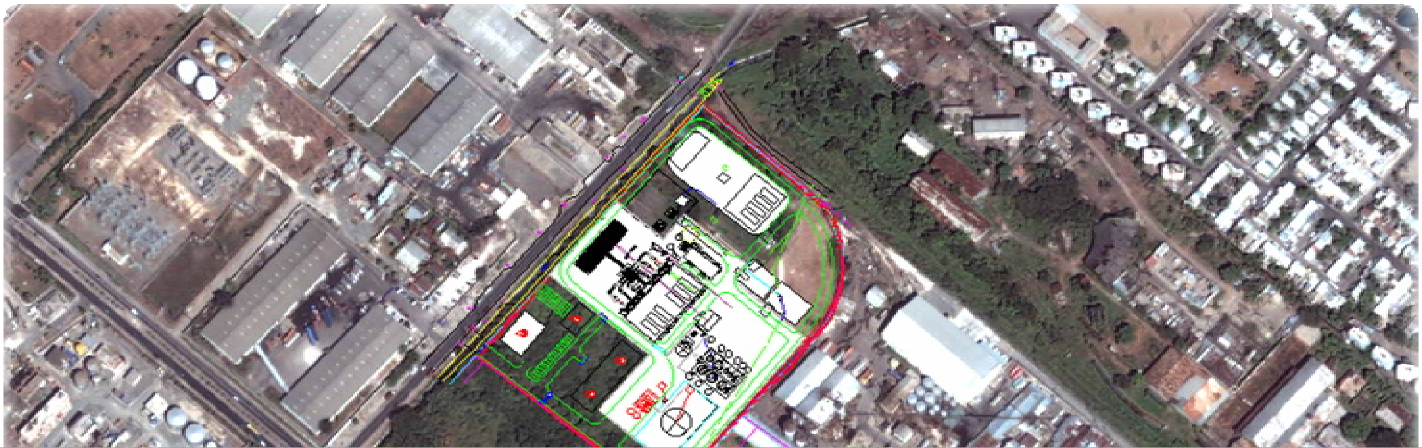

ENVIRONMENTAL IMPACT ASSESSMENT OF THE PROPOSED JAMAICA ENERGY PARTNERS 60 MEGAWATT WEST KINGSTON POWER PLANT AT INDUSTRIAL TERRACE, KINGSTON, JAMAICA

Submitted to:

Jamaica Energy Partners
10 Grenada Way
Kingston 5

Prepared by:

CL ENVIRONMENTAL
Taking Care of You and Your Environment.

OCTOBER 2009

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Submitted to

JAMAICA ENERGY PARTNERS,

10 Grenada Way

Kingston 5

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OCTOBER 2009

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1.0 Executive Summary

Jamaica Energy Partners (JEP) has been a private supplier of electricity to the Jamaican power grid since 1995, as a result of an agreement with the Jamaica Public Service Company Limited (JPS). JEP operates two power barges, namely Dr. Birds I and II, with a combined generating capacity of approximately 124MW; this is approximately fifteen percent (15%) of Jamaica's installed capacity. Their first power barge, Dr. Bird I, a 74 MW power barge was commissioned in 1995 whilst the most recent addition was a 50 MW power barge, which was commissioned in 2006. Both these barges have medium speed diesel generating sets. JEP, over the last twelve years have established an unparalleled track record of reliability and efficiency.

Jamaica Energy Partners is desirous of installing six (6) land based 11 MW medium speed diesel Wärtsilä 12V46 engines to meet the increased national electricity demand.

Rationale

There are three main reasons why the additional generating capacity is needed;

i. Load growth
ii. The need for more efficient power generation to replace old and inefficient generating units on the grid; and
iii. The need for generation in or close to Kingston where the major load centre is.

Jamaica has an installed capacity of 817.75 MW with a peak demand of approximately 620 MW.

There is approximately 220 MW of installed capacity in Kingston; however Kingston experiences a peak demand of approximately 341MW which is a shortfall of approximately 121 MW. This shortfall is met by importation of power from other regions of Jamaica.

The proposed site is located on land previously utilized by the National Water Commission to operate the Western Sewage treatment plant. This location is identified on the 1:10,000 map series as the western purification works and has been utilized for sewerage treatment since 1939 (Matley, 1951).

The Power plant will be constructed by Wärtsilä Finland Oy using relevant international industrial standards (including International Organization for Standardization (ISO), European Standards (EN), German Standard (Deutsche Institute für Normung) (DIN), Finnish Standards Association (SFS) and the American Petroleum Institute (API).

It will contain several specialised features of note, including:

- Storage for 5,000 cubic metres of Heavy Fuel Oil or 15 days of full power operation of all the engines.
- Tank Facilities
    - LFO Day Tank: 300 cubic metres
    - HFO buffer Tank: 200 cubic metres
    - HFO Day Tank: 300 cubic metres
    - Fresh Lube Oil Storage: 55 cubic metres
    - Used Lube Oil Storage: 35 cubic metres
    - Intermediate Lube Oil Storage: 13 cubic metres
    - Oily Water Buffer Tank: 55 cubic metres
    - Sludge: 150 cubic metres
    - Maintenance Water: 10 cubic metres
    - Treated Water Storage 20 cubic metres
    - Fire Water Tank 700 cubic metres
    - Urea Tank
- Other Facilities
    - Cooling Radiator
    - Truck Unloading Station: 2 Truck Bays
    - Selective catalytic convertor
- The Fuel Tanks will be bunded to hold 120% of the volume in the tanks in the unlikely event of a leak or spill.
- The facility can operate with Light or Heavy Fuel Oil. The Light (back-up) and Heavy (main) Fuel Oil Tanks will be equipped with valves; level indicators and alarms for high and low fuel levels. In addition it can be retrofitted to use Liquefied Natural Gas (LNG).

- The walls and roof of the Power Plant Building, Electrical Building and Fuel Treatment Building House will be insulated with Mineral Wool for fire proofing. In addition, a series of portable fire extinguishers, water hoses, hydrants, fire alarms and smoke detectors will be installed in the facility.
- An automation system allows centralized operation of the plant from a control room. Alarms and important measurements from auxiliary units are connected to the automation system. Local independent access to critical aspects of the system is built in if required. The control room contains a PLC (Programmable Logic Controllers) based control and monitoring system which controls the generators and substation. Sensors are strategically located on the engines and auxiliaries send information from the entire operation to the PLC and computers which control the engines and substation.
- One emergency diesel generator set with a minimum capacity of 400 kW - 50 Hz.

The existing site climatic conditions are suitable for the operation of the of the proposed engine sets at its optimum. The buildings will be built to withstand a category 4 hurricane and to seismic zone 4 standard.

Potable water in the vicinity of the proposed site was generally acceptable with only the element Selenium being non compliant to World Health Organization potable water standard. Some surface water (gully and ponds onsite) were non compliant with dissolved oxygen, Detergent, Oil & Grease, Total Phosphates, Total Organic Compounds, Total Suspended Solids, Biochemical Oxygen Supply, Chemical Oxygen Demand, Faecal Coliform and Zinc. Ground water had elevated nitrates.

Biological

The site is significantly disturbed and shows evidence of recent vegetation clearing. A total 57 plant species were observed. None of the plants observed were endemic, endangered, threatened, rare, invasive alien species or pest/nuisance species.

Twenty five species of birds were recorded, seven of which were aquatic. Two of the terrestrial species were endemic, these were Jamaican Euphonia, and the Red-billed Streamertail, neither of these species are forest dependant. The low number of birds on the property was probably related to fact that the property is in the commercial zone of Kingston.

Eighty one species of insects from nine orders (39 families) were recorded. There were sixteen species of butterflies and two species of moths. These were dominated by the Nymphalidae (6 species) and the Lycaenidae (5 species) of which all species have widespread distribution.

The fourteen species of beetles (Coleoptera) were dominated by the leaf beetles (Chrysomelidae) which fed on the leaves of many shrubs and herbs. Fourteen species of plant bugs (Homoptera) were also recorded. Most of the species were collected from the grass, which were mainly from the family Cicadellidae. Over twenty species of spiders were recorded. These were not identified to the level of species but were dominated by the Salticidae (jumping spiders) and (Araneidae) orbwebb spiders. No land snails were recorded, but this was not surprising given the disturbed nature of the habitat.

Baseline noise levels at some stations exceeded the National Environment and Planning Agency daytime and nightime guidelines. Noise patterns showed moderate to high fluctuations.

Socioeconomics

The total population within the SIA (2km radius of the proposed site) in 2001 was approximately 76,643 persons (STATIN 2001 Population Census). Within the SIA, the 15-64 years age category accounted for approximately 58% of this population, with the age 0-14 years (~37%) and the age 65 and over category accounting for approximately 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 this population, approximately 12.5% were in the young category and 4.7% were in the 65 years and older category.

The proposed project is expected to take approximately 565 days and will employ some 45 persons during site clearance/demolition activities, 50 persons during the construction of the foundation and 61 persons during operation.

Process water will be from the National Water Commission's public water supply which will be processed by a Reverse Osmosis Plant. Sewage and Trade Effluent will be sent to the NWC's sewer lines in close proximity to the proposed site which ultimately leads to Soapberry Waste Treatment plant (tertiary treatment).

This project has the potential to adversely impact the air quality of the air shed surrounding the proposed development and increase noise pollution in its environs. These impacts will be properly mitigated.

While alternative locations and fuel types were investigated, the most environmentally sound and economical alternative is the development as proposed in the EIA. This option will result in the shortest possible time for the provision of the required additional generating capacity, with impacts which can be mitigated. The project will result in a more reliable and constant supply of electricity to the national power grid (Kingston in particular), which, will increase worker productivity and economic growth for the island of Jamaica.

2.0 Policy, Legal and Administrative Framework

2.1 Background

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.

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

- 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.

2.2 Jamaican Environmental Regulatory Structure

EIAs are not only recommended in project design, but also required by Jamaican legislation. The following is a review of Jamaican environmental policy and laws that are relevant to the Jamaica Energy Partners (JEP) Power Plant project.

2.2.1 National Environment and Planning Agency (NEPA)

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

2.2.2 National Legislation

2.2.2.1 Natural Resources Conservation Authority (NRCA) Act

The NRCA Act (1991) is 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.

The Act has established the Natural Resources Conservation Authority (NRCA), which has a number of powers including:

- issuing of permits to persons responsible for undertaking any construction, enterprise or development of a prescribed category in a prescribed area, including power generation facilities;
- requesting an Environmental Impact Assessment (EIA) from an applicant for a permit or the person responsible for undertaking any construction, enterprise or development; and

- revocation or suspension of permits.

The Act also gave power of enforcement of the following environmental laws to the NRCA, namely the Beach Control Act, Watershed Act and the Wild Life Protection Act.

2.2.2.2 The Natural Resources Conservation Authority (Air Quality) Regulations

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.

2.2.2.3 Town and Country Planning Authority (TCPA)

The Town and Planning Act, as amended (1987), establishes the Town and Country Planning Authority, which is responsible for land use zoning and planning regulations as described in their local Development Orders.

2.2.2.4 Kingston Development Order

The local planning authority for the development is the Kingston and St. Andrew Parish Council. Its functions include granting permission to develop land (based on the Development Order and subject to approval by TCPA), maintaining a public register on land development applications, and enforcing planning controls.

Continued proactive communication with the Parish Council is recommended in order to keep them informed and in dialogue on the activity in their jurisdiction. This will also be the approach of the environmental consulting team in deliberating environmental aspects of the planning and approval process.

2.2.2.5 Office of Utilities Regulation (OUR) Act

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.

- Carry out, on its own initiative or at the request of any person, such investigations in relation to the provision of prescribed utility services as will enable it to determine whether the interests of consumers are adequately protected.
- 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:
    - 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;
    - protect and preserve the environment; and
    - afford to its consumers economical and reliable service.

2.2.2.6 Public Health Act

The Public Health (Air, Soil and Water Pollution) Regulations (1976) 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.

2.2.2.7 The Clean Air Act

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 premise 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.

2.2.2.8 Trade Effluent Standards

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.

2.2.2.9 Noise Standards

Jamaica has no national legislation for noise, but World Bank guidelines have been adopted by NEPA and are used for benchmarking purposes along with the draft National Noise Standards that are being prepared.

2.3 World Bank Guidelines

2.3.1 National Regulatory Requirements

As a World Bank venture, this project is also subject to World Bank Environmental Guidelines, updated in 2008 (Appendix 4). It should be noted that the Jamaican EIA process was strongly influenced by the original World Bank guidance on EIAs. The EIA report, however, has been reviewed for compliance with World Bank Guidelines and meets all requirements for the Project from design to implementation.

2.3.2 Overview of World Bank Requirements

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), including:

- Executive Summary
- Policy, legal and administrative framework
- Project description
- Baseline data
- Environmental Impacts
- Analysis of Alternatives

- Environmental Management Plan (called Action Plan in this document) considering
    - Mitigation
    - Monitoring
    - Capacity development and training (to ensure maintenance)
    - Implementation Schedule and Cost Estimates for mitigation, monitoring and capacity building
    - Integration of the Plan with the Project
- Appendices including report preparers, references, record of meetings, data and list of associated reports.

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 4 Relevant sections of the Pollution Prevention and Abatement Handbook – Thermal Power: Guidelines for New Plants):

- Air Emissions
- Liquid Effluents
- Hazardous Materials and Wastes
- Solid Wastes
- Ambient Noise
- Occupational Health and Safety

This power plant is more than 50 MW.

2.4 EIA Process

2.4.1.1 NRCA/NEPA Process

Under Section 9 of the NRCA Act, all activities associated with Power Plant facilities (e.g. wind farms, hydro, thermal, nuclear) such as the JEP 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 advised JEP that an EIA would be required for their development. The consultant then liaises with the NRCA to determine the scope of the EIA through proposed Terms of Reference (TORs). The TORs are proposed by the consultant using NRCA guidelines and are approved by the NRCA. Appendix 1 gives the approved TORs for the proposed power plant development.
- The EIA is then prepared by a multi-disciplinary team of professionals (Appendix 2 for the team used in this assessment). 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).
- Ten copies of the finalised draft are then submitted to NRCA, two to the client, and the consultant keeps one (13 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 Meetings 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.

2.4.1.2 Public Participation in EIAs

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 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 3 for the NRCA reference document entitled "Guidelines for Public Participation" in EIAs.

3.0 PROJECT DESCRIPTION

Jamaica Energy Partners (JEP) has been a private supplier of electricity to the Jamaican power grid since 1995, as a result of an agreement with the Jamaica Public Service Company Limited (JPS). JEP operates two power barges, namely Dr. Birds I and II, with a combined generating capacity of approximately 124 MW; this is approximately fifteen percent (15%) of Jamaica's installed capacity. Their first power barge, Dr. Bird I, a 74 MW power barge was installed and commissioned in 1995 whilst the most recent addition was a 50 MW power barge, which was commissioned in 2006. Both these barges have medium speed diesel generating sets. JEP, over the last twelve years have established an unparalleled track record of reliability and efficiency.

Jamaica Energy Partners is desirous of installing six (6) land based 11 MW medium speed diesel Wärtsilä 12V46 engines to meet the increased national electricity demand.

3.1 Rationale

There are three main reasons why the additional generating capacity is needed;

iv. Load growth
v. The need for more efficient power generation to replace old and inefficient units on the grid; and
vi. The need for generation in or close to Kingston where the major load centre is.

Jamaica has an installed capacity of 820 MW with a peak demand of approximately 620 MW.

There is approximately 220 MW of installed capacity in Kingston; however Kingston experiences a peak demand of approximately 341MW which is a shortfall of approximately 121 MW. This shortfall is met by importation of power from other regions of Jamaica.

3.2 Proposed Project

3.2.1 Technical Overview

The facility will provide 68,000 kW and 85,000 kVA gross with net values 65,610 kW and 82,012 kVA at a 0.80 power factor. The facility is expected to generate 446,760 MWh per year.

The electricity will be produced using six (6) diesel generators operating at 11 kV at the generator terminals. Each generator set will have an active power rating of 11,349 kW and will have an automatic speed governor and an automatic voltage regulator to facilitate operation in parallel with existing generating sets on the national grid. The generators, rated at 14,187 kVA will supply power to an internal 11 kV electrical bus from which power will be exported to the grid. Power for facility auxiliary equipment will also be supplied from this electrical bus.

The primary fuel for the engines will be low sulphur (0.5% by mass), #6 residual (heavy) fuel oil. They will also be able to operate on #2 or #3 diesel fuel. Each engine will be equipped with selective catalytic converters to reduce the concentration of oxides of nitrogen in the exhaust leaving the stacks to 400 mg/Nm^3 (Based on the International Finance Corporation (IFC) guideline for degraded airshed). These engines are capable of being converted in the future to also operate on Natural Gas.

The facility will interconnect with the JPS Co. transmission grid by modifying the existing 69 kV transmission line between Hunt's Bay Substation and the Rockfort Substation. A substation will be built at the new site and the referenced transmission line will be split in two giving the new site two connections into the transmission grid.

The diesel engines to be used will be manufactured by Wartsila and will be of model type 12V46. This model designation represents a twelve (12) cylinder engine with the cylinders in two banks in a 60° "V" configuration with a cylinder bore of 460 mm and a gross power output per cylinder of 975 kW. These engines use forced induction in the form of turbo-charging to increase the volumetric efficiency and hence the power density of the engine. Electronically controlled common rail fuel injection will be used to provide improved fuel efficiency and lower exhaust emissions. The engines are designed to use the Miller combustion cycle and this will result in further gains in efficiency over the "standard" Otto cycle diesel engines as pumping losses are reduced in the intake and exhaust strokes and the thermal efficiency is improved. The expected gross electrical efficiency of each these engines will be 44.3%.

The engines will use radiators for primary heat exchange. Waste heat recovery economizers will be installed in the exhaust stacks of three engines, with the heat energy recovered to be used to apply heat to the facility thermal oil system. This system will in turn be used as the energy transfer medium for transferring heat energy through heat exchangers throughout the facility for processes such as:

- The preparation of the fuel oil for combustion
- The pre-heating of the cooling water systems for the diesel engines in preparation for starting.

A #2 diesel oil fired standby system will be provided for the heating of the thermal oil when all the DG sets with economizers are offline.

Two 55 MVA power transformers will be used to transfer the power delivered from the generator bus to the 69 kV transmission grid for delivery to the Hunt's Bay substation for further transmission and distribution. Power for facility auxiliary systems will be provided through two 11 kV/380 V transformers connected to the generator electrical bus. Circuit breakers at the 69 kV and 11 kV voltage levels will be of the Sulphur Hexafluoride (SF_6) gas circuit breaker type. A 110 V DC system will provide power for electrical switchgear, automation systems and protective relaying systems.

A standby "Black Start" generator will be installed to provide emergency power for the start up of the facility and its main diesel generator sets in the event of separation of the facility from the grid or the absence of power on the transmission grid.

Figure 1 and Figure 2 gives the layout of the proposed power plant.

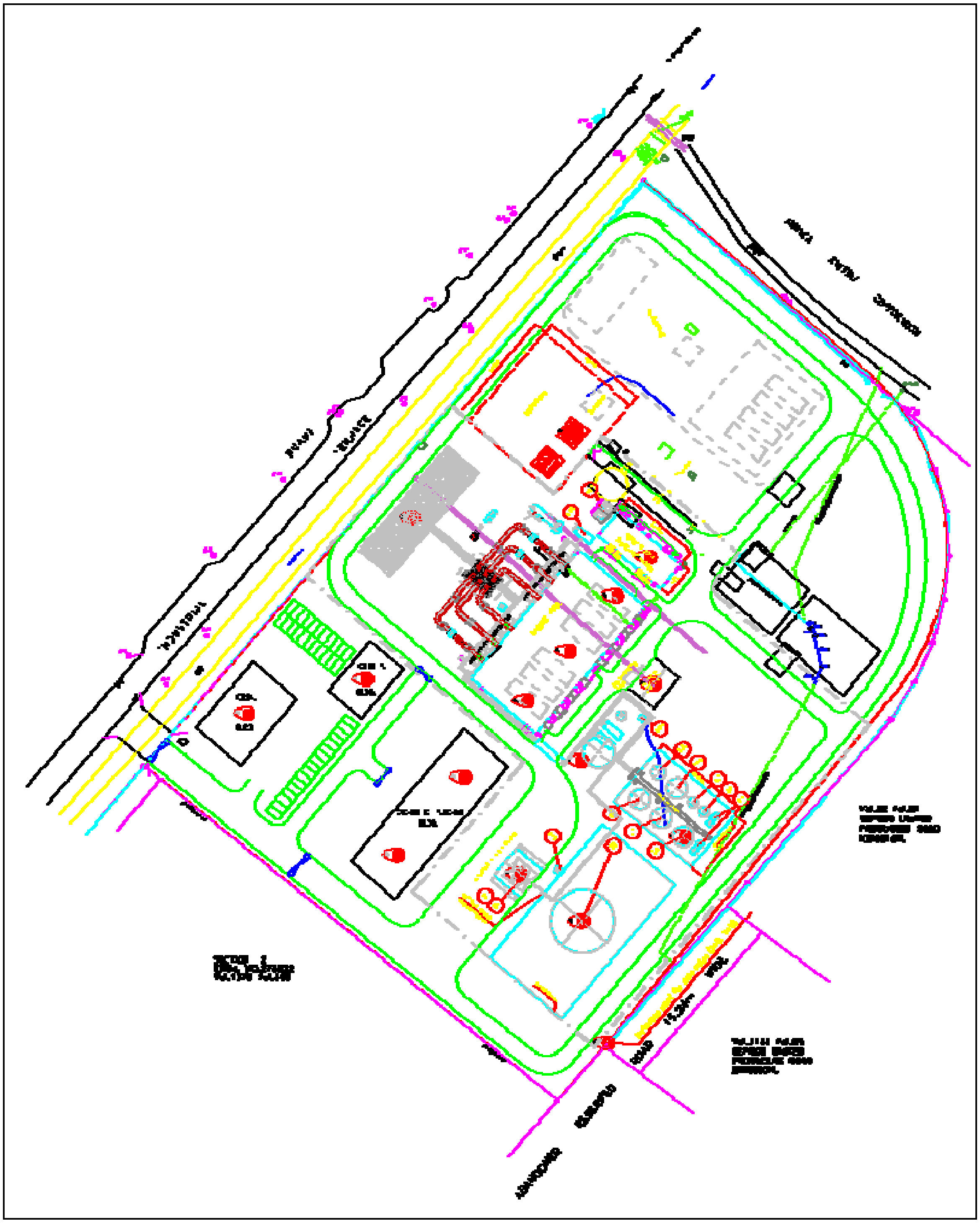


Figure 1 Schematics illustrating the plan view of the proposed JEP West Kingston 60MW power plant

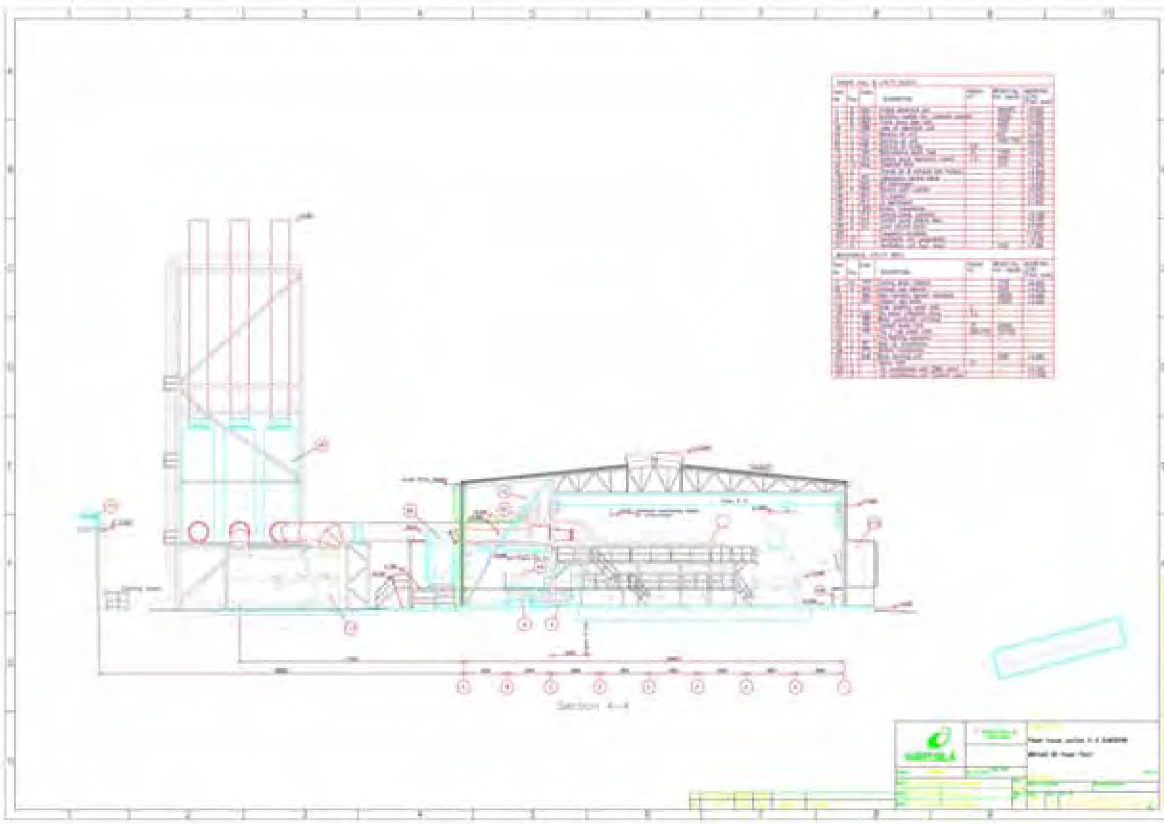


Figure 2 Side view of the proposed JEP West Kingston 60MW power plant

The proposed Project will be developed on approximately 4 hectares (≈ 10 acres) of land, of which approximately 20% will be green space.

The sewage and trade effluent will be sent to the National Water Commissions Sewer line in close proximity to the site with ultimate treatment and disposal at the Soapberry Wastewater Treatment Plant in St. Catherine.

Water for the proposed facility will be supplied from the NWC main through a reverse osmosis plant which will provide the facility with the required water quality needed for its optimum performance.

Fuel for the proposed power plant will be supplied by Petrojam. The supply will be done by either pipeline (the subject of another EIA) or trucked to the facility.

Solid waste collection and disposal will be done through private contractors.

Oily water from the facility whether from maintenance activities or from surface run off will be directed to oily water separators which will separate the sludge from the water. This water will also be sent to the NWC sewer line and the sludge stored in containers and sent to Petrojam to be reprocessed and reused.

The time required for the implementation of the proposed Project is expected to take 18 months with the estimated duration of activities outlined below (Table 1).

Table 1 Estimated duration of tasks

ACTIVITY #	TASK	ESTIMATED DURATION (DAYS)
1	CIVIL WORKS Site preparation & earthworks Construction of Foundation Installation of Superstructure Finishing Works Site Works (landscaping & roads), etc.	≈268.8
2	MECHANICAL & ELECTRICAL INSTALLATATION WORKS Installation of diesel generating (DG) sets Installation of Exhaust and Charge Air Ducting Installation of Main Transformers Pre Commissioning of DG Sets, etc.	≈ 175.2
3	COMMISSIONING, HANDING OVER & WARRANTY Commissioning of the DG Sets 1-6 Performance Tests, etc.	≈ 60

3.3 Project Location

The proposed site is located on land previously utilized by the National Water Commission to operate the Western Sewage treatment plant. This location is identified on the 1:10,000 map series as the western purification works and has been utilized for sewerage treatment since 1939 (Matley, 1951). The site is bounded to the north by Producers Road which runs parallel to the decommissioned (abandoned) Jamaica Railway Corporation Tracks. Along the western boundary is the Tivoli Gully which runs parallel to Industrial Terrance and to the East by Seprod. South of the property is an unutilized parcel of land which is bounded along its southern edge by Marcus Garvey Drive (formerly Foreshore Road) (Figure 3) and can be located on the 1:50,000 topographic sheet 18 (metric edition).

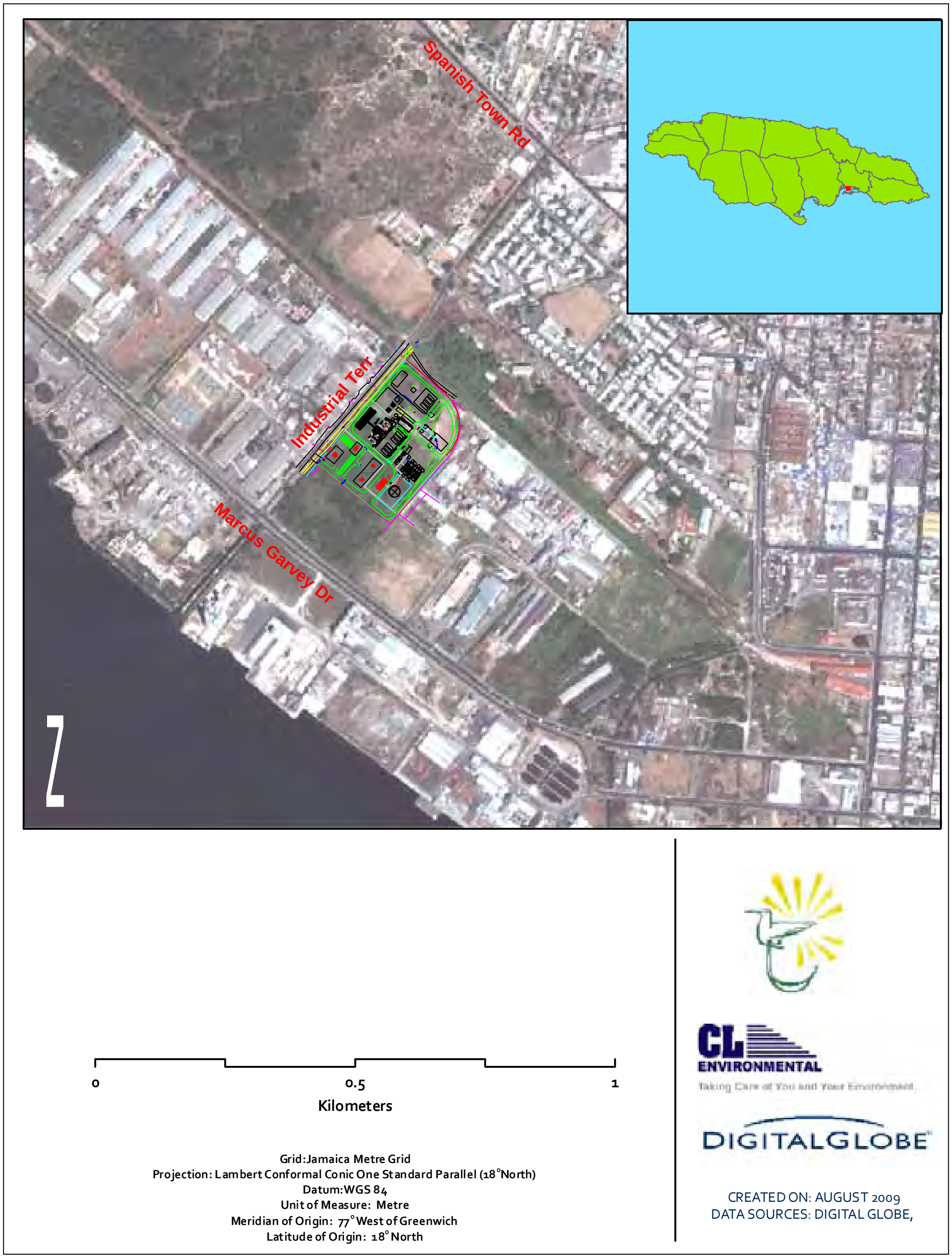


Figure 3 Location of proposed Power Plan on site previously identified on the 1:10,000 base map as Western Purification Works

3.4 Project Features

The Power plant will be constructed by Wärtsilä Finland Oy using relevant international industrial standards (including International Organization for Standardization (ISO), European Standards (EN), German Standard (Deutsche Institute für Normung) (DIN), Finnish Standards Association (SFS) and the American Petroleum Institute (API).

It will contain several specialised features of note, including:

- Storage for 5,000 cubic metres of Heavy Fuel Oil or 15 days of full power operation of all the engines.
- Tank Facilities
    - LFO Day Tank: 300 cubic metres
    - HFO buffer Tank: 200 cubic metres
    - HFO Day Tank: 300 cubic metres
    - Fresh Lube Oil Storage: 55 cubic metres
    - Used Lube Oil Storage: 35 cubic metres
    - Intermediate Lube Oil Storage: 13 cubic metres
    - Oily Water Buffer Tank: 55 cubic metres
    - Sludge: 150 cubic metres
    - Maintenance Water: 10 cubic metres
    - Treated Water Storage 20 cubic metres
    - Fire Water Tank 700 cubic metres
    - Urea Tank
- Other Facilities
    - Cooling Radiator
    - Truck Unloading Station: 2 Truck Bays
    - Selective catalytic convertor
- The Fuel Tanks will be bunded to hold 120% of the volume in the tanks in the unlikely event of a leak or spill.

- The facility can operate with Light or Heavy Fuel Oil. The Light (back-up) and Heavy (main) Fuel Oil Tanks will be equipped with valves; level indicators and alarms for high and low fuel levels. In addition it can be retrofitted to use Liquefied Natural Gas (LNG).
- The walls and roof of the Power Plant Building, Electrical Building and Fuel Treatment Building House will be insulated with Mineral Wool for fire proofing.
    - Engine Hall
        - 1 Fire alarm centre including
        - There are two independent power supplies to the fire alarm center: 230 VAC taken from the LV switchgear. One or more batteries (generally 24 VDC) with battery charger.
        - 1 Set of fire detectors connected to the fire alarm center
        - Optical smoke detectors are used for the engine hall and the auxiliary area.
        - 1 Set of manual call points connected to the fire alarm center
        - Push buttons for activating fire alarms manually are placed close to each exit road and close to the fire alarm panel or alarm center.
        - 1 Set of alarm signalling devices connected to the fire alarm center including Flashing lights (1 Hz, 1W) and Sirens
        - 10 Hydrant valve pairs
        - 10 Standpipe hose cabinet
        - 24 Portable fire extinguisher (dry powder type)
        - 6 Mobile foam unit
    - Electrical Building
        - 1 Set of fire detectors connected to the fire alarm centre
        - Ion smoke detectors are used in the switchgear rooms, offices, stores and control rooms.
        - 1 Set of manual call points connected to the fire alarm center
        - 1 Set of alarm signalling devices connected to the fire alarm center including Alarm bells (92 – 95 dB) in control room, offices, corridors and social area and Sirens

        - 2 Fire fighting, hose reel for action against fires in the Power House office block the hose reels are available in corridors.
        - 4 Portable fire extinguisher (dry powder type)
        - 6 Portable fire extinguisher (CO_2 type)
    - Fuel Treatment Building
        - 1 Set of fire detectors connected to the fire alarm center
        - Optical smoke detectors are used for the fuel treatment building.
        - 1 Set of manual call points connected to the fire alarm center
        - 3 Portable fire extinguisher (dry powder type)
- 1 Portable fire extinguisher (dry powder type). An automation system allows centralized operation of the plant from a control room. Alarms and important measurements from auxiliary units are connected to the automation system. Local independent access to critical aspects of the system is built in if required. The control room contains a PLC (Programmable Logic Controllers) based control and monitoring system which controls the generators and substation. Sensors are strategically located on the engines and auxiliaries send information from the entire operation to the PLC and computers which control the engines and substation.
- One emergency diesel generator set with a minimum capacity of 400 kW - 50 Hz.

3.4.1 Site Closure and Demolition

Before construction of the power plant can commence, proper closure and demolition of the existing structures of the old Western Sewage Plant need to be done.

This will entail the emptying (by pumping) of existing wastewater on the site contained in ponds and sumps. Currently there is sewage/wastewater in the secondary digester, settling tanks, the intake structure in the toilet/changing room as well as the pump houses. The approximate volume of sewage/wastewater contained in these structures is approximately 4,440m^3 (1,172,924 gallons). This wastewater will be collected by cesspool trucks and carried to the Greenwich Sewage Plant which is in close proximity to the site which connects to the National Water Commissions (NWC) sewer line with ultimate treatment at the Soapberry Sewage plant.

After disposal of the wastewater the demolition of existing buildings and structures will take place. There are thirteen buildings/structures that will be demolished. The demolition plan indicate that the facilities that will be demolished include concrete buildings, pump houses, settling tanks; primary and secondary waste treatment tanks and sludge drying beds (Figure 4). These structures consist of an approximate volume of 1,632m^3 of concrete or approximately 86 truckloads.

The structures to be demolished are of two types block wall and reinforced concrete. The block wall buildings will be demolished using a combination of bull-dozers/front end loaders and hand operated jack-hammers. The reinforced concrete buildings, the waste treatment tanks and other treatment structures will be demolished using a combination of hand operated jack-hammers and a crane mounted hydraulic breaker.

Water (groundwater) will be pumped from around and within the structures which fall below the water table while demolition is taking place. This water will be pumped to an area on the site that is not currently being used.

It must be mentioned that all the steelwork which formed part of the sewage treatment system has already been removed by persons that are in the scrap iron business.

Also silt, debris and other deleterious materials will be trucked and disposed of at an approved disposal site such as Riverton City. Included in this is the removal of 600mm diameter asbestos pipe culverts that are currently being stored onsite and roofing material from the existing building both of which have asbestos content of 20-40% Chrysotile. Both are encased in concrete and are not friable so they should not pose any serious health risks. The plan for disposal of these asbestos containing items will be detailed in the closure plan.

After the site closure and demolition activities have been completed, the proposed area for construction will be prepared with all vegetation being cleared excluding trees with diameter at breast height (DBH) greater than or equal to 18 cm that are not in the footprint of proposed buildings or roadways will be preserved (not including the NWC area).

Approximately 150mm of topsoil will be removed and stockpiled at the north-western corner of the site to be used in landscaping. The site will be filled with 150mm of shingle, graded and properly compacted after which approximately 150mm of marl will be placed on the shingle and graded properly.

The site closure, demolition plan, clearance and preparation activities will employ approximately 45 persons.

3.4.2 Onsite Construction

The site will consist of six main areas/structures:

- An engine hall with an external structure to support the engine exhaust stacks and an area for the engine radiators
- A building for the warehouse and stores
- An administration building
- A tank farm within a concrete containment area
- A fuel treatment building
- An area for 69 kV electrical switchgear and 69 kV/11 kV power transformers

After clearing the land, piles will be driven to provide a stable foundation for the various buildings, structures and towers to be erected at the site. This will be required due to the general soil composition of the site selected.

The boundary wall will be constructed, foundation poured and the access road built. The power house building will be built to withstand a category 4 hurricane and a zone 4 earthquake.

The construction phase is expected to employ some 50 persons during the foundation building phase.

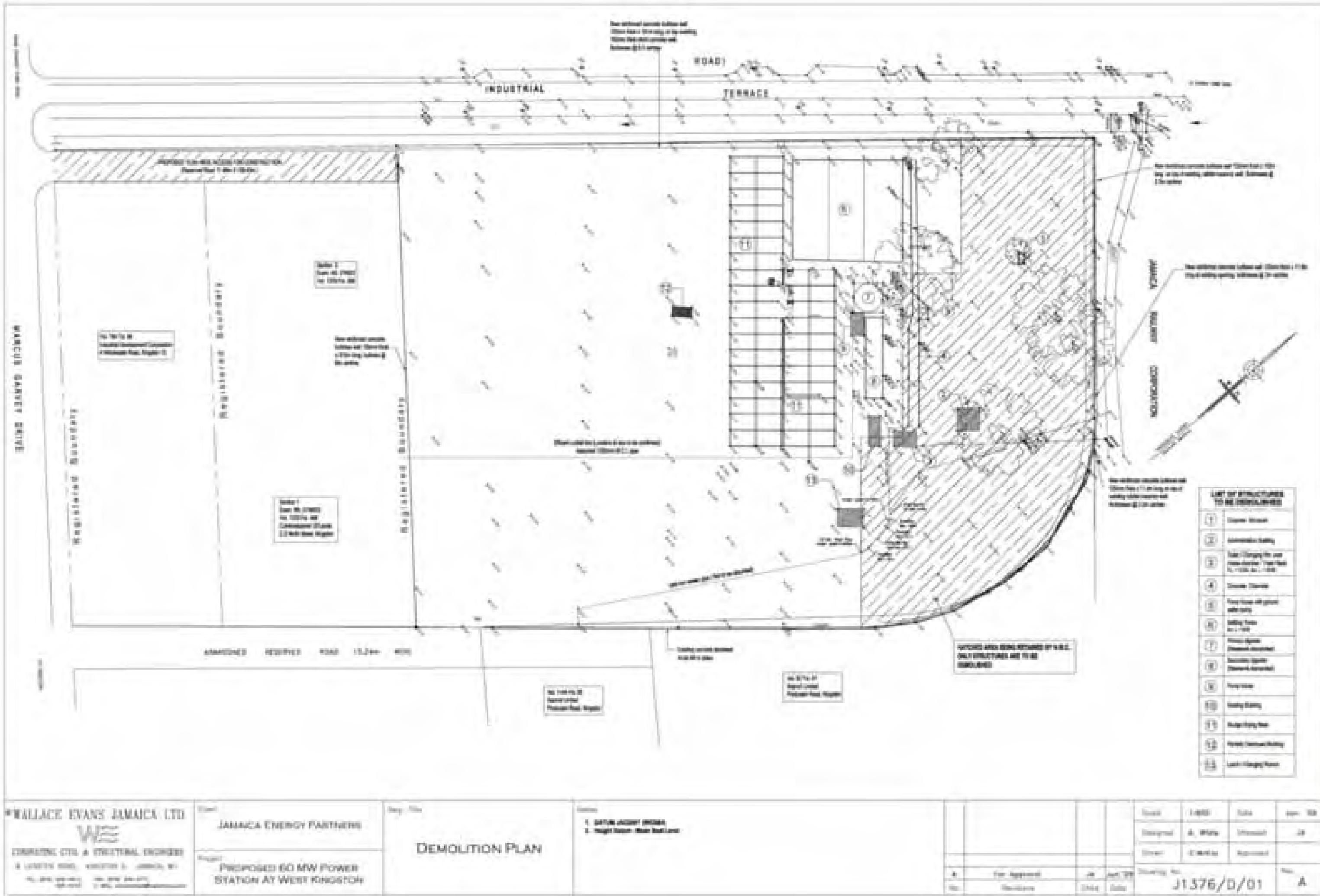


Figure 4 Demolition plan map

3.4.3 Operation

The start of operations of the facility will mark the beginning of the Environmental Monitoring, Management and Mitigation Plan for the facility. This will include the monitoring of the following parameters:

- water quality and temperature
- noise levels
- effluent and air emission levels
- any other parameters identified by the World Bank, NEPA or any other Government of Jamaica Agency

In addition, JEP will be proactive in addressing any issues raised by the neighbouring communities and local authorities.

3.4.4 Decommissioning

As part of the Environmental Monitoring and Mitigation Plan for the proposed facility, JEP will provide a decommissioning plan that will consider the most environmentally sound and cost effective means of disposal for the major parts of the power plant. This will be presented to NEPA and the World Bank within 2 years of commissioning the facility. The expected life span of the power plant is 25 years.

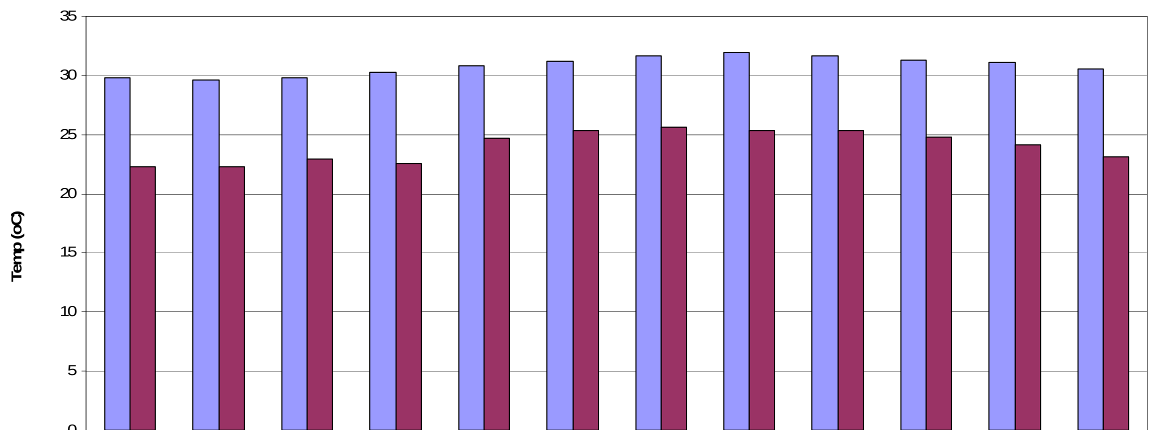
4.0 Baseline Description

4.1 Climatology, Meteorology and Air Quality

4.1.1 Climatology and Meteorology

4.1.1.1 Temperature

The mean monthly temperatures are lowest in January (22.3°C) and February (22.3°C) and highest between July and September (31.7 – 31.9°C). The minimum temperature ranges from 22.3 °C to 25.6 °C with highest temperatures in July and August and the maximum daily temperature ranges from 29.6 °C to 31.9 °C. The relatively narrow range in temperature reflects the moderating influence of the sea (Figure 5).



