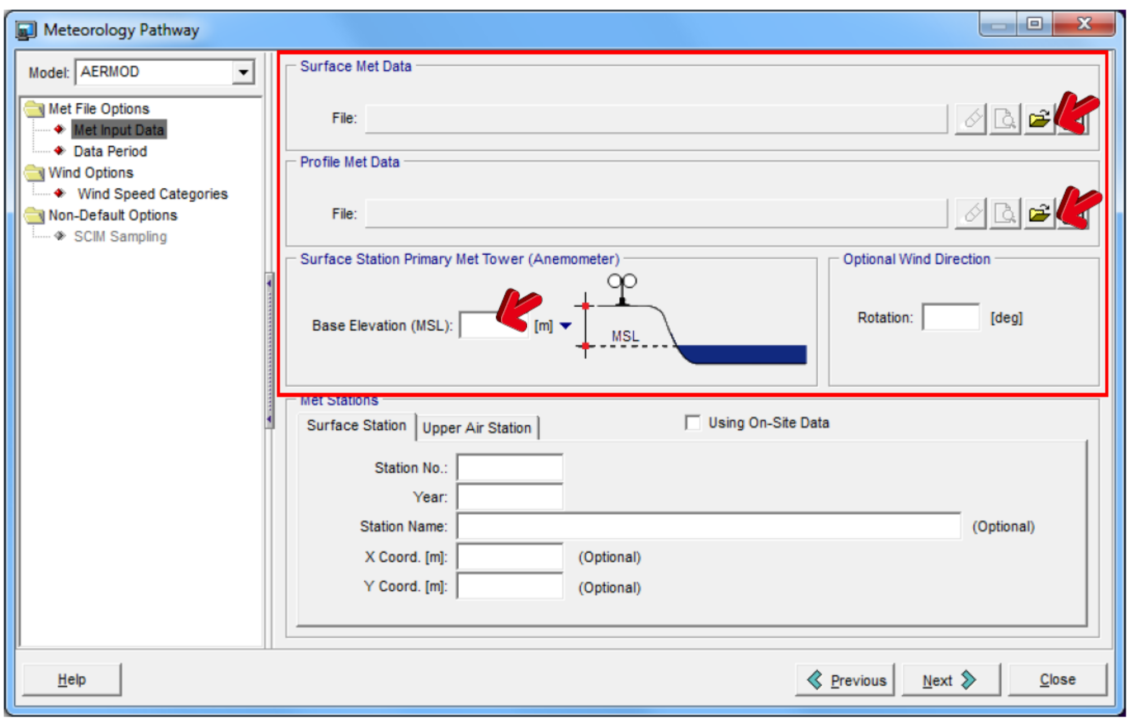
After you preprocess your surface (*.SAM) and upper air (*.UA) met data using **AERMET View**, two (2) meteorological output files will be generated:

1. Surface Met Data (*.SFC)
2. Profile Met Data (*.PFL)

Under the **Meteorology Pathway – Met Input Data** window, specify the Surface Met Data file (*.SFC) and the Profile Met Data file (*.PFL) generated by AERMET.

Under the same window, specify the base elevation for the surface station as:

Base Elevation (MSL) = 47 [m]



Appendix 11 – Study Team

- **CL Environmental Co. Ltd.:**
  - Carlton Campbell, Ph.D., CIEC (Noise modelling and Socio-economics)
  - Matthew Lee, M.Sc. (Water Quality, Marine Survey)
  - Kristoffer Lue, M.Phil. (Water Quality, Marine Survey)
  - Rachel D'Silva, B.Sc. (Water Quality, Marine Survey)
  - Karen McIntyre, M.Sc. (Legislation, Socioeconomics and GIS)
  - Janette Manning, M.Phil. (Socioeconomics)
  - Glen Patrick (Field Technician – Air Quality and Noise)
  - Errol Harrison (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)
  - Jessica Stewart, B Sc, Eng (Oceanography, Shoreline Vulnerability)
  - Kristifer Freeman, B Sc, Eng. (Oceanography, Shoreline Vulnerability)
  - Marc Henry (Drafting and Design)

- **Associate Consultant:**
  - George-Levi Gayle, Ph.D. (Cost Benefit Analysis)
  - Eric Garraway, Ph.D., (Faunal Survey)
  - Catherine Murphy, Ph.D., (Faunal Survey)
  - Philip Rose, Ph.D., (Vegetation Survey)

Appendix 12 – Glossary of Technical Terms

A

ACCRETION
May be either natural or artificial. Natural accretion is the buildup of land, solely by the action of the forces of nature, on a beach by deposition of water – or airborne material. Artificial accretion is a similar buildup of land by reason of an act of man, such as the accretion formed by a GROYNE or BREAKWATER, or beach fill deposited by mechanical means.

ADVECTION
Changes in a sea water property (salinity, temperature, oxygen content, etc.) that takes place in the presence of currents. Also, changes in atmospheric properties in the earth's atmosphere.

ALLUVIAL DEPOSIT
Detrital material which is transported by a river and deposited – usually temporarily – at points along the flood plain of a river. Commonly composed of sands and gravels.

AMPLITUDE, WAVE
(1) The magnitude of the displacement of a wave from a mean value. An ocean wave has an amplitude equal to the vertical distance from still-water level to wave crest. For a sinusoidal wave, the amplitude is one-half the wave height. (2) The semi range of a constituent tide.