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max Temp. (C)	29.8	29.6	29.8	30.3	30.8	31.2	31.7	31.9	31.7	31.3	31.1	30.5
Min Temp. (C)	22.3	22.3	22.9	22.6	24.7	25.3	25.6	25.3	25.3	24.8	24.1	23.1

Figure 5 *Mean monthly temperatures for Norman Manley International Airport*

4.1.1.2 Humidity

The mean monthly relative humidity ranges between 60 and 80 percent. Relative humidity is lower in the afternoons (Figure 6).

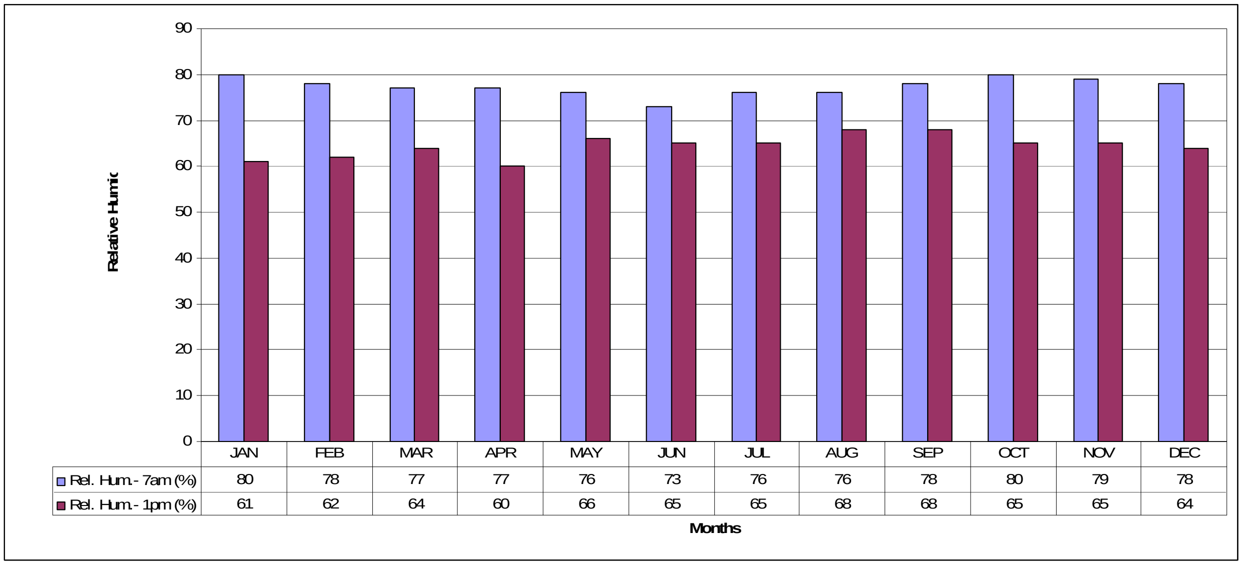


Figure 6 Mean monthly relative humidity for Norman Manley International Airport

4.1.1.3 Rainfall

The annual mean rainfall is 62.1 mm. The data indicates that there are two rainy seasons in the year; these times are the May to June period and the August to October period where the highest intensities occur (Figure 7 and Figure 8). October has the highest average monthly rainfall (167 mm) and days with rain (10 days).

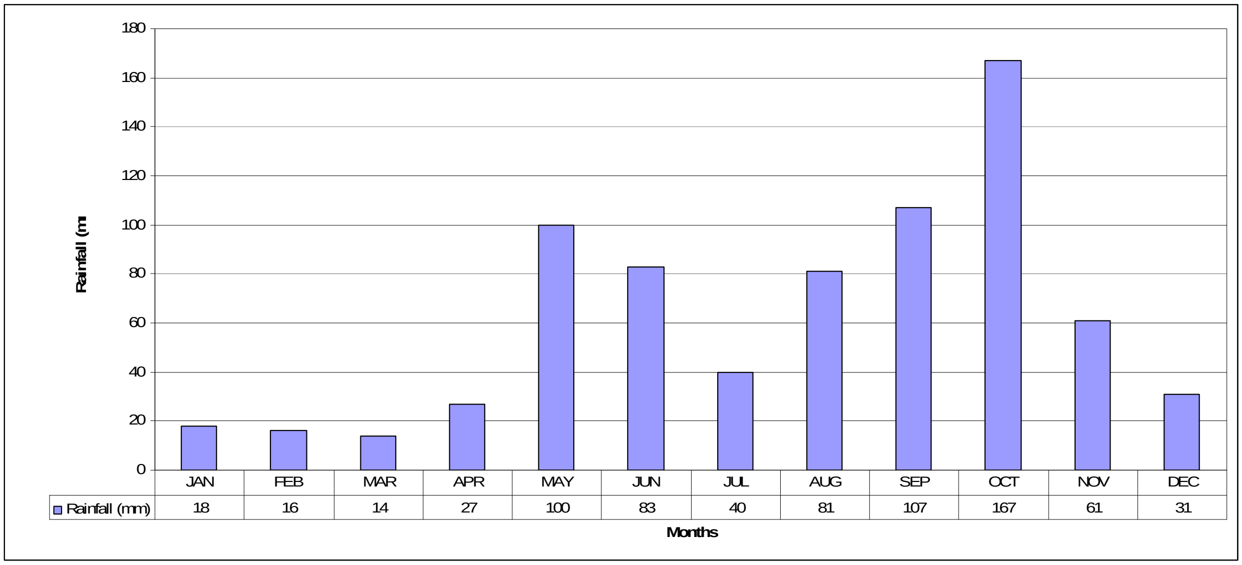


Figure 7 Mean monthly rainfall data for Norman Manley International Airport

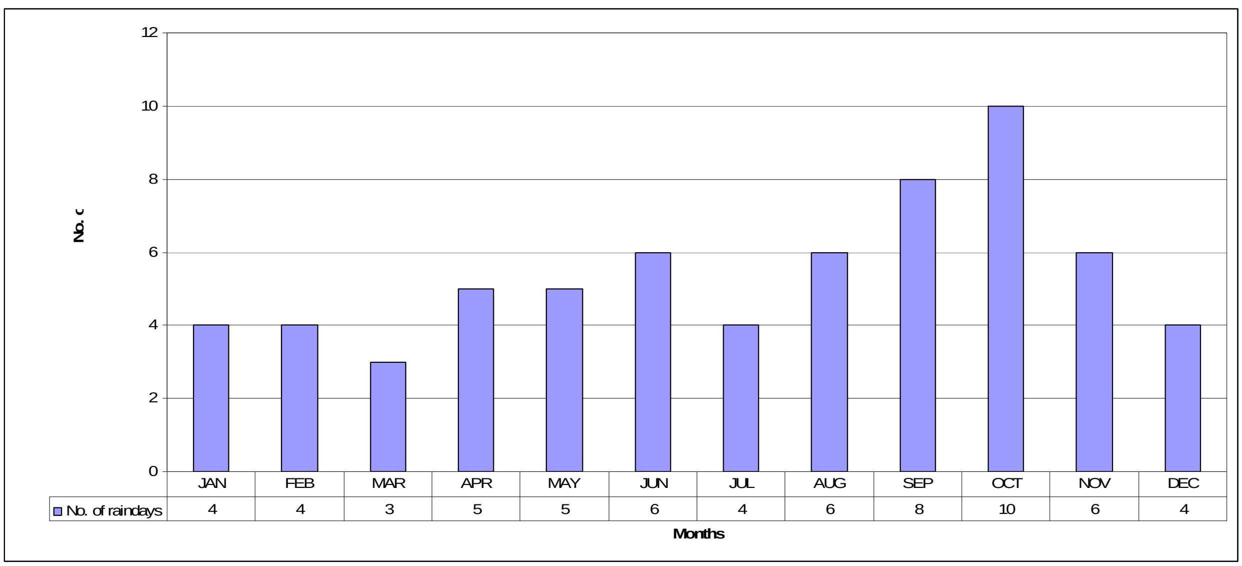


Figure 8 Mean number of rain days for Norman Manley International Airport

4.1.1.4 Wind

The dominant winds over Jamaica are the northeast trade winds. Figure 9 shows an annual wind rose for the Norman Manley International Airport (NMIA) from January 1999 through December 2004. The predominant wind direction is from the east southeast with average wind speeds of 7.70 m/s. These are the prevailing sea-breeze directions and reflect the effects of the mountains that lie along an east west axis. The mountains deflect the dominant north-easterly trade winds and provide the easterly component to the winds.

A monthly analysis of wind direction and speeds indicated that monthly the winds generally blew to the west with wind speeds ranging from 6.32 to 10.97 m/s with the highest wind speeds occurring in the months June to August (10.97, 9.57 and 9.22 m/s respectively) (Figure 10).

Any stack emissions from the proposed plant would travel away from the residential areas, such as Tivoli.

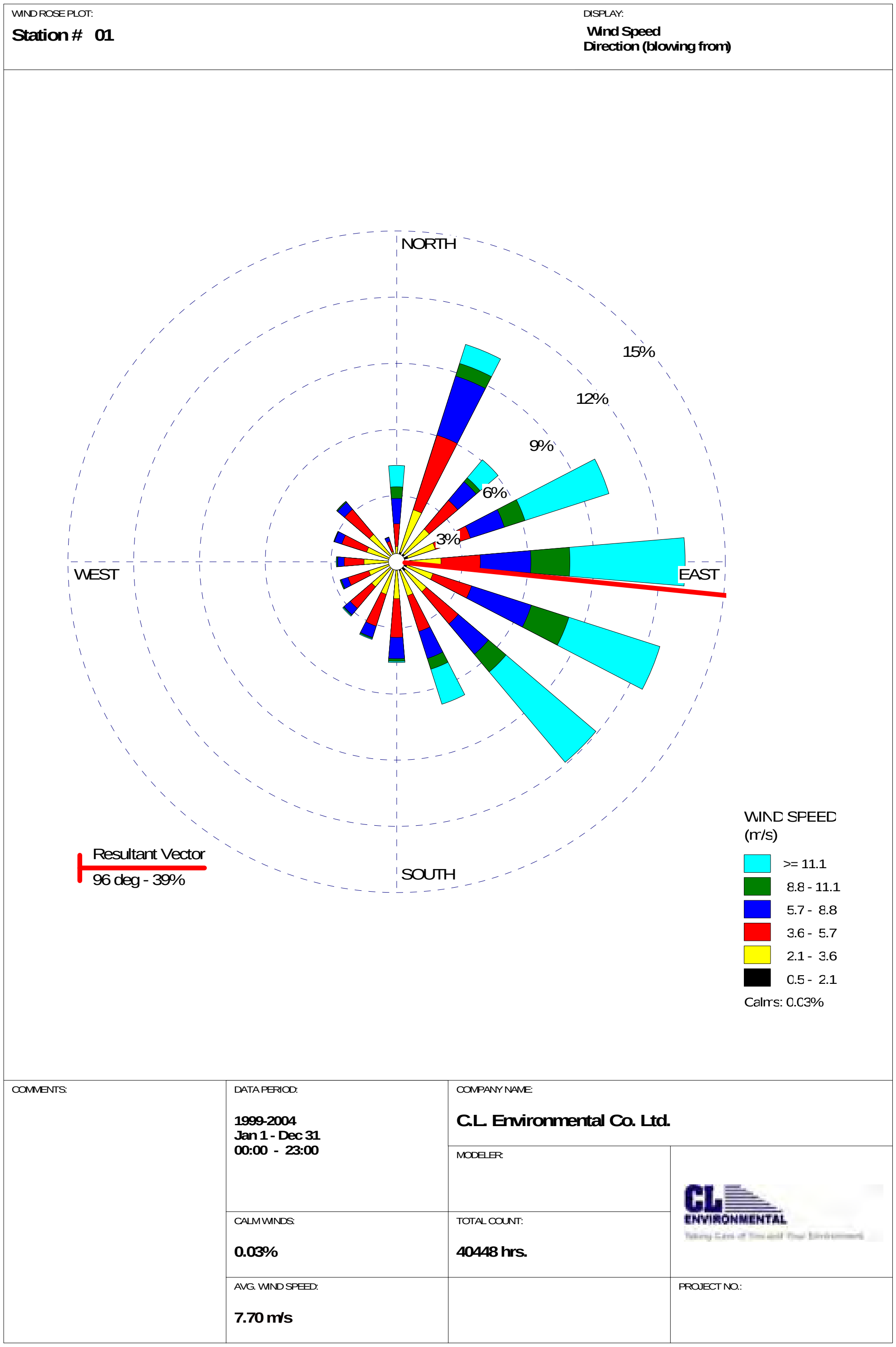
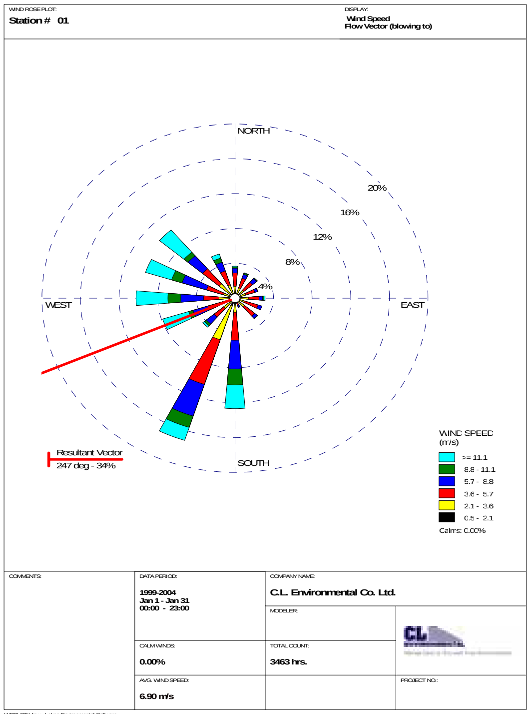
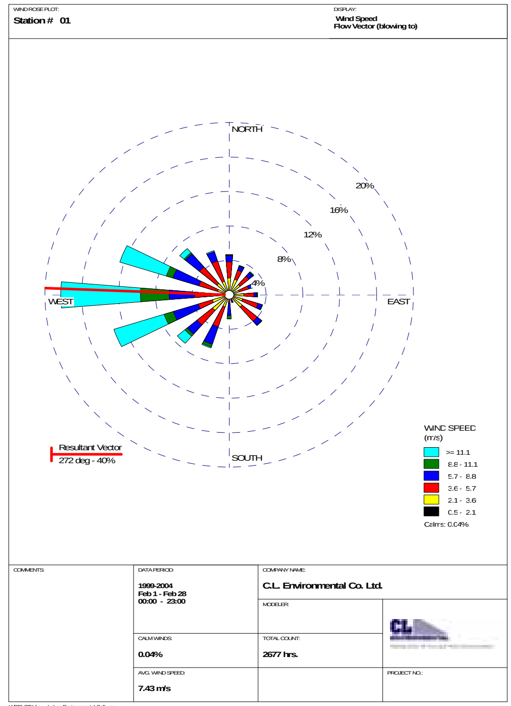


Figure 9 Annual wind rose for Norman Manley International Airport (1999-2004)



January



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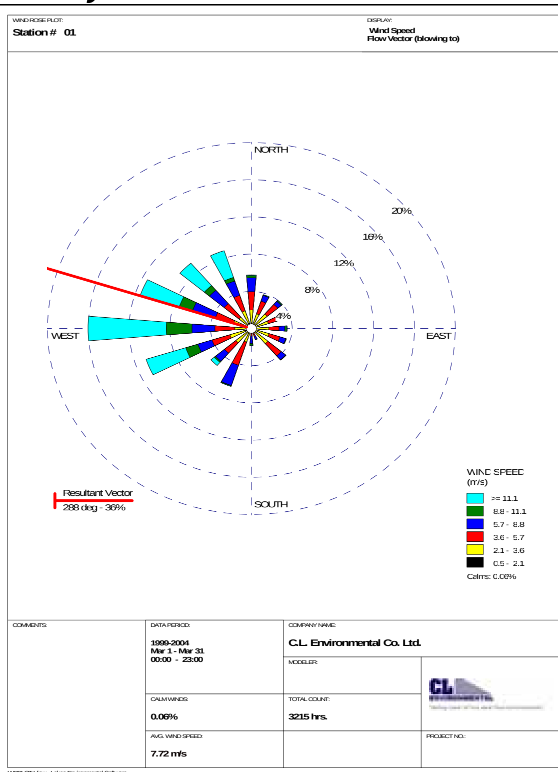

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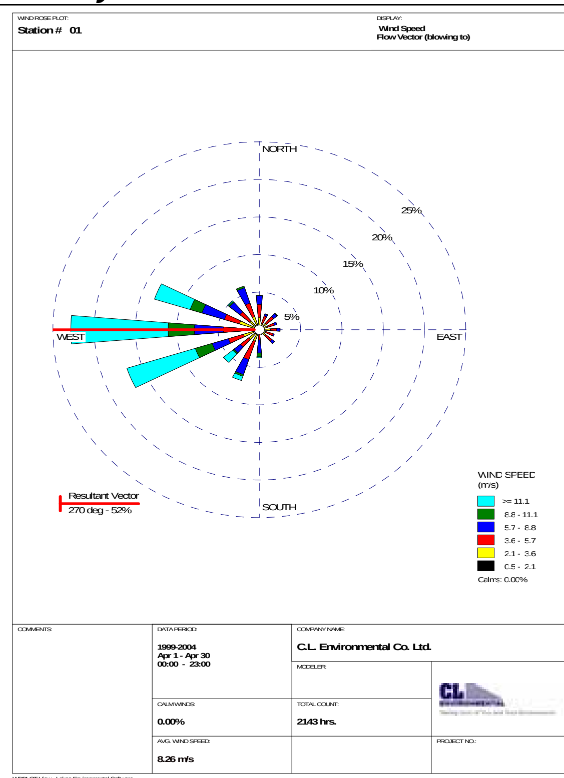

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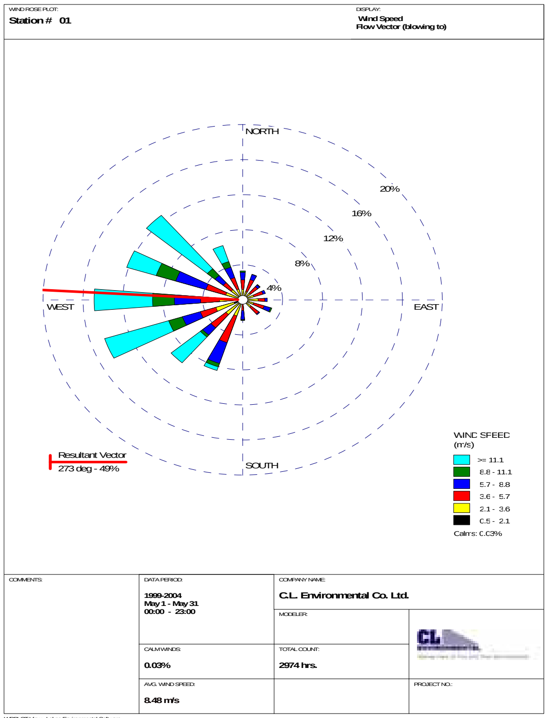
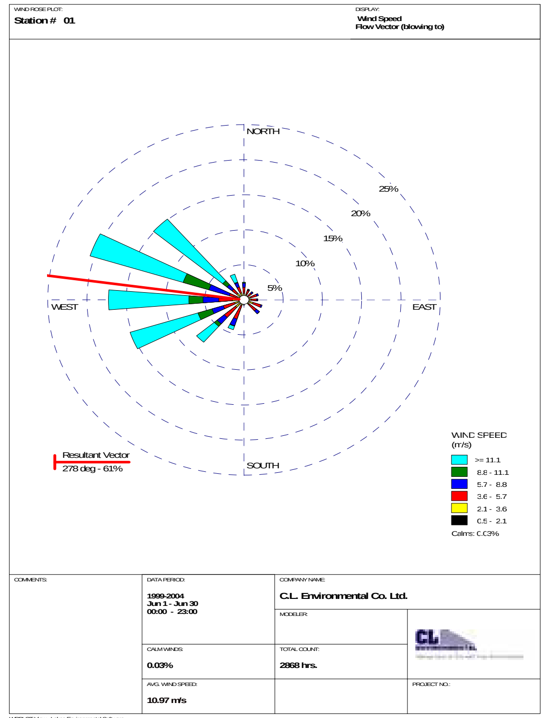


May



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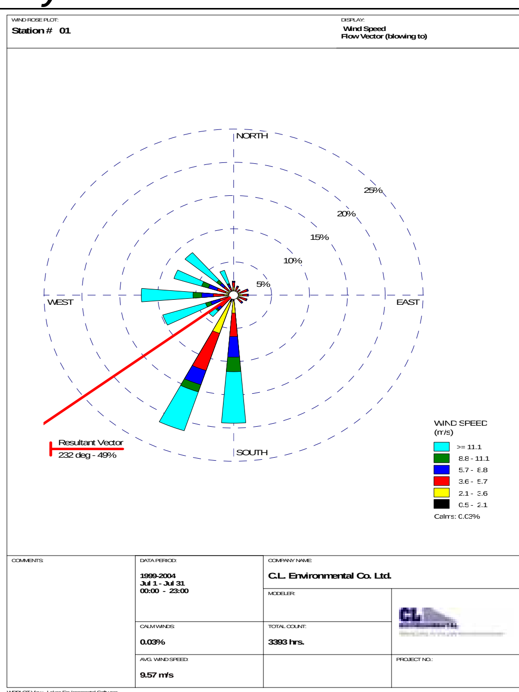

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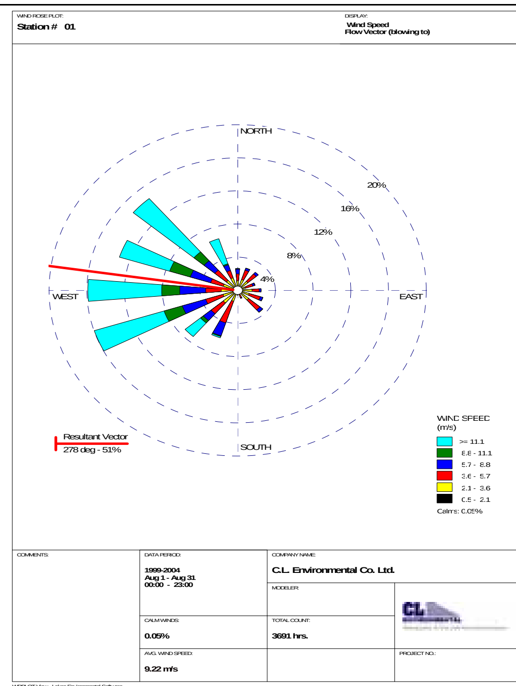

August

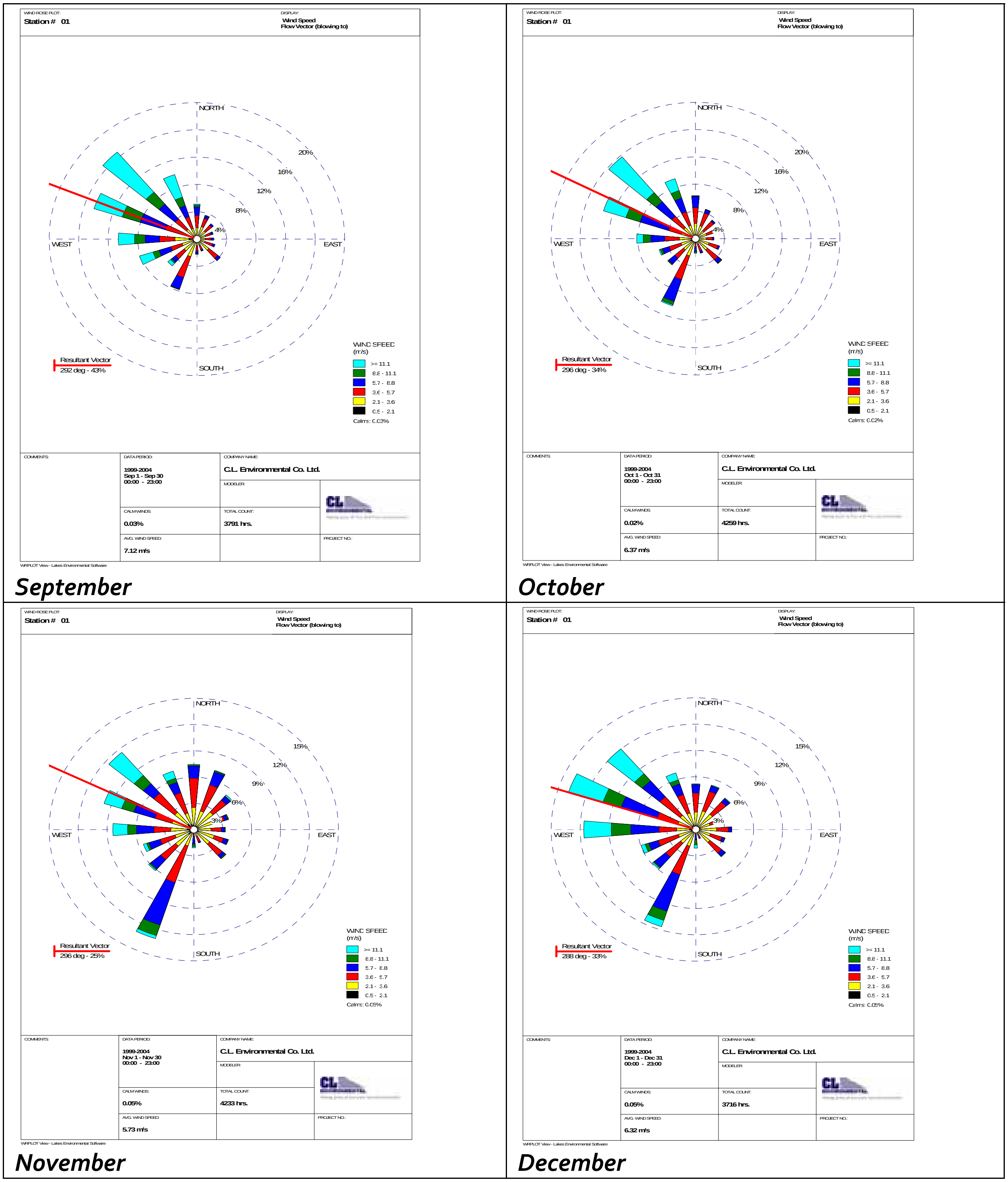

Figure 10 Monthly wind rose for Norman Manley International Airport (1999-2004)

4.1.2 Air Quality

Continuous Ambient Air Quality monitoring data for the Hunts Bay air shed was not available prior to September 2009. However, passive monitors have been used to measure air quality from time to time over the last nine years for limited periods of time, most of this monitoring was done for areas in Kingston that are not within the air shed under consideration (the Hunt's Bay Air Shed). However, for the Petrojam EIA conducted in 2008 limited monitoring was conducted within the Hunt's Bay Airshed using passive monitors.

Data from the Petrojam EIA Report (April 2009) indicated that at various times during 2001, 2004 and 2006 weekly averaged NO2 concentrations ranged from 10 – 46 μgm^{-3}. The lowest weekly averaged NO_2 were at sites NNW of the proposed site (Chancery Hall, Norbrook Heights and Constant Spring Golf Club). NO2 concentration was highest at Cross Roads, Half Way Tree and Matilda's Corner all of which were located near high traffic intersections. Samples were taken at a site located on Marcus Garvey Drive between Petrojam refinery and the JPS Hunts Bay station ranged from 20 – 39 μgm^{-3}. It goes on to say that the extrapolation of these weekly averages to annual average would be below the Jamaican National Ambient Air Quality Standard (JNAAQS) for annual NO2 concentration of 100 μgm^{-3}.

Two week average SO2 from passive SO2 monitors at six sites located away from the proposed site from April 2007 – July 2007 ranged from 7 to 42 μgm^{-3}. The highest values were measured at Camperdown High School which is located approximately 3km east of the proposed site.

TSP and PM10 concentrations have been measured by NEPA at their Head Office at Caledonia Avenue (Cross Roads), their Laboratory at 191 Hope Road and at Harbour View. These sites are all located away from the proposed site. The TSP and PM10 concentrations in 2006 and 2007 were generally below the 24 hour JNAAQS.

Since September 2009, Jamaica Energy Partners commissioned two ambient air quality monitoring stations for the continuous monitoring of air quality in the Hunts bay air shed as part of there effort to verify model predictions that indicated that the airshed is currently degraded. The data collected from these stations for the month of September are summarized in Table 2 below.

Table 2 Ambient air quality data collected in the Hunts Bay air shed in the month of September 2009

STATIONS / AVERAGES	SO_2 [ug/m^3]	NO_2 [ug/m^3]
GARMEX - Maximum 1 Hr. Avg.	278	63
CUSTOMS - Maximum 1 Hr. Avg.	100	64
AVERAGE for both stations - Maximum 1 Hr. Avg.	**189**	**63**
NEPA'S Standards for 1 Hr. Avg.[ug/m3]	**700**	**400**
GARMEX - Maximum 24 Hr. Avg.	47	35
CUSTOMS - Maximum 24 Hr. Avg.	6	31
AVERAGE for both stations - Maximum 24 Hr. Avg.	**27**	**33**
NEPA'S Standards for 24 Hr. Avg. [ug/m3]	**365 / 280**	**NA**
GARMEX - Avg. for the period (24 days)	34	21
CUSTOMS - Avg. for the period (13 days)	1	22
AVERAGE for both stations (for the monitoring period)	18	22
NEPA'S Standards for Annual Avg. [ug/m3]	**80**	**100**
% DATA COVERAGE (from Comissioning to September 30, 2009)		
GARMEX (%)	91%	89%
CUSTOMS (%)	98%	99%
AVERAGES	95%	94%
Target Coverage (%)	95.00%	95.00%

4.2 Physiography, Geology and Structure

4.2.1 Introduction

The proposed site for the JEP Power Plant was visited on July 27, 2009 and July 31, 2009 to examine the physiography, geology and soils of the proposed site. The surface area consists of a variety of superficial sediments and soil, a single sample was collected from a ditch on the site.

4.2.2 Physiography

The remains of the former sewerage plant were still visible including settling ponds (Plate 1) and buildings which appear to have previously housed equipment (Plate 2) were identified. The site is more or less flat-lying area with isolated low hummocks. The northern section of the property is at an elevation of approximately 3m (10ft) above sea level (1:10,000 map Central Sheet Series E922, 1972) and slopes gently southward towards Kingston Harbour.

Plate 1 Remnants of sewerage ponds still present at the site

Plate 2 Existing building on site: Remnants from the NWC Treatment Plant

Percolation rates at the site following rainfall do not appear to be equal, as sections of the site have soft wet sediment and small quantities of water pooling in these areas in contrast to adjacent sections where ground is dry and firm (Plate 3).

Plate 3 Example of areas of poor percolation on site

4.2.2.1 Physical Features

The regional geological descriptions of the area are contained on Geological Sheet 25 (1:50,000 imperial series) published by the Mines and Geology Division (1974), which indicated that the area is underlain by the Liguanea Formation of the Upper Coastal Group. However, the geological sheet does not portray the nature and distribution of superficial deposits (Late Pleistocene to Recent). This formation consists of alternating layers of gravel, sand, loam and some clay and was formed by overlapping deltas fans of streams originating from the mountains to the north and consists of some marine fossils towards the sea-ward edge.

The sample collected from the site for this investigation was taken from material removed from a pit (Plate 4) and is a poorly consolidated reddish brown material consisting primarily of medium to fine sands with some clay. Clasts present in the alluvium show no structures and are primarily igneous in origin. Some sedimentary clasts were also identified in the sample. They range in size from less than 1mm to greater than 10cm, indicating a very poor sorting, and are well rounded to angular. Rootlets are also present throughout the alluvium. No fossils were identified in the samples analyzed; however, a bored conch fragment was found on a pile of rubble south of the property.

Plate 4 Field sample was collected from excavated material shown here

4.2.2.2 Subsurface Descriptions

Borehole information for four wells provided by the Water Resources Authority (WRA) indicated a mixed sequence of gravels, sands, silts and clays in the vicinity of the site (Figure 11). These records are consistent with the borehole data gained by Geotech (Jentech Consultant Ltd., 2009) at the site itself. Superficial deposits are normally not fully consolidated.

Figure 11 Location map of the four Water Resources Authority wells discussed, with the area under consideration indicated by Green Box

At the Tivoli Depot-Marcus Garvey Drive Well located west of the site, conglomerates were identified at the surface to a depth of 17.07m (56ft) which was underlain by a 4.6m (15ft) thick layer of sand and gravel below which, at a depth of 21.6m (71 ft), a 1.5m (5ft) layer of clay was identified. Lithological descriptions of the three wells located east of the site; Producers Road #1A, Producers Road #2, Producers Road #2A showed layers of loam, sand, clay and gravel up to depths of 30.5m (100ft).

Of the eastern well sites, subsurface lithology at Producers Road #1A consisted of a 1.5m (5ft) thick layer of clay and land fill material, identified at the surface. This was underlain by 7.6m (25ft) of medium – fine grained sand and silt. An 18.3m (60ft) thick layer of coarse grained sand and gravels occur at 9.1m (30ft) from the surface and is underlain by 3.0m (10ft) of medium – coarse grained sand and small gravels.

The lithological descriptions of the well identified as Producers Road #2A, showed that this area has a 0.9m (3ft) thick layer of clay at the surface. This was underlain by 8.2m (27ft) of silt and clayey sand. An 18.3m (60ft) thick layer of coarse sand and gravel with clay layers was identified at 9.1m (30ft) below the surface and this was underlain by 3.0m (10ft) of clay.

Descriptions of the well identified as Producers Road #2 showed the occurrence of a 1.2m (4ft) thick layer of sandy loam at a depth of 1.8m (6ft) from the surface. This was underlain by a 3.0m (10ft) thick layer of sand and clay at 3.0m (10ft) depth followed by a 4.6m (15ft) thick layer of sand, gravel and clay at 6.1m (20ft) below the surface. A layer of coarse gravel 5.8m (19ft) thick, followed by a 1.8m (6ft) thick layer of coarse sand were identified at 10.7m (35ft) and 16.5m (54ft), respectively, below the surface. An 2.4m (8ft) layer of sandy loam was identified at a depth of 18.3m (60ft), which was underlain by 4.9m (16ft) of clay over 4.0m (13ft) of coarse sand which lays on 0.9m (3ft) of clay identified at 29.6m (97ft) from the surface.

4.3 Hydrology and Hydraulics

4.3.1 Model Description

4.3.1.1 RIVERCAD XP

Hydraulic analysis of the concrete U-drain mentioned earlier which runs along the western boundary of the site was done using the BOSS International RIVERCAD XP modelling software. This software incorporates the US Army Corps of Engineers' (Hydraulic Engineering Corps) River Analysis System (HEC–RAS) into AUTOCAD. The model uses topographic data and flow data to simulate the movement of the stream across a plain. This model was executed using a steady state analysis of the peak flow conditions for the 1 in 50 year and 1 in 100 year return periods using the existing conditions.

4.3.1.2 Soil Conservation Service (SCS) Method

The SCS method is an empirical model for rainfall runoffs which is based on the potential for the soil to absorb a certain amount of moisture. On the basis of field observations, this potential storage S (millimeters or inches) was related to a 'curve number' *CN* which is a characteristic of the soil type, land use and the initial degree of saturation known as the antecedent moisture condition.

Curve Numbers

The curve number used in the SCS method was extracted from the recommended set of values given in the 'Storm Design Manual' - put together by Niagara county board.

The selected curve number was 95 for the type of soils and the observed land use corroborated by that stated in the "Soil and Land-Use Surveys."

Runoff

Hydrological modelling of the catchment gave an output of approximately 225 cubic meters per second of peak runoff for the 1 in 50 Year Return Period and 256 cubic meters per second for the 1 in 100 year return period rainfall events. A type 3 rainfall distribution curve was used in the analysis.

4.3.2 Hydraulics

4.3.2.1 Methodology

Hydraulic analysis of the concrete U-drain was done using the BOSS International's RIVERCAD XP. It was done using the steady state analysis of the peak flow condition for the 100 year pre-project scenario.

In order to run the analysis, boundary conditions needed to be established. Considering that the profile type being used was subcritical, only downstream boundary conditions were required for the RIVERCAD XP model.

The boundary conditions were established for each of the three scenarios run. Table 3 shows the boundary conditions for each scenario.

Table 3 Boundary conditions for the three scenarios analysed

	Rainfall Return Period	Scenario Description	Profile Type	Downstream Condition	Water Surface Elevation
Scenario 1	50 year	Existing conditions	Subcritical	Normal depth	
	100 year	Existing conditions	Subcritical	Normal depth	
Scenario 2	50 year	Existing + Storm surge	Subcritical	Known WS Elevation	1.93 m
	100 year	Existing + Storm surge	Subcritical	Known WS Elevation	2.2 m
Scenario 3	100 year	Blocked Culvert	Subcritical	Normal depth	

The model was first calibrated using the anecdotal information and rainfall data received regarding Hurricane Gustav which Passed Jamaica in 2008. The Pre-project scenario was then modelled changing only the rainfall depth to that of the 50 year and 100 year return rainfall events.

During the CEAC team's site visit, interviews were conducted with two residents in the area. Mr. Clive Bartly, a Tivoli Gardens resident for over 25 years, stated that he had no recollection of flooding on the site or its immediate surroundings. This was confirmed by Miss Dixon, a resident of Tivoli Gardens since 1968 who also had no recollection of any flooding on the site or surroundings.

The Office of Disaster Preparedness and Emergency Management (ODPEM) was also contacted to find out if there was any recorded flooding on the site. ODPEM stated that there was some flooding in the past in the general area but could not conclusively say whether there was any flooding on the actual site.

The only drainage feature in the area is the Tivoli Gully. This feature originates at the intersection of Retirement Road and Cross Roads (Central Sheet 1:10,000 series) but also carries run off from the Seymour Avenue area via the Mico Gully which meets Tivoli Gully in the vicinity of Torrington Bridge in the Cross Roads area.

Due to its level nature, the on-site drainage is poor, with standing water in several places. This is due in part to the variable percolation characteristics of the topsoil, as well as slight depressions in the ground. Matley (1951) indicated that the treated sludge from the sewerage plant was stockpiled at the site for sale as fertilizer. Remnants of these stockpiles may contribute to the variable characteristics of the topsoil.

4.3.2.2 The Catchments

It is important to delineate the catchments associated with the proposed site so as to calculate the expected runoff flows reaching the site. Although the catchment associated with the site itself is small, it was also important to incorporate the catchments associated with the concrete U-drain which runs along the western boundary as this drain potentially conducts a significant amount of runoff which if hindered in any way (blockage or other) would leading to flooding of the site.

It is also important to note that upstream the drain receives water from two smaller drains which conduct water from the Mona area and the New Kingston and Half Way Tree area. There are three main catchments associated with this site. Table 4 shows the catchment names and their respective land areas as well as Figure 12 which illustrates the catchment boundaries.

Table 4 Catchments associated with the concrete u-drain and the proposed site

Catchment Name	Area	Units
Catchment 1	139.2	HA
Catchment 2	33.1	HA
Catchment 3	194.0	HA

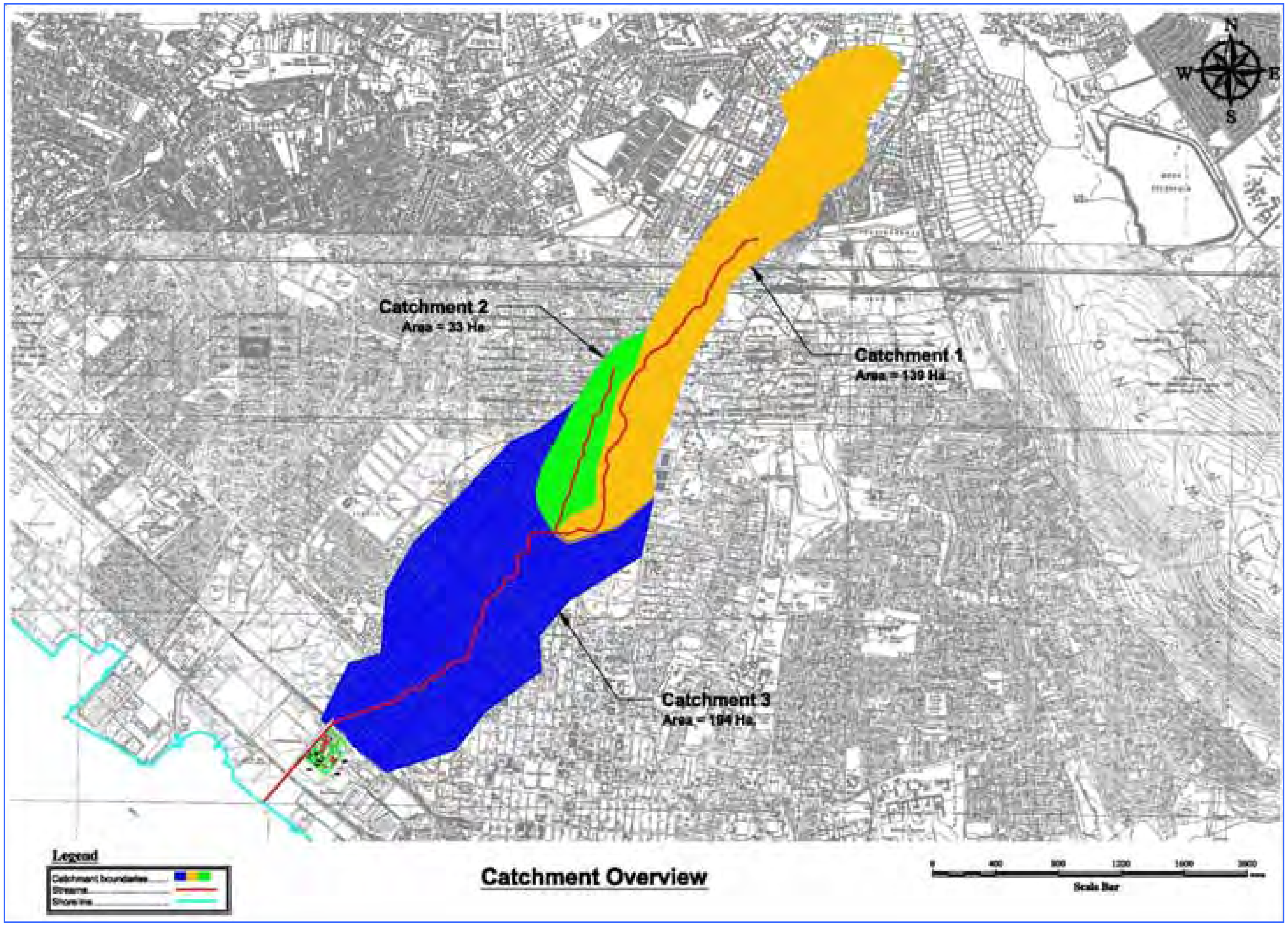

Figure 12 Catchments associated with the site and concrete u-drain.

The meteorological data for the catchment was obtained from the Meteorological Office of Jamaica. Gauges closest to the catchments were located and the value of the one expected to affect the catchment most directly was used as input for the hydrological analysis. Half Way Tree was determined to be the most relevant station giving a rainfall depth of 350mm/24hr for the 50 year return period rainfall event and 399 mm/24hr for the 100 year return period. Table 5 shows this data.

Table 5 Rainfall return period and intensity for Half Way Tree

Station	Rainfall Return Period	Rainfall Intensity	Units
Half Way Tree	50 year	350	mm/24hrs
	100year	399	mm/24hrs

4.3.3 Drainage Assessment

4.3.3.1 Existing Drainage Features

There is one major drain associated with the site which runs parallel to the western boundary. This is a concrete U-drain which is a receiving drain for two other major drains upstream which conduct runoff from the Mona area and the New Kingston area. The concrete U-drain is approximately 6.4 m wide and 2.1 m deep. The drain borders western side of the proposed site and Industrial Terrace, passing under Marcus Garvey Drive via a box culvert before continuing south to discharge into the Kingston Harbour. The box culvert under Marcus Garvey Drive is 6.4 m wide and 1.2 m deep. Plate 5 and Plate 6 show the concrete U-drain and the Box culvert under Marcus Garvey Drive.

Plate 5 Picture shows concrete u-drain which borders the western boundary of the site and Industrial Terrace.

Plate 6 Box Culvert under Marcus Garvey Drive.

It was important to investigate the capacity of the existing drainage features in the area so as to decide whether drain in its present configuration would be able to handle any additional runoff that the power plant might generate. It was also important to check the proposed internal drainage of the power plant to conclude its feasibility as well as its conformity to the National Works Agency (NWA) guidelines for drainage design.

4.3.3.2 Concrete U-drain

Using the rational method, the concrete U-drain, in its present configuration (6.4m wide and 2.1 m deep), has a capacity of 115.57 cubic metres per second. This is equivalent to the 1 in 5 year rainfall return period. Table 6 shows the computation of the drain capacity.