B

BACK REEF
Back reefs are shallow water areas that extend from shore to the reef crest, the highest part of the reef that separates the back reef from the fore reef.

BANK
(1) The rising ground bordering a lake, river, or sea; or of a river or channel, for which it is designated as right or left as the observer is facing downstream. (2) An elevation of the sea floor or large area, located on a continental (or island) shelf and over which the depth is relatively shallow but sufficient for safe surface navigation (e.g., Georges Bank); a group of shoals. (3) In its secondary sense, used only with a qualifying word such as “sandbank,” “gravelbank,” or “spoil bank,” a shallow area consisting of shifting forms of silt, sand, mud, and gravel.

BARRIER REEF
A coral REEF parallel to and separated from the coast by a lagoon that is too deep for coral growth. Generally, barrier reefs follow the coasts for long distances and are cut through at irregular intervals by channels or passes. Example: Great Barrier Reef, Queensland, Australia.

BASIN
A depressed area with no surface outlet, such as a lake basin or an enclosed sea.

BATHYMETRY
The measurement of water depths in oceans, seas, and lakes; also information derived from such measurements.

BAY
A recess in the shore or an inlet of a sea between two capes or headlands, not as large as a gulf but larger than a cove. See also BIGHT, EMBAYMENT.

BEACH
The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach--unless otherwise specified--is the mean low water line. A beach includes foreshore and backshore.

BEACH ACCRETION
See ACCRETION.

BEACH EROSION
The carrying away of beach materials by wave action, tidal currents, littoral currents, or wind.

BEACH FACE
The section of the beach normally exposed to the action of the wave uprush. The FORESHORE of a BEACH. (Not synonymous with SHOREFACE)

BEACH PROFILE
A cross-section taken perpendicular to a given beach contour; the profile may include the face of a dune or sea wall; extend over the backshore, across the foreshore, and seaward underwater into the NEARSHORE zone.

BED
The bottom of a watercourse, or any body of water.

BENEFITS
The asset value of a scheme, usually measured in terms of the cost of damages avoided by the scheme, or the valuation of perceived amenity or environmental improvements

BENTHIC
Pertaining to the sub-aquatic bottom.

BIGHT
A bend in a coastline forming an open BAY. A BAY formed by such a bend.

BIOLOGICAL OXYGEN DEMAND (BOD)

The amount of oxygen taken up by aerobic microbes that decompose organic matter in a unit volume of water over a given time. It is used as a measure of the degree of organic pollution of water. The more organic matter the water contains, the more oxygen is used by microorganisms.

BOTTOM (nature of)

The composition or character of the bed of an ocean or other body of water (e.g., clay, coral, gravel, mud, ooze, pebbles, rock, shell, shingle, hard, or soft).

BREAKING

Reduction in wave energy and height in the surf zone due to limited water depth

C

CALCAREOUS

Containing calcium carbonate ($CaCO_3$), chiefly as the minerals calcite and aragonite. When applied to rock, it implies that as much as 50 percent of the rock is carbonate (e.g., calcareous sand).

CHANNEL

(1) A natural or artificial waterway of perceptible extent which either periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. (2) The part of a body of water deep enough to be used for navigation through an area otherwise too shallow for navigation. (3) A large strait, as the English Channel. (4) The deepest part of a stream, bay, or strait through which the main volume or current of water flows.

CHART DATUM

The plane or level to which soundings (or elevations) or tide heights are referenced (usually LOW WATER DATUM). The surface is called a tidal datum when referred to a certain phase of tide. To provide a safety factor for navigation, some level lower than MEAN SEA LEVEL is generally selected for hydrographic charts, such as MEAN LOW WATER or MEAN LOWER LOW WATER. See DATUM PLANE.

CHLOROPHYLL A

A type of chlorophyll that is most common and predominant in all oxygen-evolving photosynthetic organisms such as higher plants, red and green algae. It is best at absorbing wavelength in the 400-450 nm and 650-700 nm of the electromagnetic spectrum.

CHOPPY SEA

Short, rough waves tumbling with a short and quick motion. Short-crested waves that may spring up quickly in a moderate breeze, and break easily at the crest.

CLAY

A fine grained, plastic, sediment with a typical grain size less than 0.004 mm. Possesses electromagnetic properties which bind the grains together to give a bulk strength or cohesion. See SOIL CLASSIFICATION.

CLIMATE
The characteristic weather of a region, particularly regarding temperature and precipitation, averaged over some significant internal of time (years).

CLOSURE DEPTH
The water depth beyond which repetitive profile or topographic surveys (collected over several years) do not detect vertical sea bed changes, generally considered the seaward limit of littoral transport. The depth can be determined from repeated cross-shore profile surveys or estimated using formulas based on wave statistics. Note that this does not imply the lack of sediment motion beyond this depth.

COAST
(1) A strip of land of indefinite width (may be several kilometres) that extends from the SHORELINE inland to the first major change in terrain features. (2) The part of a country regarded as near the coast.

COASTAL AREA
The land and sea area bordering the SHORELINE.

COASTAL ZONE
The coastal zone may be simply defined as that transitional area between the land and sea. The coastal zone includes beaches and wetlands. Jamaica's coastal zone has important infrastructure including our ports, airports, oil refinery, road and electricity networks, and many towns and cities. It also includes important tourism related infrastructure (hotels and attractions). Coastal wetlands are valuable habitats for fish and other marine life. Coastal zones provide a buffer from flooding due to storm surges due to hurricanes.[34]

COASTLINE
(1) Technically, the line that forms the boundary between the coast and the shore. (2) Commonly, the line that forms the boundary between the land and the water, esp. the water of a sea or ocean. The SHORELINE.

COHESIVE SEDIMENT
Sediment containing significant proportion of clays, the electromagnetic properties of which cause the sediment to bind together.

CONSOLIDATION
The gradual, slow compression of a cohesive soil due to weight acting on it, which occurs as water is driven out of the voids in the soil. Consolidation only occurs in clays or other soils of low permeability.

CONTINENTAL SHELF
(1) The zone bordering a continent extending from the line of permanent immersion to the depth, usually about 100 m to 200 m, where there is a marked or rather steep descent toward the great depths of the ocean. (2) The area under active littoral processes during the HOLOCENE period. (3) The

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[34] http://myspot.mona.uwi.edu/physics/sites/default/files/physics/uploads/02_CCAndCoastal%20Zones2.pdf

region of the oceanic bottom that extends outward from the shoreline with an average slope of less than 1:100, to a line where the gradient begins to exceed 1:40 (the CONTINENTAL SLOPE).

CONTOUR
A line on a map or chart representing points of equal elevation with relation to a DATUM. It is called an ISOBATH when connecting points of equal depth below a datum. Also called DEPTH CONTOUR.

CORAL
Corals are marine invertebrates in class Anthozoa of phylum Cnidaria typically living in compact colonies of many identical individual "polyps". The group includes the important reef builders that inhabit tropical oceans and secrete calcium carbonate to form a hard skeleton.

CORAL REEF
A coral-algal mound or ridge of in-place coral colonies and skeletal fragments, carbonate sand, and organically-secreted calcium carbonate. A coral reef is built up around a wave-resistant framework, usually of older coral colonies.

CORIOLIS EFFECT
Force due to the Earth's rotation, capable of generating currents. It causes moving bodies to be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. The "force" is proportional to the speed and latitude of the moving object. It is zero at the equator and maximum at the poles.

CPCe (Coral Point Count with Excel extensions)
A visual basic software program for the determination of coral and substrate coverage using random point counts.

CROSS-SHORE
Perpendicular to the SHORELINE

CURRENT
(1) The flowing of water, or other liquid or gas. (2) That portion of a stream of water which is moving with a velocity much greater than the average or in which the progress of the water is principally concentrated. (3) Ocean currents can be classified in a number of different ways. Some important types include the following: (1) Periodic - due to the effect of the tides; such Currents may be rotating rather than having a simple back and forth motion. The currents accompanying tides are known as tidal currents; (2) Temporary - due to seasonal winds; (3) Permanent or ocean - constitute a part of the general ocean circulation. The term DRIFT CURRENT is often applied to a slow broad movement of the oceanic water; (4) Nearshore - caused principally by waves breaking along a shore.

CYCLONE
A system of winds that rotates about a center of low atmospheric pressure. Rotation is clockwise in the Southern Hemisphere and anti-clockwise in the Northern Hemisphere. In the Indian Ocean, the term refers to the powerful storms called HURRICANES in the Atlantic.

D

DATUM
Any permanent line, plane or surface used as a reference datum to which elevations are referred.

DATUM, CHART
See CHART DATUM.

DECIBELS (dB)
Is a dimensionless unit used to report sound pressure level (SPL or Lp). Decibels are used to represent the wide pressure range a human ear can detect. It is a logarithmic scale is used to report sound pressures.

DEEP WATER
Water so deep that surface waves are little affected by the ocean bottom. Generally, water deeper than one-half the surface wavelength is considered deep water. Compare SHALLOW WATER.

DEEP WATER WAVES
A wave in water the depth of which is greater than one-half the WAVE LENGTH

DEGRADATION
The geologic process by means of which various parts of the surface of the earth are worn away and their general level lowered, by the action of wind and water.

DELTA
(1) An ALLUVIAL DEPOSIT, usually triangular or semi-circular, at the mouth of a river or stream. The delta is normally built up only where there is no tidal or current action capable of removing the sediment at the same rate as it is deposited, and hence the delta builds forward from the coastline. (2) A TIDAL DELTA is a similar deposit at the mouth of a tidal INLET, the result of TIDAL CURRENTS that flow in and out of the inlet.

DENSITY
Mass (in kg) per unit of volume of a substance; kg/m3. For pure water, the density is 1000 kg/m3, for seawater the density is usually more. Density increases with increasing salinity, and decreases with increasing temperature. More information can be found in "properties of seawater". For stone and sand, usually a density of 2600 kg/m3 is assumed. Concrete is less dense, in the order of 2400 kg/m3. Some types of basalt may reach 2800 kg/m3. For sand, including the voids, one may use 1600 kg/m3, while mud often has a density of 1100 - 1200 kg/m3.

DEPENDENCY RATIOS
It is the portion of a population which is composed of dependents (people who are too young or too old to work). The dependency ratio is equal to the number of individuals aged below 15 or above 64 divided by the number of individuals aged 15 to 64, expressed as a percentage.

DEPRESSION
A general term signifying any depressed or lower area in the ocean floor.

DEPTH
The vertical distance from a specified datum to the sea floor.

DISCHARGE
The volume of water per unit of time flowing along a pipe or channel.