Table 6 Computation of the concrete u-drain capacity

Input Parameters	**Values**	**Units**
Area	1940397	m^2
Mannings Coefficient	0.035	
Lengths		
Main stream length, L	2804.65	m
Secondary length	1181	m
Distance from outlet to centroid, Lc	345.9	m
Elevations		
Lower elevation	8.00	m
Upper elevation	40.50	m
Upper elevation-catchment ridge	59.50	m
Slope		
Main channel slope	1.2%	
Catchment slope	4.4%	
Ct	1.50	
Cp	0.17	
Runoff Coefficient, C	40%	
Curve Number, CN	95	
Box Channel	**Values**	**Units**
Length of main channel	2804.65	m
Slope	1.16%	
Mannings Coefficient	0.015	
Width	6.400	m
Depth	2.134	m
Flow	**115.57**	**m^3/sec**
Tt	**0.092**	**hours**

4.3.3.3 Proposed Internal Drainage Network

The proposed drainage network is governed by four main catchments which will be defined during the final grading of the site. The two internal catchments will be graded to conduct runoff to a HDPE culvert which runs in a southerly direction along the catchment boundary to discharge in a concrete U-drain. This U-drain conducts the runoff in a westerly direction to discharge into the existing U-drain which borders the western boundary of the site.

The eastern catchment will be graded to conduct the runoff to a HDPE culvert to be placed along the eastern boundary of the site. This culvert will channel the runoff to the proposed concrete U-drain mentioned earlier and on to the existing drain along the western boundary.

The western catchment will be graded toward the site boundary to discharge directly into the existing U-drain via 6 * 600 mm HDPE culverts. Figure 13 illustrates the drainage network.

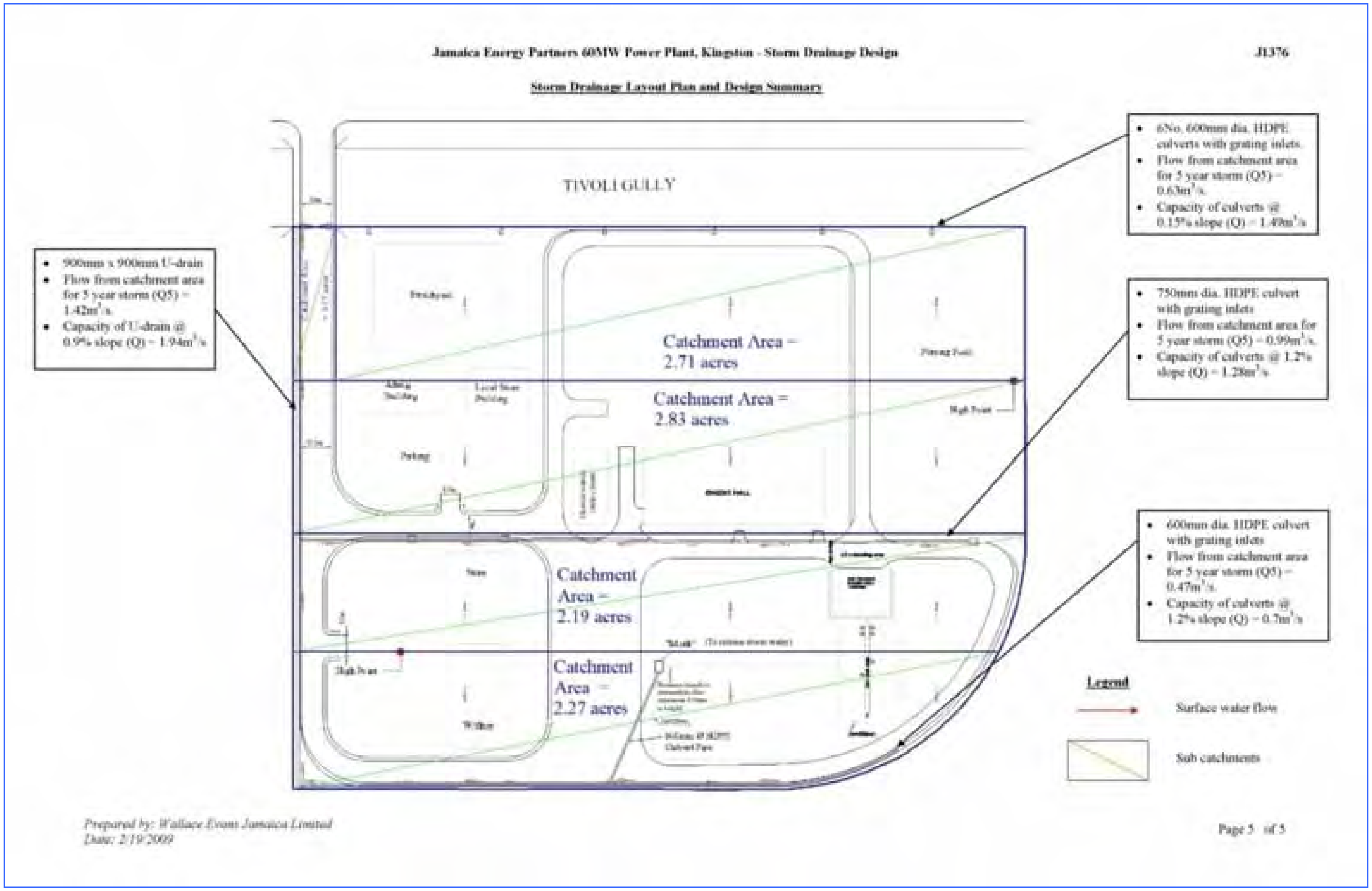

Figure 13 Storm Drainage Layout Plan and Design

4.4 Natural Hazards

The natural and anthropogenic hazards include:

a) Fluvial Flooding
b) Subsidence
c) Liquefaction
d) Hurricanes
e) Storm Surge
f) Tsunami Events
g) Sea-level Rise

4.4.1 Fluvial Flooding

Fluvial flooding can result from overland flow and from riverine flooding. Flooding from intense rainfall events will produce overland flow derived from areas that are built up and with little opportunity for soil percolation. This would indicate a fast rise in overland flow, which would need to be accommodated by the drainage works at site.

Anecdotal reports from residents of the area indicated that the lower section of Tivoli Gully, immediately adjacent to the site, has not been known to overflow at the site within living memory. However, runoff carried in this section of Tivoli Gully includes that carried by The Mico Gully as well. Both gullies transect a large urban area and as a result carry debris, large quantities of which are non-biodegradable (Plate 7) from areas to the north. This debris has the potential to clog the lower extremities of the gully, closer to the sea, thereby reducing flow as they are not flushed from the channel during low rainfall periods.

Plate 7 View of the Tivoli Gully (looking south) from Producers Road

Extreme discharge elevations could be increased by (a) subsidence at the site; (b) increased sea-level; (c) increased severity of intense rainfall; (d) blockage of the gully by anthropogenic debris; (e) coincidence of intense rainfall with storm surge. Marine flooding hazards are indicated below.

4.4.2 Subsidence

Pumping of groundwater from nearby wells, together with the presence of peaty layers and organic muck in the superficial deposits could induce subsidence locally. Whether or not subsidence has actually occurred at the site would need to be determined through examination of present and previous survey records.

4.4.3 Flood Plain Mapping

4.4.3.1 Methodology

The RIVERCAD XP model uses topographic data as well as flow data to simulate the flow paths and hence generate the floodplain and water levels. The methodology used for the analysis is as follows:

1. Data collection to include project description
2. Anecdotal evidence

3. Description of the environment to include:
    a. The topography of the catchments
    b. Soils
4. Delineation of catchments and calculation of runoffs using the SCS method.
5. Use of BOSS Internationals RIVERCAD XP software to model the concrete U-drain which runs along the western boundary of the site for the 100 year rainfall event.
6. Analyze :
    a. The existing conditions (10, 25, 50 and 100 year return periods)
    b. The existing conditions (50 and 100 year return periods) with a storm surge
    c. The blocked culvert scenario (100 year return period)
7. Preparation of flood plain maps

4.4.3.2 Results

The analysis of the three different scenarios revealed that the existing site may experience flooding even in the 10 year rainfall event across the majority of the site Flood prone areas were noticed off-site, west of Industrial Terrace on the Garmex Factory property, south of Marcus Garvey Drive in the undeveloped lot spreading east and west into the Jamaica Public Service (JPS), Hunts Bay power plant and the Petrojam plant. Considering that the site has an average elevation of 3 m, water depths of up to 4. 63 m was noticed for the 1 in 25 year rainfall event and 4.74 m for the 100 year rainfall event. Table 7 shows the results from the RIVERCAD modelling.

Table 7 Results from Flood Plain modelling for the different scenarios along with the proposed critical floor levels for sensitive instruments/machinery

	Rainfall Return Period	Description of Scenario	Flood water Surface Elevation (m)	Water Depth above Existing Ground (m)	Critical Floor Elevation (Proposed) (m)
Scenario 1	50 year	1 in 50 year event + Storm Surge	4.7	1.7	5
	100 year	1 in 50 year event + Storm Surge	4.74	1.74	5.04
Scenario 2	10 year	1 in 10 year event (Existing Conditions)	4.54	1.54	4.84
	25 year	1 in 25 year event (Existing Conditions)	4.63	1.63	4.93
	50 year	1 in 50 year event (Existing Conditions)	4.74	1.74	5.04
	100 year	1 in 50 year event (Exisiting Conditions)	4.74	1.74	5.04
Scenario 3	100 year	1 in 100 year event (Blocked Culvert)	4.74	1.74	5.04

4.4.3.3 Consideration of Combined Rainfall and Storm Surge

A power plant is expected to operate on a 24hr cycle and thus the design must consider the worse case scenarios. One such scenario is a situation where a heavy rainfall event occurs in the area during a storm surge event in Kingston Harbour.

The results of this scenario showed little flooding in the northwest quadrant of the site for both the 1 in 50 year and 1 in 100 year rainfall events. The expected flood water surface elevation in that section of the site was 4.7 m for the 50 year event and 4.74 m for the 100 year event. The proposed site has an existing average elevation of 3 m which therefore concludes water depths of up to 1 .74 m can be expected during a 100 year event.

The majority of the flooding was noticed south of Marcus Garvey drive in the undeveloped lot, south of the proposed site. The flooding spreads parallel to the southern boundary of Marcus Garvey Drive to invade the JPS Hunts Bay property as well as the Petrojam property to the southeast. Some flooding is also evident west of the site on the Garmex property. Figure 14 and Figure 15 which illustrate these flood prone areas.

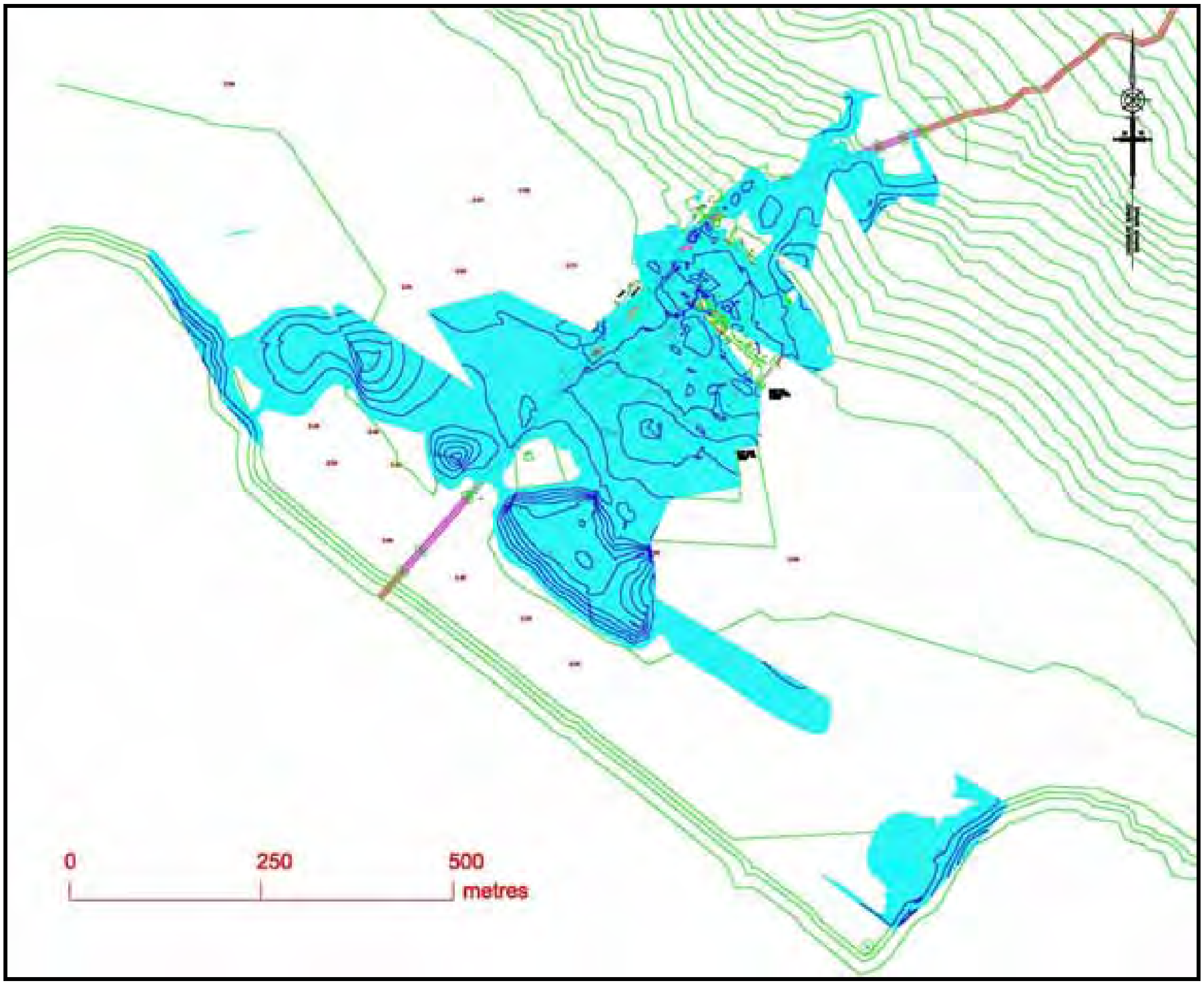

Figure 14 1 in 50 year rainfall event + 50 year storm surge

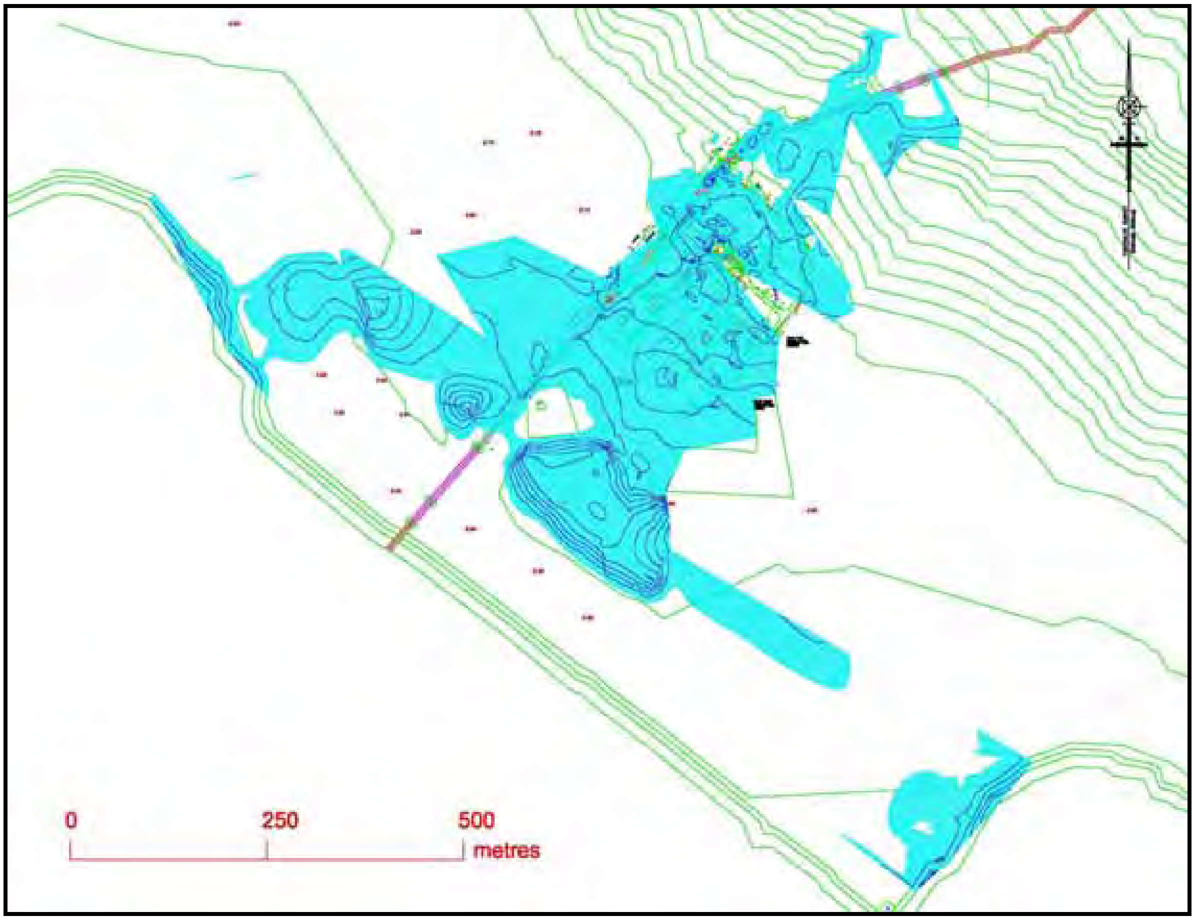

Figure 15 1 in 100 year rainfall event + storm surge

4.4.3.4 Existing Conditions Scenario

The results of the existing conditions scenario analysis showed flooding onsite with the possible flood area on site identical to the previous scenario where storm surge was presented as a factor. Flood water surface elevations on site were 4.54 m and 4.63 m for the 10 year and 25 year events respectively with the 100 year event being 4.74 m. These elevations equate to water depths above the existing ground of 1.54 m and 1.63 m for the 10 year and 25 year events. This proves that the storm surge has no real influence on the flooding of the site.

The Flooding south of Marcus Garvey drive is still very prominent as well as some flooding noticed west of the site. Figure 16, Figure 17, Figure 18 and Figure 19 which illustrate the flood prone areas predicted for the 10 year, 25 year, 50 year and 100 year.

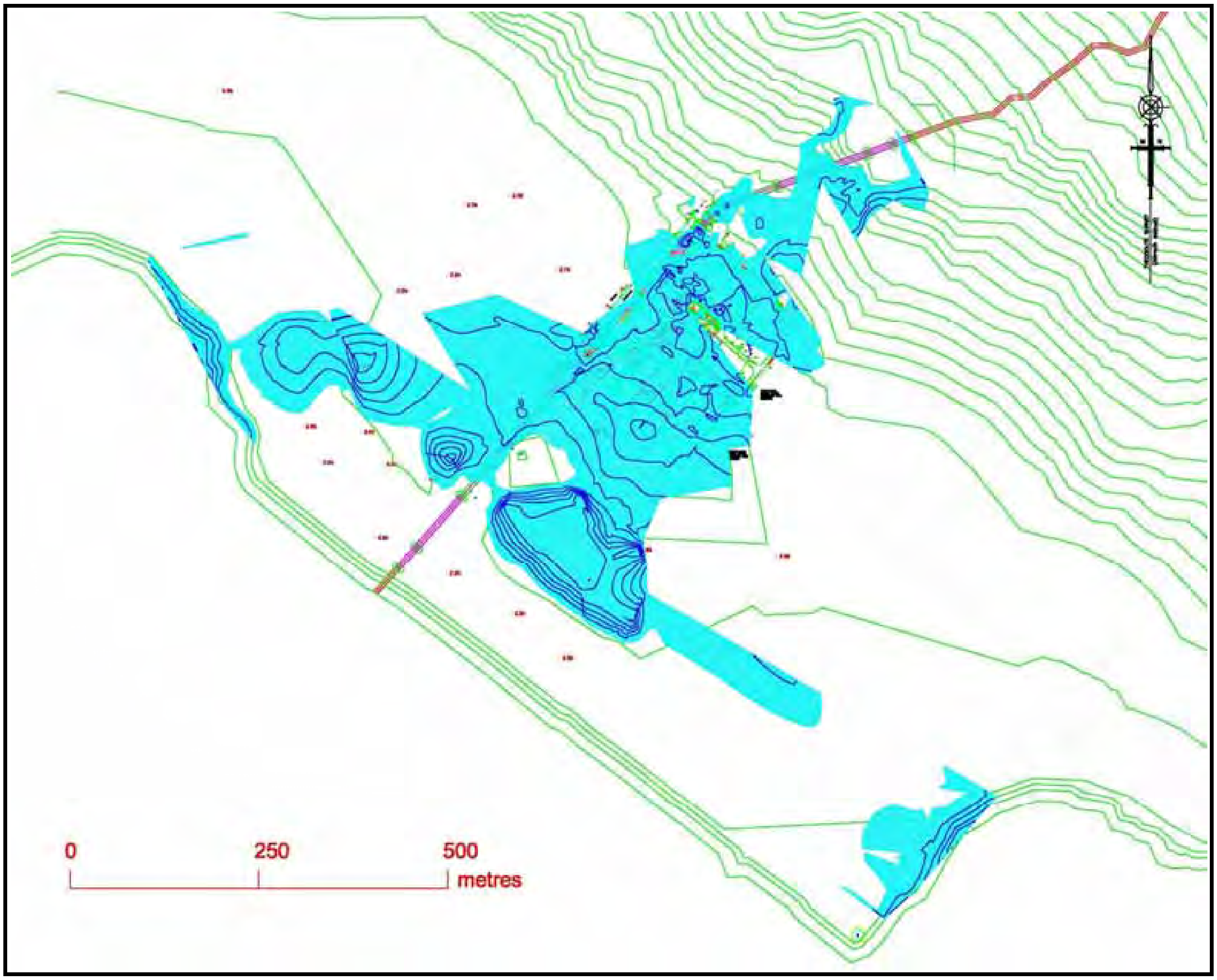

Figure 16 1 in 10 year rainfall event (existing conditions)

Figure 17 1 in 25 year rainfall event (existing conditions)

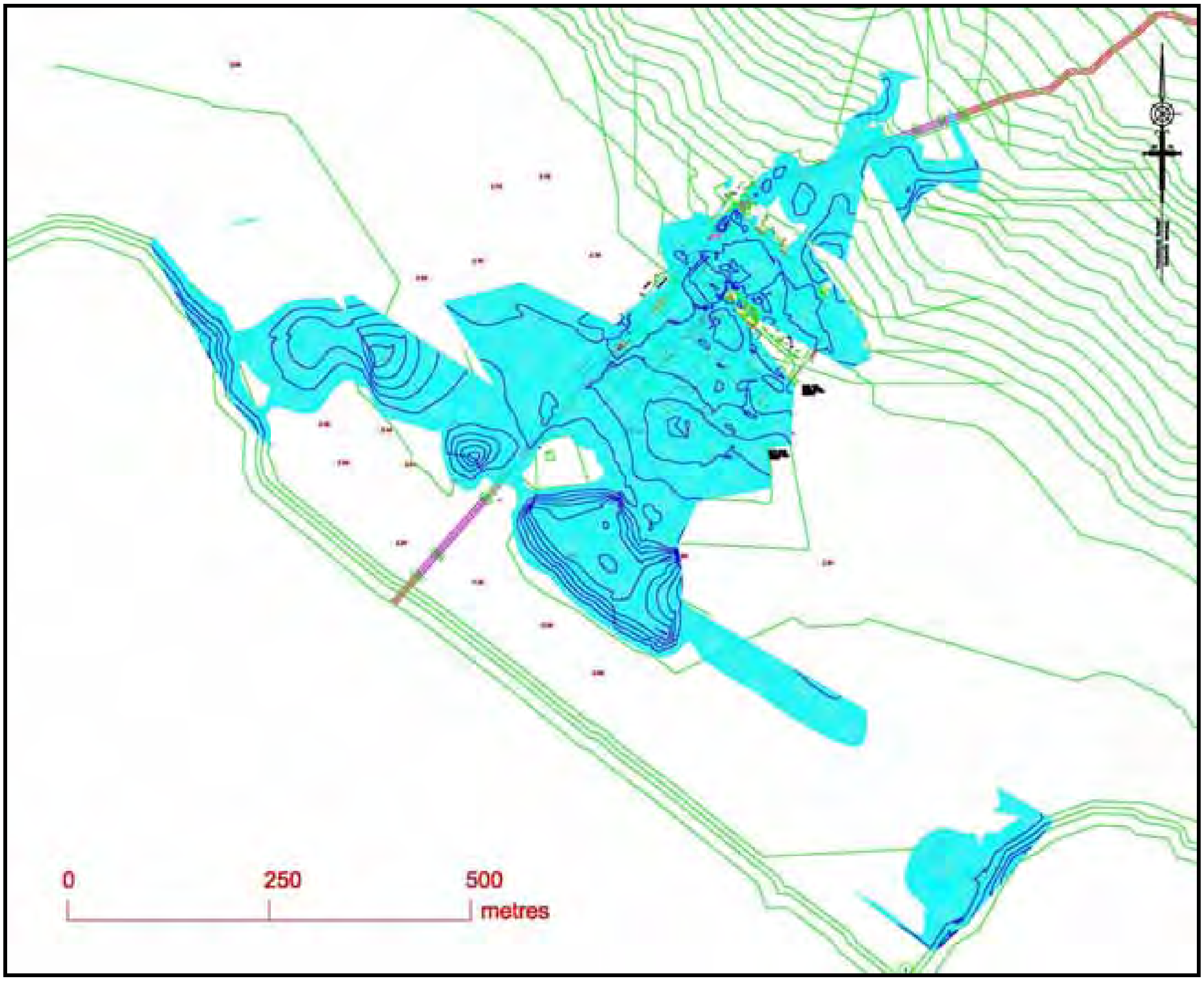

Figure 18 1 in 50 year rainfall event (existing conditions)

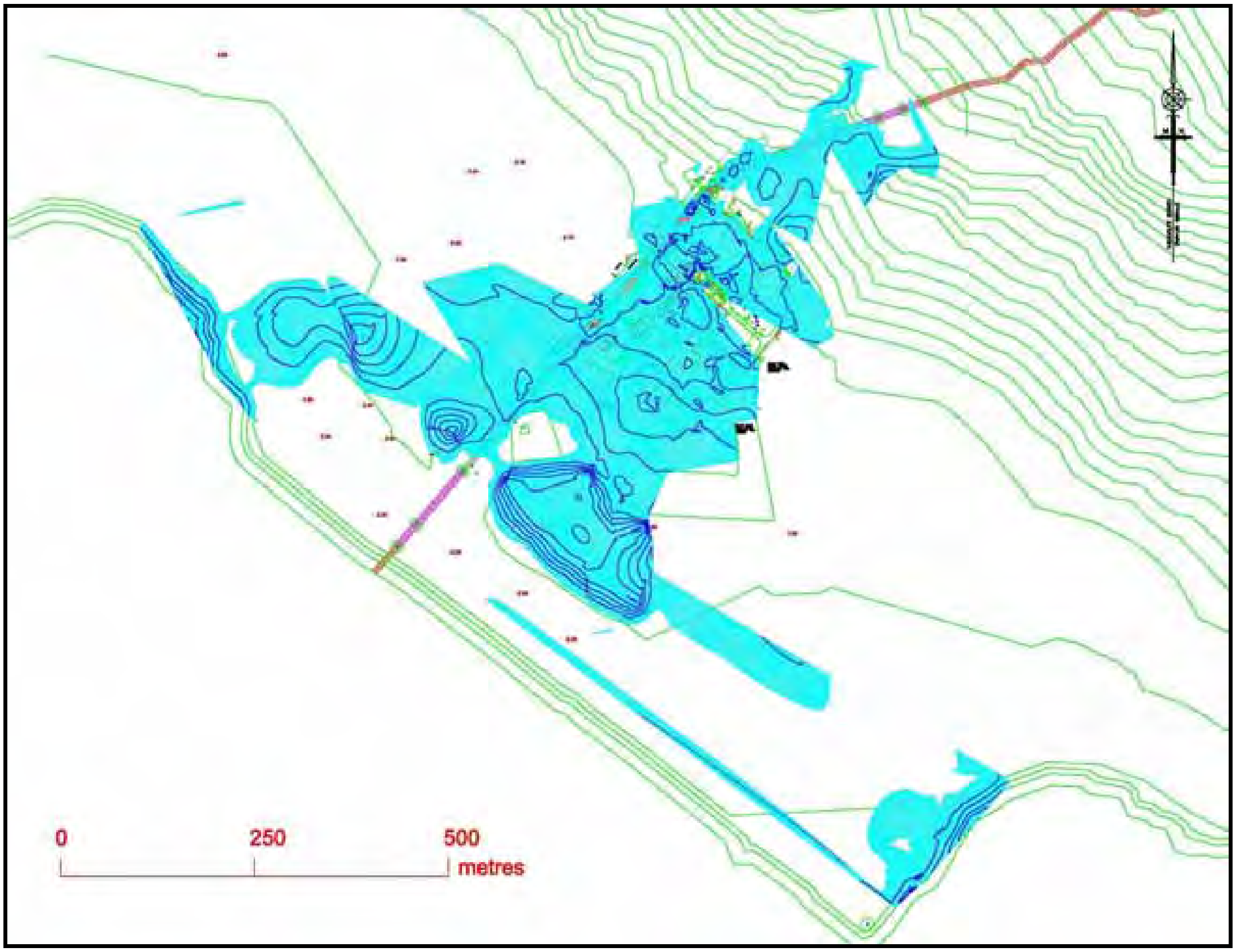

Figure 19 1 in 100 year rainfall event (existing conditions)

4.4.3.5 Blocked Culvert Scenario

It was important to try to simulate a scenario where the concrete box culvert under Marcus Garvey Drive was blocked. This is a common occurrence in open drains and so must be taken into account. Blocking of the culvert entrance could lead to backing up of the water in the drain which could cause flooding to the site. The culvert is 6.4 m wide and 1.2 m deep.

Results showed that the site is still only prone to flooding in the western quadrant with an area of approximately 400 square meters and a flood water surface elevation of 4.74 m for the 100 year event. Flooding is still significant south of Marcus Garvey Drive which can be explained by the water overflowing the western bank of the drain (which is lower than the right bank) and being conducted across the intersection of Industrial Terrace and Marcus Garvey Drive. Figure 20 shows the flood prone areas for this scenario.

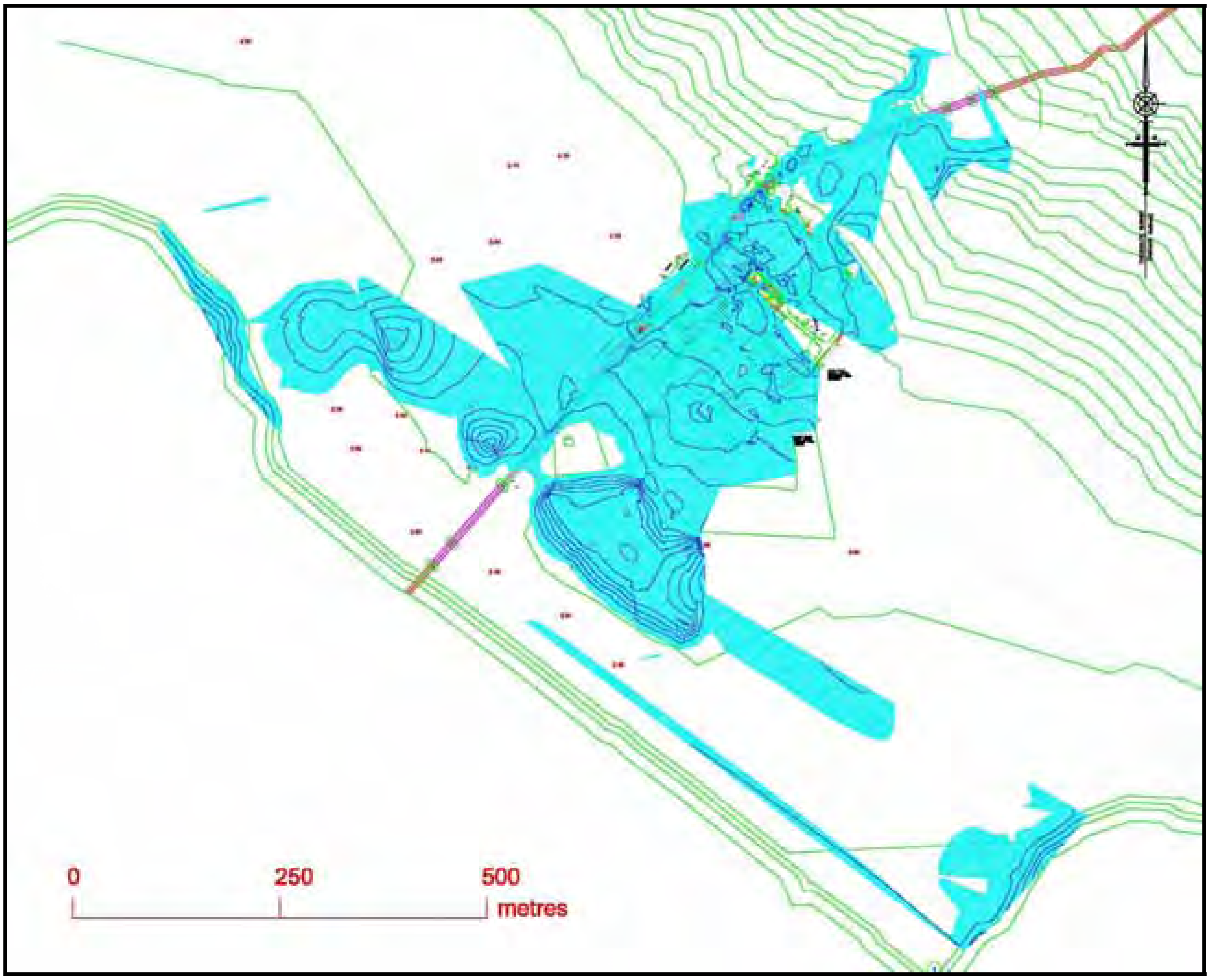

Figure 20 1 in 100 year rainfall event (Blocked Culvert)

4.4.4 Earthquakes

Earthquake hazard zones for Jamaica were determined over the period from 1692 to the present. This zoning shows that the Kingston area lies within the zone of highest probability of high intensity earthquakes in Jamaica. Data from the Earthquake Unit at the University of the West Indies indicate that for Modified Mercalli Intensities (MMI), the Kingston area has an average exposure rate of >20 occurrences per century (Figure 21). MMI is the threshold for damage to ordinary but well-built structures.

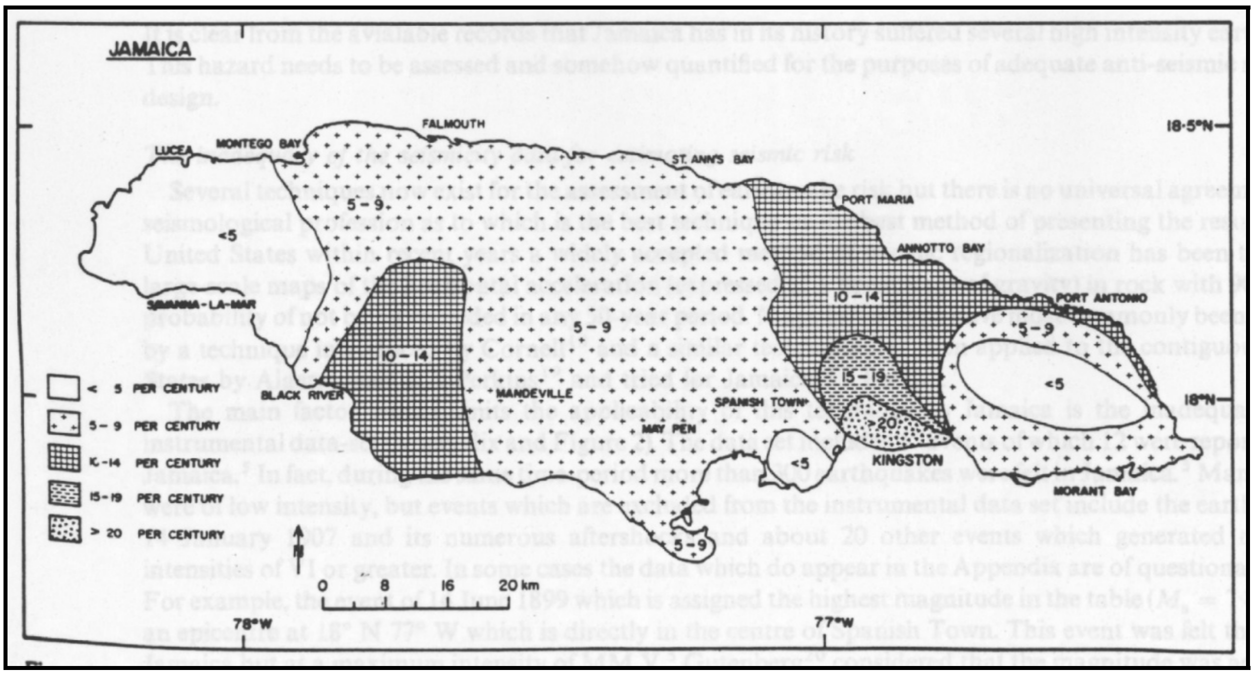

Figure 21 Map showing number of times per century that intensities of MM VI or greater have been reported, 1880-1960 (from Shepherd & Aspinall, 1980)

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 best by thicknesses up to about 100 m (Aspinall & Shepherd, 1978). Alluvium and engineered soils that exist at the project site are highly susceptible to ground shaking and tend to amplify the effects of ground motion through earthquakes.

Horizontal ground acceleration, expected Modified Mercalli Intensity and Horizontal ground velocity with a 10% probability of exceedance are indicated in Figure 22, Figure 23 and Figure 24 (CDMP). For the area of interest these are 145 gals to a little over 170 gals; less than MMI 7; around 9 to 11 cm/s respectively.

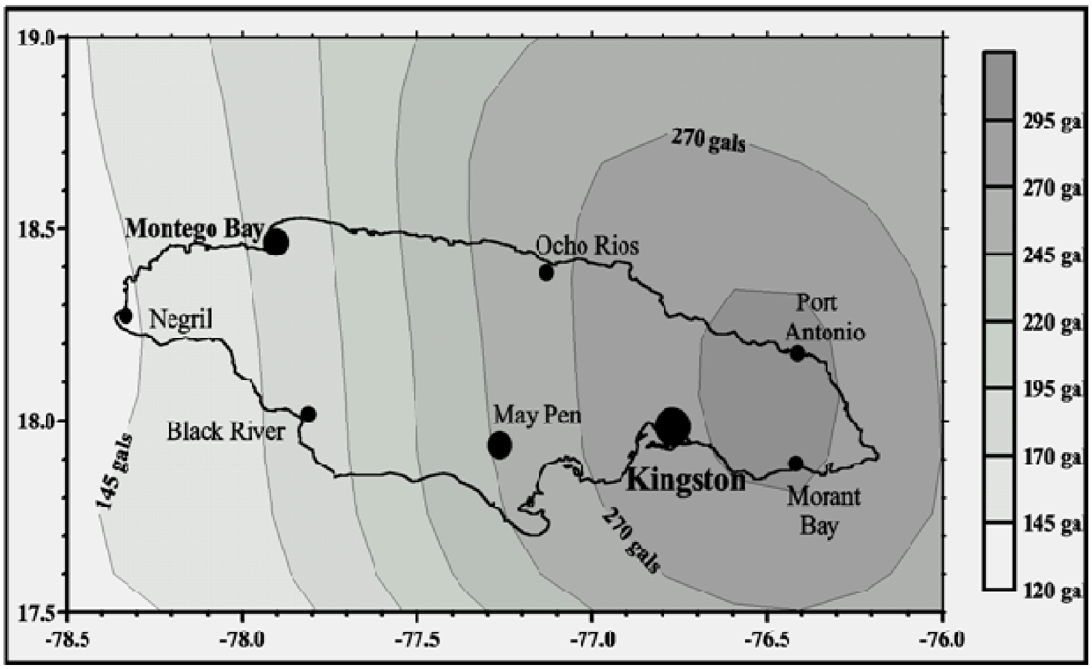

Figure 22 Horizontal ground acceleration (gals) with 10% probability of exceedance in any 50-year period. Contour interval 25 gals

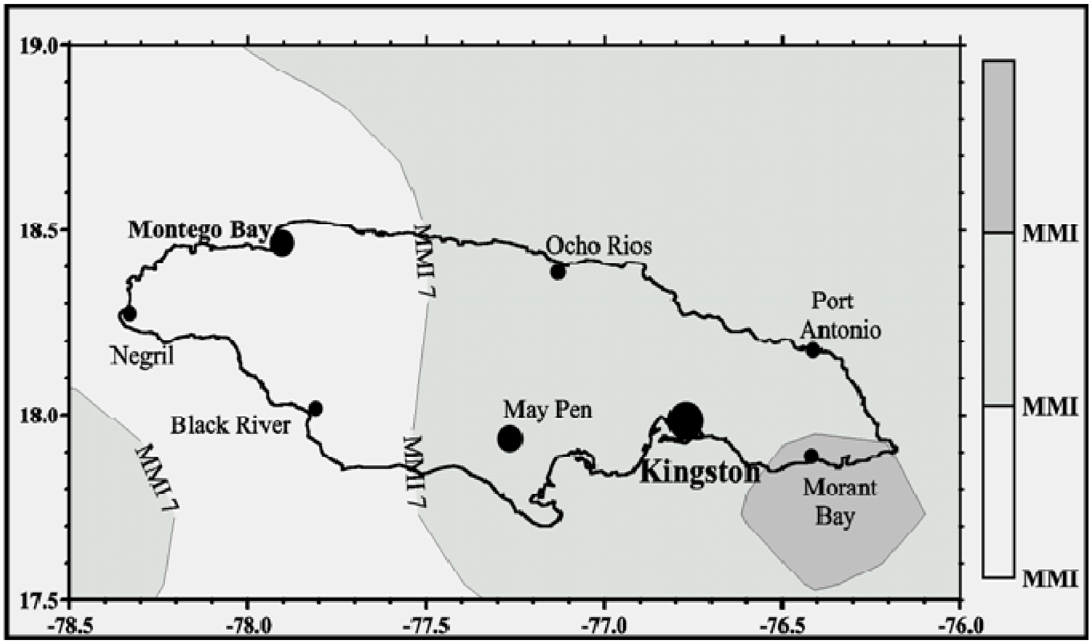

Figure 23 Expected maximum Mercalli Intensity with a 10% probability of exceedance in any 50-year period

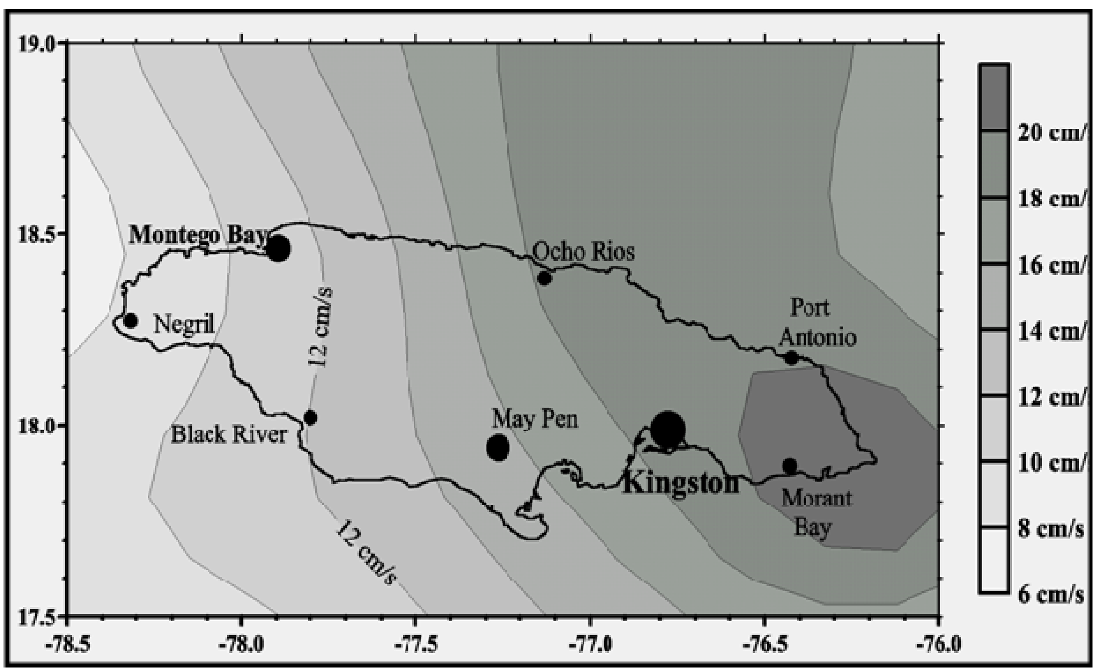

Figure 24 Horizontal ground velocity (cm/s) with a 10% probability of exceedance in any 50-year period. Contour interval is 2 cm/sec. Ref. http://www.oas.org/CDMP/document/seismap/jamaica

4.4.5 Liquefaction

Liquefaction due to seismic events is the other main possibility for consideration resulting from the nature of the geology of the deposits. Liquefaction could result in foundation failure and subsidence and/or lateral spreading at the site. This likelihood has been addressed in the Jentech Report (2009).