DISPERSION
Pattern of geographic distribution of individuals within a species. (2) Distortion of the shape of a seismic wave train or ocean wave train because of variations of velocity with frequency.

DIURNAL
Having a period or cycle of approximately one TIDAL DAY

DREDGING
The practice of excavating or displacing the bottom or shoreline of a water body. Dredging can be accomplished with mechanical or hydraulic machines. Most is done to maintain channel depths or berths for navigational purposes; other dredging is for shellfish harvesting, for cleanup of polluted sediments, and for placement of sand on beaches.

DUNES
(1) Ridges or mounds of loose, wind-blown material, usually sand. (2) Bed forms smaller than bars but larger than ripples that are out of phase with any water-surface gravity waves associated with them.

DURATION
In wave forecasting, the length of time the wind blows in nearly the same direction over the FETCH (generating area).

DURATION, MINIMUM
The time necessary for steady-state wave conditions to develop for a given wind velocity over a given fetch length.

E

ECHO SOUNDER
An electronic instrument used to determine the depth of water by measuring the time interval between the emission of a sonic or ultrasonic signal and the return of its echo from the bottom.

ECOSYSTEM
The living organisms and the nonliving environment interacting in a given area, encompassing the relationships between biological, geochemical, and geophysical systems.

ELEVATION
The vertical distance from mean sea level or other established datum plane to a point on the earth's surface; height above sea level. Although sea floor elevation below msl should be marked as a negative value, many charts show positive numerals for water depth.

ENTRANCE
The avenue of access or opening to a navigable channel or inlet.

EROSION
The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.

F

FAECAL COLIFORM
A group of bacteria normally present in large numbers in the intestinal tracts of humans and other warm-blooded animals. Frequently used as an indicator of sewage pollution.

FAUNA
The entire group of animals found in an area.

FETCH
The area in which SEAS are generated by a wind having a fairly constant direction and speed. Sometimes used synonymously with FETCH LENGTH.

FETCH LENGTH
The horizontal distance (in the direction of the wind) over which a wind generates seas or creates a WIND SETUP.

FETCH-LIMITED
Situation in which wave energy (or wave height) is limited by the size of the wave generation area (fetch).

FILTER
Intermediate layer, preventing fine materials of an underlayer from being washed through the voids of an upper layer.

FLOOD
(1) Period when tide level is rising; often taken to mean the flood current which occurs during this period (2) A flow beyond the carrying capacity of a channel.

FLORA
The entire group of plants found in an area.

FLUVIAL
Of or pertaining to rivers; produced by the action of a river or stream (e.g.,fluvial sediment).

FORESHORE
The part of the shore, lying between the crest of the seaward berm (or upper limit of wave wash at high tide) and the ordinary low-water mark, that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall. See BEACH FACE.

FORE REEF
The fore-reef is found on the oceanic side of the reef crest. It slopes downwards, sometimes to great depths. This is where coral diversity of highest.

FRINGING REEF
A coral REEF attached directly to an insular or continental shore. There may be a shallow channel or lagoon between the reef and the adjacent mainland.

G

GAUGE (GAGE)
Instrument for measuring the water level relative to a datum or for measuring other parameters

GEOGRAPHICAL INFORMATION SYSTEM (GIS)
Database of information which is geographically referenced, usually with an associated visualization system.

GEOMORPHOLOGY
(1) That branch of physical geography which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc. (2) The investigation of the history of geologic changes through the interpretation of topographic forms.

GDP
Gross domestic product is the market value of all officially recognized final goods and services produced within a country in a given period of time (normally a year).

GLOBAL POSITIONING SYSTEM (GPS)
A navigational and positioning system developed by the U.S. Department of Defense, by which the location of a position on or above the Earth can be determined by a special receiver at that point interpreting signals received simultaneously from several of a constellation of special satellites.

GRADIENT
(1) A measure of slope (soil- or water-surface) in meters of rise or fall per meter of horizontal distance. (2) More general, a change of a value per unit of distance, e.g. the gradient in longshore transport causes erosion or accretion. (3) With reference to winds or currents, the rate of increase or decrease in speed, usually in the vertical; or the curve that represents this rate.

GRADING
Distribution, with regard to size or weight, of individual stones within a bulk volume; heavy, light and fine grading are distinguished.

GRAVEL
Unconsolidated natural accumulation of rounded rock fragments coarser than sand but finer than pebbles (2-4 mm diameter).

H

HACH HYDROLAB DATASONDE-5
A tethered device used to measure various water quality parameters.

HARBOUR
Any protected water area affording a place of safety for vessels. See also PORT. A harbor may be natural or man-made.

HERTZ (Hz)
The time that it takes for a vibrating particle to complete one vibration is known as the time period. The number of vibrations (pressure variations) per second is called the frequency of the sound, and is measured in Hertz (Hz). The frequency of a sound produces its distinctive tone. Thus, the rumble of distant thunder has a low frequency, while a whistle has a high frequency.

HIGH TIDE, HIGH WATER (HW)
The maximum elevation reached by each rising tide. See TIDE.

HIGH WATER (HW)
Maximum height reached by a rising tide. The height may be solely due to the periodic tidal forces or it may have superimposed upon it the effects of prevailing meteorological conditions. Nontechnically, also called the HIGH TIDE.

HIGH WATER LINE
In strictness, the intersection of the plane of mean high water with the shore. The shoreline delineated on the nautical charts of the National Ocean Service is an approximation of the high water line. For specific occurrences, the highest elevation on the shore reached during a storm or rising tide, including meteorological effects.