4.4.6 Hurricanes

Hurricanes produce heavy rainfall, high winds, and storm surge, all of which have the potential to cause damage and dislocation at the proposed location. The high velocity winds can cause structural damage. Jamaica lies within the Caribbean hurricane belt and has been directly affected by numerous hurricanes. Hurricanes and tropical storms are frequently accompanied by heavy rainfall. It has also been widely suggested that the Atlantic-Caribbean region is moving, and has already started to move, into a cycle of wetter and more severe tropical disturbances (IPCC, 2001).

During the hurricane season (June to November) these low-pressure systems form in the mid-Atlantic off the African west coast between latitudes 5 to 25 N, and move northwesterly into the Caribbean basin. Detailed storm data are available from the US National Hurricane Center archives for the last 20 years 1987 to 2007. The analysis was conducted on storms passing within 200 km of Jamaica. During that period 8 hurricanes, 3 tropical depression, 6 tropical storms and 1 tropical wave (Table 8 and Figure 25).

The experience of the last three major hurricanes that affected Jamaica, Gilbert in 1988, Ivan in 2004 and Hurricane Dean in 2006 suggests that the Palisadoes peninsula reduces the build-up of storm surge within the Kingston Harbour. This minimizes the potential threat to the coastline in the north and northeast sections of the harbour where the proposed site is located.

Table 8 Names and categories of storms that passed within 200 km of Jamaica 1987 - 2007

Name	*Year*	*Category*	*Maximum Wind Speed (Knots)*
ARTHUR	1990	Tropical Depression	30
BONNIE	2004	Tropical Wave	25
CHARLEY	2004	Hurricane	65
DEAN	2007	Hurricane	125
DEBBY	2000	Tropical Storm	35
DENNIS	2005	Hurricane	120
EMILY	2005	Hurricane	140
ERNESTO	2006	Tropical Storm	45
GILBERT	1988	Hurricane	115
GORDON	1994	Tropical Storm	40
HELENE	2000	Tropical Depression	30
IRIS	2001	Hurricane	75
ISIDORE	2002	Tropical Storm	45
IVAN	2004	Hurricane	145
LILI	2002	Hurricane	65
MARCO	1996	Tropical Depression	30
OLGA	2007	Tropical Storm	35
WILMA	2005	Tropical Storm	35

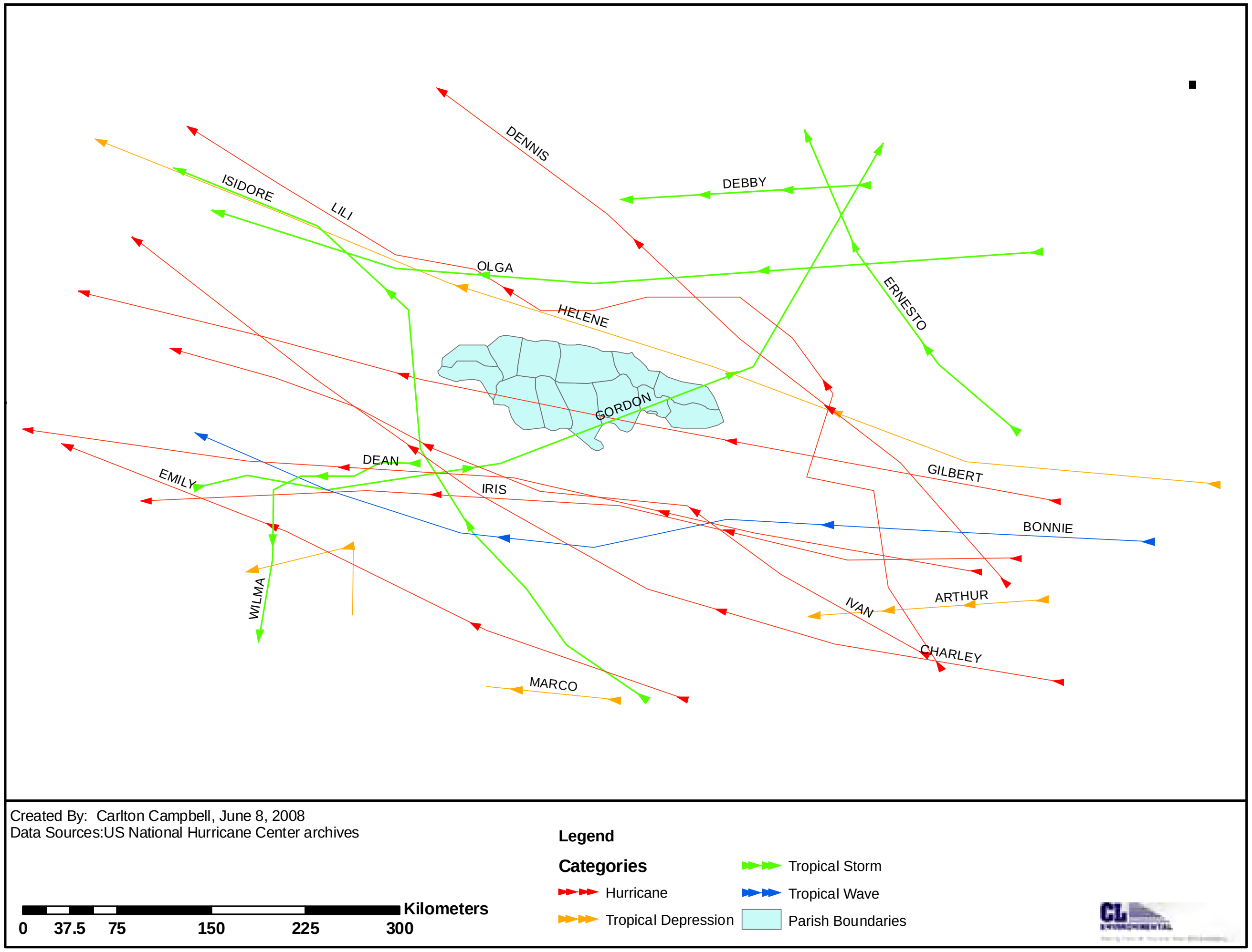

Figure 25 Storms that have passed within 200km of Jamaica within the last 20 years (1987 – 2007)

4.4.7 Storm Surge

Interviews with residents in the area did not reveal much information regarding storm surge in the area. No resident could recall any flooding due to a storm surge in the area.

The impact of storm surge on the coast adjacent to the site from two recent severe hurricanes, Ivan 2004 and Dean 2007 conducted by the Mines and Geology Division did not identify storm surge associated damages occurring at this site.

It was necessary to define the 50 year and 100 year Storm surge levels to the south of the site to determine what effects it would have on the flood water levels in the drain and on the flood plain.

A previous study was done by the CEAC team for the Port Royal street shoreline approximately 2 km east of the site. Like the Port Royal street shoreline, the location of the site is peculiar in that it is inside Kingston Harbour and not directly exposed to offshore incident hurricane waves. Notwithstanding this, the storm surge (from wave breaking and wind set-up) and barometric pressure rise outside of the harbour is transmitted within the harbour. It was therefore important to estimate the outside deepwater wave climate in order to understand the extreme water levels within the harbour.

4.4.7.1 Methodology

It was necessary to define the deepwater hurricane wave climate at a point offshore Kingston Harbour (Figure 26). The location of the point is:

- Latitude: 17.83 North
- Longitude: 76.78 West

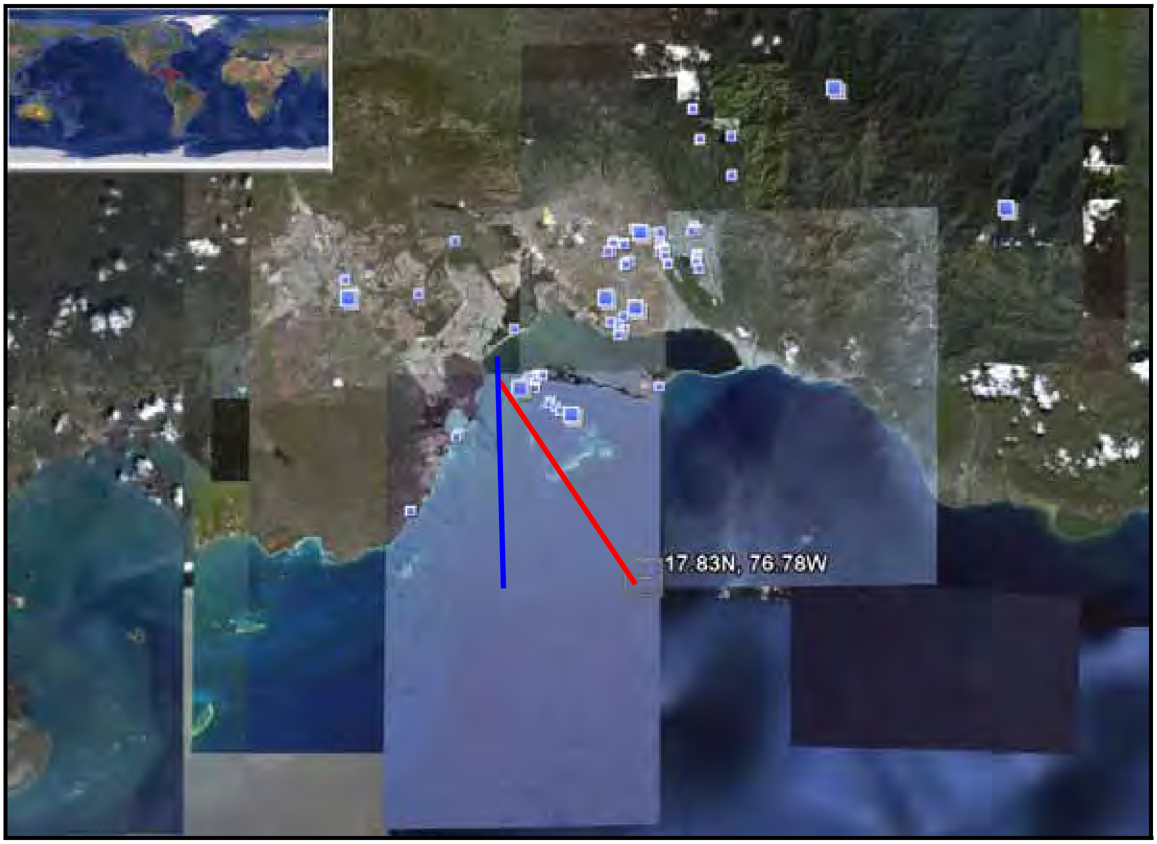

Figure 26 Location of offshore point used for Extremal analysis, showing southern and south-eastern track used in the analysis

The National Hurricane Center (NOAA) database of hurricane track data in the Caribbean Sea was utilized to carry out a hindcast, wave breaking (along two tracks) followed by a statistical analysis to determine the hurricane: waves, wind and set-up conditions

The database of hurricanes, dating back to 1886, was searched for storms that passed within a 500km radius from the site. 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 search radius of 300km 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 exceedence probability by Weibull's distribution.
4. A bathymetric profile from deepwater 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.

4.4.7.2 Occurrences and Directions

The results of the search from the database for hurricanes that came within the search radius of the site are shown in Table 9. Extremal analysis results are summarized in the bi-variant Table 10. The results of the search clearly indicate the sites overall vulnerability to such systems. In summary:

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

The bi-variant table analysis indicates that the waves generated offshore the site have approached from all seaward possible. However, the most frequent hurricane waves have been noted to come from a south-easterly direction. In summary, there are:

- 30 (x6 hours) occurrences from the east
- 58 (x6 hours) occurrence from the south-east
- 50 (x6 hours) occurrence from the south

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

Table 9 Name of storms that passed within 300 km of Kingston Harbour since 1886

	Storm No.	Name	Date	Max. SS Category			Storm No.	Name	Date	Max. SS Category			Storm No.	Name	Date	Max. SS Category	
1	10	NOTNAMED	1852	2-	MODERATE	31	426	NOTNAMED	1910	1-	WEAK	61	910	FRANCELIA	1969	3-	EXTENSIVE
2	38	NOTNAMED	1857	2-	MODERATE	32	446	NOTNAMED	1915	4-	EXTREME	62	966	CARMEN	1974	4-	EXTREME
3	50	NOTNAMED	1859	3-	EXTENSIVE	33	448	NOTNAMED	1915	2-	MODERATE	63	969	FIFI	1974	2-	MODERATE
4	83	NOTNAMED	1864	1-	WEAK	34	449	NOTNAMED	1915	4-	EXTREME	64	1095	GILBERT	1988	5-	CATASTROPHIC
5	94	NOTNAMED	1866	3-	EXTENSIVE	35	453	NOTNAMED	1916	3-	EXTENSIVE	65	1111	ARTHUR	1990	1-	WEAK
6	127	NOTNAMED	1870	2-	MODERATE	36	455	NOTNAMED	1916	3-	EXTENSIVE	66	1186	MARCO	1996	1-	WEAK
7	157	NOTNAMED	1874	2-	MODERATE	37	462	NOTNAMED	1916	3-	EXTENSIVE	67	1220	LENNY	1999	4-	EXTREME
8	188	NOTNAMED	1878	1-	WEAK	38	466	NOTNAMED	1917	3-	EXTENSIVE	68	1228	HELENE	2000	1-	WEAK
9	194	NOTNAMED	1879	1-	WEAK	39	467	NOTNAMED	1918	2-	MODERATE	69	1244	IRIS	2001	4-	EXTREME
10	198	NOTNAMED	1880	4-	EXTREME	40	503	NOTNAMED	1924	2-	MODERATE	70	1259	ISIDORE	2002	3-	EXTENSIVE
11	199	NOTNAMED	1880	1-	WEAK	41	526	NOTNAMED	1928	1-	WEAK	71	1262	LILI	2002	4-	EXTREME
12	227	NOTNAMED	1884	2-	MODERATE	42	537	NOTNAMED	1931	1-	WEAK	72	1326	IVAN	2004	5-	CATASTROPHIC
13	240	NOTNAMED	1886	2-	MODERATE	43	539	NOTNAMED	1931	3-	EXTENSIVE	73	1336	DENNIS	2005	4-	EXTREME
14	241	NOTNAMED	1886	2-	MODERATE	44	550	NOTNAMED	1932	3-	EXTENSIVE	74	1337	EMILY	2005	5-	CATASTROPHIC
15	242	NOTNAMED	1886	3-	EXTENSIVE	45	560	NOTNAMED	1933	1-	WEAK	75	1366	ERNESTO	2006	1-	WEAK
16	252	NOTNAMED	1887	2-	MODERATE	46	569	NOTNAMED	1933	2-	MODERATE	76	1374	DEAN	2007	5-	CATASTROPHIC
17	277	NOTNAMED	1889	2-	MODERATE	47	573	NOTNAMED	1933	2-	MODERATE	77	1401	GUSTAV	2008	4-	EXTREME
18	321	NOTNAMED	1895	2-	MODERATE	48	591	NOTNAMED	1935	1-	WEAK						
19	324	NOTNAMED	1895	3-	EXTENSIVE	49	619	NOTNAMED	1938	2-	MODERATE						
20	329	NOTNAMED	1896	3-	EXTENSIVE	50	620	NOTNAMED	1938	2-	MODERATE						
21	344	NOTNAMED	1898	1-	WEAK	51	646	NOTNAMED	1942	3-	EXTENSIVE						
22	345	NOTNAMED	1898	1-	WEAK	52	648	NOTNAMED	1942	1-	WEAK						
23	375	NOTNAMED	1903	3-	EXTENSIVE	53	666	NOTNAMED	1944	1-	WEAK						
24	391	NOTNAMED	1905	2-	MODERATE	54	668	NOTNAMED	1944	3-	EXTENSIVE						
25	400	NOTNAMED	1906	4-	EXTREME	55	739	CHARLIE	1951	4-	EXTREME						
26	418	NOTNAMED	1909	4-	EXTREME	56	740	DOG	1951	3-	EXTENSIVE						
27	419	NOTNAMED	1909	1-	WEAK	57	761	FLORENCE	1953	3-	EXTENSIVE						
28	422	NOTNAMED	1909	4-	EXTREME	58	776	HAZEL	1954	4-	EXTREME						
29	424	NOTNAMED	1909	3-	EXTENSIVE	59	788	JANET	1955	5-	CATASTROPHIC						
30	425	NOTNAMED	1909	1-	WEAK	60	890	BEULAH	1967	5-	CATASTROPHIC						

Table 10 Bivariant table of Extremal wave climate for Kingston Harbour Shelf

Wind direction- NW

Tp(s)	Wave height(m)										Total
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6											
8											
10											
12											
14											
16											
18											
20											
Total											

Wind direction- N

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6											
8											
10											
12											
14											
16											
18											
20											
Total											

Wind direction- NE

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6											
8											
10											
12											
14											
16											
18											
20											
Total											

Wind direction- W

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6		1									1
8		4									4
10											
12											
14											
16											
18											
20											
Total		5									5

All directions

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6		23									23
8		99	33								132
10			33	11							44
12				4							4
14											
16											
18											
20											
Total		122	66	15							203

Wind direction- E

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6		1									1
8		11	5								16
10			9	3							12
12				1							1
14											
16											
18											
20											
Total		12	14	4							30

Wind direction- SW

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6		9									9
8		39	8								47
10			4								4
12											
14											
16											
18											
20											
Total		48	12								60

Wind direction- S

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6		8									8
8		28	2								30
10			10	2							12
12											
14											
16											
18											
20											
Total		36	12	2							50

Wind direction- SE

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6		4									4
8		17	18								35
10			10	6							16
12				3							3
14											
16											
18											
20											
Total		21	28	9							58

4.4.7.3 Deepwater Wave Heights

As seen in Table 11 and Table 12, the Extremal analysis results indicate that the 100-year return period event has a deepwater wave height of:

- 6.2 m for southerly waves
- 7.7 m for south-easterly waves
- 9.0 m for easterly waves.

Overall, these are relatively large waves and their potential resulting nearshore climates were investigated.

Table 11 Extremal analysis wave height (Hs) and direction of Kingston Harbor's shelf

Return Periods	Wave height (m)								
	All	SW	W	NW	N	NE	E	SE	S
1	2.5	1.5					1.5	1.5	1.5
2	3.7	3.4					4.6	4.4	3.5
5	4.9	4.0					5.8	5.5	4.5
10	5.8	4.2					6.5	6.2	5.0
20	6.6	4.5					7.0	6.7	5.4
25	6.8	4.5					7.2	6.8	5.5
50	7.6	4.7					7.7	7.3	5.9
75	8.0	4.8					7.9	7.5	6.0
100	8.4	4.9					8.1	7.7	6.2
150	8.8	4.9					8.3	7.9	6.3
200	9.1	5.0					8.5	8.0	6.5

Table 12 Extremal analysis wave period (Tp) and direction of Kingston Harbour's shelf

Return Periods	Wave Period (s)								
	All	SW	W	NW	N	NE	E	SE	S
1	8.0	6.2					6.2	6.2	6.2
2	9.6	9.3					10.7	10.5	9.5
5	11.1	10.0					12.0	11.7	10.6
10	12.0	10.3					12.7	12.4	11.1
20	12.7	10.6					13.2	12.8	11.6
25	13.0	10.6					13.3	13.0	11.7
50	13.7	10.8					13.7	13.4	12.0
75	14.0	10.9					13.9	13.6	12.2
100	14.3	11.0					14.1	13.7	12.4
150	14.7	11.1					14.3	13.9	12.5
200	14.9	11.2					14.4	14.0	12.6

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

- Wave breaking and shoaling
- Wind set-up
- Refraction
- Tides
- Global Sea Level Rise (over a 20 year project life)
- Inverse Barometric Pressure Rise

The south-eastern profile is as shown in Table 13. The results for the south-easterly profile were focused on in this analysis as it was most extreme. The profile terminates at the western end of the Harbour. The results indicate that the expected 50 year and 100 Year storm surges are 1.93 and 2.20 metres respectively.

Table 13 Extremal Storm surge predictions for the site along the south eastern profile

Return Period	Total setup (m)								
	All	SW	W	NW	N	NE	E	SE	S
1							0.05	0.05	
2	0.19	0.09					0.34	0.49	0.19
5	0.49	0.16					0.64	0.94	0.37
10	0.75	0.22					0.85	1.26	0.51
20	1.03	0.28					1.05	1.55	0.65
25	1.12	0.29					1.11	1.65	0.69
50	1.43	0.36					1.31	1.93	0.83
75	1.61	0.39					1.42	2.09	0.91
100	1.74	0.42					1.49	2.20	0.96
150	1.94	0.45					1.60	2.36	1.04
200	2.08	0.48					1.68	2.47	1.10

The proposed site is very close to the Kingston Harbour shoreline (approximately 550 m) and is therefore prone to flooding due to storm surge during a major rainfall event. It was therefore important to investigate the possibility of flooding due to storm surge.

4.4.7.4 Comparison to US AID OAS Predictions

The storm surge analysis of Port Royal Street (2km east of the site) conducted by the CEAC team in a previous project revealed that the1 in 50 year and the 1 in 100 year event is expected to generate a static water surface elevations of 1.93 m and 2.20 m respectively. These predictions are however far lower than the OAS/Taos predictions from 1999.

The 100 year return period storm surge predicted by the OAS/Taos is 6.941 metres for the 90 percent confidence interval which is significantly higher than the 2.2 metres predicted from the storm surge model used by the CEAC team. Table 14 shows the OAS/Taos storm surge predictions for the Kingston harbour and Figure 27 shows storm surge inundation lines for the CEAC predicted 50 year and 100 year water surface elevations as well as the OAS/Toas prediction.

Table 14 Set-up predictions (m) from USAID-OAS Caribbean Disaster Mitigation Project April 1999 TAOS Model

	MLE	50%	75%	90%	95%	99%
10 year	2.737	2.758	2.958	3.122	3.193	3.397
25 year	3.848	3.897	4.193	4.519	4.791	5.505
50 year	4.693	4.714	5.157	5.636	5.932	7.112
100 year	5.539	5.586	6.136	6.941	7.542	8.777

Figure 27 Inundation map showing water surface elevations for the CEAC predicted 50 year and 100 year storm surges as well as the US AID OAS 100 year prediction

4.4.8 Tsunami Events

Tsunami events are rare events resulting from seismic disturbances that produce waves capable of extensive inundation of low-lying coastal areas. Two such events are known from the Kingston Harbour region, those of 1692 and 1907 earthquakes. There is virtually no information on the inundation heights reached during those events.

Reports on inundation distances for the 1907 earthquake from the resulting tsunami at Annotto Bay and Port Maria (north coast of Jamaica) suggested heights there in excess of 10km. However, the severity of tsunami inundation is closely related to bathymetry and shoreline features. In Kingston

Harbour, tsunami activity from an intense local event is likely to be in the form of a seich, producing oscillatory waves that might extend over several hours.

4.4.9 Sea-Level Rise

The degree of future sea-level rise resulting from climate change has been widely debated. The original figures provided by the IPCC (2007) of about 80cm by 2050 have been challenged by subsequent scientists (ANANTHASWAMY, 2009) as being too conservative. Recent estimates suggest that a rise of 80 cm is likely by 2050 (ANANTHASWAMY, 2009; MGU, 2007). The normal design life of a power station is about 20-25 years (although several Jamaican stations have been in service for much longer).

The main effect of sea-level rise will be to reduce the return periods of storm surge from hurricanes by as much as 50 to 80 percent. This could result in storm surge inundation at the site by 2050 or later, but confirmatory evidence is not available.

4.5 Water Quality

4.5.1 Methodology

Table 15 gives the name and description of each water quality station, as well as the type of water. Figure 28 depicts the locations of the water quality sampling stations. Sampling was conducted on August 3, 2009 between the hours of 8:00am and 12:30pm. At each location, samples were collected in pre-cleaned plastic and glass bottles, stored on ice and sent to three different laboratories, whereby each laboratory was required to test for a different set of parameters. The laboratories used were Scientific Research Council, Environment Technical and Analytical Services Ltd., Mines and Geology Division of the Ministry of Mining and Telecommunications, and TestAmerica Laboratories Inc. in Miami, Florida, USA.

A second sampling event, which is representative of a rainy (wet) season (done following approximately 1 week of rainfall), was conducted on September 23, 2009 between the hours of 10:00am and 1:00pm. These samples were sent to the Scientific Research Council for analysis.

At each location, Temperature, salinity, conductivity, pH and Dissolved Oxygen were measured in situ using a Yellow Springs Instruments (YSI) model 556 multi probe meter.

Table 15 Description of water quality stations sampled

Location Name	Description	Type of Water
JEP1	Tivoli Depot – Garmex Freezone	Groundwater
JEP2	Tivoli Gully Mouth	Wastewater
JEP3	NWC piped water	Potable/Piped water
JEP4	Seprod #2	Groundwater
JEP5	Channel on site	Wastewater
JEP6	Pond on site	Wastewater
JEP7	Tivoli Gully (upper section)	Wastewater
JEP8	Tank located in building on site	Wastewater

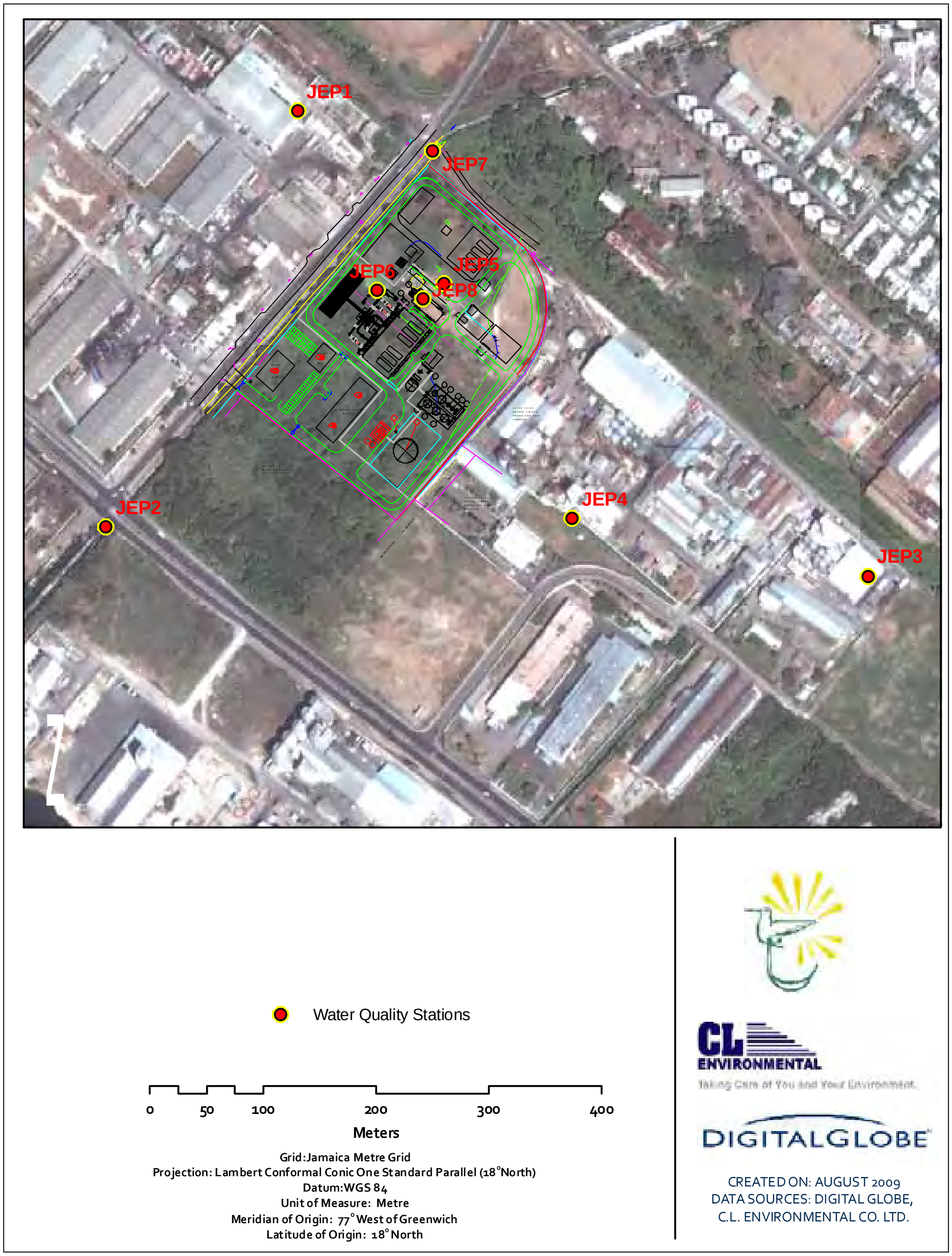

Figure 28 Water Quality Stations

4.5.2 Potable Water

The results from the potable water sample are detailed in Table 16, Table 17, Table 18 and Table 19 below.

Table 16 Results of potable water sampling

PARAMETERS	JEP3	WHO Drinking Water Stds.
Temperature (ºC)	35.1	
Conductivity (mS/cm)	0.682	
Salinity (ppt)	0.33	
Dissolved Oxygen (mg/l)	6.2	
pH	7.7	6-9

Table 17 Results of potable water sampling

Parameters	JEP3	WHO Drinking Water Stds.
Ammonia (mgN/l)	<0.02	
Barium (mg/l)		0.7
Beryllium (mg/l)		
Boron (mg/l)		0.5
Calcium (mg/l)	99.7	
Chloride (mg/l)	74.3	
Colour (Pt-co)	<15	
Detergent (mg/l)	0.72	
Fluoride (mg/l)	0.13	1.5
Iron (µg/l)	107	
Magnesium (mg/l)	15.5	
Manganese (µg/l)	<20	400
Nitrates (mg/l)	8.83	50
Oil and Grease (mg/l)	2	
Phenols (mg/l)		
Total Phosphate (mg/l)	<0.23	

Parameters	JEP3	WHO Drinking Water Stds.
Sodium (mg/l)	46.2	
Sulphate (mg/l)	57.6	
Total Dissolved Solids (mg/l)	425	
Total Organic Compounds (mg/l)	148	
Total Suspended Solids (mg/l)	<1	
Biochemical Oxygen Demand (mg/l)	<2	
Chemical Oxygen Demand (mg/l)	ND	
Faecal Coliform (MPN/100ml)	7.35	
Residual Chlorine (mg/l)	0.05	≥0.05
HEAVY METALS		
Arsenic (µg/l)	<10	10
Cadmium (µg/l)	<20	3
Chromium (µg/l)	<20	50
Copper (µg/l)	31	2000
Cyanide (mg/l)		0.07
Lead (µg/l)	<20	10
Mercury (µg/l)	<0.5	6
Nickel (µg/l)	<20	70
Selenium (µg/l)	**39**	10
Silver (mg/l)		
Tin (mg/l)		
Zinc (mg/l)	74	

Table 18 Results of potable water sampling (Wet Season)

PARAMETERS	JEP3	WHO Drinking Water Stds.
Temperature (°C)	31.42	
Conductivity (mS/cm)	0.579	
Salinity (ppt)	0.28	
Dissolved Oxygen (mg/l)	7.76	
pH	7.67	6-9

Table 19 Results of potable water sampling (Wet Season)

Parameters	JEP3	WHO Drinking Water Stds.
Biochemical Oxygen Demand (mg/l)	<2	
Chemical Oxygen Demand (mg/l)	ND	
Faecal Coliform (MPN/100ml)	<1.1	
Residual Chlorine (mg/l)	0.02	≥0.05
Sulphate (mg/l)	39	
Nitrates (mg/l)	8.8	
Total Nitrogen)mg/l)	ND	
Orthophosphates (mg/l)	0.05	
Total Suspended Solids (mg/l)	ND	
Oil and Grease (mg/l)	5.75	

***ND – None Detected (Below detection limits). Numbers highlighted in red are non compliant with the standards.**

4.5.3 Surface Water

The results of the analyses are provided in Table 20, Table 21, Table 22 and Table 23 below. Dissolved oxygen readings for locations JEP5 and JEP6 were both below 4mg/l and were therefore non compliant with NEPA trade effluent standards. For the second sampling event (wet season), all locations except JEP7 had dissolved oxygen readings below 4mg/l, thus non compliant with NEPA standards. All locations had pH values within the desired range for both NEPA and World Bank standards. Temperature, conductivity and salinity values are deemed normal for all locations.

Ammonia (JEP 2, JEP 5 and JEP 6), Detergent (JEP 2), Oil & Grease (JEP 5, JEP 6 and JEP 7), Total Phosphates (JEP 2, JEP 5, JEP 6 and JEP 7), Total Organic Compounds (JEP 2, JEP 5, JEP 6 and JEP 7), Total Suspended Solids (JEP 5), Biochemical Oxygen Supply (JEP 5), Chemical Oxygen Demand (JEP 5, JEP 6 and JEP 7), Faecal Coliform (JEP 2, JEP 5, JEP 6 and JEP 7) and Zinc (JEP 2, JEP 5, JEP 6 and JEP 7) were all non compliant with the standards. For the second sampling event (wet season), Biochemical Oxygen Demand (JEP5), Chemical Oxygen Demand (JEP2, JEP5, JEP6, and JEP7), Faecal Coliform (JEP2. JEP5, JEP6, JEP7 and JEP8), Orthophosphates (JEP5, JEP6, and JEP7), Total Suspended Solids (JEP5) and Oil & Grease (JEP5 and JEP7) were all non compliant with the standards.

Table 20 Results of surface wastewater sampling at four locations

PARAMETERS	JEP2	JEP5	JEP6	JEP7	NEPA Trade Effluent Stds.	World Bank Stds.
Temperature (ºC)	27.92	32.01	30.58	32.21		
Conductivity (mS/cm)	0.83	0.79	0.77	0.85		
Salinity (ppt)	0.4	0.38	0.37	0.41		
Dissolved Oxygen (mg/l)	4.4	2	2.2	4.6	4	
pH	7.8	7.4	7.53	7.6	6.5-8.5	6-9

Table 21 Summary of biological and chemical data concerning the surface wastewater (JEP2, JEP5, JEP6, JEP7, JEP8) in and around the site

Parameters	JEP2	JEP5	JEP6	JEP7	JEP8	World Bank Stds.	NEPA Trade Effluent Stds.
Ammonia (mgN/l)	**1.49**	**1.11**	**1.18**	0.97			1
Barium (mg/l)	0.13		0.11	0.14	0.13		5
Beryllium (mg/l)	ND		ND	ND	ND		0.5
Boron (mg/l)	ND		ND	ND	ND		5
Calcium (mg/l)	64.4	85.2	82	96.2			none
Chloride (mg/l)	52.3	41.5	43.7	48.8			300
Colour (Pt-co)	<15	37	32	36			100
Detergent (mg/l)	10.05	9.35	8.15	8			15
Fluoride (mg/l)	0.32	<0.02	<0.02	0.16			3
Iron (µg/l)	173	667	134	103		1000	3000
Magnesium (mg/l)	20.1	15.6	14.1	20.5			none
Manganese (µg/l)	121	31	43	39			1000
Nitrates (mg/l)	1.5	1.38	3.03	2.56			10
Oil and Grease (mg/l)	5.75	**13.67**	**15**	**14**		10	10
Phenols (mg/l)	0.0072		0.019	0.017	ND		0.1
Total Phosphate (mg/l)	**5.7**	**10**	**8.6**	**7.1**			5
Sodium (mg/l)	77	62.3	61	78.7			100
Sulphate (mg/l)	110	108	66.6	123			250
Total Dissolved Solids (mg/l)	413	427	532	455			1000
Total Organic Compounds (mg/l)	**168**	**256**	**164**	**224**			100
Total Suspended Solids (mg/l)	8.33	**160**	28	**77**		50	150
Biochemical Oxygen Demand (mg/l)	19.3	**119**	<2	<2			<30
Chemical Oxygen Demand (mg/l)	33	**352**	**172**	**168**			<100

Parameters	JEP2	JEP5	JEP6	JEP7	JEP8	World Bank Stds.	NEPA Trade Effluent Stds.
Faecal Coliform (MPN/100ml)	**>1600**	**>1600**	**>1600**	**>1600**			100
Residual Chlorine (mg/l)	0.06	<0.02	<0.02	<0.02		0.2	
Petroleum Range Organics (mg/l)							
C8-C40	ND		0.25	2.7	0.4		
C8-C10	ND		ND	ND	ND		
C10-C28	ND		0.14	2.8	0.26		
C28-C40	ND		0.1	0.32	0.17		
<u>HEAVY METALS</u>							
Arsenic (µg/l)	<10	<10	<10	<10		500	500
Cadmium (µg/l)	<20	<20	<20	<20		100	100
Chromium (µg/l)	<20	<20	<20	<20		500	1000
Copper (µg/l)	<10	<10	<10	<10		500	100
Cyanide (mg/l)	ND		ND	ND	ND		0.2
Lead (µg/l)	<20	<20	<20	<20		500	100
Mercury (µg/l)	<0.5	<0.5	<0.5	<0.5		5	20
Nickel (µg/l)	<20	<20	<20	<20			1000
Selenium (µg/l)	108	31	215	42			500
Silver (mg/l)	ND		ND	ND	ND		100
Tin (mg/l)	ND		ND	ND	ND		none
Zinc (mg/l)	**14**	**77**	**14**	**30**		1	1.5

***ND – None Detected (Below detection limits). Numbers highlighted in red are non compliant with the standards.**

Table 22 Results of surface wastewater sampling at four locations (Wet Season)

PARAMETERS	JEP2	JEP5	JEP6	JEP7	JEP8	NEPA Trade Effluent Stds.	World Bank Stds.
Temperature (°C)	32.57	30.42	29.67	30.61	27.59		
Conductivity (mS/cm)	0.76	0.704	0.752	0.439	0.871		
Salinity (ppt)	0.37	0.34	0.36	0.21	0.42		
Dissolved Oxygen (mg/l)	2.49	0.81	0.84	4.31	1.13	4	
pH	7.81	7.73	7.47	7.93	7.6	6.5-8.5	6-9

Table 23 Summary of biological and chemical data concerning the surface wastewater (JEP2, JEP5, JEP6, JEP7 and JEP8) in and around the site (Wet Season)

Parameters	JEP2	JEP5	JEP6	JEP7	JEP8	World Bank Stds.	NEPA Trade Effluent Stds.
Biochemical Oxygen Demand (mg/l)	**<2**	**135**	**<2**	**<2**	**3.07**		**<30**
Chemical Oxygen Demand (mg/l)	**174**	**321**	**122**	**291**	**2**		**<100**
Faecal Coliform (MPN/100ml)	**>1600**	**>1600**	**>1600**	**>1600**	**>1600**		**100**
Residual Chlorine (mg/l)	**<0.02**	**<0.02**	**<0.02**	**<0.02**	**0.03**	**0.2**	
Sulphate (mg/l)	**66**	**58**	**47**	**65**	**69**		**250**
Nitrates (mg/l)	**2.2**	**3.08**	**5.72**	**2.2**	**3.52**		**10**
Total Nitrogen (mg/l)	**11.1**	**24.5**	**17.9**	**20.4**	**5.2**		
Orthophosphates (mg/l)	**4.1**	**6.8**	**6.9**	**5.3**	**0.97**		**5**
Total Suspended Solids (mg/l)	**52**	**158**	**6**	**16**	**ND**	**50**	**150**
Oil and Grease (mg/l)	**7.27**	**18.67**	**9.11**	**15.33**	**1.89**	**10**	**10**

***ND – None Detected (Below detection limits). Numbers highlighted in red are non compliant with the standards.**

The NWC has a "Trade Effluent influent standard" for the water it receives into its sewerage systems. The wastewater that is currently onsite is expected to meet those standards since the plan is to discharge this wastewater into a nearby NWC sewer line. These NWC standards are outlined in Table 24 below.

Table 24 NWC Trade Effluent influent standard (Source: NWC)

PARAMETER	CONCENTRATION
BOD – Biochemical Oxygen Demand	250 mg/l
TSS – Total Suspended Solids	240 mg/l
Total Nitrogen	50.0 mg/l
Alkalinity/Acidity - pH	6 - 9
Sulphate	250 mg/l
Phosphate	8 mg/l
Temperature	No wastewater discharge shall have a temperature in excess of 35 °C

The quality of the wastewater (JEP 5, JEP 6 and JEP 8) to be disposed of meets the NWC influent standards.

4.5.4 Ground Water

Table 25 shows a summary of historical data concerning the groundwater quality (JEP1 – Tivoli Depot, JEP4 – Seprod#2). Nitrate levels at both locations are extremely high as expected for groundwater, and are not compliant with the WHO standard.

Table 25 Results of historical water quality data for ground water in proximity to the proposed site

Parameter	JEP1 – Tivoli Depot (1982)	JEP4 – Seprod#2 (1974)
Total Dissolved Solids (mg/l)	780	
Calcium (mg/l)		176
Magnesium (mg/l)		53
Sodium (mg/l)		120

Parameter	JEP1 – Tivoli Depot (1982)	JEP4 – Seprod#2 (1974)
Chloride (mg/l)	111	220
Sulphate (mg/l)		86
Nitrate (mg/l)	115	248
Hardness (mgCaCO3/l)	656	
Alkalinity (mgCaCO3/l)	354	352
Potassium (mg/l)		3.1
Bicarbonate (mg/l)		431

Water sampling was conducted on the two wells above for the EIA and the results are listed below (Table 26, Table 27, Table 28 and Table 29).

Table 26 Results of ground water sampling at two locations

PARAMETERS	JEP1	JEP4
Temperature (°C)	28.29	28.78
Conductivity (mS/cm)	1.034	0.85
Salinity (ppt)	0.51	0.44
Dissolved Oxygen (mg/l)	6.76	6.8
pH	7.5	7.6

Table 27 Summary of biological and chemical data concerning the groundwater (JEP2, JEP5, JEP6, JEP7 and JEP8) in and around the site

Parameters	JEP1	JEP4
Ammonia (mgN/l)	0.16	0.04
Barium (mg/l)	0.52	0.34
Beryllium (mg/l)	ND	ND
Boron (mg/l)	ND	ND
Calcium (mg/l)	113	129
Chloride (mg/l)	70.5	72.4
Colour (Pt-co)	<15	<15

Parameters	JEP1	JEP4
Detergent (mg/l)	1.67	0.65
Fluoride (mg/l)	0.15	0.21
Iron (µg/l)	<20	<20
Magnesium (mg/l)	25.6	26.7
Manganese (µg/l)	<20	<20
Nitrates (mg/l)	86	91.3
Oil and Grease (mg/l)	1.67	1.17
Phenols (mg/l)	ND	ND
Total Phosphate (mg/l)	0.56	0.44
Sodium (mg/l)	93.5	98.4
Sulphate (mg/l)	91.3	109
Total Dissolved Solids (mg/l)	643	672
Total Organic Compounds (mg/l)	266	228
Total Suspended Solids (mg/l)	<1	<1
Biochemical Oxygen Demand (mg/l)	<2	<2
Chemical Oxygen Demand (mg/l)	ND	ND
Faecal Coliform (MPN/100ml)	4.5	1.8
Residual Chlorine (mg/l)	0.03	0.03
Petroleum Range Organics (mg/l)		
C8-C40	ND	ND
C8-C10	ND	ND
C10-C28	ND	ND
C28-C40	ND	ND
HEAVY METALS		
Arsenic (µg/l)	<10	<10
Cadmium (µg/l)	<20	<20
Chromium (µg/l)	<20	<20
Copper (µg/l)	<10	<10
Cyanide (mg/l)	ND	ND
Lead (µg/l)	<20	<20

Parameters	JEP1	JEP4
Mercury (µg/l)	<0.5	<0.5
Nickel (µg/l)	<20	<20
Selenium (µg/l)	16	76
Silver (mg/l)	ND	ND
Tin (mg/l)	ND	ND
Zinc (mg/l)	<10	<10

***ND – None Detected (Below detection limits).**

Table 28 Results of ground water sampling at two locations (Wet Season)

PARAMETERS	JEP1	JEP4
Temperature (ºC)	28.4	29.16
Conductivity (mS/cm)	1.023	1.072
Salinity (ppt)	0.5	0.53
Dissolved Oxygen (mg/l)	6.8	6.8
pH	7.44	7.67

Table 29 Summary of biological and chemical data concerning groundwater (JEP1 and JEP4) in and around the site (Wet Season)

Parameters	JEP1	JEP4
Biochemical Oxygen Demand (mg/l)	<2	<2
Chemical Oxygen Demand (mg/l)	ND	ND
Faecal Coliform (MPN/100ml)	17	7.3
Residual Chlorine (mg/l)	0.02	0.02
Sulphate (mg/l)	48	57
Nitrates (mg/l)	40.04	36.52
Total Nitrogen (mg/l)	ND	ND

Parameters	JEP1	JEP4
Orthophosphates (mg/l)	0.26	0.22
Total Suspended Solids (mg/l)	ND	12
Oil and Grease (mg/l)	1.36	5.5

***ND – None Detected (Below detection limits).**

4.6 Biological Resources

4.6.1 Flora

4.6.1.1 Introduction

Marginal and abandoned lands in Jamaica are often termed 'ruinate' and refer to vegetation of secondary growth which are formed after activities such as burning, catch cropping and abandonment. The type of ruinate found signifies the history of the area; for example, whether it was abandoned arable or pasture land or marginal land after catch cropping (Asprey and Robbins, 1953). Some plants common to ruinate areas include *Cleome spinosa*, *Achyranthes indica*, *Bidens pilosa* and representatives of the genus *Amaranthus*, *Cyperus*, *Heliotropium*, *Waltheria*, *Sida*, *Solanum*, *Acacia*, *Boerhavia*, *Alternanthera* and *Desmodium*.

4.6.1.2 Methodology

The vegetation assessment of the project site was conducted July 14 - 15. Due to the disturbed state of the site, walk-throughs were employed where plant species encountered were noted. Plants that are rare, endangered, endemic, threatened, invasive alien species and pest/nuisance species were also noted.

Species that could not be identified *in-situ* were collected, tagged and pressed for further identification at the University of the West Indies (UWI) Herbarium.

4.6.1.3 Observations

The proposed site for the Jamaica Energy Partners (JEP) Power Plant is located on Marcus Garvey Drive, which is its southern boundary. The proposed site is bordered to the north by the old Greenwich Wastewater Treatment Facility, east by Seprod Jamaica Limited and west by the minor road, Industrial Terrace. The site is significantly disturbed and shows evidence of recent vegetation clearing (Plate 8).

Plate 8 Pictures showing disturbance on-site and vegetation clearance

The dominant species observed was *Panicum maximum* (Guinea Grass). *Antigonon leptopus* (Coralita), *Ipomoea tiliacea* (Wild Potato), *Passiflora malformis* (Sweet Cup) and *Alternanthera ficoidea* (Crab Withe) which formed the dominant ground cover as well as hummocks throughout the site. Tree species observed included *Cassia siamea* (Siamese Cassia), *Ricinus communis* (Oil Nut), *Acacia* sp., *Ziziphus mauritiana* (Coolie Plum), *Pithecellobium unguis-cati* (Privet), *Cordia alba* (Duppy Cherry), *Guazuma ulmifolia* (Bastard Cedar), *Albizia lebbeck* (Woman's Tongue Tree) and *Delonia regia* (Poinciana) (Plate 9).

In areas where saturation and/or ponding were present, species such as *Ludwigia octovalvis* and *Typha domingensis* (Reedmace), commonly found in or near water and ditches were observed. Reedmace can also be found in fresh and brackish waters (Plate 10).

Plate 9 Pictures showing dominant species and trees observed on the proposed site

Herbs and shrubs typical of pastures, open and disturbed waste places, weed of cultivation, roadsides and/or dry river beds were also observed. These included *Achyranthes indica* (Devil's Horse-Whip), *Physalis angulata* (Wild Gouma), *Mimosa pudica* (Shame Weed), *Cassia occidentalis* (Dandelion) and *Heliotropium indicum* (Scorpion Weed) to name a few.

Plate 10 Reedmace observed in a pond on the proposed site

"Wild" food crops such as *Amaranthus* sp. (Calaloo), *Cucurbita* sp. (Pumpkin), *Lycopersicon esculentum* (Tomato), *Malachra alceifolia* (Wild Okra), *Solanum erianthum* (Wild Susumber), *Solanum torvum* (Susumber) and *Ziziphus mauritiana* (Coolie Plum) were also observed.

A total 57 plant species were observed (Table 30). None of the plants observed were endemic, endangered, threatened, rare, invasive alien species or pest/nuisance species.

Table 30 Vegetation observed on the proposed Power Plant site

Scientific Name	Common Name
Abutilon ?hirtum	
***Acacia* sp.**	
Achyranthes indica	Devil's Horse-Whip
Albizia lebbeck	Woman's Tongue Tree
Alternanthera ficoidea	Crab Withe
***Amaranthus* sp.**	Calaloo
Antigonon leptopus	Coralita, Coralilla
Asystasia gangetica	
Bidens pilosa	Spanish Needle
Bidens pilosa* var. *radiata	

Scientific Name	Common Name
***Boerhavia* sp.**	
Calotropis procera	French Cotton, Dumb Cotton, Auricula Tree
Cassia occidentalis	Dandelion, Piss-a-bed, Stinking Weed, Wild Coffee
Cassia siamea	Siamese Cassia
***Cassia* sp.**	
Cleome spinosa	
Cordia alba	Duppy Cherry
***Cucurbita* sp.**	Pumpkin
***Cyperus* spp.**	
Datura stramonium* var. *stramonium	Devil's Trumpet, Jimson Weed, Trimona
Delonix regia	Poinciana, Flamboyant
Desmodium adscendens	
***Fimbristylis* spp.**	
Guazuma ulmifolia	Bastard Cedar, Ba'ceda
Heliotropium ?angiospermum	Dog's Tail
Heliotropium indicum	Scorpion Weed, Wild Clary
Ipomoea tiliacea	Wild Potato, Wild Slip
***Gossypium* sp.**	Cotton
Lippia nodiflora	
Ludwigia octovalvis	
Lycopersicon esculentum	Tomato
Malachra alceifolia	Wild Okra
Mikania micrantha	Guaco
Mimosa pudica	Shame Weed, Shame-O-Lady
Morinda citrifolia	Noni
Nerium oleander	Oleander
Panicum maximum	Guinea Grass
Passiflora malformis	Sweet Cup
***Phaseolus* sp.**	
Physalis angulata	Wild Gouma, Winter Cherry

Scientific Name	Common Name
Pithecellobium unguis-cati	Privet, Bread-and-Cheese
Pluchea odorata	Bitter Tobacco
Ricinus communis	Oil Nut, Castor Oil Plant
Ruellia tuberosa	Duppy Gun, Menow Weed
Sida acuta	Broomweed
Solanum americanum	Black Nightshade, Gouma
Solanum erianthum	Wild Susumber
Solanum torvum	Susumber, Gully Bean, Turkey Berry
Spilanthes urens	Pigeon Coop
Stachytarpheta jamaicensis	Vervine
Stenotaphrum secundatum	Crab Grass, Pimento Grass
Turnera ulmifolia	Ramgoat-dash-a-long
Typha domingensis	Reedmace
Vernonia cinerea	
Waltheria indica	Raichie
Ziziphus mauritiana	Coolie Plum, Crab Apple, Jujube
Zoysia tenuifolia	

4.6.2 Fauna

4.6.2.1 Introduction

The property consists of grassland, with small shrubs, several weeds and few large trees. There are also old concrete buildings, networks of canals, old concrete tanks and sewage ponds on the property. The ponds and several of the canals on the property receive raw sewage from the adjoining communities. Several of the sewage ponds and also the canals are overrun with silt and vegetation. The property also floods occasional; this was evident with the vegetation and dried mud flats.

4.6.2.2 Methodology

Avifauna

For the evaluation of bird species the following methods were utilized:

1. Line Transect Census Method
   - Due to the small size of the property and the extensive networks of footpaths within the proposed area, the line transect was selected to conduct the avifaunal assessment. The survey was conducted over 3 days. The line transect method entails walking at a steady pace along selected routes for a given distance or time period and noting all the birds seen or heard in the area (Wunderle, 1994). The line transect survey was conducted from sunrise until approximately 10:30 am in the morning.
   - Advantages of line transect method include (Bibby et. al., 1998):
     - It covers the area quickly and the number of bird sightings is usually higher;
     - It reduces the chance of double counting; and
     - It is good for observing mobile and conspicuous species.
   - Technique Weaknesses
     - As with all survey techniques, there are weaknesses, which influence overall results. Below are given factors which affect both census techniques used.
     - Time of Day – the best time for conducting a census is in the morning from sunrise until about 10am in the lowlands. It is recognized that as the day continues it gets hotter and the ability to detect birds decreases due to lack of movement (Wunderle, 1994);
     - Time of Year – the change in behaviour of birds during the breeding and non-breeding seasons affect detection. However for this report, the assessment was done in the non-breeding season, when birds are less vocal (Wunderle, 1994); and
     - Weather – things such as wind, rain, fog or if the day is too hot, affect conducting a census (Wunderle, 1994).
2. Observance of the Sewage ponds
   - This method is based on the principle of counting birds at an area, where water has accumulated. Bird species and their numbers are recorded for a time period usually 20 – 30 minutes. Identification of species was done through sight (visual identification) and sound (audio identification).

Invertebrates

1. Line Transect

Invertebrate assessments focused on larger species (body length ≥ 3 mm) of land snails, myriapods, spiders, hymenopterans and butterflies. The site was traversed along parallel transect lines 20m apart. All species observed within a belt of ± 5m along the transect line were recorded. Snails, myriapoda, spiders, and hymenoptera with a body length ≥ 3mm were recorded.

Species detected were identified in the field, if possible; however, it was not always possible to identify some insects in flight. In such cases a flight net was used to collect specimens which were taken to the laboratory for storage and identification. A DAFOR rating was established for all recorded species for each transect. Specimens of some species were collected for verification or identification in the laboratory.

2. Sweep Nets

Species were collected from the vegetation using a sweep net along the transect. A 15cm sweep net with cotton bag was swept from the side through the shrub and herb layer while the researcher walked along the transect. The material collected was placed in killing jars then later transferred to plastic jars for transportation to the laboratory. In the laboratory, the animals were removed, sorted, labelled and stored. The species were later identified and counted.

3. Soil and Litter

Soil and litter samples were collected and placed in new plastic bags for transportation to the laboratory. In the laboratory, the sample was searched under a dissecting microscope and the animals present collected.

4.6.2.3 Observations

Avifaunal Composition

Twenty five species of birds were recorded, seven of which were aquatic. Two of the terrestrial species were endemic, these were Jamaican Euphonia, and the Red-billed Streamertail, neither of these species are forest dependant.

Terrestrial Birds

The majority of the birds seen on the property were Columbids. The Rock Dove, commonly known as the Domestic Pigeon, was the most abundant species. The property is located near the Newport Animal Feed Mill, which provides a source of food for this species. The Common Ground Dove, White-crowned Pigeon and Zenaida Dove were the other common Columbid species seen on the property. The white-crowned pigeons were seen nesting in one of the trees.

The numbers of the other terrestrial bird were very low. Only two endemic birds were seen on the property and these were not forest dependent. No migrant birds were encountered during the survey as a result of the time of the year the survey was done. The Great Antillean Nighthawk was the only nocturnal bird seen on the property. Interviews with the watchmen on the property have indicated the presence of the Barn Owl.

The low number of birds on the property was probably related to fact that the property is in the commercial zone of Kingston. Consequently, there are few green areas for birds to use, a relatively high noise level, high human and vehicular traffic.

Water Birds

Six species of water birds were seen on the property, however, there was little foraging. The property is located near the sea and as such, a number of water birds will appear on the property; for example, the Frigatebird, Black-neck stilt and the White Ibis. The Little Blue Heron, Cattle Egret and Glossy Ibis were seen foraging in the water ways. However, no water birds were seen foraging in the sewage ponds.

Invertebrates

Insects

Eighty one species of insects from nine orders (39 families) were recorded. There were sixteen species of butterflies and two species of moths. These were dominated by the Nymphalidae (6 species) and the Lycaenidae (5 species) of which all species have widespread distribution.

The fourteen species of beetles (Coleoptera) were dominated by the leaf beetles (Chrysomelidae) which fed on the leaves of many shrubs and herbs. Fourteen species of plant bugs (Homoptera) were also recorded. Most of the species were collected from the grass, which were mainly from the family Cicadellidae (Table 31).

Table 31 Summary of Invertebrates

ORDER	NO. FAMILIES	NO. SPECIES
Lepidoptera	5	18
Coleoptera	8	14
Homoptera	3	14
Hemiptera	5	11
Hymenoptera	4	9
Diptera	8	8
Orthoptera	3	3
Odonata	2	3
Neuroptera	1	1

Other Invertebrates

Over twenty species of spiders were recorded. These were not identified to the level of species but were dominated by the Salticidae (jumping spiders) and (Araneidae) orbwebb spiders. No land snails were recorded, but this was not surprising given the disturbed nature of the habitat.

4.7 Land Use

The existing site was previously used for wastewater treatment (Western Sewage Treatment Works) by the National Water Commission. It was a mechanical plant and was designed to accommodate two (2) to three (3) million gallons of sewage daily. Mechanical plants can be big tanks with booms[2] that move across the surface of the water slowly for a period of time thus allowing solids present to settle. The solids or sludge, as it is often termed, are relocated to 'drying beds' and are removed when dry and can be used as fertilizer. The plant was a typical example of a primary sewage treatment facility. The remaining effluent[3] still contains impurities such as bacteria, nutrients, suspended solids and industrial pollutants, if present and flows into the sea.

The wastewater treatment plant is currently unused and the pipeline to the newly constructed Soapberry Wastewater Treatment plant traverses this property.

4.7.1 Existing

The proposed site of the Jamaica Energy Partners 60 MW West Kingston Power Plant is surrounded by industrial developments. The closest residential area is Tivoli Gardens which is situated approximately 300 m northeast of the proposed site. The housing developments in proximity to the proposed sites can be classified as low to low middle income developments.

Additionally, the proposed property was once the site of the Western Purification Works (sewerage treatment plant) for the National Water Commission (NWC).

Existing land use in the study area is commercial, industrial, residential, educational and recreational. Other uses include a cemetery (May Pen Cemetery), telecommunication modules and cellular towers and an airstrip (Figure 29).

Commercially, the study area has offices, financial centres (e.g. Bank of Jamaica), restaurants, bars, a market (Coronation Market), a fishing village (Greenwich Farm) and factories such as the Newport Feed Mills. Industrial facilities include the Jamaica Public Service Company Ltd. Hunts Bay electric power station and Petrojam Refinery.

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[2] A barrier composed of a chain of floating logs enclosing other free-floating logs, typically used to catch floating debris or to obstruct passage (http://dictionary.reference.com/browse/boom).
[3] Sewage that has been treated in a septic tank or sewage treatment plant (http://dictionary.reference.com/browse/effluent).

There are also health facilities which include the Kingston Public and the Victoria Jubilee Hospitals and health centres such as Slipe Pen Road, East Queen Street and Denham Town to name a few.

There are thirteen (13) major residential areas within the (Social Impact Area (SIA)). These include Tivoli, Trench Town, Jones Town, Greenwich Town, Denham Town, Wilton Gardens/Rema, Arnett Gardens, Whitfield Town and Rose Town to name a few.

Recreational facilities are located at Tivoli and Arnett Gardens where there are community centres, football fields and hard courts for netball and basketball

4.7.2 Future Developments

There is a proposal to expand the Petrojam Refinery 1km west of the proposed JEP West Kingston 60 MW plant site. There is also a proposal for a joint venture Petrojam and the Jamaica Public Service for a Pet Coke electricity generating plant.

The proposed development (JEP West Kingston 60MW plant) occurs within an industrial area and therefore will fit into the existing land usage of the area.

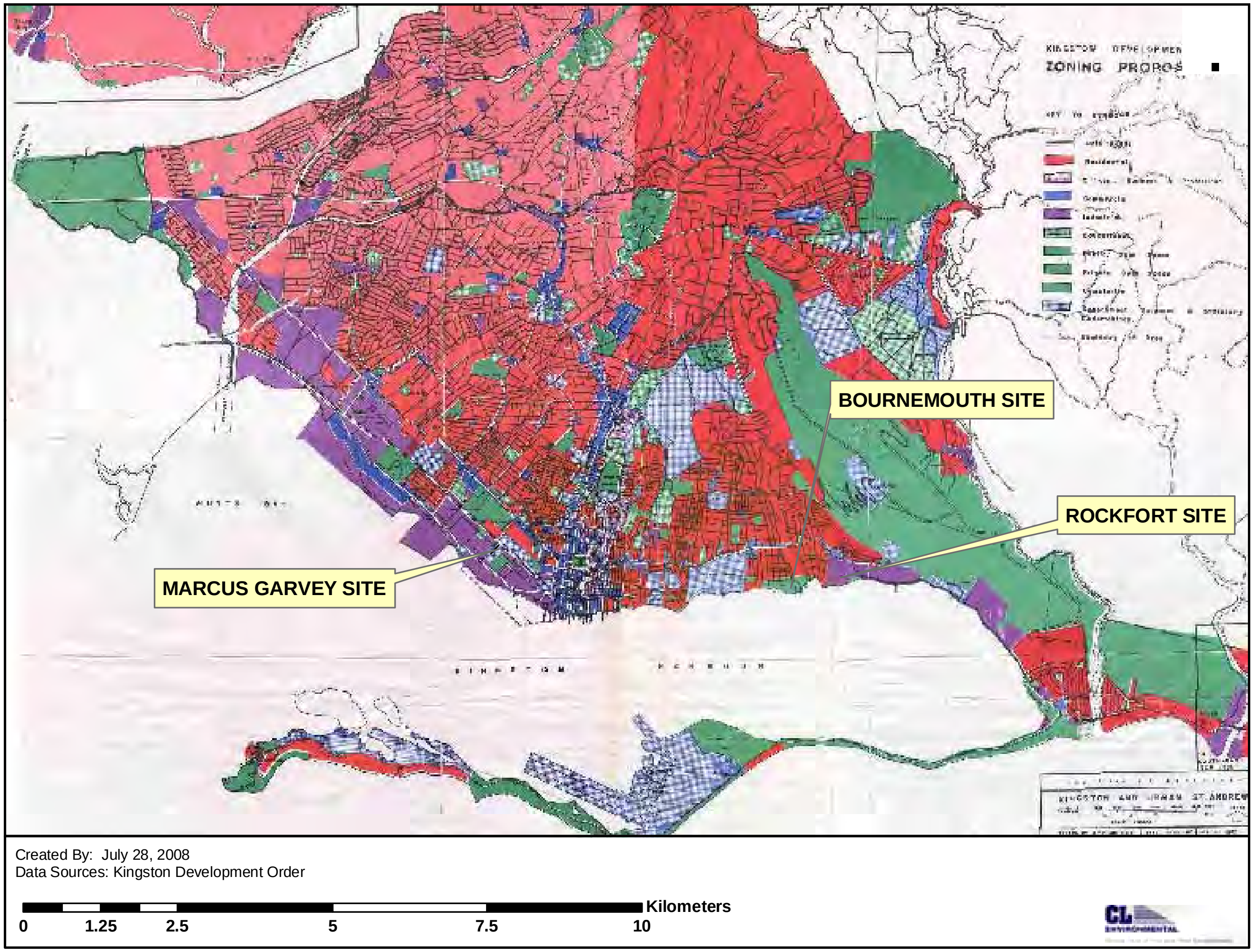


Figure 29 Locations of proposed sites in relation to land use zonation of the Kingston Development Plan map

4.8 Noise

4.8.1 Methodology

Two data logging noise survey exercises were conducted to establish baseline conditions at the proposed location of the Jamaica Energy Partners (JEP) West Kingston 60 MW facility located on lands previously occupied by the National Water Commission (NWC) Western Sewage works situated along Industrial Terrace in Kingston and its environs.

The first data logging exercise was conducted for thirty six (36) hours between 19:00 hrs Tuesday 28th, to 7:00 hrs Thursday 30th, July 2009. The readings were taken at seven (7) locations (Stations 1 – 7) depicted in Figure 30. This included a Wednesday which is the day when the popular "Passa passa street dance" which occurs usually from Wednesday night until sunrise Thursday morning.

The second data logging exercise was conducted for sixty (60) hours between 19:00 hrs Saturday 1st, to 7:00 hrs Tuesday 4th, August 2009. The readings were taken at eight (8) locations (Stations 1 – 8) depicted in Figure 30. This exercise recorded noise levels during a holiday (Emancipation Day- August 1) and would give and indication of what occurs within the community during that time as it relates to noise generation.

Noise level readings were taken by using Quest Technologies SoundPro DL Type 1 hand held sound level meters with real time frequency analyzer setup in an outdoor monitoring kit. The octave band analysis was conducted concurrently with the noise level measurements. Measurements were taken in the third octave which provided thirty three (33) octave bands from 12.5 Hz to 20 kHz (low, medium and high frequency bands).

The noise meters were calibrated pre and post noise assessment by using a Quest QC - 10 sound calibrator (Appendix 5). The meters were programmed using the Quest suite Professional II (QSP II) software to collect third octave, average sound level (Leq) over the period, Lmin (The lowest level measured during the assessment) and Lmax (The highest level measured during the assessment) every ten (10) seconds.

Average noise levels over the period were calculated within the QSP II software using the formula:

$$\text{Average dBA} = 20 \log 1/N \sum_{j=1}^{N} 10^{(Lj/20)}$$

where N = number of measurements, L_j = 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.

The descriptions, GPS locations in (JAD2001 and Latitude and Longitude coordinate systems) of these noise stations are listed in Table 32 and depicted in Figure 30.

Table 32 Station numbers and locations in JAD2001 and Latitude/Longitude

STATIONS	LOCATIONS	JAD 2001 (m)		LAT/LONG (DECIMAL DEGREES)	
		E	N	N	W
	PROPERTY BOUNDARY				
1	Railway	770672.606	647070.082	17.973	-76.805
2	Seprod	770666.478	646898.513	17.972	-76.805
3	Marcus Garvey Drive	770515.590	646873.237	17.972	-76.806
4	Industrial Terrace	770524.781	647007.275	17.973	-76.806
	ENVIRONS				
5	Tivoli Gardens High School	770632.299	647346.296	17.976	-76.805
6	Charles Chinloy Preschool & Day Care	770770.167	647259.554	17.975	-76.804
7	Tivoli Gardens Community	770849.128	647165.372	17.974	-76.803
8	Factories Corporation of Jamaica	770496.027	647070.769	17.973	-76.806

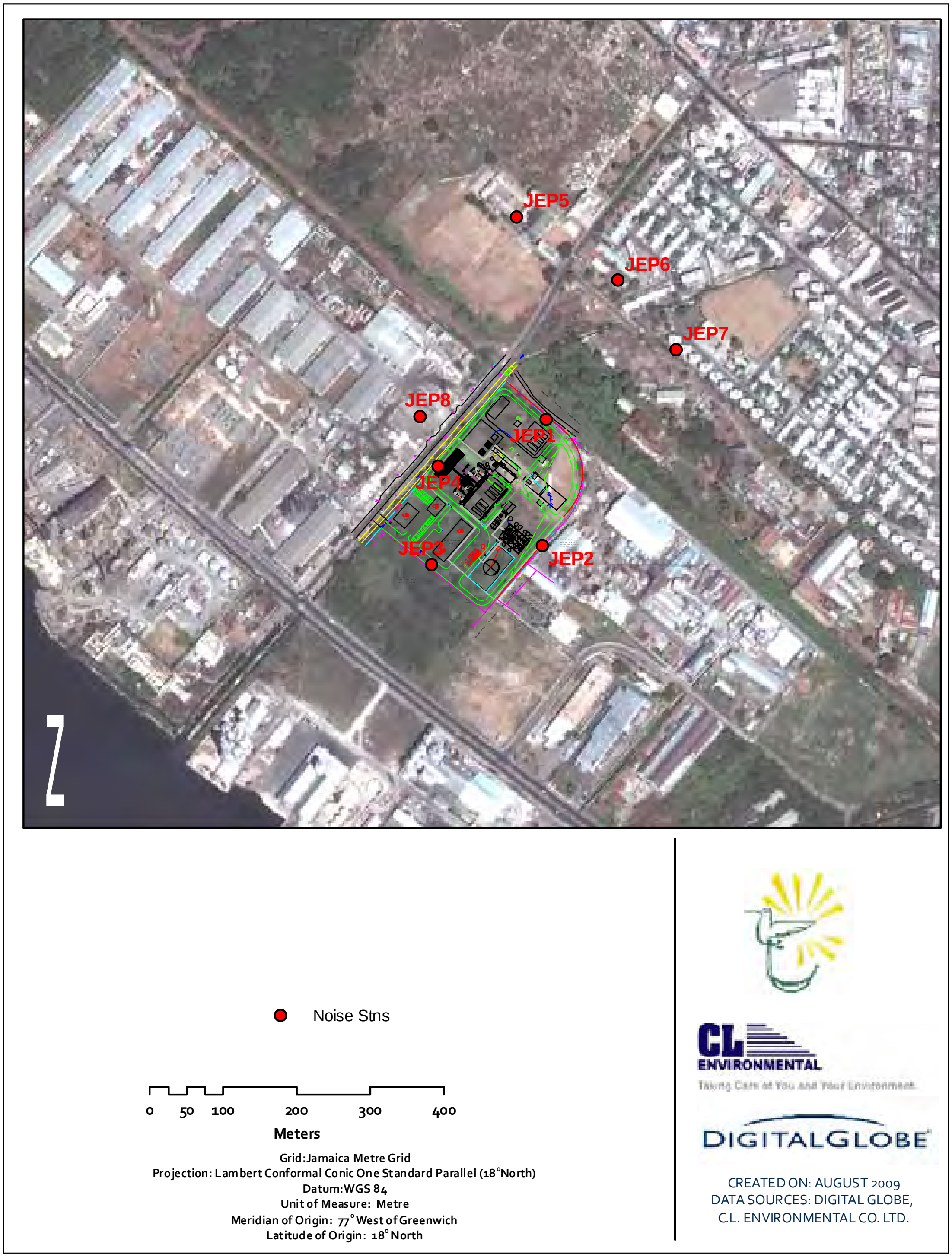


Figure 30 Locations of noise survey stations

4.8.2 Results

The results for the assessments are presented in Table 33, Table 34, Table 35 and Table 36.

Table 33 Results of noise measurements during the 36 hrs of measurements (19:00 hrs Tuesday 28th, to 7:00 hrs Thursday 30th, July 2009)

STATION #	LOCATION	CATEGORY	Lmin (dBA)	Lmax (dBA)	L_{Aeq} (36h)	L10	L90
1	Railway	Industrial	41.0	74.3	54.8	57.8	46.2
2	Seprod	Industrial	39.9	75.1	54.8	59.2	44.9
3	Marcus Garvey Drive	Industrial	44.0	75.4	57.4	61.0	48.5
4	Industrial Terrace	Industrial	44.8	88.9	60.7	64.1	49.6
5	Tivoli Gardens High School	Institutional	39.2	77.8	57.2	58.6	46.2
6	Charles Chinloy Preschool & Day Care	Institutional	42.0	78.0	56.3	59.1	48.7
7	Tivoli Gardens Community	Residential	45.0	98.5	60.3	63.4	51.2

Table 34 Results of noise measurements during the 60 hrs of measurements (19:00 hrs Saturday 1st, to 7:00 hrs Tuesday 4th, August 2009)

STATION #	LOCATION	CATEGORY	Lmin (dBA)	Lmax (dBA)	L_{Aeq} (60h)	L10	L90
1	Railway	Industrial	37.2	76.3	54.6	57.4	45.2
2	Seprod	Industrial	36.4	73.9	52.5	55.6	43.8
3	Marcus Garvey Drive	Industrial	37.8	77.8	54.7	57.2	46.4
4	Industrial Terrace	Industrial	37.6	89.9	57.7	60.6	46.7
5	Tivoli Gardens High School	Institutional	37.1	78.2	54.8	58.6	43.4
6	Charles Chinloy Preschool & Day Care	Institutional	39.6	79.8	57.1	60.3	47.2
7	Tivoli Gardens Community	Residential	43.2	93.7	60.5	62.5	49.8

STATION #	LOCATION	CATEGORY	Lmin (dBA)	Lmax (dBA)	L_{Aeq} (60h)	L10	L90
8	Factories Corporation of Jamaica	Industrial	36.0	89.6	60.7	64.6	44.5

The noise at all the stations was in the low frequency of 12.5 Hz except Station 7 (16 Hz).

Table 35 Results of noise measurements during (19:00 hrs Tuesday 28th, to 7:00 hrs Thursday 30th, July 2009)

STATION #	LOCATION	CATEGORY	7 am. – 10 pm. (dBA)	10 pm. – 7 am. (dBA)
1	Railway	Industrial	55.7	53.8
2	Seprod	Industrial	53.9	55.6
3	Marcus Garvey Drive	Industrial	57.2	57.6
4	Industrial Terrace	Industrial	61.6	59.9
5	Tivoli Gardens High School	Institutional	59.5	51.9
6	Charles Chinloy Preschool & Day Care	Institutional	58.1	53.3
7	Tivoli Gardens Community	Residential	61.9	58.0

Table 36 Results of noise measurements during (19:00 hrs Saturday 1st, to 7:00 hrs Tuesday 4th, August 2009)

STATION #	LOCATION	CATEGORY	7 am. – 10 pm. (dBA)	10 pm. – 7 am. (dBA)
1	Railway	Industrial	56.2	51.2
2	Seprod	Industrial	53.3	51.5
3	Marcus Garvey Drive	Industrial	56.3	51.7
4	Industrial Terrace	Industrial	59.5	53.7
5	Tivoli Gardens High School	Institutional	57.0	48.0
6	Charles Chinloy Preschool & Day Care	Institutional	58.0	55.9
7	Tivoli Gardens Community	Residential	61.9	58.0

STATION #	LOCATION	CATEGORY	7 am. – 10 pm. (dBA)	10 pm. – 7 am. (dBA)
8	Factories Corporation of Jamaica	Industrial	62.4	57.0

4.8.2.1 L10 and L90

The two most common $\mathbf{L_n}$ values used are $\mathbf{L_{10}}$ and $\mathbf{L_{90}}$ and these are sometimes called the 'annoyance level' and 'background level' respectively. $\mathbf{L_{10}}$ is almost the only statistical value used for the descriptor of the higher levels, but $\mathbf{L_{90}}$, 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 sporadic or intermittent noise. L90 is the noise level exceeded for 90% of the time of the measurement duration. It is generally considered to be representing the background or ambient level of a noise environment.

A L10 – L90 of < 5dBA indicate no significant fluctuation in noise level, a L10 – L90 of 5 – 15 dBA indicates moderate fluctuation and a L10 – L90 of > 15dBA indicate large fluctuations in the noise level.

The L10 – L90 was examined for all the noise stations over the two monitoring runs June 28th – 30th, 2009 and August 1st – 4th, 2009. The results are summarised below in Table 37 and represented in Figure 31 through to Figure 45.

Table 37 L10 – L90

LOCATION	NOISE FLUCTUATION
Railway	No significant to moderate
Seprod	Moderate
Marcus Garvey Drive	No significant to moderate
Industrial Terrace	Moderate to high
Tivoli Gardens High School	Moderate to high
Charles Chinloy Preschool & Day Care	Moderate to high

LOCATION	NOISE FLUCTUATION
Tivoli Gardens Community	Moderate to high
Factories Corporation of Jamaica	Moderate to high

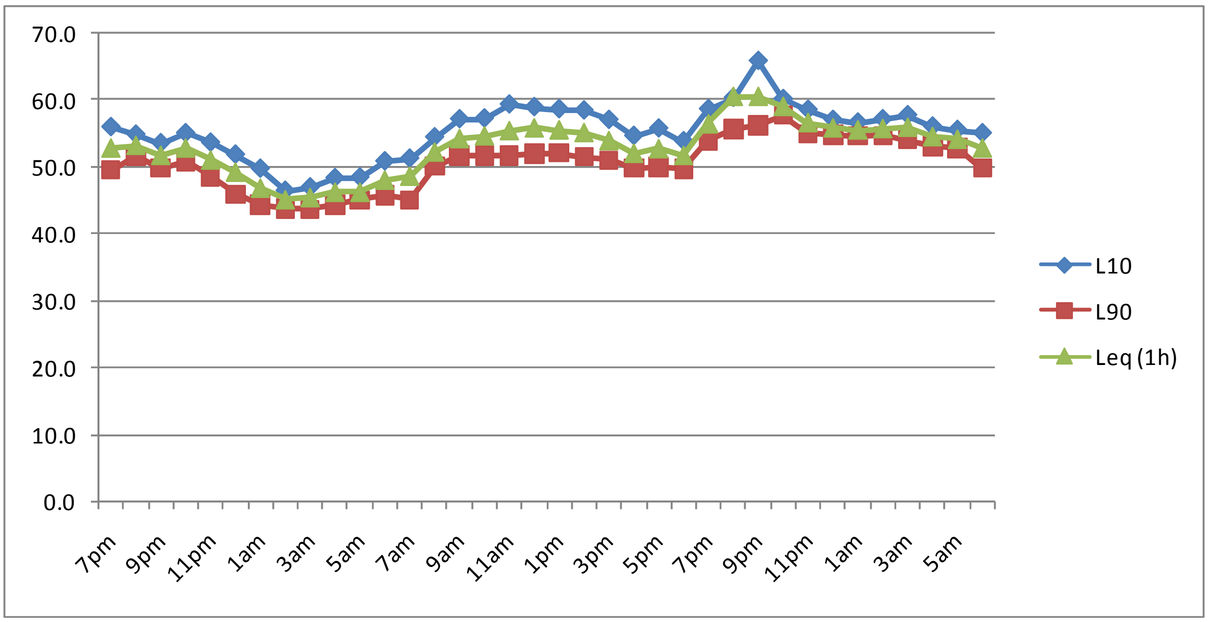


Figure 31 L10, L90 and Leq (1h) graph for Railway noise station (July 28th – 30, 2009)

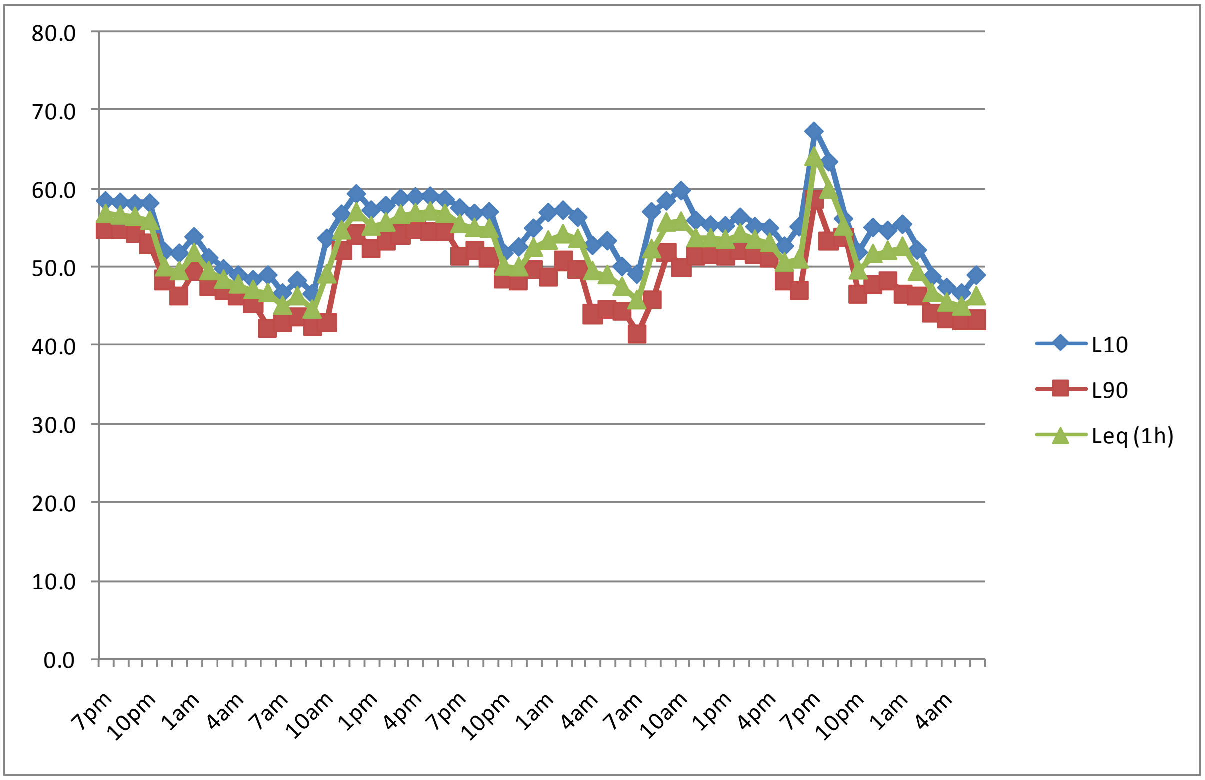


Figure 32 L10, L90 and Leq (1h) graph for Railway noise station (August 1st – 4th,, 2009)

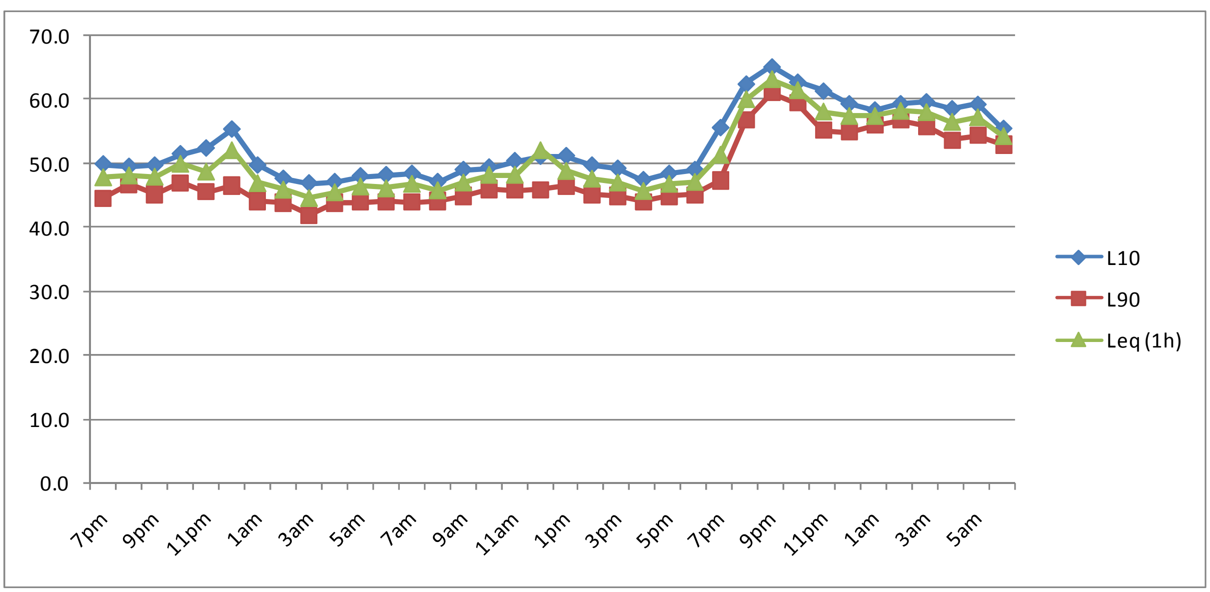


Figure 33 L10, L90 and Leq (1h) graph for Seprod noise station (July 28th – 30, 2009)

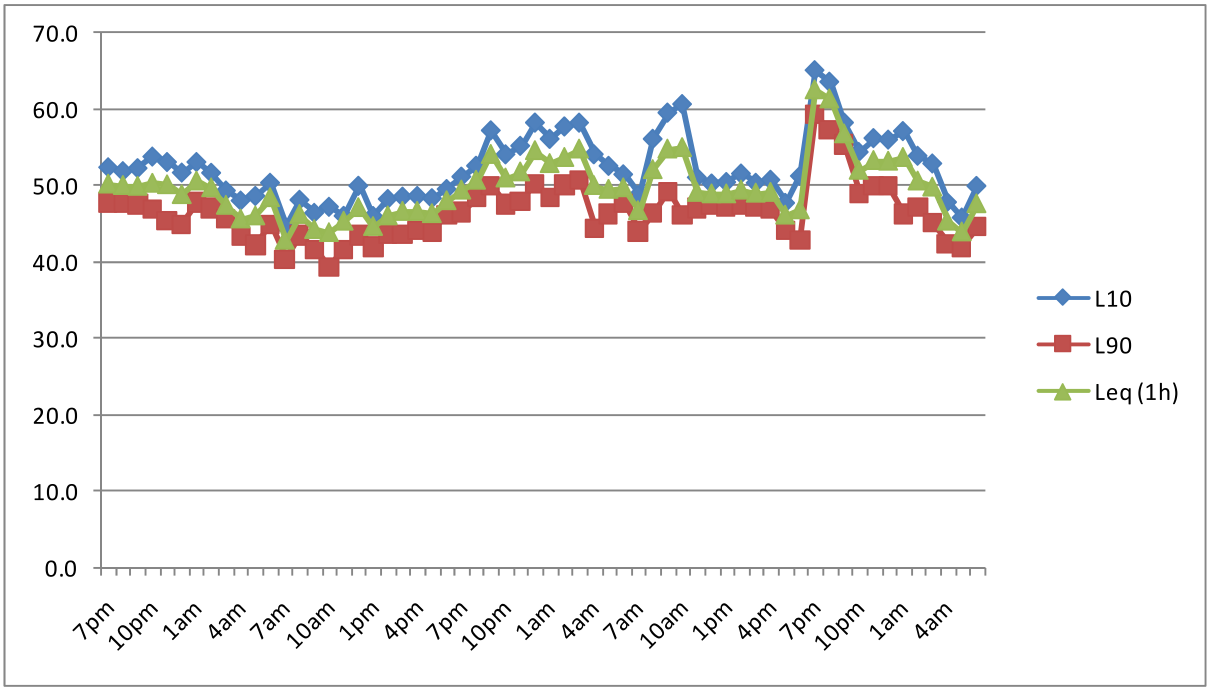


Figure 34 L10, L90 and Leq (1h) graph for Seprod noise station (August 1st – 4th,, 2009)

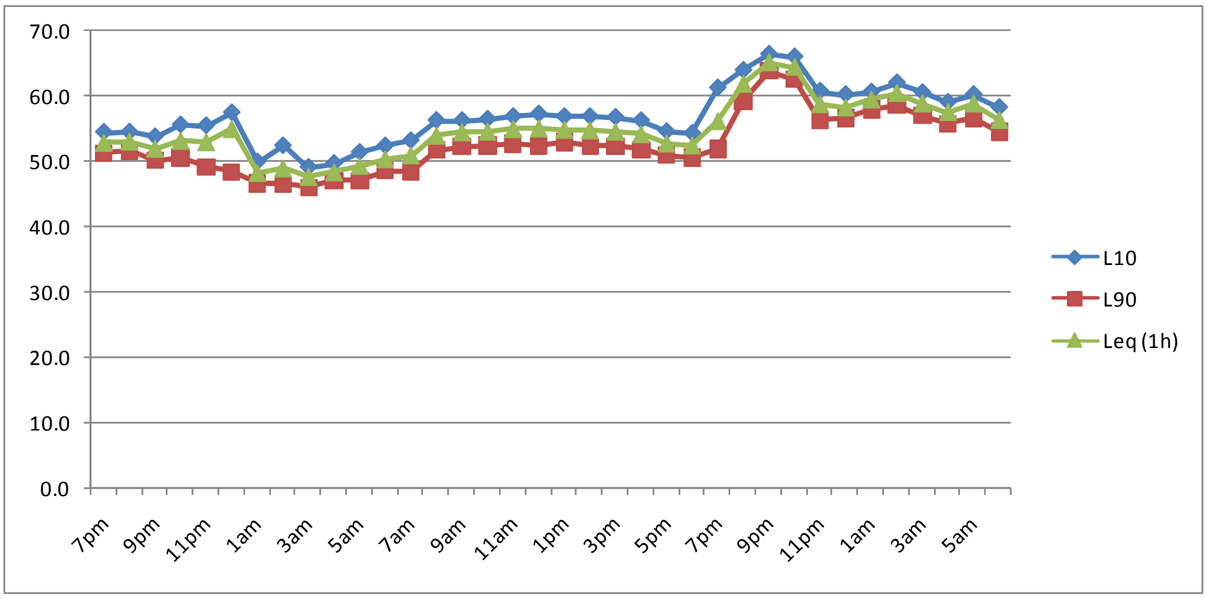


Figure 35 L10, L90 and Leq (1h) graph for Marcus Garvey noise station (July 28th – 30, 2009)

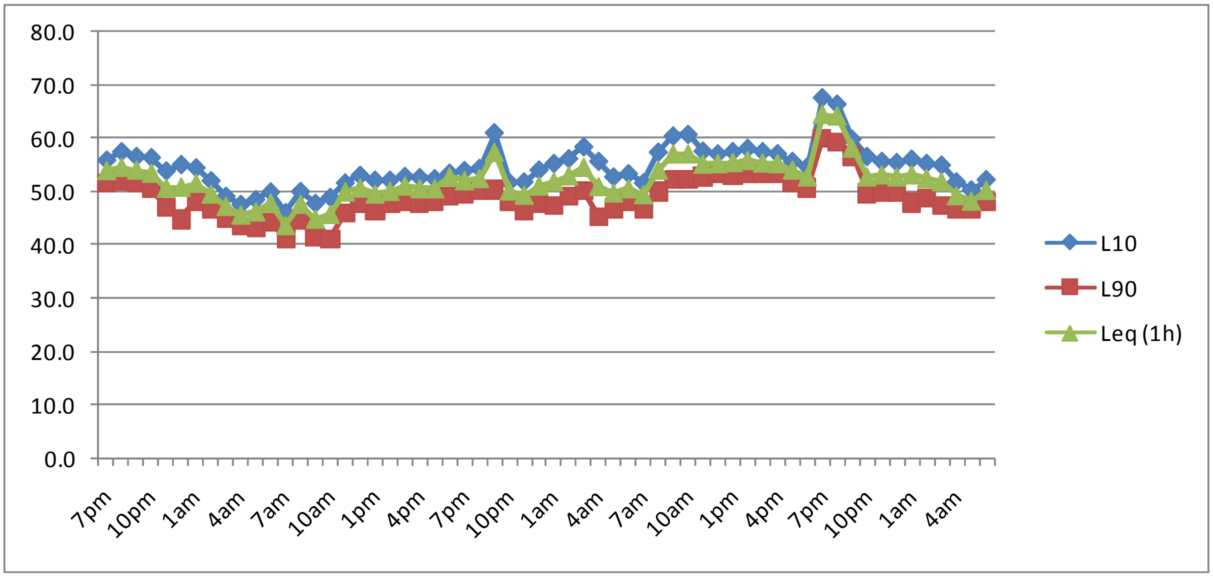


Figure 36 L10, L90 and Leq (1h) graph for Marcus Garvey noise station (August 1st – 4th,, 2009)