HIGH WATER MARK
A reference mark on a structure or natural object, indicating the maximum stage of tide or flood.

HINDCASTING
In wave prediction, the retrospective forecasting of waves using measured wind information.

HISTORIC EVENT ANALYSIS

Extreme analysis based on hindcasting typically ten events over a period of 100 years.

HURRICANE
An intense tropical cyclone in which winds tend to spiral inward toward a core of low pressure, with maximum surface wind velocities that equal or exceed 33.5 m/sec (75 mph or 65 knots) for several minutes or longer at some points. TROPICAL STORM is the term applied if maximum winds are less than 33.5 m/sec but greater than a whole gale (63 mph or 55 knots). Term is used in the Atlantic, Gulf of Mexico, and eastern Pacific.

HURRICANE PATH or TRACK
Line of movement (propagation) of the eye through an area.

HYDROGRAPHY
(1) The description and study of seas, lakes, rivers and other waters. (2) The science of locating aids and dangers to navigation. (3) The description of physical properties of the waters of a region.

I

INCIDENT WAVE
Wave moving landward.

INLET
(1) A short, narrow waterway connecting a bay, lagoon, or similar body of water with a large parent body of water.

(2) An arm of the sea (or other body of water) that is long compared to its width and may extend a considerable distance inland.

IRREGULAR WAVES
Waves with random wave periods (and in practice, also heights), which are typical for natural wind-induced waves.

J

JONSWAP SPECTRUM
Wave spectrum typical of growing deep water waves developed from field experiments and measurements of waves and wave spectra in the Joint North Sea Wave Project.

K

KNOT
The unit of speed used in navigation equal to 1 nautical mile (6,076.115 ft or 1,852 m) per hour.

L

LANDMARK
A conspicuous object, natural or artificial, located near or on land, which aids in fixing the position of an observer.

LEEWARD
The direction toward which the wind is blowing; the direction toward which waves are traveling.

LENGTH OF WAVE
The horizontal distance between similar points on two successive waves measured perpendicularly to the crest.

LITTORAL
Of or pertaining to a shore, especially of the sea. Often used as a general term for the coastal zone influenced by wave action, or, more specifically, the shore zone between the high and low water marks.

LITTORAL DRIFT, LITTORAL TRANSPORT
The movement of beach material in the littoral zone by waves and currents. Includes movement parallel (long shore drift) and sometimes also perpendicular (cross-shore transport) to the shore

LOAD
The quantity of sediment transported by a current. It includes the suspended load of small particles and the BED LOAD of large particles that move along the bottom.

LONGSHORE
Parallel to and near the shoreline; ALONGSHORE.

LOW TIDE (LOW WATER, LW)
The minimum elevation reached by each falling tide. See TIDE.

LOW WATER (LW)
The minimum height reached by each falling tide. Nontechnically, also called LOW TIDE.

LOW WATER LINE
The line where the established LOW WATER DATUM intersects the shore. The plane of reference that constitutes the LOW WATER DATUM differs in different regions.

LUGOL'S PRESERVE
A solution of elemental iodine and potassium iodide in water.

M

MANGROVE
A tree or shrub which grows in tidal, chiefly tropical, coastal swamps, having numerous tangled roots that grow above ground and form dense thickets.

MARKER, REFERENCE
A mark of permanent character close to a survey station, to which it is related by an accurately measured distance and azimuth (or bearing).

MARKER, SURVEY
An object placed at the site of a station to identify the surveyed location of that station.

MEAN DEPTH
The average DEPTH of the water area between the still water level and the SHOREFACE profile from the waterline to any chosen distance seaward.

MEAN HIGH WATER (MHW)
The average height of the high waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal. So determined, mean high water in the latter case is the same as mean higher high water.

MEAN SEA LEVEL
The average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings. Not necessarily equal to MEAN TIDE LEVEL. It is also the average water level that would exist in the absence of tides.

MEAN TIDE LEVEL
A plane midway between MEAN HIGH WATER and MEAN LOW WATER. Not necessarily equal to MEAN SEA LEVEL.

MEAN WAVE HEIGHT
The mean of all individual waves in an observation interval of approximately half an hour. In case of a Rayleigh-distribution 63% of the significant wave height.

MEDIAN DIAMETER
The diameter which marks the division of a given sand sample into two equal parts by weight, one part containing all grains larger than that diameter and the other part containing all grains smaller.

MINIMUM DURATION
See DURATION, MINIMUM.

MINIMUM FETCH
The least distance in which steady-state wave conditions will develop for a wind of given speed blowing a given duration of time.

MORPHOLOGY
River/estuary/lake/seabed form and its change with time.

MOUTH
Entrance to an inland water body (e.g., river).

MUD
A fluid-to-plastic mixture of finely divided particles of solid material and water.

N

NEARSHORE
(1) In beach terminology an indefinite zone extending seaward from the SHORELINE well beyond the BREAKER ZONE. (2) The zone which extends from the swash zone to the position marking the start of the offshore zone, typically at water depths of the order of 20 m.

NISKIN
Device used to collect water samples at discrete depths in the water column.

NOISE
Noise is unwanted sound without agreeable musical quality. It is unwanted /undesired sound or sound in the wrong place at the wrong time. It is considered a pollutant and can be measured.

NUMERICAL MODELLING
Refers to analysis of coastal processes using computational models.

O

OCEANOGRAPHY
The study of the sea, embracing and indicating all knowledge pertaining to the sea's physical boundaries, the chemistry and physics of seawater, marine biology, and marine geology.

OFFSHORE
(1) In beach terminology, the comparatively flat zone of variable width, extending from the SHOREFACE to the edge of the CONTINENTAL SHELF. It is continually submerged. (2) The direction seaward from the shore. (3) The zone beyond the nearshore zone where sediment motion induced by waves alone effectively ceases and where the influence of the sea bed on wave action is small in comparison with the effect of wind. (4) The breaker zone directly seaward of the low tide line.

OFFSHORE CURRENT
(1) Any current in the offshore zone. (2) Any current flowing away from shore.

ONSHORE
A direction landward from the sea.

OSCILLATION
(1) A periodic motion backward and forward. (2) Vibration or variance above and below a mean value.

OUTCROP
A surface exposure of bare rock, not covered by soil or vegetation.

OUTFALL
A structure extending into a body of water for the purpose of discharging sewage, storm runoff, or cooling water.

P

PARTICLE VELOCITY
The velocity induced by wave motion with which a specific particle moves within a wave.

PEAK PERIOD
The wave period determined by the inverse of the frequency at which the wave energy spectrum reaches its maximum.

PERCOLATION
The process by which water flows through the interstices of a sediment. Specifically, in wave phenomena, the process by which wave action forces water through the interstices of the bottom sediment and which tends to reduce wave heights.

PHASE
In surface wave motion, a point in the period to which the wave motion has advanced with respect to a given initial reference point.

PHOTOSYNTHETICALLY ACTIVE RADIATION (PAR)
The amount of light available for photosynthesis, which is light in the 400 to 700 nanometer wavelength range.

PHYTOPLANKTON
Microscopic plant-like organisms that inhabit oceans and bodies of freshwater requiring sunlight in order to live and grow.

PIER
A structure, usually of open construction, extending out into the water from the shore, to serve as a landing place, recreational facility, etc., rather than to afford coastal protection or affect the movement of water. In the Great Lakes, a term sometimes improperly applied to jetties.

PM 10
These are airborne particles that fall between 2.5 and 10 micrometers in diameter. They are considered coarse particles which are generated from sources such as crushing or grinding operations, and dust stirred up by vehicles traveling on roads.

PM 2.5
These are airborne particles that have diameters below 2.5 micrometres. Sources of these fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

POPULATION DENSITY
The number of persons per square kilometre or acre of land area.

PROBABILITY
The chance that a prescribed event will occur, represented by a number (p) in the range 0 - 1. It can be estimated empirically from the relative frequency (i.e. the number of times the particular event occurs, divided by the total count of all events in the class considered).

PROPAGATION OF WAVES
The transmission of waves through water.

PROPAGULE
A vegetative structure that can become detached from a plant and give rise to a new plant, e.g. a bud, sucker, or spore.

R

REEF
An offshore consolidated rock hazard to navigation, with a least depth of about 20 meters (10 fathoms) or less. Often refers to coral FRINGING REEFS in tropical waters

REEF, BARRIER
See BARRIER REEF.

REEF BREAKWATER
Rubble mound of single-sized stones with a crest at or below sea level which is allowed to be (re)shaped by the waves.

REEF CREST
The reef crest is found between the back reef and the fore-reef, and ths is the area of the reef with the highest wave action.

REFRACTION (of water waves)
(1) The process by which the direction of a wave moving in shallow water at an angle to the contours is changed: the part of the wave advancing in shallower water moves more slowly than that part still advancing in deeper water, causing the wave crest to bend toward alignment with the underwater contours. (2) The bending of wave crests by currents.

REGULAR WAVES
Waves with a single height, period, and direction.

RETURN PERIOD
Average period of time between occurrences of a given event.

ROCK
(1) An aggregate of one or more minerals; or a body of undifferentiated mineral matter (e.g., obsidian). The three classes of rocks are: (a) Igneous – crystalline rocks formed from molten material. Examples are granite and basalt. (b) Sedimentary – resulting from the consolidation of loose sediment that has accumulated in layers. Examples are sandstone, shale and limestone. (c) Metamorphic – formed from preexisting rock as a result of burial, heat, and pressure. (2) A rocky mass lying at or near the surface of the water or along a jagged coastline, especially where dangerous to shipping.

S

SALINITY
Number of grams of salt per thousand grams of sea water, usually expressed in parts per thousand (symbol: ‰).

SAND
Sediment particles, often largely composed of quartz, with a diameter of between 0.062 mm and 2 mm, generally classified as fine, medium, coarse or very coarse. Beach sand may sometimes be composed of organic sediments such as calcareous reef debris or shell fragments.

SEA
(1) A large body of salt water, second in rank to an ocean, more or less landlocked and generally part of, or connected with, an ocean or a larger sea. Examples: Mediterranean Sea; South China Sea. (2) Waves caused by wind at the place and time of observation. (3) State of the ocean or lake surface, in regard to waves.

SEA GRASS
Members of marine seed plants that grow chiefly on sand or sand-mud bottom. They are most abundant in water less than 9 m deep. The common types are: Turtle grass (Thallasia), Manatee grass (Syringodium) and Eel grass (Zostera).

SEA LEVEL
See MEAN SEA LEVEL.

SEA LEVEL RISE
The long-term trend in MEAN SEA LEVEL.