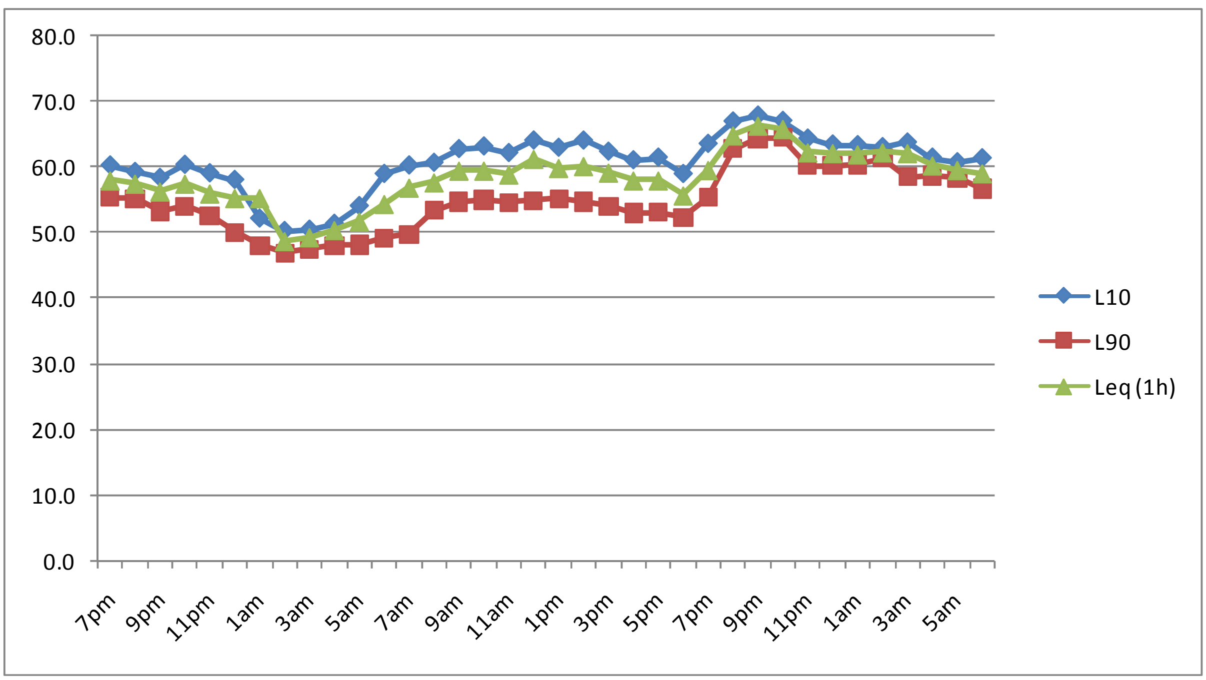


Figure 37 L10, L90 and Leq (1h) graph for Industrial Terrace noise station (July 28th – 30, 2009)

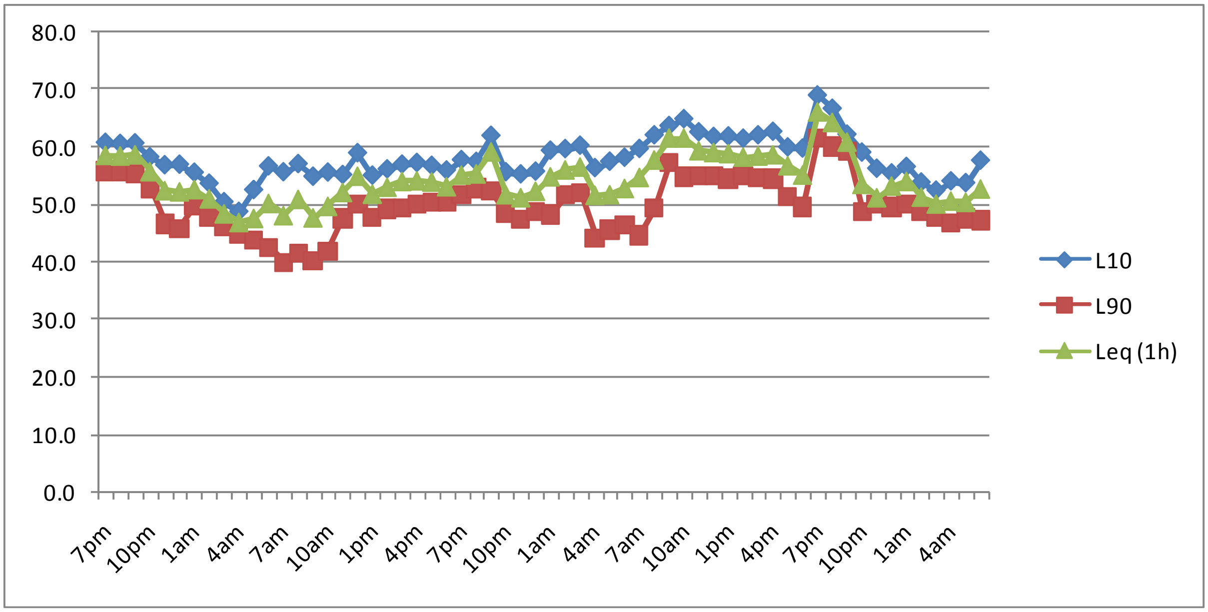


Figure 38 L10, L90 and Leq (1h) graph for Industrial Terrace noise station (August 1st – 4th,, 2009)

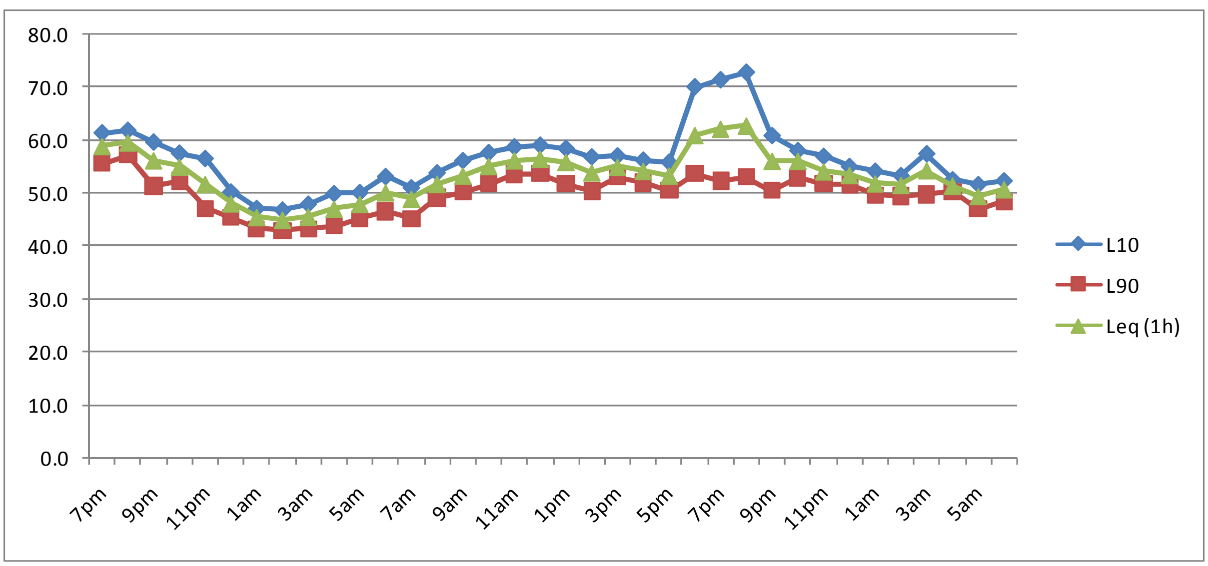


Figure 39 L10, L90 and Leq (1h) graph for Tivoli Gardens High School noise station (July 28th – 30, 2009)

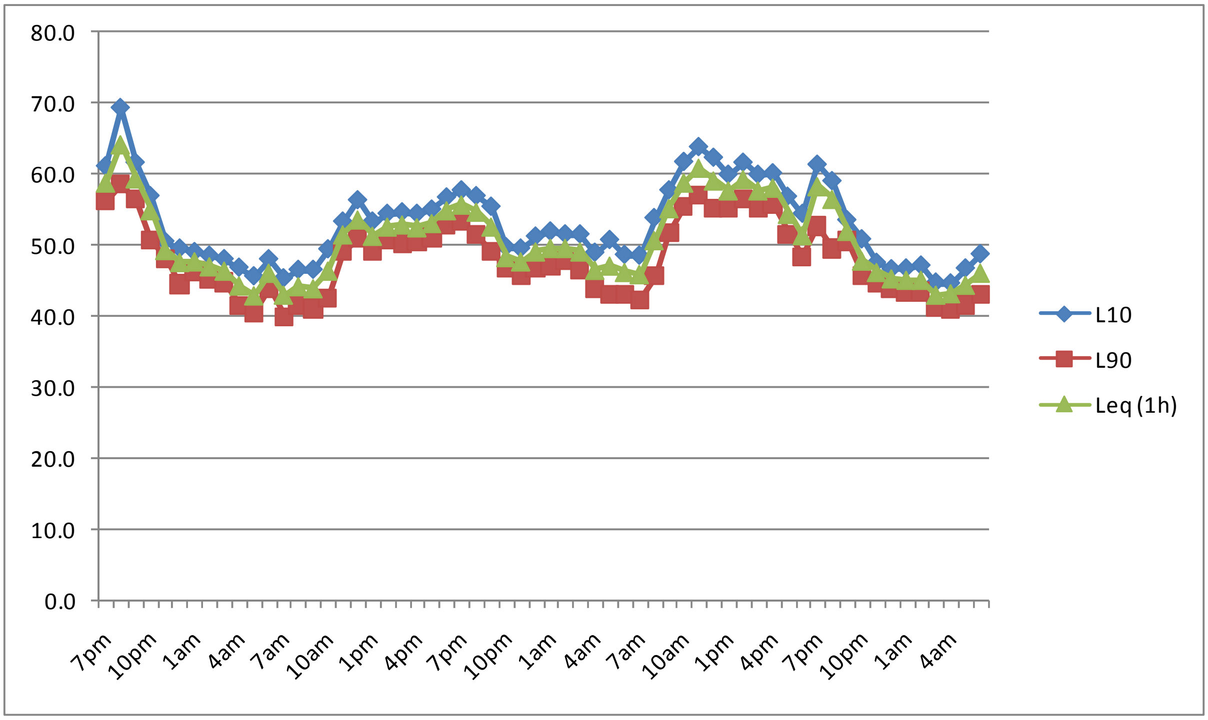


Figure 40 L10, L90 and Leq (1h) graph for Tivoli Gardens High School noise station (August 1st – 4th,, 2009)

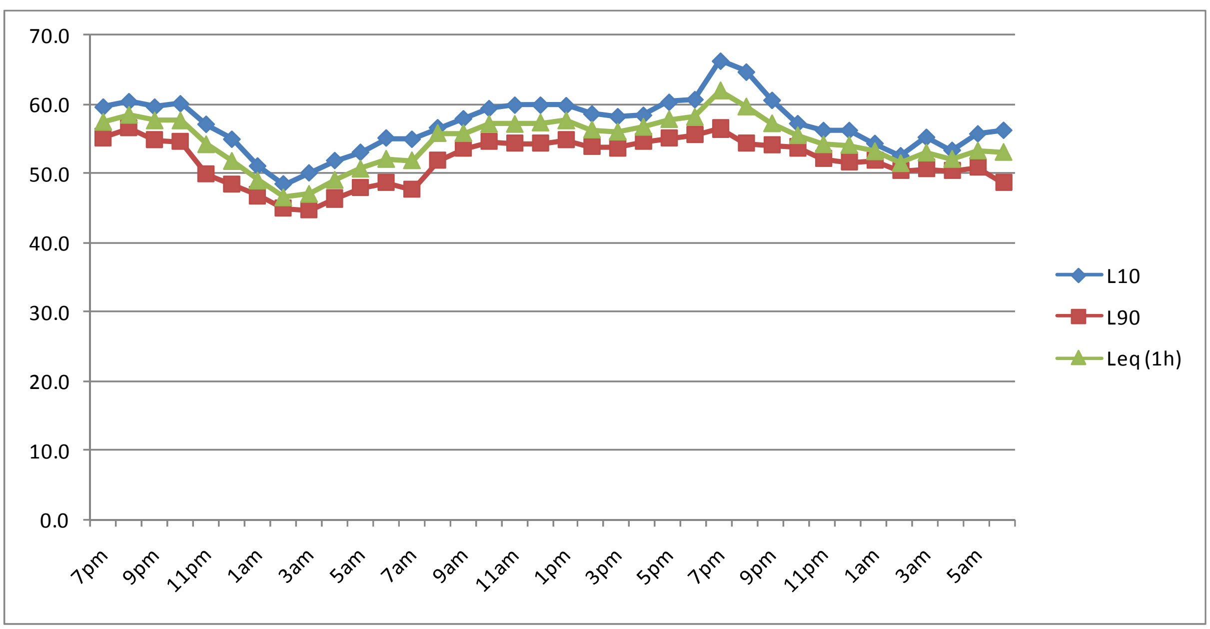


Figure 41 L10, L90 and Leq (1h) graph for Charles Chinloy Preschool & Day Care noise station (July 28th – 30, 2009)

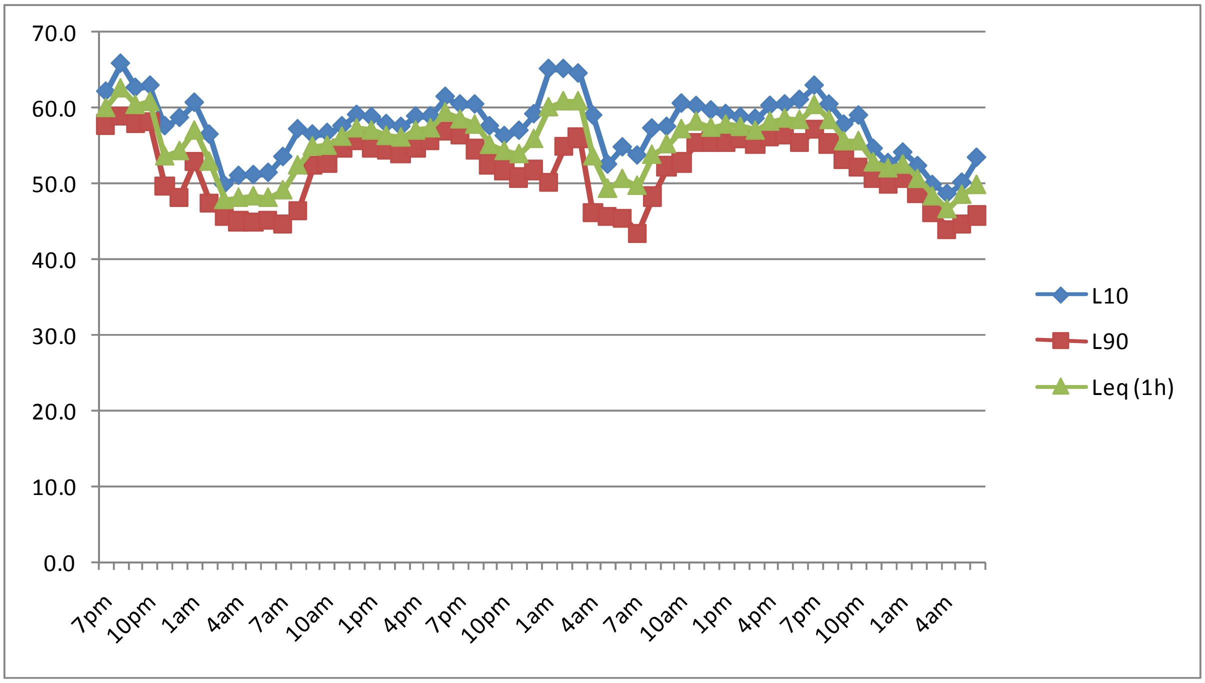


Figure 42 L10, L90 and Leq (1h) graph for Charles Chinloy Preschool & Day Care noise station (August 1st – 4th,, 2009)

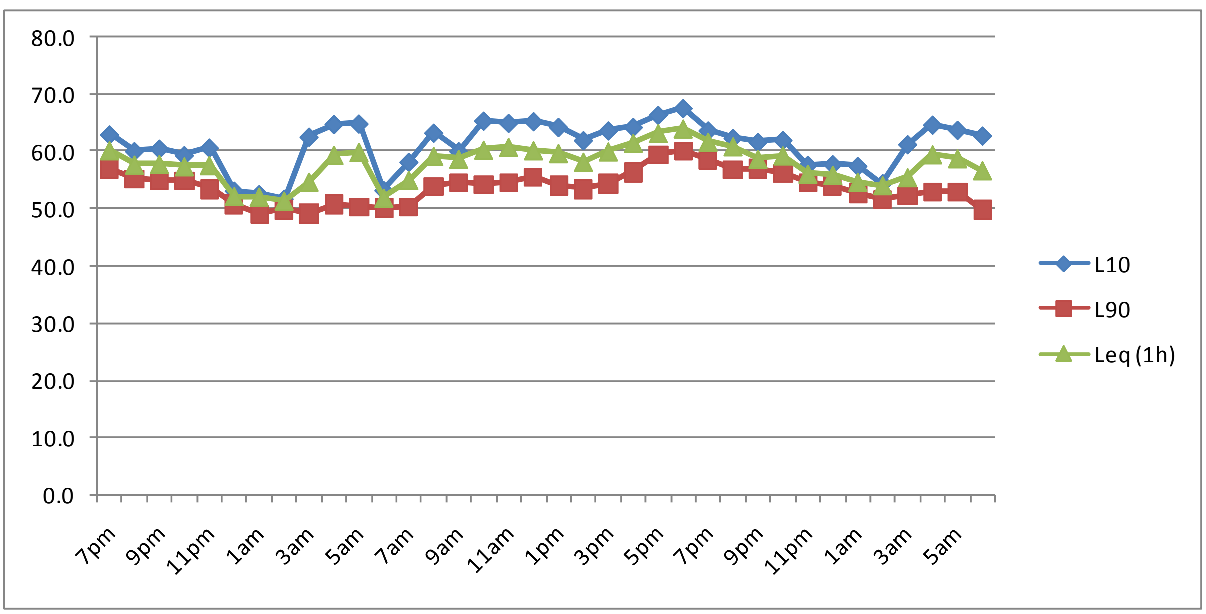


Figure 43 L10, L90 and Leq (1h) graph for Tivoli Gardens Community noise station (July 28th – 30, 2009)

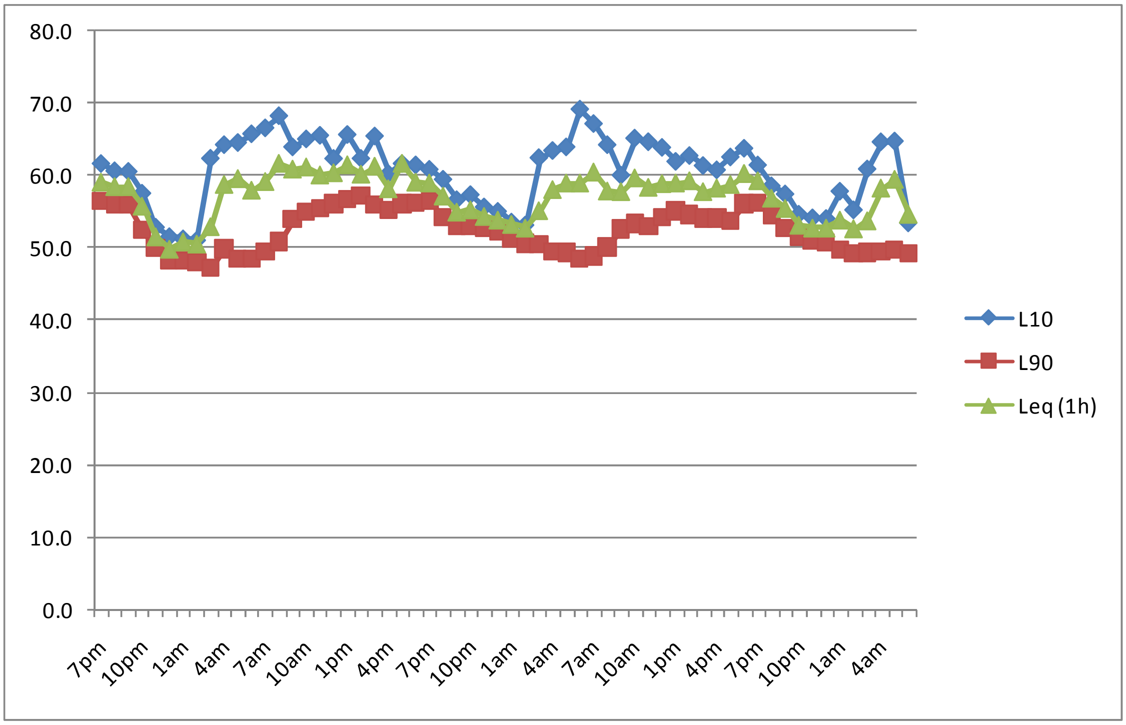


Figure 44 L10, L90 and Leq (1h) graph for Tivoli Gardens Community noise station (August 1st – 4th,, 2009)

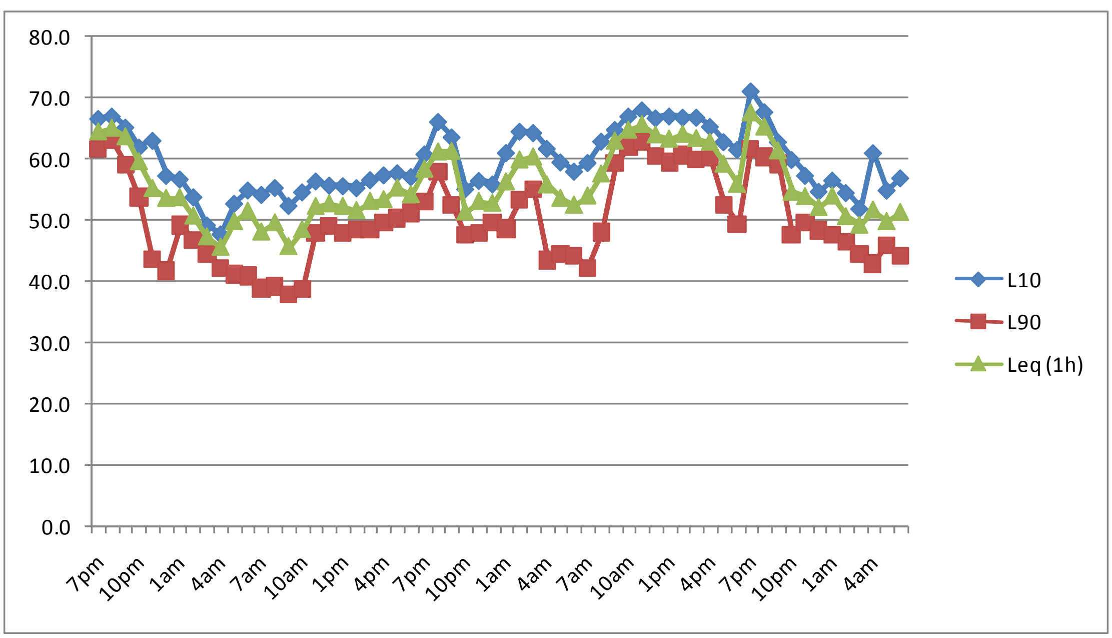


Figure 45 L10, L90 and Leq (1h) graph for Factories Corporation of Jamaica Garmex Freezone noise station (August 1st – 4th,, 2009)

4.9 Historical and Cultural Resources

There are 8 known historic sites within 2km of the proposed site. The sites are:

i. The Kingston Railway Station which was constructed in 1845 was built along the Jamaican/Georgian lines of architecture. It was constructed on a grand scale, symbolizing the economic importance of the city of Kingston as the centre of trade.

ii. The Ward Theatre which was a gift to the city of Kingston in 1912 by Colonel Charles Ward who was the Custos of Kingston then.

iii. The Kingston Parish Church was erected around 1911 on the foundations of the original church. With the exception of the tower, the present structure is similar in design to the original building which was destroyed in the 1907 earthquake. The clock tower was added after World War 1 in memory of those who had died in the war. It is said that the clock tower gave rise to the saying that describes true Kingstonians 'born under the clock', that is, those born within site of the Church's clock tower.

iv. The Institute of Jamaica was established in 1879 during the governorship of Sir Anthony Musgrave, for the encouragement of Literature, Science and Art. It was regarded as the chief agency designed to help Government in the promotion and preservation of culture in the island. Originally established in 1879 as the Science Museum, the Natural Science section of the Institute became known as the Natural History Division in 1974. It is the repository of the national collection of flora and fauna. The Museums Division of the Institute was created in 1976. It has the responsibility for thousands of artifacts and other displays of relevance to the history of Jamaica. The National Library was established in 1979. It is based on the collection of the older West India Reference Library founded in 1879. Its primary function is the collection and preservation of publications of cultural and historical importance.

v. East Queen Street Baptist Church is one of several historic churches in Kingston. Dedicated on January 22, 1822, the church had the largest Baptist membership in the world (2937 members) at the time of its dedication.

vi. National Heroes Park stands on lands that were once one of the most popular spots in Kingston. For 101 years, the land was the centre for horse racing in Jamaica. It was also the site for other sporting activities such as cricket and cycle racing. Being a place where people naturally gathered, the area was also the venue for travelling circuses that visited the island from time to time.

In its long history, several interesting events are associated with the site. These include:

a) August 2, 1838, grand festivities marking the end of apprenticeship and the beginning of full freedom were held here.
b) Queen Victoria's Golden and Diamond Jubilees were honoured here in 1887 and 1897 respectively.
c) The Jamaica National Exhibition was held from January 27, to May 2, 1891, in a building called Quebec Lodge. This site is now occupied by the Wolmer's School.
d) In 1953, the Kingston Race Course was renamed the George VI Memorial Park in honour of the late King George VI, father of Queen Elizabeth II. The grounds were prepared for the Queen's first visit to the island.
e) In the same year, a War Memorial to honour those who died in the First World War was removed from its original location at Church Street and relocated here. Each year, on Remembrance Day, the first Sunday in November, veterans gather around the Cenotaph to honour the memory of those who died in World Wars I & II.
f) The site was officially renamed the National Heroes Park in 1973 and is now a permanent place for honouring our heroes whose monuments are erected in an area known as the Shrine.
g) Another section, reserved for prime ministers and outstanding patriots, adjoins the Shrine area, to the north.

vii. St. William Grant Park named in honour of the 1938 labour leader William Grant who was an associate of the Rt. Excellent Sir Alexander Bustamante, National Hero and former Prime Minister. The Park was previously known as Victoria Park in honour of Queen Victoria of England, but after Independence the name was changed. In the Park are several monuments, the principal one, being that of Queen Victoria. To the north of the Park is the statue of National Hero, Rt. Excellent Norman Manley and to the south is the statue of the Rt. Excellent Sir Alexander Bustamante.

viii. The old Jewish Cemetery at 1 Hunt's Bay in St. Andrew, is an important landmark in the history of Jamaica as it is the oldest denominational cemetery on the island and is one of the oldest Jewish cemeteries in the Western' Hemisphere.

It was founded by the Jews of Port Royal in the latter part of the seventeenth century when a Jewish community flourished there. Port Royal was an impressive commercial centre. Jews who arrived there took a prominent part in its activities. The Jews excelled in the trade of gold and silver, and in money changing.

Those buried in the cemetery were brought by rowing boats from Port Royal. It appears that no bodies were taken to the Hunt's Bay cemetery after the eighteenth century since the latest tomb that of Moses Ferro, bears the date 1771. In 1938, the cemetery was re-consecrated by Rabbi Silverman, a spiritual leader of the Jewish community and on that occasion Sir Edward Denham, then Governor of Jamaica, spoke of the need for the preservation of the ancient landmarks of the colony of which Hunt's Bay was one. Today the cemetery has again fallen into disrepair. Many of the old tombs have a: trilingual inscription - Portuguese, Hebrew and English.

The oldest tomb is believed to be that of Abraham Gabay who died 6 NISAN 5432 (6th April, 1672). Other tombs dating from the seventeenth century are those of Isaac Narbaes 1686, Esther Baruh 1689 and Rachael de Castro 1696. Many of the tombs have a rose and hourglass, symbolic of life's fleeting hours chiselled on the stones. Others have a tree being cut down by a hand bearing an axe, while others a skull and crossbones.

The Jamaica National Heritage Trust declared the Old Jewish Cemetery national monument on July 15, 1993.

Source: The Sunday Herald May 12-18, 2002

The information was sourced from http://www.jnht.com/parish.php?ph=Kingston.

4.10 Socio Economics

The Social Impact Area (SIA) for this study was demarcated as two (2) kilometres from the proposed power plant location. This is outlined in the map below (Figure 46).

4.10.1 Introduction

4.10.1.1 Methodology

Fifty questionnaires were administered randomly throughout the study area (Appendix 6). In addition, windscreen surveys were conducted in the communities to verify and update the information on the maps. Historical socioeconomic data were obtained from the 2001 population census.

Population was calculated using the formula [$i2 = i1 (1 + p)^x$]; where i1 = initial population, i2 = final population, p = actual growth rate and x = number of years. 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. Domestic garbage generation was calculated at 4.11 kg/household/day (National Solid Waste Management Authority).

Considerable amounts of information presented in this section were gleaned from Community Profiles for Tivoli Gardens and Denham Town compiled by the Social Development Commission (SDC) in April 2009. Tivoli Gardens and Denham Town are the two main communities within the SIA and thus general conclusions resulting from these profiles may be considered representative of the SIA.

Figure 46 Map showing the Social Impact Area (SIA)

4.10.1.2 Demography

The total population within the SIA in 2001 was approximately 76,643 persons (STATIN 2001 Population Census). Within the SIA, the 15-64 years age category accounted for approximately 58% of this population, with the age 0-14 years (~37%) and the age 65 and over category accounting for approximately 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 this population, approximately 12.5% were in the young category and 4.7% were in the 65 years and older category (Table 31).

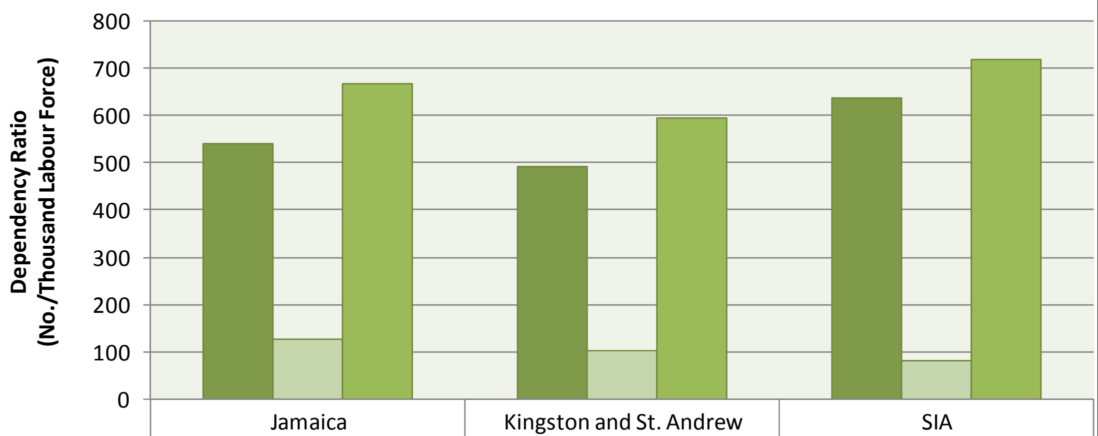
Table 38 shows the percentage composition of each age category to the population. This is compared on a national, regional and local level (at varying distance from the proposed power plant). The data show that the percentage contribution to the population for the 0-14 years category was higher in the SIA (local) when compared to the regional (KSA) and the national figures. The 15-64 and 65 & over years categories were generally lower than the local and national figures however.

Table 38 Age categories as a percentage of the population (Source: STATIN Population Census 2001)

Age Categories	Jamaica (%)	KSA (%)	SIA- 2km (%)	SIA- 1.5km (%)	SIA- 1km (%)	SIA- 0.5km (%)
0-14	32	30.2	37	37.5	38	35.5
15 - 64	60	63	58	57.8	57.3	58.9
65 & Over	8	6.8	5	4.7	4.7	5.6

The sex ratio (males per one hundred females) in the SIA in 2001 was 90.97, which indicates that a higher percentage of the population in the SIA were females. Only the 0-14 years category had more males than females. This sex ratio was lower than the national (Jamaica) (96.9) thus indicating that the national populations has a higher level of males. On the other hand, the SIA sex ratio is comparable to the regional KSA ratio of 90.73.

The child dependency ratio for the SIA in 2001 was 636.7 per 1000 persons of labour force age; old age dependency ratio stood at 80.4 per 1000 persons of labour force age; and societal dependency ratio of 717.1 per 1000 persons of labour force. This indicates that the youth (child dependency) is more dependent on the labour force for support when compared with the elderly. Comparisons of the dependency ratios indicate that the child dependency ratio for the study area (SIA) was higher than the regional and national figures. The old age dependency ratio for the study area was lower than both the regional and national figures, whilst the societal dependency ratios for the study area were higher Figure 47.



	Jamaica	Kingston and St. Andrew	SIA
Child Dependency	539	492.2	636.7
Old Age Dependency	128	102.2	80.4
Societal Dependency	667	594.4	717.1

Figure 47 Comparison of dependency ratios

The growth rate for the Parishes of Kingston and St. Andrew over the last intercensal period (1991-2000) were -0.38% and 2.9 % per annum respectively.

Based on the growth rates, at the time of this study the population was approximately 87,228 persons and is expected to reach 138,370 persons over the next twenty five years, if the current population growth rate remains the same.

In Tivoli Gardens, 65.8% of the total population fall under the age of 30 years and an estimated 39.8 % are below the age of 15. Similarly, in Denham Town, almost 70% of the population is below 30 years of age with 40.7% between 0 and 14 years. These figures for the youthful component of the population (0-14 years) are similar to those estimated for the SIA, all of which are greater than the figures for KSA and Jamaica. Both communities and thus the SIA may be considered as a youthful population. It is interesting to note as well that there were noted to be more male children compared to female children in both communities.

Those aged 65 years and more are considered the "dependent elderly" population and figures for this were estimated to be 3.6% and 2.4% for Tivoli Gardens and Denham Town respectively. Both these figures are lower than that for the country and KSA and this is also seen with the dependent elderly population percentages obtained for the SIA (~5%). Unlike the gender patterns seen for children, there were more females within the elderly group than there were males for both communities.

4.10.1.3 Population Density

The land area within the SIA was calculated to be approximately 8,668,557.17 m^2 (8.67 km^2). With a population of 76,643 persons the overall population density was calculated to be approximately 8,840.02 persons/km^2. This population density is dramatically greater than the regional KSA level, which is at approximately 1422.90 persons/km^2 and the national figure (237.7 persons/ km^2).

4.10.2 Employment and Income

Considerable amounts of information presented in this section were gleaned from Community Profiles for Tivoli Gardens and Denham Town compiled by the Social Development Commission (SDC) in April 2009. Tivoli Gardens and Denham Town are the two main communities within the SIA.

It is estimated that approximately 71% of the Denham Town population was employed, with a slightly lower percentage of 61% in Tivoli Gardens. In the case of Denham Town there appeared to be no significant difference with respect to gender, whilst in the neighbouring area, Tivoli Gardens, employment was found to be slightly higher amongst males. In Denham Town, 52% of the employed household heads were self employed, approximately 31% on a full time basis, 10 % on a part time basis and 6% as contractual workers.

The main economic activities existing within Tivoli Gardens and Denham Town collectively are as follows:

- Shop keeping
- Peddling

- Hair Dressing
- Barbering
- Teaching
- Nursing/ Hospital Attendant
- Janitorial Duties
- Clerks
- Cashiers
- Store Attendants
- Hustling and Juggling
- Higglering
- Office Attendants
- Dress Making
- Cabinet Making
- Construction

In both Denham Town and Tivoli Gardens, and thus representative of the SIA, it was found that females dominated skill areas such as beauty care and service, hospitality and secretarial/office clerk skills. On the other hand, their male counterparts dominated the more technical skill areas such as construction and cabinet making, in addition to the professional category. Retail Trade, Construction and Cabinet Making were the economic sectors that generated the most employment for the two communities within the SIA.

It was reported for Tivoli Gardens that less than 3% of all head of households earned below the minimum monthly wage category, 44% earned between $6,000 -$24,999 JMD per month and approximately 2 % earned in the region of $40,000.00 JMD or more per month. In neighbouring area of Denham Town, a large percentage of household heads did not supply information regarding their monthly earnings. Less than 5% of responders stated that they earned below minimum wage, 22% between $6,000 -$24,999 JMD and 1% between $40000-$79999 JMD. Within the SIA it can be said that the majority of the heads of the households who provided responses earned between $6,000 and $24,999 per month. Common sources of additional income included salaries from other members of the household remittances from overseas and local family and friends.

64% of persons residing Tivoli Gardens below the age of 40 years were unemployed; 30% of which were aged between 14 and 24 years of age. Comparable percentages were found in the case of Denham Town, in which 46% of unemployment was with the youth cohort of 14-24 years. Reasons for unemployment included "no reason", trying to find employment, lack of skills/ qualifications and illness.

4.10.3 Education

The educational attainment of persons four years and older are represented in Table 39. Most persons within the SIA attained a secondary school education followed by those attaining a primary education. The educational statistics of the SIA were similar to the national and parish with the exception that there were a noticeably lower percentage of those attaining a university and other tertiary education in the SIA.

Table 39 Educational attainment as a percentage of the population for persons 4 years and older

Category	Jamaica	Kingston and St. Andrew	SIA
Pre-Primary	4.7	6.8	5.5
Primary	31.2	37.6	25.0
Secondary	49.7	83.8	59.9
University	3.1	11.2	0.6
Other Tertiary	5.9	15.3	0.3
Other	2.8	5.6	3.9
Not Stated	1.7	3.8	3.2
None	0.9	1.1	1.2

As seen below in Table 40, there are 19 schools within the SIA, 7 of which are categorised as primary, 4 as all age, 5 as high and 1 as primary/ high. The locations of these schools are depicted in Figure 48. Also shown in this figure is the high proportion of the population in proximity to the proposed power plant location attaining a secondary education. This suggests that the labour pool is relatively educated, and as such, there should be no problem in obtaining non technical workers from the community by the developers.

Table 40 Schools located within the SIA (Source: Mona GeoInformatics Institute)

Name	Type	Parish
Greenwich Primary	Primary	St. Andrew
Trench Town Primary	Primary	St. Andrew
Jones Town Primary	Primary	St. Andrew
St. Andrew Primary	Primary	St. Andrew
Allman Town Primary	Primary	Kingston
Iris Gelley Primary	Primary	St. Andrew

Name	Type	Parish
Chetolah Park Primary	Primary	Kingston
Denham Town Primary / High	Primary / High	Kingston
Boys Town All Age	All Age	Kingston
Greenwich All Age	All Age	St. Andrew
Central Branch All Age	All Age	Kingston
Whitfield All Age	All Age	St. Andrew
St. Anne's High	High	Kingston
Charlie Smith High	High	St. Andrew
Tivoli Gardens High	High	Kingston
Trench Town High	High	St. Andrew
St. Annie's School	NA	Kingston
St. Andrew Technical	High	Kingston

According to Community Profiles created by the Social Development Commission (SDC) in April 2009, approximately 70% of all households in Tivoli Gardens and 72% in Denham Town indicated that there was a member enrolled in an educational institution, the majority of which were enrolled in primary/ prep level institutions. A sharp decrease in the number of persons enrolled in educational institutions beyond the secondary level was noted. This decrease is also reflected in the educational attainment of the population in the SIA in educational levels above the secondary level.

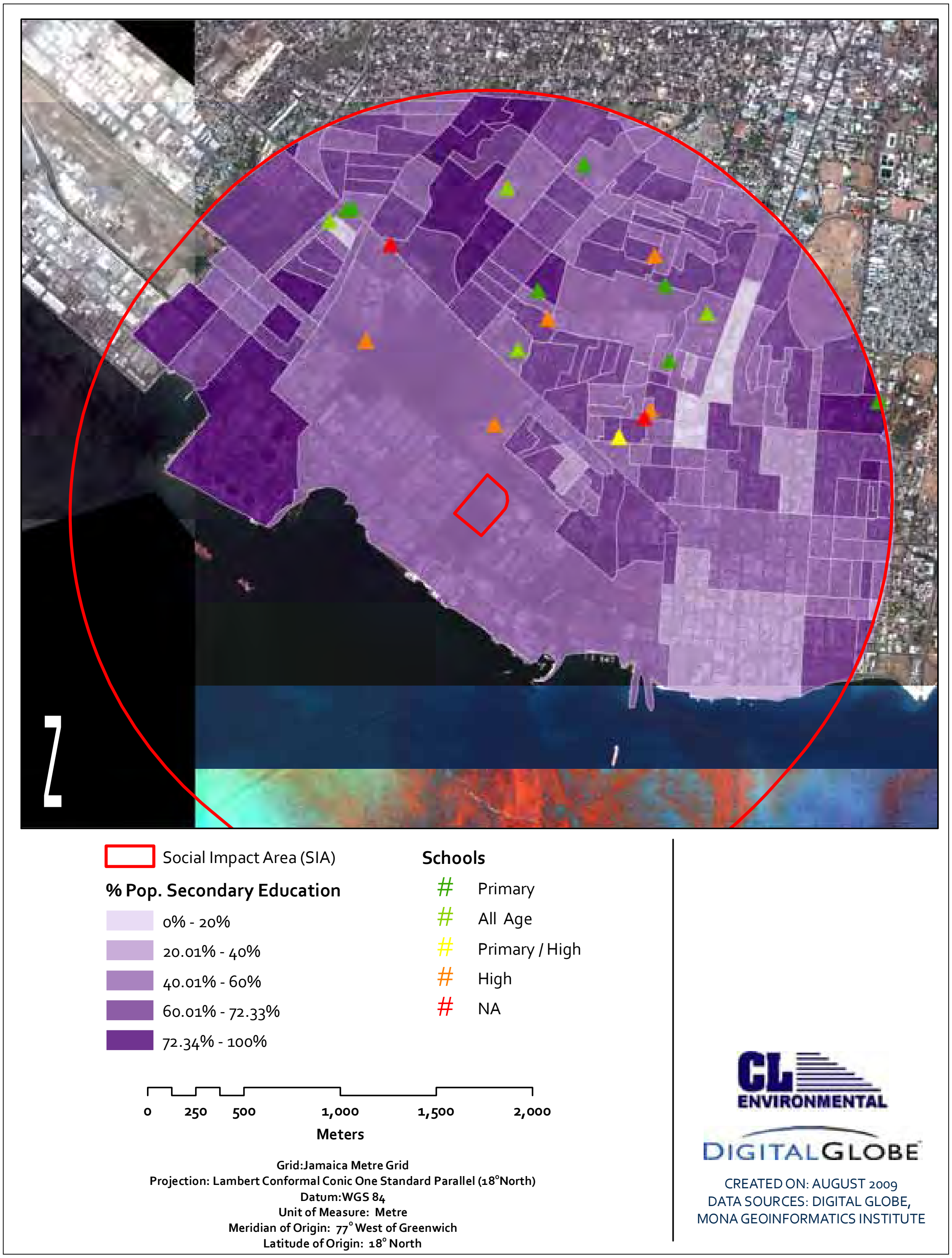


Figure 48 Percentage population attaining a secondary education

4.10.4 Housing

For the purposes of this study the definition of housing unit, dwelling and household are those used in the conduct of the population census conducted by the Statistical Institute of Jamaica. This 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 10,439 housing units, 23,042 dwellings and 23,706 households within the SIA in 2001. The average number of dwelling in each housing unit was 2.21 and the average household to each dwelling was 1.03. The average household size in the SIA was 3.45 persons/household (Table 41).

A comparison of the SIA and national and regional ratios indicate that they were generally similar except for the higher dwelling/housing unit ratio in the SIA and the higher regional (parish) average household size.