SEDIMENT
(1) Loose, fragments of rocks, minerals or organic material which are transported from their source for varying distances and deposited by air, wind, ice and water. Other sediments are precipitated from the overlying water or form chemically, in place. Sediment includes all the unconsolidated materials on the sea floor. (2) The fine grained material deposited by water or wind.

SETBACK
A required open space, specified in shoreline master programs, measured horizontally upland from a perpendicular to the ordinary high water mark.

SETUP, WAVE
Super elevation of the water surface over normal surge elevation due to onshore mass transport of the water by wave action alone.

SETUP, WIND
See WIND SETUP.

SHALLOW WATER
(1) Commonly, water of such a depth that surface waves are noticeably affected by bottom topography. It is customary to consider water of depths less than one-half the surface wavelength as shallow water. See TRANSITIONAL ZONE and DEEP WATER. (2) More strictly, in hydrodynamics with regard to progressive gravity waves, water in which the depth is less than 1/25 the wavelength.

SHOALING
Decrease in water depth. The transformation of wave profile as they propagate inshore.

SHORE
The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines. A shore of unconsolidated material is usually called a BEACH. Also used in a general sense to mean the coastal area (e.g., to live at the shore). Also sometimes known as the LITTORAL.

SHOREFACE
The narrow zone seaward from the low tide SHORELINE, covered by water, over which the beach sands and gravels actively oscillate with changing wave conditions.

SHORELINE
The intersection of a specified plane of water with the shore or beach (e.g., the high water shoreline would be the intersection of the plane of mean high water with the shore or beach). The line delineating the shoreline on National Ocean Service nautical charts and surveys approximates the mean high water line (United States).

SIGNIFICANT WAVE
A statistical term relating to the one-third highest waves of a given wave group and defined by the average of their heights and periods. The composition of the higher waves depends upon the extent to which the lower waves are considered. Experience indicates that a careful observer who attempts to establish the character of the higher waves will record values which approximately fit the definition of the significant wave.

SIGNIFICANT WAVE HEIGHT
The average height of the one-third highest waves of a given wave group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, the average height of the highest one-third of a selected number of waves, this number being determined by dividing the time of record by the significant period.

SIGNIFICANT WAVE PERIOD
An arbitrary period generally taken as the period of the one-third highest waves within a given group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, this is determined as the average period of the most frequently recurring of the larger well-defined waves in the record under study.

SILT
Sediment particles with a grain size between 0.004 mm and 0.062 mm, i.e. coarser than clay particles but finer than sand. See SOIL CLASSIFICATION.

SINUSOIDAL WAVE
An oscillatory wave having the form of a sinusoid.

SLOPE
The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25, indicating one unit rise in 25 units of horizontal distance; or in a decimal fraction (0.04). Also called GRADIENT.

SOCIAL IMPACT AREA (SIA)
Estimated spatial extent of the proposed project's effect on surrounding communities, demarcated as a buffer of specified distance, e.g. 2 km from the proposed project.

SOIL

A layer of weathered, unconsolidated material on top of bed rock; in geologic usage, usually defined as containing organic matter and being capable of supporting plant growth.

SOIL CLASSIFICATION (size)
An arbitrary division of a continuous scale of grain sizes such that each scale unit or grade may serve as a convenient class interval for conducting the analysis or for expressing the results of an analysis. There are many classifications used.

SORTING
Process of selection and separation of sediment grains according to their grain size (or grain shape or specific gravity).

SOUND
(1) (noun) a relatively long arm of the sea or ocean forming a channel between an island and a mainland or connecting two larger bodies, as a sea and the ocean, or two parts of the same body; usually wider and more extensive than a STRAIT (e.g., Long Island Sound). (2) (verb) To measure the depth of the water.

SOUNDING
A measured depth of water. On hydrographic CHARTS the soundings are adjusted to a specific plane of reference (SOUNDING DATUM).

SOUNDING DATUM
The plane to which soundings are referred. See also CHART DATUM.

SPECIFIC GRAVITY
The ratio of the weight of unit volume of any material to the weight of unit volume of water at 4 deg C, $G_s = \gamma s/\gamma w$. Typical values of Gs for soil solids are 2.65 to 2.72.

SPL (Sound Pressure Level)
A ratio of one sound pressure to a reference pressure.

SPL = 20 log (L/Lr) dB   where Lr is the reference pressure

SPIT

See TOMBOLO.

SPRING TIDE
A tide that occurs at or near the time of new or full moon (SYZYGY) and which rises highest and falls lowest from the mean sea level.

STILL-WATER LEVEL (SWL)

The surface of the water if all wave and wind action were to cease. In deep water this level approximates the midpoint of the wave height. In shallow water it is nearer to the trough than the crest. Also called the UNDISTURBED WATER LEVEL.

STONE
Quarried or artificially-broken rock for use in construction, either as aggregate or cut into shaped blocks as dimension stone.

STORM SURGE
A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as that due to wind stress.

SURGE
(1) The name applied to wave motion with a period intermediate between that of the ordinary wind wave and that of the tide, say from ½ to 60 min. It is low height, usually less than 0.9 m (3 ft). (2) In fluid flow, long interval variations in velocity and pressure, not necessarily periodic, perhaps even transient in nature. (3) see STORM SURGE.

SURVEY, CONTROL
A survey that provides coordinates (horizontal or vertical) of points to which supplementary surveys are adjusted.