Table 41 Comparison of national, regional and local housing ratios (Source: STATIN Population Census 2001)

	Jamaica	Kingston and St. Andrew	SIA
Dwelling/Housing Unit	1.2	1.47	2.21
Households/Dwelling	1.03	1.05	1.03
Average Household Size	3.48	3.38	3.45

Approximately 54% of the housing units in the SIA were of the separate detached type, 41.3% were attached, 1.9% part of a commercial building, 0.9% categorized as other, 0.3% improvised housing, and 1.4% did not state.

The majority of the households in the SIA in 2001 used 1-2 rooms for sleeping (91.0%). Approximately 5.4% of the households occupied three rooms, 1.4% used four rooms 1.8% used five rooms and 0.2% did not report the number of rooms used for sleeping. Most of the households (58.5%) used one room for sleeping.

According to Community Profiles created by the Social Development Commission (SDC) in April 2009, the most occurring number of persons living in a household in Tivoli Gardens is three. Single person households account for an estimated 15 % of households and households with five and more persons account for 37.3% of all households. The average household size is 4.1 in Tivoli Gardens and 3.9 in Denham Town, both of which are slightly greater than the national estimate of 3.3 persons. This exceedance of the national estimate for household size may be expected of the SIA.

Greater than half of the household heads in Denham Town and Tivoli Gardens were female according to the SDC Community Profiles (58% and 62.2% respectively) and this is noted to exceed the figure for female headed households in the Downtown Development Area (DA) and the KMA.

In Denham Town and Tivoli Gardens, according to the 2009 SDC Community profiles, the majority of dwellings were constructed using block and concrete (62.4% and 51% respectively), with the second highest majority using board (32% and 40% respectively). It was suggested that those built using board are primarily the Board Villas which were initially constructed for temporary housing but are now being used permanently.

Approximately 48% of the household heads in Denham Town whilst a much lower percentage of 25% of household heads in Tivoli Gardens stated that there dwellings were in "good" condition. The majority of the household heads in Tivoli Gardens believed that the condition of their houses were "very poor" (34.5%) and it was suggested that this is perhaps owing to the poor maintenance by residents rather than building type as most structure are concrete.

4.10.4.1 Land Tenure

In 2001, 7.6% of the households in the SIA owned the land on which they lived. Approximately 1.0% leased the land on which they were, 10.5% rented, 9.8% lived rent free, 1.0% "squatted" and 0.4% had other arrangements. An extremely high percentage (69.7%) did not report the type of ownership arrangements they had, probably due to informal arrangements ("squatting"), to which they did not want to admit to (Table 42).

There are a drastically lower percentage of households in the SIA owning the land they are living on compared to the national and regional setting. In general, the lower percentages seen for all land tenure categories when compared to the national and regional scales is largely influenced by the fact that over half of the households opted not to state their living arrangement.

Table 42 Percentage household tenure nationally, parish and SIA (Source: STATIN Population Census 2001)

Category	Jamaica	Kingston and St. Andrew	SIA
Owned	37.5	25.1	7.6
Leased	5	4.7	1.0
Rented	14.8	17.9	10.5
Rent free	17	10.4	9.8
Squatted	2.9	2.4	1.0
Other	0.9	0.9	0.4
Not Reported	21.9	38.4	69.7

4.10.5 Infrastructure

4.10.5.1 Lighting

The regional and study area data were generally similar; however there is a lower percentage of households in Jamaica using electricity when compared with the regional and SIA households. There was an approximately fivefold increase in the households using kerosene in Jamaica as their main means of lighting, when compared with the regional and SIA context. Table 43 details the percentage of households using a particular category of lighting.

Table 43 Percentage households by source of lighting (Source: STATIN Population Census 2001)

Category	Jamaica	Kingston and St. Andrew	SIA
Electricity	87	95.5	96.1
Kerosene	10.6	2.0	1.6
Other	0.4	0.2	0.2
Not reported	2	2.1	2.1

4.10.5.2 Telephone/Telecommunications

The parishes of Kingston and St. Andrew and the study area are served with landlines provided by Cable and Wireless Jamaica Limited. Wireless communication (cellular) is provided by Cable and Wireless, Digicel Jamaica Limited and Claro Jamaica Limited.

It is not anticipated that there will be any problems as it relates to the provision of telephone service to the proposed development.

4.10.5.3 Domestic Water Supply

Approximately Ninety One percent (91.3%) of the households within the SIA received their domestic water supply from the National Water Commission (NWC) (Table 44). This public agency is responsible for providing Jamaica's domestic water supply. Water demand for the SIA is estimated to be 19,811,223 litres/day (≈5,233,571 gals/day) and is expected to increase to 31,426,594 litres/day (≈8,302,028 gals/day) over the next twenty five years.

Table 44 Percentage of households by water supply (Source: STATIN Population Census 2001)

	Category	Jamaica	Kingston and St. Andrew	SIA
Public Source	Piped in Dwelling	43.8	64.6	37.4
	Piped in Yard	16.3	20.5	51.4
	Stand Pipe	10.5	3.7	2.5
	Catchment	1.9	0.4	0.0
Private Source	Into Dwelling	6.3	4.9	4.5
	Catchment	9.9	0.6	0.0
	Spring/River	4.6	0.9	0.0
	Other	4.5	1.6	0.0
	Not Reported	2.2	2.6	2.4

The proposed plant will obtain potable water from the NWC (Appendix 7) and from private arrangements with bottled water suppliers.

It is estimated that the total water required for use on the plant is 38.17 cubic metres per day (≈10,083.45 gals/day).

4.10.5.4 Wastewater Generation and Disposal

It is estimated that approximately 15,848,978 litres/day (≈4,186,857 gals/day) of wastewater is generated within the study area and is expected to increase to 25,141,275 litres/day (≈6,641,622 gals/day) over the next twenty five years.

Within the SIA a higher percentage of households used water closets or had no facilities when compared to the national and parish data (Table 45). Of interest as well is the lower percentage of the SIA utilising pit latrines when compared to the national and regional data for 2001.

Table 45 Sewage disposal methods as a percentage of the households (Source: STATIN Population Census 2001)

Method of Disposal	Jamaica	Kingston and St. Andrew	SIA
Pit Latrine	37.9	10.7	3.2
Water Closet	58.2	85.5	91.6
Not Reported	1.4	1.7	1.5
No Facility	2.5	1.7	3.3

Wastewater Flows from the Proposed Power Plant (Predicted)

The plant will generate sewage and trade effluent, both will be sent to the NWC sewerage system (Appendix 6) with ultimate treatment and disposal at Soapberry Wastewater Treatment Plant. This plant has the capacity to treat approximately 18 million gallons of wastewater daily and of which approximately 40% of its capacity is currently being used. The addition of the proposed project will not have the potential to negatively impact the collection and treatment of wastewater.

The wastewater flows are derived from different sources on the plant and will therefore have different types and/or levels of pollutants. The diagram in Figure 49 was provided by the manufacturers of the proposed plant and shows a schematic of the expected water balance on the plant, from input/demand to waste. The recommended intake is approximately one and a half cubic metre per hour (1.59 m^3/hr).

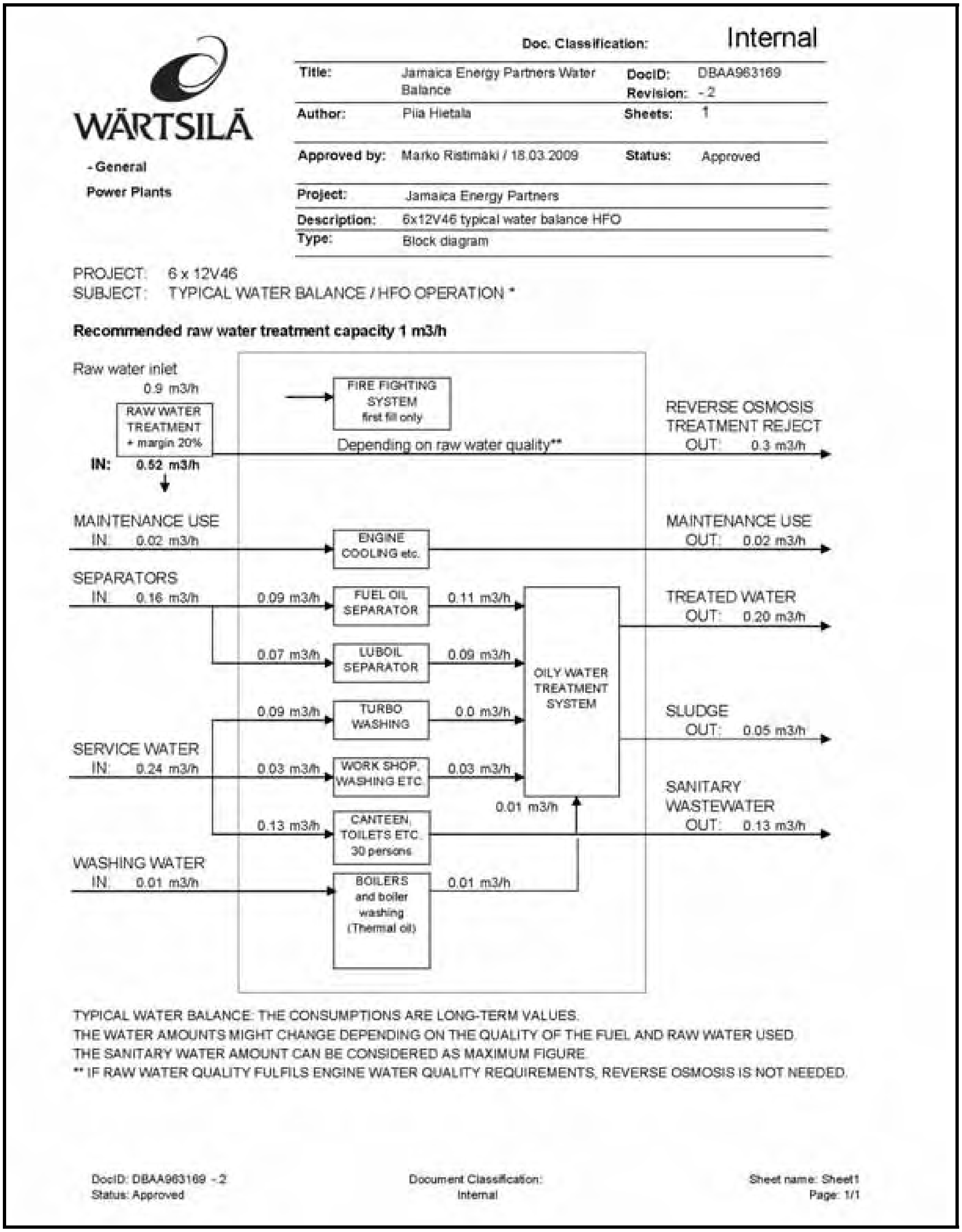


Figure 49 Water balance on proposed JEP plant on Industrial Terrace

The recommended total water required for use is on the plant is 38.17 cubic metres per day, which is approximately 77% greater than the 21.53 cubic metres expected for wastewater (Table 46).

Table 46 Expected water balance for the plant taken from manufacturer's water balance diagram

Plant water Demand Water Consumption		
	Flow	
System	m3/h	m3/day
RO feed water	1.59	38.17
Maintenance use	0.02	0.48
Separators	0.16	3.84
Service water	0.24	5.76
Washing water	0.01	0.24
SCR	0.69	16.57
Total	**1.59**	**38.17**
Plant Effluent Generation		
	m3/h	m3/day
RO Reject	0.48	11.45
Maintenance use - make up for cooling etc	0.02	0.48
Oily water separator	0.20	4.80
Sanitary waste water	0.20	4.80
Total	**0.90**	**21.53**

RO REJECT

The water supply for the overall processes will be sourced from the NWC mains. The manufacturer has established water quality standards for feed water to the plant which were compared to the quality of the water supplied by the National Water Commission. The results show that the hardness of the water far exceeds the maximum to be used in the plant processes (Table 47). It is expected that the RO plant will bring this raw water into specification.

Table 47 Comparison of the NWC water quality to that required for the plant processes

Substance	NWC Water	Engine cooling, turbine washing and separators	Unit
General appearance		Visually clear and colourless. No smell.	
pH at 25 °C		> 6,5	
Conductivity at 25 °C		< 100	mS/m
TDS	425		mg/l
Total hardness TH	426.3	< 10	°dH
Alkalinity HCO3			mg/l
p-alkalinity			mval/l
Oxygen O2	-		mg/l
Iron Fe and copper Cu	0.138		mg/l
Silica SiO2	-	< 50	mg/l
Organics (KMnO4 value)	-		mg/l
Oil	-		mg/l
Chlorides Cl	74.3	< 80	mg/l
Phosphates	0.23		mg/l
Sulphates SO4	57.6	< 150	mg/l
Sodium + potassium Na+K	46.2		mg/l
Suspended solids	1	< 10	mg/l

Typically, 60 to 80 percent of the water supplied to the RO unit would leave the unit as treated water (product). The other 20 to 40 percent would leave the unit as reject, approximately 98 percent of the impurities would be removed from the feed water, however, the percentage of impurity removed would vary based on the contaminant being removed. The resulting reject water will be approximately 2.45 to 4.9 times as concentrated as the feed water assuming 98% contaminant removal. The estimation of the concentration of the reject water is outlined in Table 48 and Table 49. The results were compared to the NEPA trade effluent standards and the results show:

- The concentration of the parameters in the RO reject water exceeds both the NWC and FCJ well feed water by a factor of 4.92 when 98 percent of the impurities are rejected by the RO plant.
- When compared to the NEPA trade effluent standards, nine of the thirty five parameters exceeded the minimum concentration.
- Two of the parameters from the NWC water exceeded the TES minimum concentration

Given that the source water is polluted, the client should apply to NEPA for relaxation of the standards for discharging this waste.

Table 48 Estimation of reject and product water concentration after NWC water passes through after RO plant

Parameters	NEPA Trade Effluent	NWC Feedwater	Product water	Reject water
Ammonia (mgN/l)	1.0	0.020	0.0004	0.098
Barium (mg/l)	5.0			
Beryllium (mg/l)	0.5			
Boron (mg/l)	5.0			
Calcium (mg/l)	none	99.7	2.0	490.5
Chloride (mg/l)	300.0	74.3	1.5	365.6
Colour (Pt-co)	100.0	15.0	0.3	73.8
Detergent (mg/l)	15.0	0.7	0.0	3.5
Fluoride (mg/l)	3.0	0.1	0.0	0.6
Iron (µg/l)	3000.0	107.0	2.1	526.4
Magnesium (mg/l)	none	15.5	0.3	76.3
Manganese (µg/l)	1000.0	20.0	0.4	98.4
Nitrates (mg/l)	10.0	8.8	0.2	43.4
Oil and Grease (mg/l)	10.0	2.0	0.0	9.8
Phenols (mg/l)	0.1			
Total Phosphate (mg/l)	5.0	0.2	0.0	1.1
Sodium (mg/l)	100.0	46.2	0.9	227.3
Sulphate (mg/l)	250.0	57.6	1.2	283.4
Total Dissolved Solids (mg/l)	1000.0	425.0	8.5	2091.0
Total Organic Compounds (mg/l)	100.0	148.0	3.0	728.2
Total Suspended Solids (mg/l)	150.0	1.0	0.02	4.9
Biochemical Oxygen Demand (mg/l)	<30	2.0	0.04	9.8
Chemical Oxygen Demand (mg/l)				
Faecal Coliform (MPN/100ml)	100.0	7.4	0.1	36.2
Residual Chlorine (mg/l)		0.1	0.001	0.2
HEAVY METALS				
Arsenic (µg/l)	500.0	10.0	0.2	49.2
Cadmium (µg/l)	100.0	20.0	0.4	98.4
Chromium (µg/l)	1000.0	20.0	0.4	98.4
Copper (µg/l)	100.0	31.0	0.6	152.5
Cyanide (mg/l)	0.2			
Lead (µg/l)	100.0	20.0	0.4	98.4
Mercury (µg/l)	20.0	0.5	0.0	2.5
Nickel (µg/l)	1000.0	20.0	0.4	98.4
Selenium (µg/l)	500.0	39.0	0.8	191.9
Silver (mg/l)	100.0			
Tin (mg/l)	none			
Zinc (mg/l)	1.5	74.0	1.5	364.1

Table 49 Estimation of reject and product water concentration after FCJ water passes through after RO plant

Parameters	NEPA Trade Effluent	FCJ well	Product water	Reject water
Ammonia (mgN/l)	1.0	0.16	0.0032	0.787
Barium (mg/l)	5.0	0.52	0.0104	2.558
Beryllium (mg/l)	0.5	ND		
Boron (mg/l)	5.0	ND		
Calcium (mg/l)	none	113	2.3	556.0
Chloride (mg/l)	300.0	70.5	1.4	346.9
Colour (Pt-co)	100.0	15	0.3	73.8
Detergent (mg/l)	15.0	1.67	0.0	8.2
Fluoride (mg/l)	3.0	0.15	0.0	0.7
Iron (µg/l)	3000.0	20	0.4	98.4
Magnesium (mg/l)	none	25.6	0.5	126.0
Manganese (µg/l)	1000.0	20	0.4	98.4
Nitrates (mg/l)	10.0	86	1.7	423.1
Oil and Grease (mg/l)	10.0	1.67	0.0	8.2
Phenols (mg/l)	0.1	ND		
Total Phosphate (mg/l)	5.0	0.56	0.0	2.8
Sodium (mg/l)	100.0	93.5	1.9	460.0
Sulphate (mg/l)	250.0	91.3	1.8	449.2
Total Dissolved Solids (mg/l)	1000.0	643	12.9	3163.6
Total Organic Compounds (mg/l)	100.0	266	5.3	1308.7
Total Suspended Solids (mg/l)	150.0	1	0.02	4.9
Biochemical Oxygen Demand (mg/l)	<30	2	0.04	9.8
Chemical Oxygen Demand (mg/l)				
Faecal Coliform (MPN/100ml)	100.0	4.5	0.1	22.1
Residual Chlorine (mg/l)		0.03	0.001	0.1
HEAVY METALS				
Arsenic (µg/l)	500.0	10	0.2	49.2
Cadmium (µg/l)	100.0	20	0.4	98.4
Chromium (µg/l)	1000.0	20	0.4	98.4
Copper (µg/l)	100.0	10	0.2	49.2
Cyanide (mg/l)	0.2	ND		
Lead (µg/l)	100.0	20	0.4	98.4
Mercury (µg/l)	20.0	0.5	0.0	2.5
Nickel (µg/l)	1000.0	20	0.4	98.4
Selenium (µg/l)	500.0	16	0.3	78.7
Silver (mg/l)	100.0	ND		
Tin (mg/l)	none	ND		
Zinc (mg/l)	1.5	10	0.2	49.2

Air Filter Wash

Intake Air filters (Plate 11) will remove/trap solid particles from the air which enters the combustion engine. Over time the filters will become clogged, reducing the overall air intake efficiency. The filters will need to be cleaned or replaced at intervals of 3 to 6 months depending on the air quality of the surrounding environment.

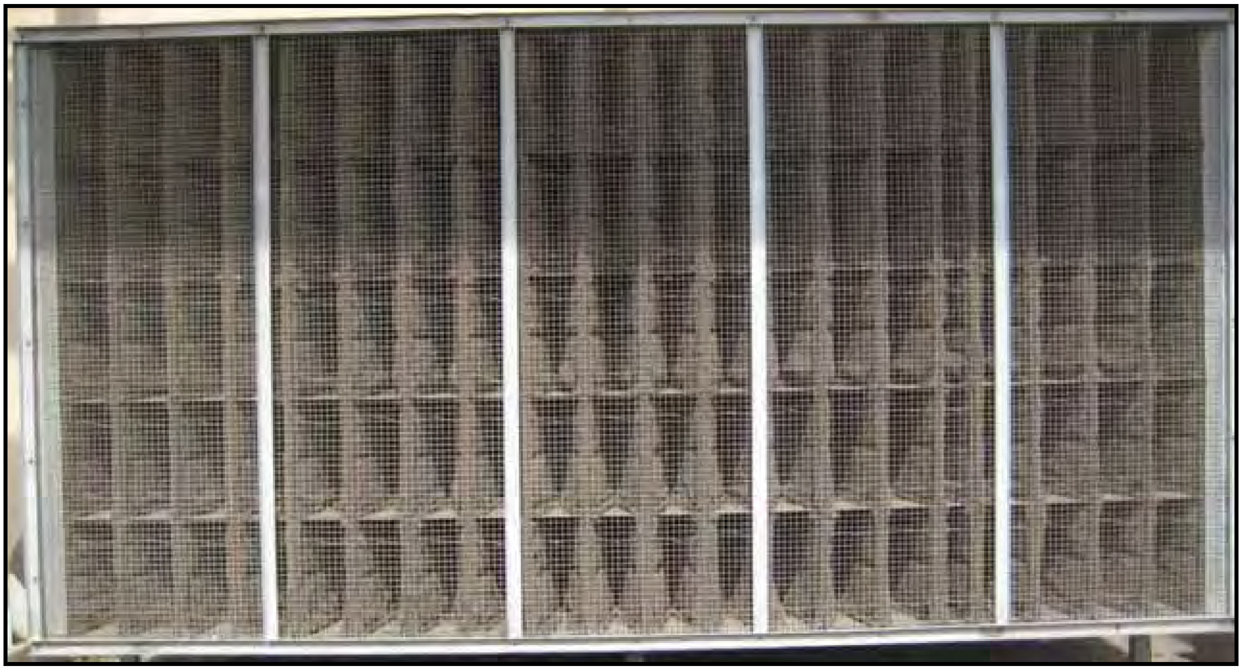


Plate 11 Photo of a typical stack of disposable intake air filters

The types of filter or maintenance requirements were not available at the time of the writing of this report. However, most plants of this type use filters that are disposable. If the designer chooses this type, then the used filters may be disposed of at an approved landfill. Otherwise the filters are washed and the residue/sludge may be sent to an approved landfill.

Oily Water

Oily Water Separator

Oily water on the site will generally originate from two areas, 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 oily water separators and car park runoff will be directed to storm drains which will terminate in oily water separators as well.

Guideline by the Environment Agency for England and Wales recommend Class 1 separators for both circumstances.

These separators are designed to achieve a concentration of less than 5mg/l of oil under standard test conditions, should be used when the separator is required to remove very small oil droplets, such as those arising from car park run-off.

The runoffs in this area will end up in the Kingston Harbour which is at very sensitive area. A full retention separator is recommended for this facility. 'Full retention' separators treat the full flow that can be delivered by the drainage system, which is normally equivalent to the flow generated by a rainfall intensity of 50mm/hr. On large sites, some short term flooding may be an acceptable means of limiting the flow rate and hence the size of full retention systems. Additionally a retention area/"bund" adequately sized could be utilized to hold the excess water in the case of accidents or rainfall which may overwhelm the oily water separator.

4.10.5.5 Solid Waste Generation and Disposal

The National Solid Waste Management Authority is responsible for domestic solid waste collection within the study area. Presently, collection is done twice 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 City landfill located in St. Andrew, approximately 8 km (≈5 miles) west of the proposed power plant.

Solid waste collection for commercial and industrial facilities is done by arrangements by these entities with private contractors.

It is estimated that households in the study area generated approximately 91,305kg (≈ 91.3 tonnes) of solid waste in 2001. Based on the population growth, it has been estimated that at the time of this study, approximately 105,443 kg (≈ 105.4 tonnes) of solid waste was being generated and it is expected that within the next twenty five years, if the population growth rate remains the same, the amount will be 164,841 kg (≈ 164.8 tonnes).

The 2001 census data indicated that approximately 82.3% of the households in the parishes of Kingston and St. Andrew had their garbage collected by public means (National Solid Waste Management Authority), with a higher percentage (89.3%) in the SIA. It also showed that the next preferred method of disposal in the SIA (8%) was by dumping (Table 50 and Figure 50). This solid waste has the tendency to end up in drain and on unoccupied lands.

Table 50 Percentage households by method of garbage disposal (Source: STATIN Population Census 2001)

Disposal Method	Jamaica	Kingston and St. Andrew	SIA
Public Collection	47.7	82.3	89.3
Private Collection	0.5	0.5	0.0
Burn	43	9.9	1.2
Bury	1.2	0.4	0.0
Dump	6	4.5	8.0
Other Method	0.3	0.2	0.1
Not reported	1.3	2.0	1.3

Solid waste generation at the new facility is expected to consist mainly of operational (oily rags, scrap metals etc.) and office waste. This will be collected by private Contractors and transported to the Riverton City landfill for disposal or properly recycled.

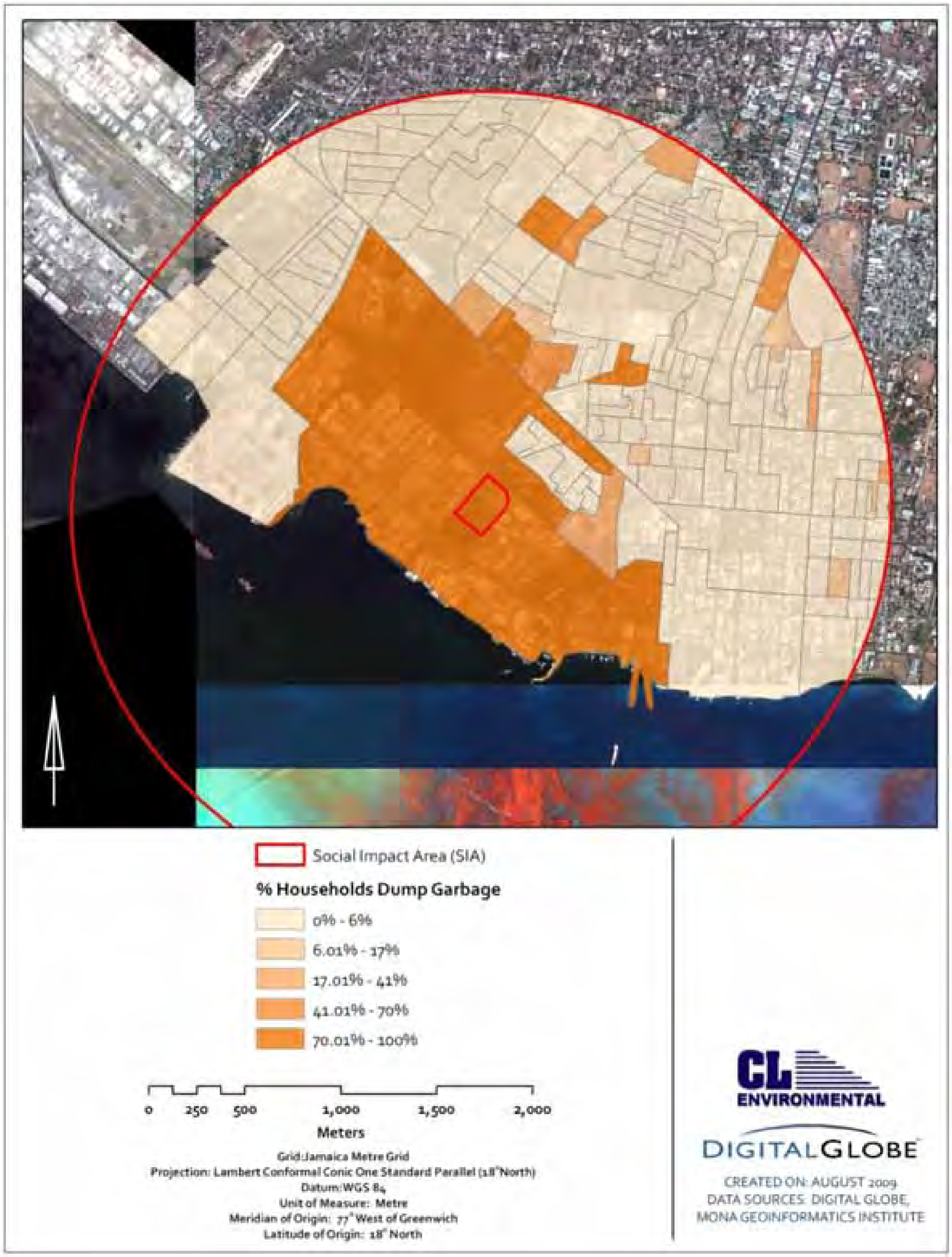


Figure 50 Percentage households in the SIA burning garbage

4.10.5.6 Health Services

There are 3 hospitals within the SIA, namely Victoria Jubilee, Kingston Public and Maxfield Medical (Figure 51), all of which belong to the Southeast Regional Health Authority. Kingston Public Hospital (KPH) and Victoria Jubilee Hospital (VJH) are both publically owned and Type A and S respectively. These 2 hospitals are closer to the proposed site than is Maxfield Medical, which is a private hospital.

Six (6) health centres exist within the SIA, 3 of which are Type III (Majestic Gardens, Denham Town and Operation Friendship), and the remainder Types II (Lenworth Jacobs), V (Slipe Pen Road) and VII (East Queen Street).

In the SDC Community profiles for Denham Town and Tivoli Gardens it is stated that the most frequently identified health facility is the hospital, followed by the health centres/ clinics. Obstacles with accessing the services included the lengthy waiting times, cost constraints and unavailability of medication.

The most common health problems experienced in both communities were lifestyle and respiratory related and included hypertension, asthma, heart diseases, arthritis and diabetes. 56% of households in Denham Town and 47% in Tivoli Gardens reported that a member had a long standing health problem.

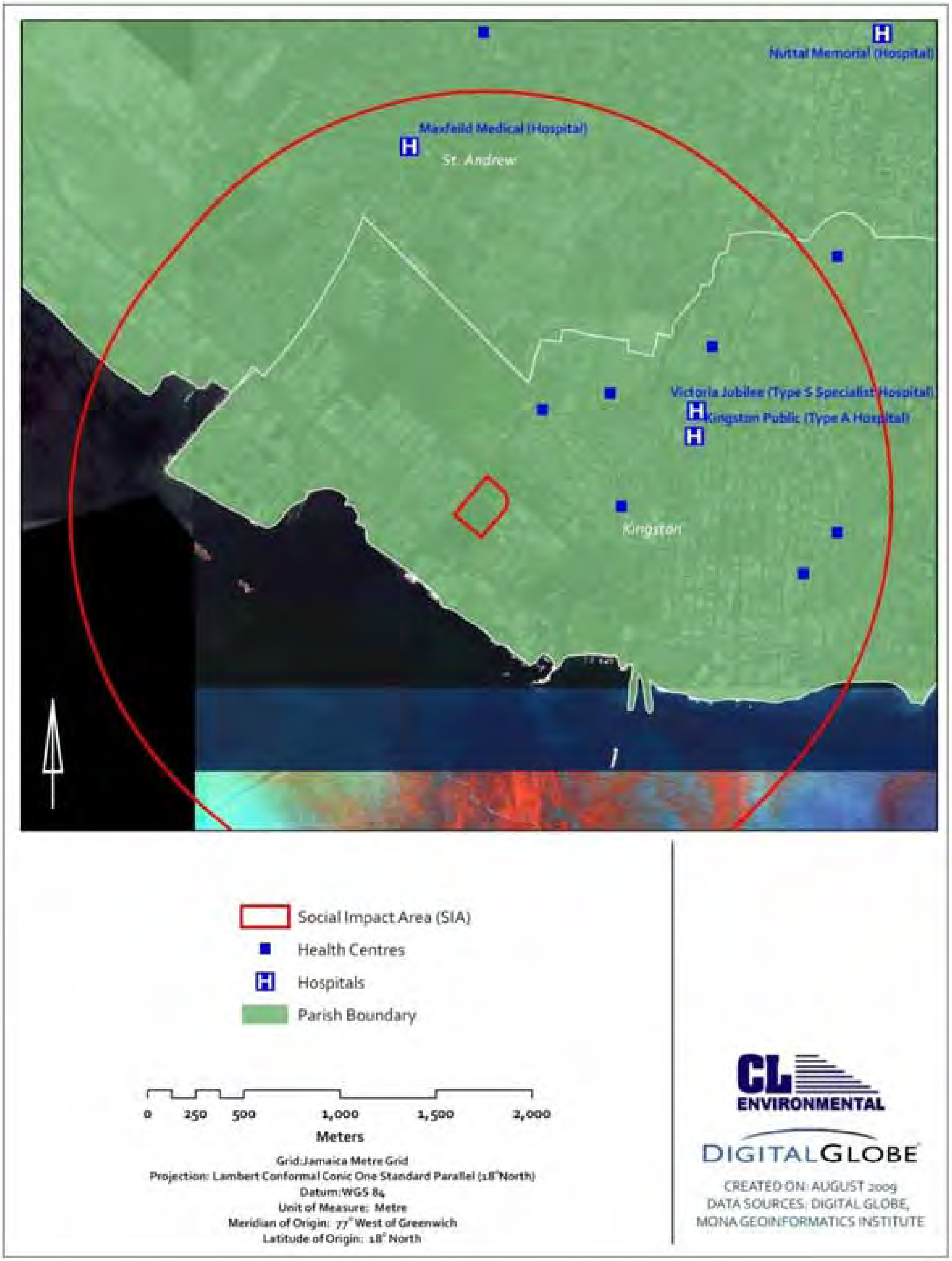


Figure 51 Health services located within the SIA

4.10.6 Other Services

4.10.6.1 Fire Station

There are two (2) fire stations located within the SIA, namely those located at York Park and Trench Town (Figure 52). Both are situated approximately 1.3 km (~0.8 miles) from the proposed development. Currently, Trench Town 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 York Park.

The proposed development will have its own designed fire control system, with a series of indoor hose rack stations, fire hydrants, portable fire extinguishers, foam units and a carbon dioxide system.

4.10.6.2 Police Station

Denham Town and Marine are the 2 police stations found in proximity to the proposed site (~ 0.5 km). Denham Town station would respond at the proposed site. In total however, there are 11 police stations situated within the SIA (Figure 52).

In this area the main crimes are related to hijacking of goods carrying trucks. The police station is adequately staffed.

Most residents in Denham Town considered their community to be very safe. Likewise, there is a general feeling among households that the level of crime experienced in Tivoli Gardens is low and the community is very safe. Approximately 94% of households in Tivoli Gardens and 96% in Denham Town indicated that no one in the household had been a victim of any crimes during the last twelve months.

Robberies, shootings and murder were the more frequent crimes affecting Tivoli Gardens and this accounted for less than 2% of the population. Interestingly In the Community Profile for Denham Town, it was stated that 60% of crimes were unreported.

Approximately 40% of households in Denham Town were stated to be plagued by gangs and gang warfare as a type of public safety issue, whilst this percentage was far less in Tivoli Gardens (less than 2%). The presence of derelict buildings, overgrown lots and absences of street lights in less developed areas were identified as major public safety issues in both communities. An estimated 55% of all households in Tivoli Gardens indicated that they were not affected by any public security issue however.

It is stated in the SDC Community Profiles that Denham Town and Tivoli Gardens communities are served by the Denham Town Police Station at which there are currently 40 police officers assigned to that location and 8 service vehicles.

4.10.6.3 Post Office

Two post offices are situated within the SIA. That located in Denham Town is 0.6 km from the proposed site, whilst that at Kings Street is located 1.4 km from the proposed site (Figure 52). The Denham Town post office would be responsible to serve the areas in proximity to the proposed power plant location.

4.10.6.4 Other Facilities

In addition to the services already outlined, the Tivoli Gardens community is equipped with two playing fields and three hard courts. In addition, as indicated in SDC profile, there are five community based organizations and a partially active Community Development Council. The main stakeholders identified were CSI, SDC, HEART NTA and Jamaica Social Investment Fund (JSIF). In Denham Town, a golden age home, community centre, playing field and two hard courts were stated to exist in addition to the educational institutions, health services and police stations already mentioned. There is one active Community Development Council a partially active community based organization. The main stakeholders in Denham Town are similar to those present in Tivoli Gardens and include the Ministry of National security through the Citizens Security and Justice Programme (CSJP), SDC, HEART Trust/ NTA and JSIF.

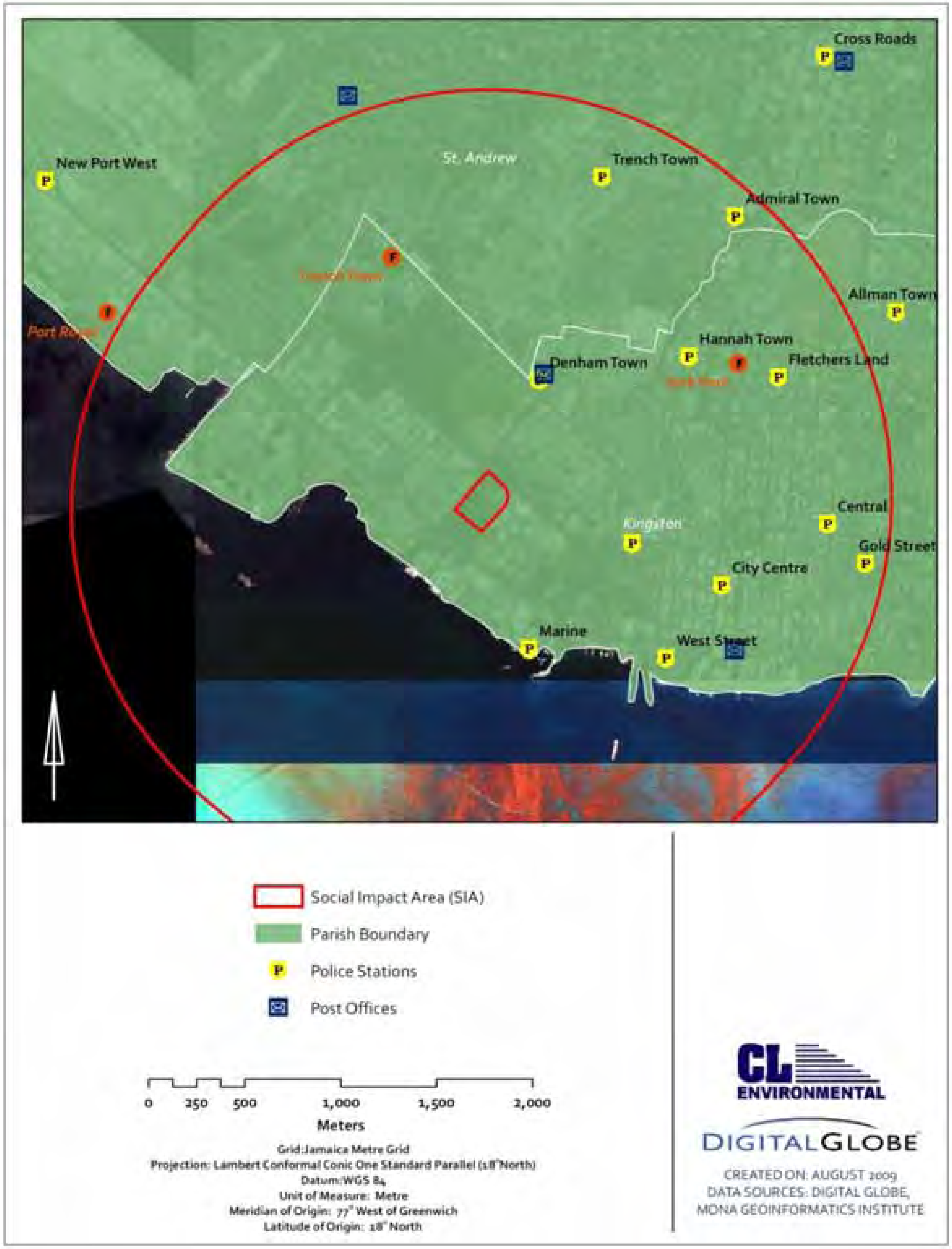


Figure 52 Other services, including post offices, police stations and fire stations within the SIA

4.11 Community Consultation and Perception

Most (67.4%) of those interviewed were not aware of the pending development. Of those who knew about it, all were informed by word of mouth.

Approximately twenty two percent (22.4%) of the respondents said that the existing facility (JPS Hunts Bay) did not impact on their lifestyle in anyway. Approximately twenty two percent (22.5%) indicated that the JPS Hunts facility impacted on their lifestyle positively by providing employment and electricity, 2.1% negatively because of the noise it generates and fifty three percent (53%) did not have an opinion.

Most persons interviewed (63.4%) were of the opinion that the proposed 60 MW West Kingston Power Plant was suitable for the location, 22% did not agree and 14.6% were not sure. When asked how the operation of the JEP 60 MW West Kingston Power Plant would affect their lifestyle, the majority (59.1%) of the interviewees had no opinion, 18.4% said that it would have no effect; 10.2% said it would provide an alternative to JPS, 8.2% had health concerns (include noise impacts and possibility of radiation) and 4.1% did not know how it would affect them.

All of the interviewees were aware of church groups within the SIA.

The majority (60%) of the persons interviewed were not aware of any environmental groups within the area.

Approximately 80% of the community organizations were considered very active, however, approximately 22% of those interviewed indicated that they were actively involved in any community organization.

They have listed the following as their greatest needs;

i. Unemployment

ii. The need for the area to be developed

iii. The need for better roads

Special Interest Groups – (Political Directorate, CDC, NGO's)

They were in support of the proposed development with the proviso that the neither the communities nor the environment are adversely affected.

There were positive feedback from these persons including that the proposed development would result in the general improvement of the environment in that area, increase the electricity supply and reliability to Jamaica and the provision of employment. They however, expressed concerns about the potential for increased asthma, lung cancer and noise.

There was also a suggestion that the surrounding communities, to the proposed site, be intimately involved in the proposed emergency plan.

There was also the concern if the existing National Water Commission sewer system would be able to support the additional demand for wastewater disposal in its present condition.

4.12 Roads and Transportation

Marcus Garvey Drive is the established trucking route for goods or materials being transported along the southern corridor. It is therefore expected that materials being transported to and from the site will utilize this route. Spanish Town Road however is not utilized by trucks because of its present condition. The surface is uneven and bumpy, quite unsuitable for trucks fully laden with materials.

4.12.1 Roads Classification and Capacity

The National Works Agency has developed a table of criteria for the roads in Jamaica, which is the standard against which existing roads were compared. This table is found in the Development Manual[4] as Table 1. Table 51 outlines the NWA Road Classification.

4.12.1.1 Class A – Marcus Garvey Drive

[4] Development and investment Manual, Vol 3, Section 1
Roads, Infrastructure, Drainage and Traffic Management, p.4

Marcus Garvey Drive is classified as a Class A Main road which is maintained by the National Works Agency. Class A roads as described in the development manual are roads of national importance which carry daily traffic volumes in excess of 1,000 vehicles, and link one or more major area/town of the island with other major national regions. Figure 53 shows the location of the NWA road which passes the site.

Marcus Garvey Drive as observed, within 100 metres of the intersection with Industrial Terrace, has two lanes with 1.5m sidewalks and a median. The width of the carriageway on each side of the median was measured at 9.14 meters. This is in comparison to the 7.2m wide carriageway recommended in the Development manual.