SURVEY, HYDROGRAPHIC
A survey that has as its principal purpose the determination of geometric and dynamic characteristics of bodies of water.

SURVEY, TOPOGRAPHIC
A survey which has, for its major purpose, the determination of the configuration (relief) of the surface of the land and the location of natural and artificial objects thereon.

SUSPENDED LOAD
(1) The material moving in suspension in a fluid, kept up by the upward components of the turbulent currents or by colloidal suspension. (2) The material collected in or computed from samples collected with a SUSPENDED LOAD SAMPLER. Where it is necessary to distinguish between the two meanings given above, the first one may be called the "true

SWELL
Wind-generated waves that have traveled out of their generating area. Swell characteristically exhibits a more regular and longer period and has flatter crests than waves within their fetch (SEAS).

T

TIDAL PERIOD
The interval of time between two consecutive, like phases of the TIDE.

TIDAL RANGE
The difference in height between consecutive high and low (or HIGHER HIGH and LOWER LOW) waters.

TIDE
The periodic rising and falling of the water that results from gravitational attraction of the Moon and Sun and other astronomical bodies acting upon the rotating Earth. Although the accompanying horizontal movement of the water resulting from the same cause is also sometimes called the tide, it is preferable to designate the latter as TIDAL CURRENT, reserving the name TIDE for the vertical movement.

TOPOGRAPHIC MAP
A map on which elevations are shown by means of contour lines.

TOPOGRAPHY
The configuration of a surface, including its relief and the positions of its streams, roads, building, etc.

TOTAL DISSOLVED SOLIDS (TDS)
Compounds in the water that cannot be removed by a traditional filter and are made up of salts or compounds which dissociate in water to form ions.

TOTAL PETROLEUM HYDROCARBON (TPH)
A mixture of chemicals made mainly from hydrogen and carbon.

TOTAL SUSPENDED SOLIDS (TSS)
Solid materials, including organic and inorganic, that are suspended in the water.

TROPICAL CYCLONE
See HURRICANE

TROPICAL STORM
A tropical cyclone with maximum winds less than 34 m/sec (75 mile per hour). Compare with HURRICANE (winds greater than 34 m/sec).

TROUGH
A long and broad submarine DEPRESSION with gently sloping sides.

TROUGH OF WAVE
The lowest part of a waveform between successive crests. Also, that part of a wave below still-water level.

TSUNAMI
A long-period water wave caused by an underwater disturbance such as a volcanic eruption or earthquake. Also SEISMIC SEA WAVE. Commonly miscalled "tidal wave."

TURBIDITY
(1) A condition of a liquid due to fine visible material in suspension, which may not be of sufficient size to be seen as individual particles by the naked eye but which prevents the passage of light through the liquid. (2) A measure of fine suspended matter in liquids.

TURBULENT FLOW
Any flow which is not LAMINAR, i.e., the stream lines of the fluid, instead of remaining parallel, become confused and intermingled.

V

VISCOSITY (or internal friction)
That molecular property of a fluid that enables it to support tangential stresses for a finite time and thus to resist deformation. Resistance to flow.

W

WATER DEPTH
Distance between the seabed and the still water level.

WATER LEVEL
Elevation of still water level relative to some datum.

WATERLINE
A juncture of land and sea. This line migrates, changing with the tide or other fluctuation in the water level. Where waves are present on the beach, this line is also known as the limit of backrush (approximately, the intersection of the land with the still-water level.)

WAVE
A ridge, deformation, or undulation of the surface of a liquid.

WAVE CLIMATE
The seasonal and annual distribution of wave height, period and direction.

WAVE DIRECTION
The direction from which a wave approaches.

WAVE DIRECTIONAL SPECTRUM
Distribution of wave energy as a function of wave frequency and direction.

WAVE FORECASTING
The theoretical determination of future wave characteristics, usually from observed or predicted meteorological phenomena.

WAVE FREQUENCY
The inverse of wave period.

WAVE FREQUENCY SPECTRUM
Distribution of wave energy as a function of frequency.

WAVE HEIGHT
The vertical distance between a crest and the preceding trough. See also SIGNIFICANT WAVE HEIGHT.

WAVE PERIOD
The time for a wave crest to traverse a distance equal to one wavelength. The time for two successive wave crests to pass a fixed point. See also SIGNIFICANT WAVE PERIOD.

WAVE PROPAGATION
The transmission of waves through water.

WAVE SPECTRUM
In ocean wave studies, a graph, table, or mathematical equation showing the distribution of wave energy as a function of wave frequency. The spectrum may be based on observations or theoretical considerations. Several forms of graphical display are widely used.

WAVE TRANSFORMATION
Change in wave energy due to the action of physical processes.

WAVELENGTH
The horizontal distance between similar points on two successive waves measured perpendicular to the crest.

WEIBULL DISTRIBUTION
A model probability distribution, commonly used in wave analysis.

WETLANDS
Lands whose saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities that live in the soil and on its surface (e.g. Mangrove forests).

WELL-SORTED
Clastic sediment or rock that consists of particles all having approximately the same size. Example: sand dunes.

WIND SETUP
On reservoirs and smaller bodies of water (1) the vertical rise in the still-water level on the leeward side of a body of water caused by wind stresses on the surface of the water; (2) the difference in still-water levels on the windward and the leeward sides of a body of water caused by wind stresses on the surface of the water. STORM SURGE (usually reserved for use on the ocean and large bodies of water).