Table 51 NWA Road Classification Table

Characteristic	Local (C & PC Roads)	Collector/ (B Roads)	Arterial (A & B Roads)	Major Arterial By-pass/Highways (A Roads)	Expressways/ Motorways
Importance	Roads of local importance	Roads of regional importance	Roads of national importance	Roads of national importance	Roads of national importance
Traffic Movement versus property access	Property access primary function	Traffic movement and property access of equal importance	Traffic movement primary consideration; some property access control	Traffic movement primary consideration; subject to property access control	Traffic movement primary consideration; no property access or control
Average daily traffic (both directions)	< or = 1000	500 - 2000	> or = 1000	> or = 1000	> or = 5000
Desirable connection	Local, collector	Collector, local, arterial	Collector, arterial	Collector, arterial, highways/by-pass	Major arterial, Expressways, highways
Flow characteristics	Interrupted flow (at grade)	Interrupted flow (at grade)	Interrupted flow (at grade)	Limited interruption (at grade)	Very limited interruption (grade separation)
Legal speed limit (km/h)	=50	> = 50	> = 50	= 80	> 80
Accommodation of pedestrian	Side walk on one or both sides	Side walk on both sides	Side walk on both sides	Side walk on both sides	Pedestrians prohibited
Public transportation	Recommended	Permitted (bus stop)	Preferred (bus stop)	Permitted (bus Stop)	Not applicable (bus stop)
Typical right of way width, m	9.14	>=12.2	>= 15.24	> = 23	> = 30

Industrial Terrace

Marcus Garvey Drive & Spanish Town Road

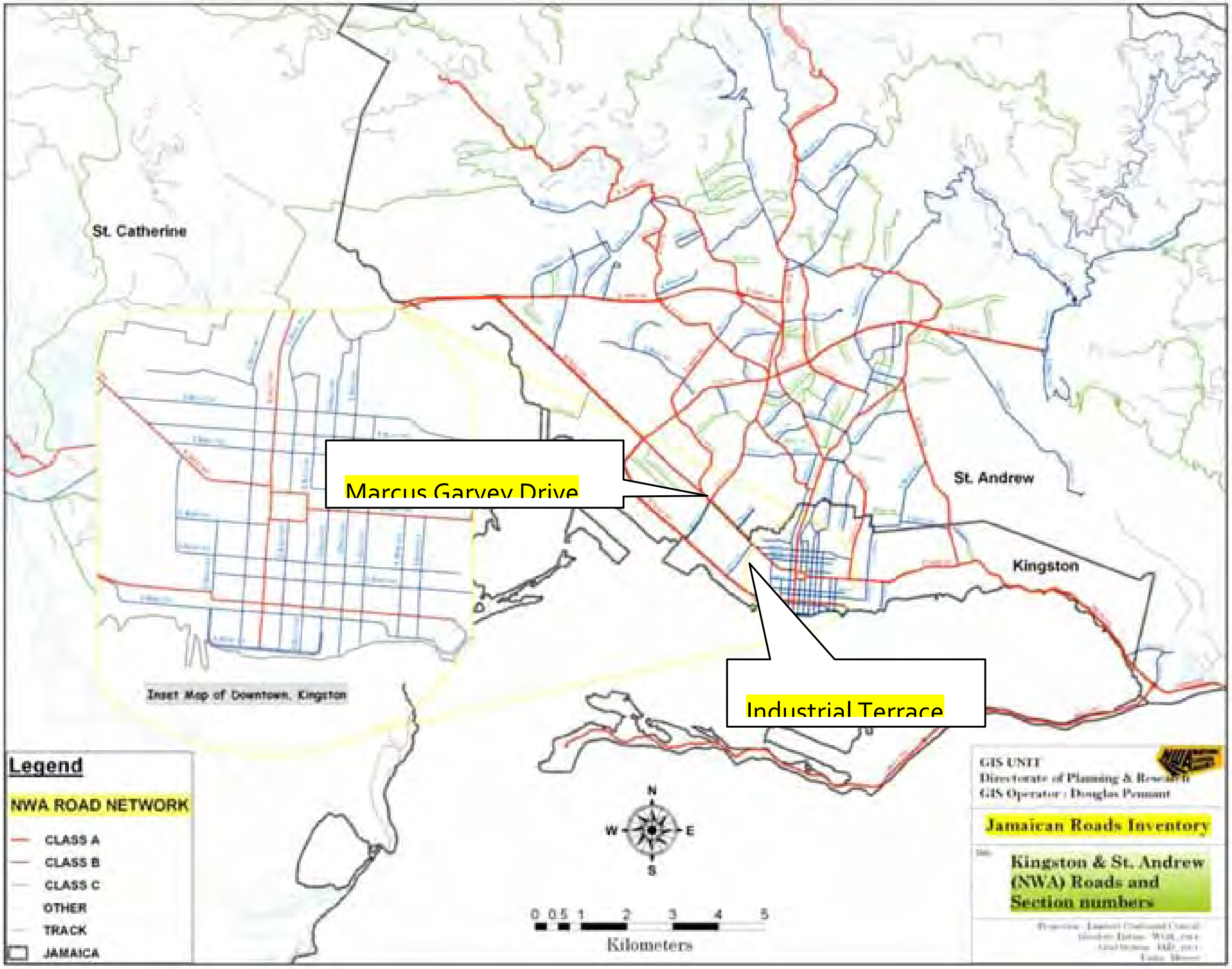


Figure 53 NWA Map of Kingston showing the Classes of NWA roads

The established speed limit for this section of road is 30 miles per hour or 50 kilometres per hour; this is due to the fact that both sides of the road in this area is developed.

The site distance on this road at the intersection is more than 200 metres to the east and 200 to the west.

4.12.1.2 Class B – Collector Road – Industrial Terrace

Industrial Terrace is classified by the National Works Agency as a collector road. These types of roads are those which function mainly to link arterial and local roads and also to access properties. The average daily traffic on these roads typically ranges between 500 and 1000 both ways. The site will be serviced by Industrial Terrace.

The average carriageway width as measured is approximately 8.23 metres. There are 1.2m sidewalks on both sides of the road for over 60% of its length.

The legal speed limits established for roads in developed areas is 50 km/h or 30 mph. The observed sight distance on this road is greater than 100 metres. Plate 12 shows a photo of the road from the intersection.

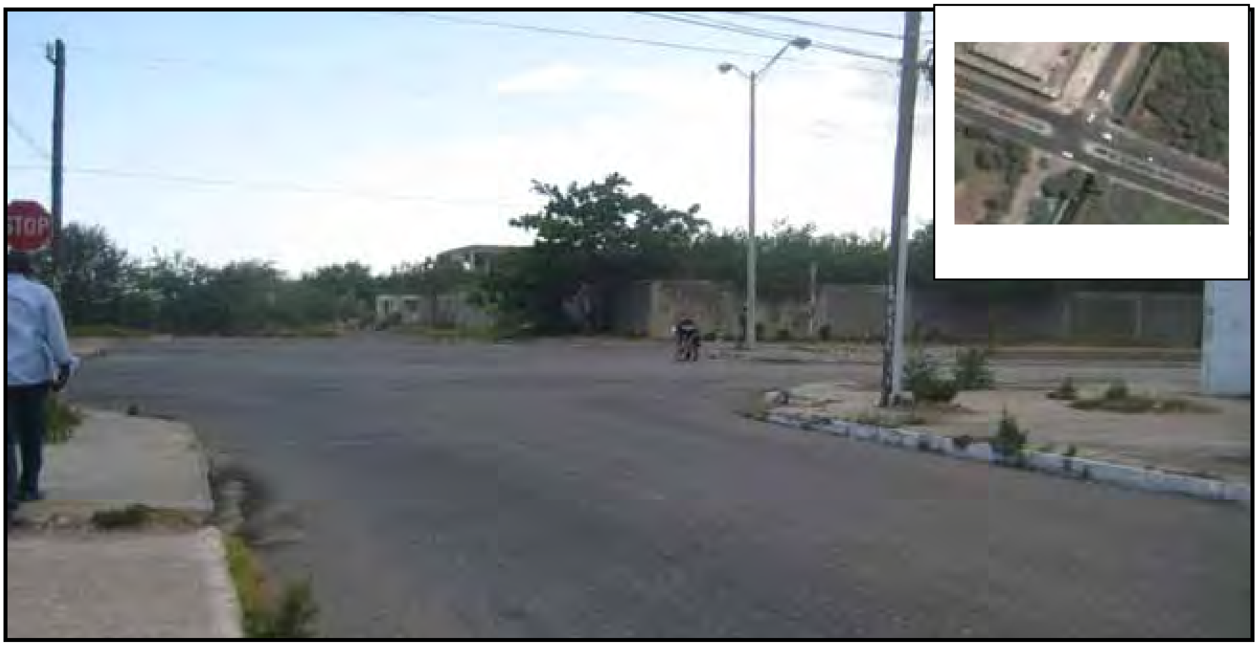


Plate 12 Photo taken on Industrial Terrace showing the intersection of Marcus Garvey drive with Industrial Terrace

4.12.2 Existing Trip Volumes

The traffic count data was obtained from the National Works Agency. This data was obtained by the Agency from a 12 hour continuous manual count done at the intersection of Marcus Garvey Drive and Industrial Terrace in September 2007. The initial raw data was done for 5 minutes intervals for different categories/classes of vehicles – namely; trucks, cars and other.

An overall summary of the data is shown in Table 52. The initial values obtained from the NWA were increased by 3 % per year to yield current figures as recommended by the National Works Agency. The results are also shown in the turning diagram in Figure 54 and graphically in cubic metres.

Table 52 Hourly summary of NWA traffic count data done at the Marcus Garvey drive –industrial Terrace intersection, September 2007

Hour	Industrial Terrace	Marcus Garvey Dr. - E	Marcus Garvey Dr. - W	Hourly Total
7-8 AM	77	903	2113	3094
8-9 AM	109	1112	1772	2993
9-10 AM	155	1078	1266	2498
10-11 AM	193	1102	1030	2325
11-12 PM	217	1171	1084	2473
12-1 PM	161	1174	1020	2355
1-2 PM	144	1368	1328	2840
2-3 PM	198	1449	863	2510
3-4 PM	186	1741	674	2600
4-5 PM	114	1946	657	2716
5-6 PM	63	1421	694	2177
6-7 PM	49	1314	626	1989
12 hour Total	1667	15779	13125	30571

The off-peak period at the intersection is between the hours of 9 am to 1 pm. During this period, the hourly total is below 2500veh/hr. It should also be noted that the hourly volumes fall off very sharply after the evening peak (Figure 55). These periods may be considered suitable for the operation or movement of construction and or delivery vehicles.

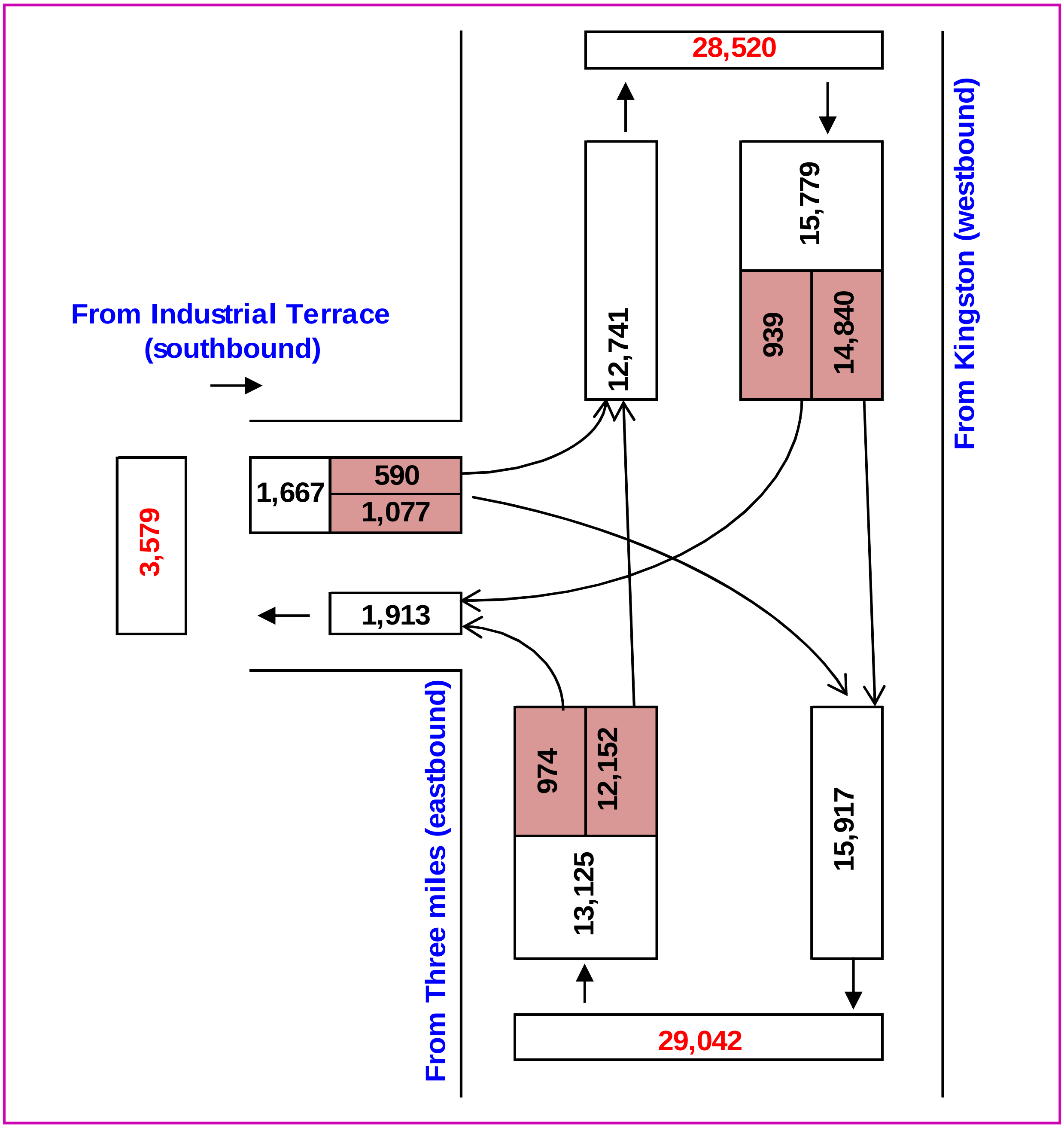


Figure 54 Turning diagram showing the 12-hour summary of NWA traffic count data done at the Marcus Garvey drive –industrial Terrace intersection, September 2007, done between the hours of 7am to 7pm.

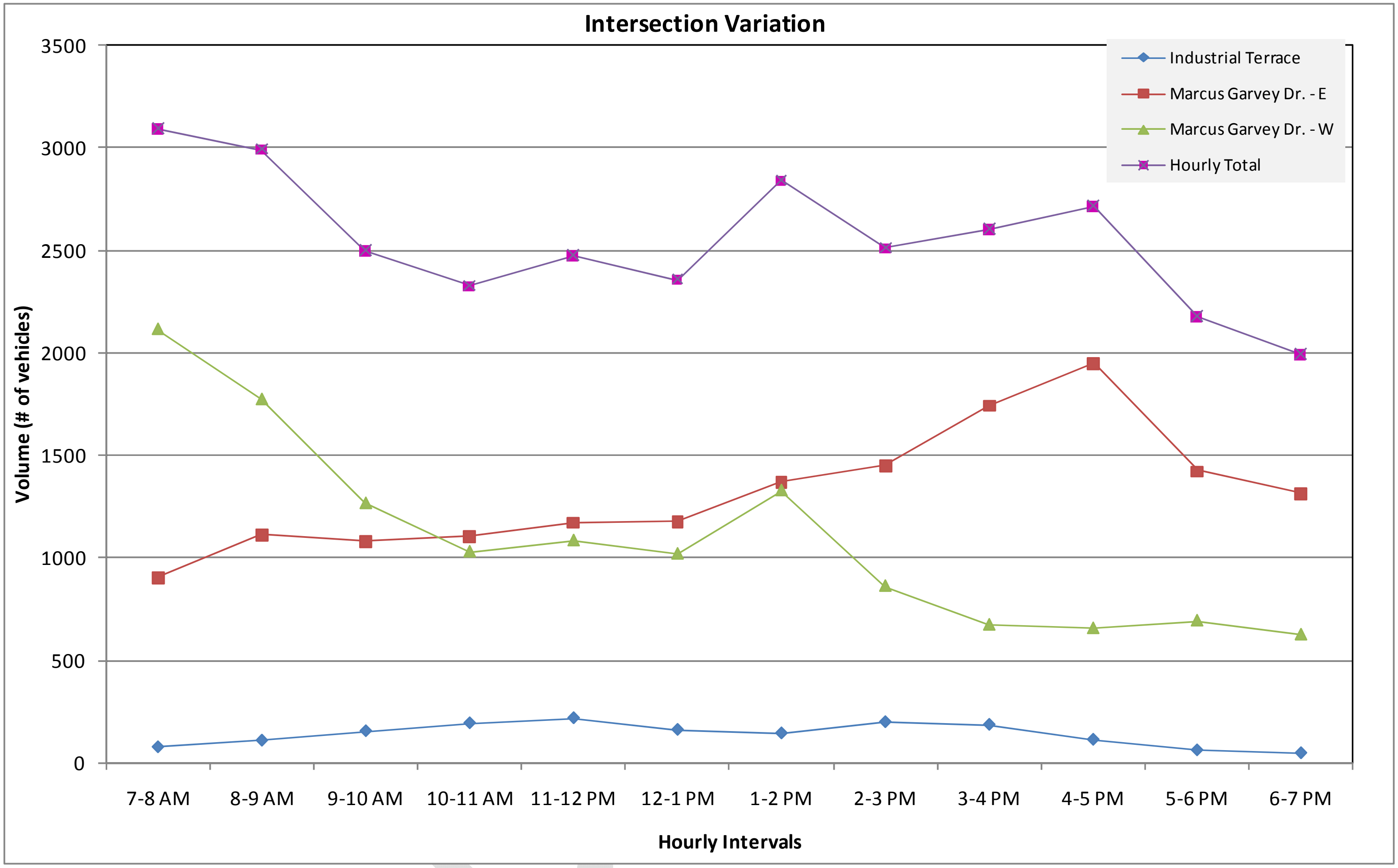


Figure 55 Plot of hourly total traffic obtained through the Marcus Garvey Drive – Industrial Terrace Intersection in September 2007.

Analysis of the raw data indicated the peak hours occurred at 7:30 to 8:30 in the mornings and 4:00pm to 5:00pm in the evenings. The turning diagrams in Figure 56 and Figure 57 show the daily average numbers of vehicles using the intersection during the morning and evening peak hours.

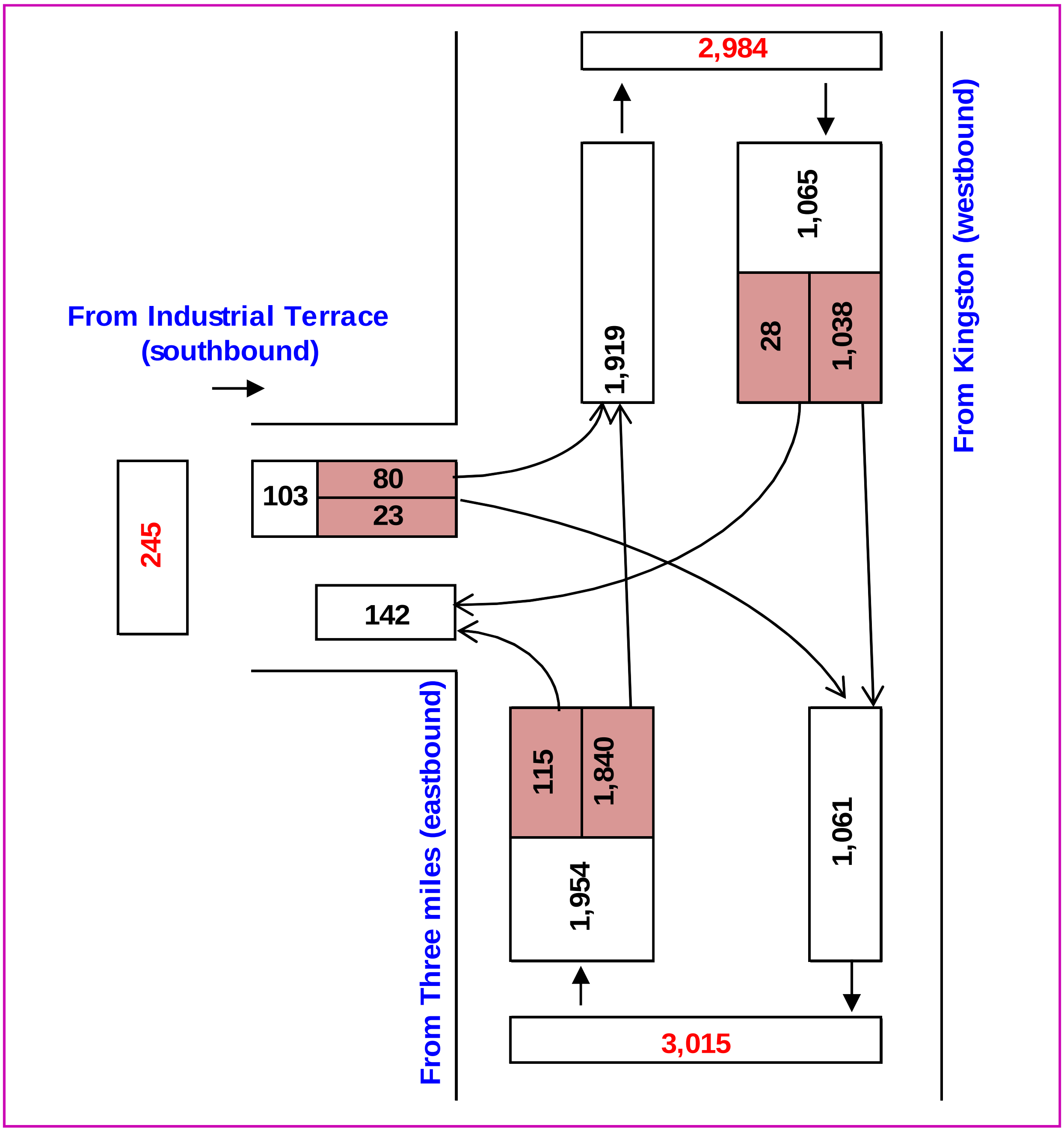


Figure 56 Average morning peak hour traffic distribution at the Marcus Garvey Drive - Industrial Terrace Intersection

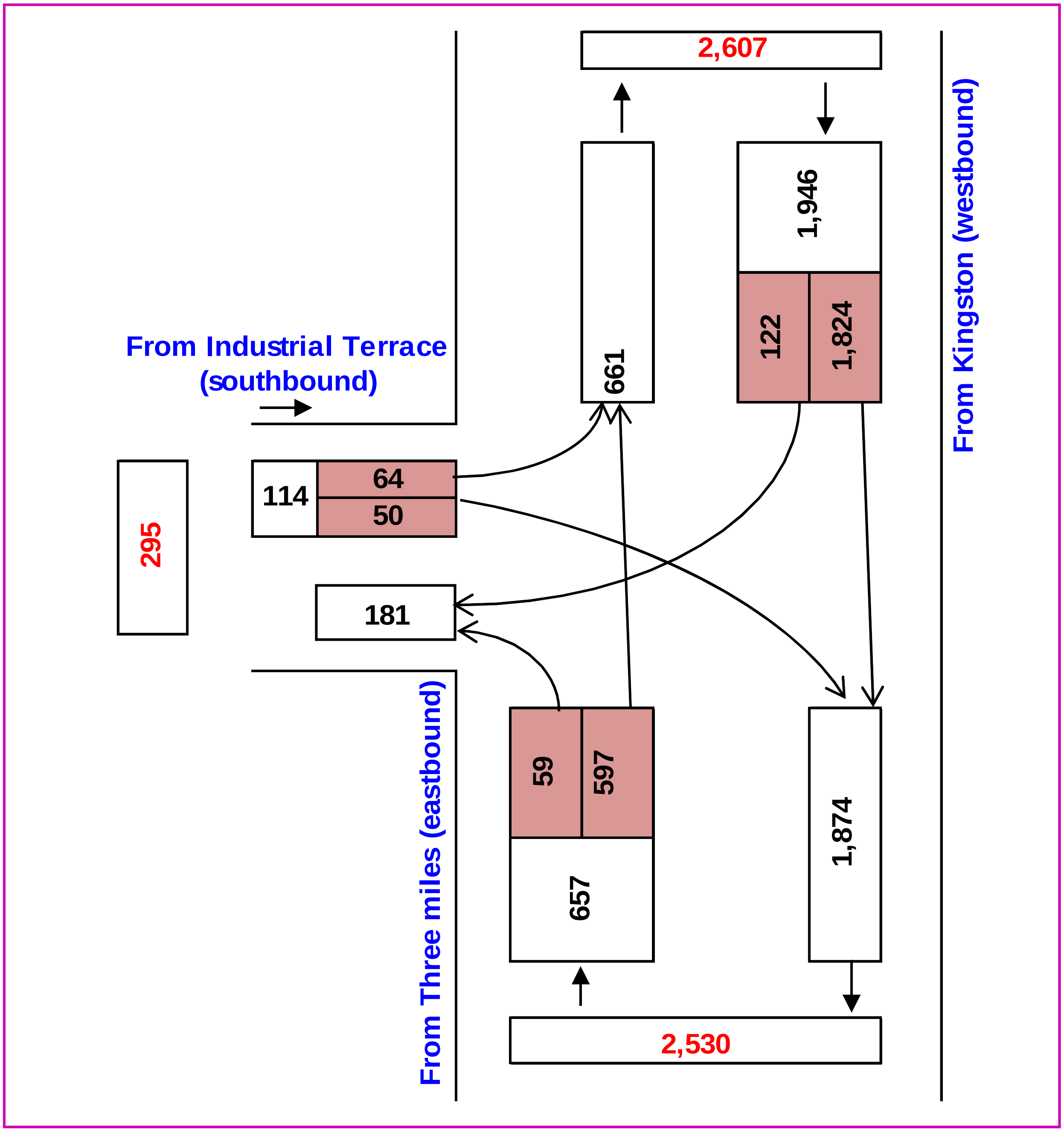


Figure 57 Evening peak hour traffic distribution at the Marcus Garvey Drive Industrial Terrace Intersection

4.12.2.1 Industrial Terrace

The period during which traffic is highest on Industrial Terrace is between the hours of 11am and 12 pm. This peak does not significantly affect the level of traffic using the intersection. North bound traffic is approximately 15 percent greater than southbound traffic. The North bound traffic appears to have an approximate 50:50 share from east and westbound traffic from Marcus Garvey Drive.

4.12.2.2 Marcus Garvey Drive – Eastbound

Approximately 15,779 trips are generated east of the intersection on a daily basis. It generally starts at around 900 vehicles/hour between 7 and 8am and increases to a peak of around 1950 vehicles/hour between 4 and 5pm before falling off. This evening peak is the chief contributor to the evening peak hour traffic noticed at the intersection.

4.12.2.3 Marcus Garvey Drive – Westbound

This number of vehicles originating west of the intersection generally has two peaks during the day. The first is the major contributor to the morning peak, occurring between 7 and 9 am. The second is also a major contributor to the mid-day peak noticed around 1-2pm.

4.12.3 Level of Service

The intersection was analyzed based in current loading versus design capacity. The methodology used for analyzing this two way stop controlled (TWSC) intersection is found in chapter seventeen of the Highway Capacity Manual 2000[5]. This method is mostly based on a gap acceptance model which is among the most popular models used for analyzing intersections. The basic order for this method is:

1. *Determine the capacity of the different movements in the intersection* - which is simply the number of vehicles that can pass a given point during a specified period under prevailing

[5] Highway Capacity Manual
Transportation Research Board
National Academy of Science, USA

roadway, traffic, and control conditions. This assumes that there is no influence from downstream traffic operation, such as the backing up of traffic into the analysis point.

2. *Determine the level of service (LOS) at the TWSC intersection* - through the use of the actual/defined loading and the capacity. This was done by using the computed control delay and is defined for each movement.

Figure 58 outlines a detailed methodology for determining the level of service for the TWSC intersection.

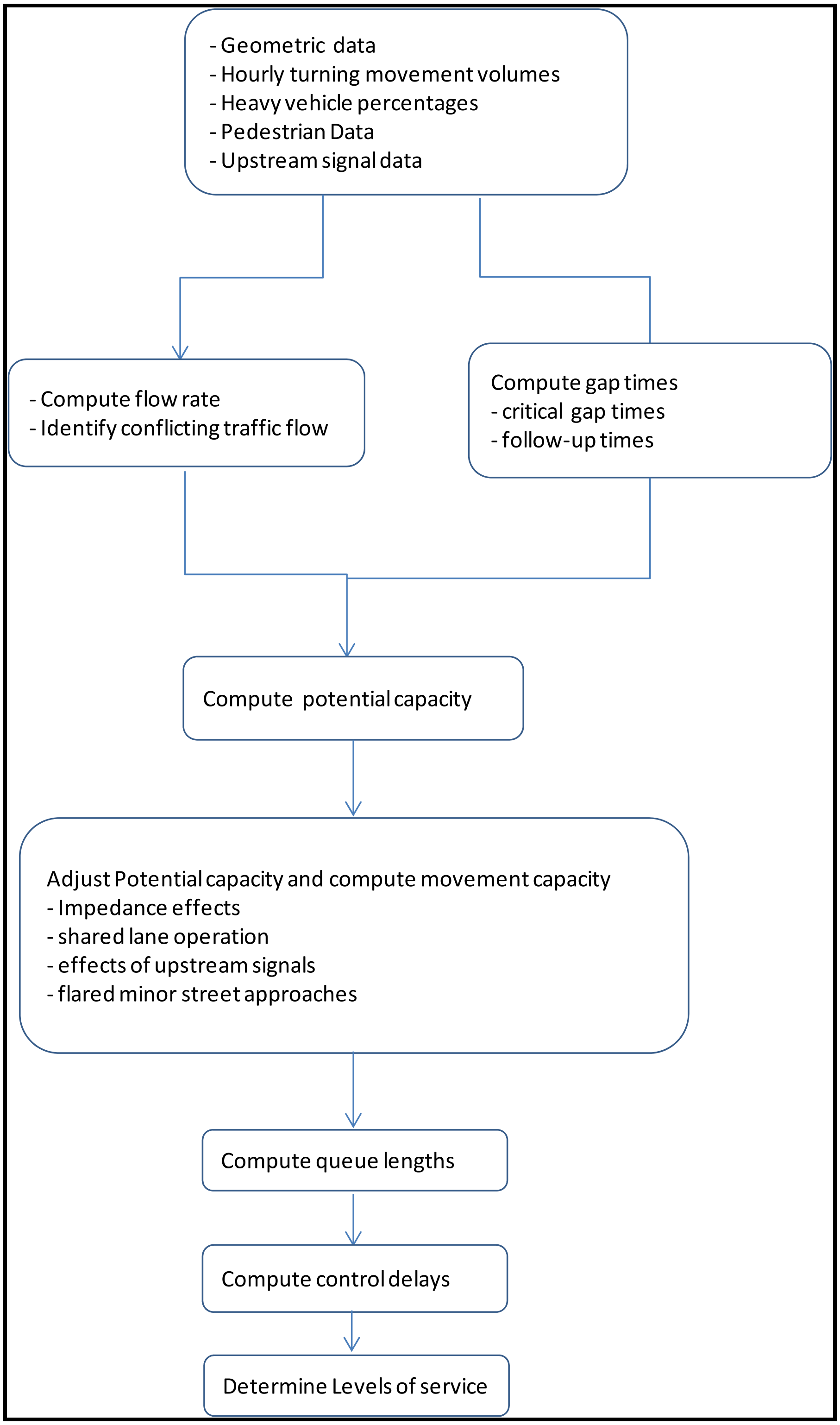


Figure 58 Outline of methodology (HCM, Exibit 17-1)

4.12.3.1 LOS Criteria

Level of service for this type of intersection – two way stop controlled (TWSC) – is determined by the computed control delay and is defined for each minor movement. LOS is not defined for the intersection as a whole.

The LOS criteria used to assess the driving conditions at the intersection is shown in Table 53 taken from the highway capacity manual.

Table 53 ` Level of service criteria (HCM, Exibit 17-2)

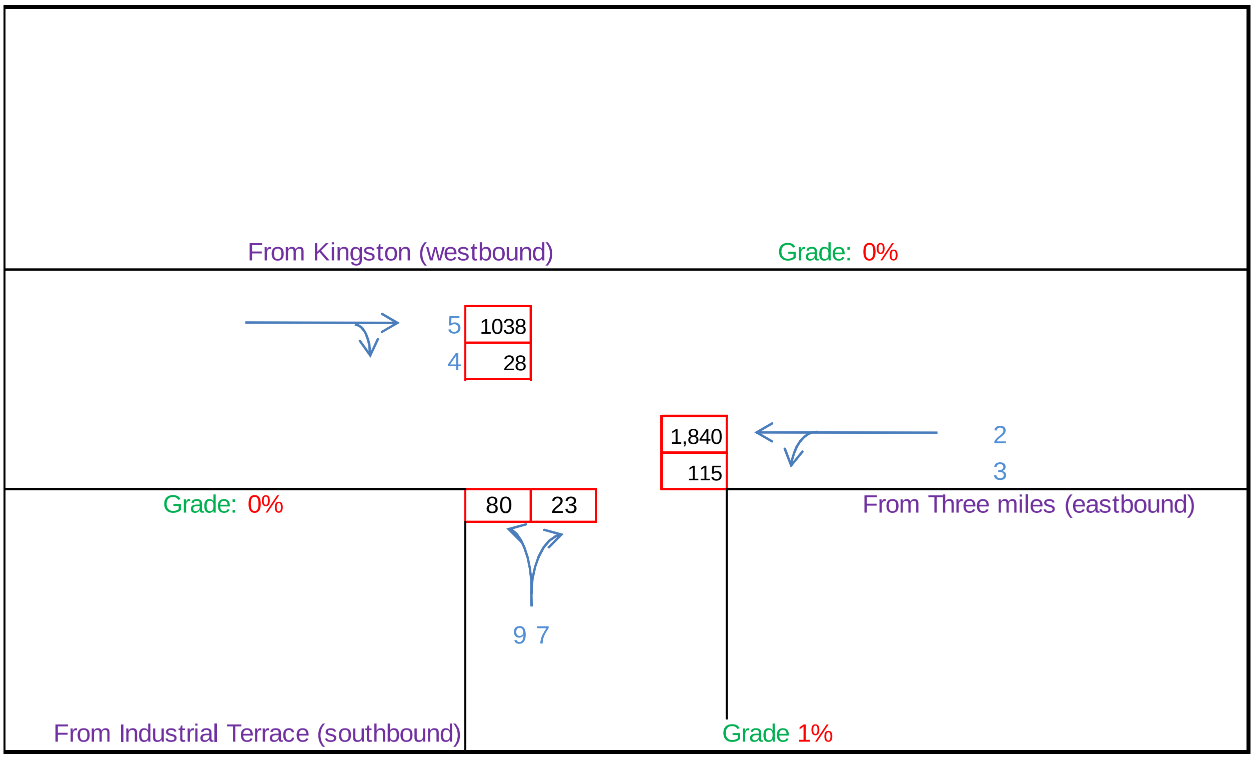
Level of Service	*Average Control Delay*
A	0-10
B	>10 - 15
C	>15 - 25
D	>25 - 35
E	>35 - 50
F	>50

4.12.3.2 Results – AM Peak

The results of the analysis for the AM peak hour shows the level of service at the intersection to be "F" for vehicles exiting Industrial Terrace and LOS of "C" for vehicles entering from Downtown Kingston (Figure 59 and Table 54).

Worksheet 1			
General Information			
Analyst	CJ	Intersection	Indistrial Terrace & Marcus Garvey Drive
Date	*10-Aug-09*	Town	
Analysis Time Period	*AM Peak*	Parish	Kingston

Geometrics and Movements



Analysis time period 0.25 h

Figure 59 Worksheet 1 - Data input and geometry for the morning peak hour at the Marcus Garvey drive – Industrial Terrace intersection

Table 54 Summary of analysis for existing morning peak hour traffic Marcus Garvey drive – Industrial Terrace intersection

Worksheet 2

Vehicle Volumes and Adjustments

Movement	Vehicle Volumes and Adjustments											
	1	2	3	4	5	6	7	8	9	10	11	12
Volume (veh/h)1		1840	115	27.6	1038		23.3		80			
Peak-hour factor, PHF1		1	1	1	1		1		1			
Hourly Flow Rate		1840	115	27.6	1038		23.3		80			
Proportion of heavy vehicles, PHV		6%	2%	8%	14%		14%		8%			

Pedestrian Volumes and Adjustments

Movement	Pedestrian Volumes and Adjustments			
	13	14	15	16
Flow , Vx (ped/h)	0	0	0	0
Lane width, w (m)	6	6	6	6
Walking speed, S_p (/m/s) default = 1.2	1.2	1.2	1.2	1.2
Percent blockage, fp (eqn 17-11)	0	0	0	0

Worksheet 3

General Information

Project description Indistrial Terrace & Marcus Garvey Drive Kingston

Lane Designation

Movements	Lane 1	Lane 2	Lane 3	Grade	Left Turn Channelized?
1,2,3	2,3	2		0%	N
4,5,6	5	4,5		0%	N
7,8,9	7,9			1%	N
10,11,12				0%	N

Flared Minor Street approach

Movement 9	Yes:	No: N	Storage space	# of vehicles
Movement 12	Yes:	No: N	Storage space	# of vehicles

Median Storage

Movements 7	Type if yes : Y	No:	Storage space	2 # of vehicles
Movement 10 & 11	Type if yes :	No: N	Storage space	# of vehicles

Upstream Signals - >0.4km

Worksheet 4

General Information

Project Description	Indistrial Terrace & Marcus Garvey Drive Kingston

Critical Gap and Follow-Up time

$t_c = t_{c,base} + t_{c,HV}P_{HV} + t_{c,G}G - t_{c,T} - t_{3,LT}$

		Major RT		Minor LT		Minor TH		Minor RT	
Movement		**1**	**4**	**9**	**12**	**8**	**11**	**7**	**10**
$T_{c,base}$ (ex. 17-5)			4.1	6.2				7.1	
$t_{c,HV}$			1.0	1.0				1.0	
P_{HV} (fr WS 2)			8%	8%				14%	
$t_{c,G}$				0.1	0.1	0.2	0.2	0.2	0.2
G (from WS 3)		0	0	0.01	0	0.01	0	0.01	0
$t_{3,LT}$			0	0				0.7	
$t_{c,T}$	single stage		0	0				0	
	two stage								
$t_{c,(Eqn\ 17\text{-}1)}$	single stage		4.2	6.3				6.5	
	two stage								

$t_f = t_{f,base} + t_{f,HV}P_{HV}$

	Major RT		Minor LT		Minor TH		Minor RT	
Movement	**1**	**4**	**9**	**12**	**8**	**11**	**7**	**10**
$t_{f,base}$ (ex. 17-5)		2.2	3.3				3.5	
$t_{f,HV}$		0.9	0.9				0.9	
P_{HV} (fr WS 2)		8%	8%				14%	
t_f (eqn 17-2)		2.3	3.4				3.6	

Worksheet 6

General Information

Project Description: Indistrial Terrace & Marcus Garvey Drive Kingston

Impedance and Capacity Calculation

Step 1: LT from Minor Street	v_9		v_{12}	
Conflicting Flows (Exibit 17-4)	$V_{c,9} =$	1897	$V_{c,12} =$	
Potential Capacity (Eqn 17-3 or 17-29)	$C_{p,9} =$	83	$C_{p,12} =$	
Ped impedance factor (eqn17-12)	$P_{p,9} =$	1	$P_{p,12} =$	
Movement Capacity (equation 17-4)	$C_{m,9} =$	83	$C_{m,12} =$	
Prob of queue-free state (Eqn 17-5)	$P_{0,9} =$	0.0461	$P_{0,12} =$	

Step 2: RT from Major Street	v_4		v_1	
Conflicting Flows (Exibit 17-4)	$V_{c,4} =$	1954	$V_{c,1} =$	
Potential Capacity (Eqn 17-3 or 17-29)	$C_{p,4} =$	286	$C_{p,1} =$	
Ped impedance factor (eqn17-12)	$P_{p,4} =$	1	$P_{p,1} =$	
Movement Capacity (equation 17-4)	$C_{m,4} =$	286	$C_{m,1} =$	
Prob of queue-free state (Eqn 17-5)	$P_{0,4} =$	0.9035	$P_{0,1} =$	

Step 5: RT from Major Street	v_7		v_{10}	
Conflicting Flows (Exibit 17-4)	$V_{c,7} =$	1897	$V_{c,10} =$	
Potential Capacity (Eqn 17-3 or 17-29)	$C_{p,7} =$	71	$C_{p,10} =$	
Ped impedance factor (eqn17-12)	$P_{p,7} =$	1	$P_{p,10} =$	
Movement Capacity (equation 17-4)	$C_{m,7} =$	71	$C_{m,10} =$	
Prob of queue-free state (Eqn 17-5)	$P_{0,7} =$	0.6715	$P_{0,10} =$	

Worksheet 8

General Information

Project Description: Indistrial Terrace & Marcus Garvey I Kingston

Shared-Lane Capacity

	v(veh/h)				**c_m (veh/h)**				C_{SH} (veh/h)
Lane	Movement 7	Movement 8		Movement 9	Movement 7	Movement 8		Movement 9	
1	23.3			79.6	71			83	80.24679
2									
3									
	Movement 10	Movement 11		Movement 12	Movement 10	Movement 11		Movement 12	
1									
2									
3									

Worksheet 9

General Information

Project Description	Indistrial Terrace & Marcus Garvey Drive	Kingston

Control Delay, Que length, Level of Service

	Lane 1			Lane 1			
	Movement 7	Movement 8	Movement 9	Movement 10	Movement 11	Movement 12	
Csep (WS 6)	71.1		83.4				
Volume (WS 2)	23.3		79.6				
delay	39.3		120.6				
Q_{sep}	0.3		2.7				
Q_{sep} + 1	1.3		3.7				
Round (Q_{sep} + 1)	1.0		4.0				
n_{max}	4						
C_{SH}	80						
C_{sep}	154						
n	2						
C_{act}	117						

Worksheet 10

General Information

Project Description	Indistrial Terrace & Marcus Garvey Drive	Kingston

Control Delay, Que length, Level of Service

Lane	V(veh/h)	c_m (veh/h)	v/c	Que length (eqn 17-37)	Control delay (s)	LOS (EX 17-2)	Delay and LOS
1 (mov 7&9)	102.91	80	1.282	8.00	286.4	F	286.4 F
2							
3							
Movement							
1							
4	27.58	286	0.097	1.00	18.9	C	18.9, C

4.12.3.3 Results – PM Peak

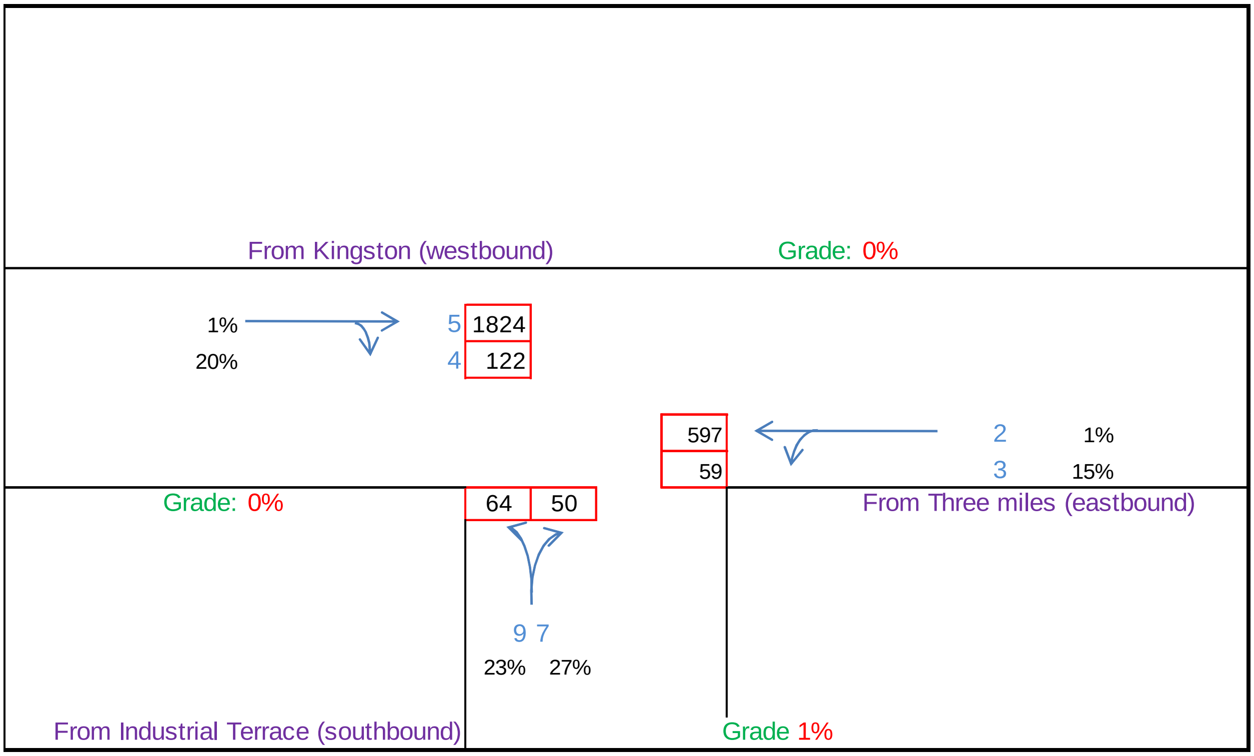
The results of the analysis for the PM peak hour show the level of service at the intersection to be "A" for vehicles exiting Industrial Terrace and LOS of "A" for vehicles entering from Downtown Kingston (Figure 60 and Table 55).

Worksheet 1

General Information

Analyst	CJ	Intersection	Indistrial Terrace & Marcus Garvey Drive
Date	*10-Aug-09*	Town	
Analysis Time Period	*PM Peak*	Parish	Kingston

Geometrics and Movements



Analysis time period 0.25 h

Figure 60 Worksheet 1 - Data input and geometry for the evening peak hour at the Marcus Garvey drive – Industrial Terrace intersection

Table 55 Summary of analysis for existing evening peak hour traffic Marcus Garvey drive – Industrial Terrace intersection

Worksheet 2

Vehicle Volumes and Adjustments

Movement	Vehicle Volumes and Adjustments											
	1	2	3	4	5	6	7	8	9	10	11	12
Volume (veh/h)1		597	59.4	122	1824		49.9		64			
Peak-hour factor, PHF1		1	1	1	1		1		1			
Hourly Flow Rate		597	59.4	122	1824		49.9		64			
Proportion of heavy vehicles, PHV		17%	16%	9%	9%		17%		12%			

Pedestrian Volumes and Adjustments

Movement	Pedestrian Volumes and Adjustments			
	13	14	15	16
Flow, Vx (ped/h)	0	0	0	0
Lane width, w (m)	6	6	6	6
Walking speed, S_p (/m/s) default = 1.2	1.2	1.2	1.2	1.2
Percent blockage, fp (eqn 17-11)	0	0	0	0

Worksheet 3

General Information

Project description: Indistrial Terrace & Marcus Garvey Drive Kingston

Lane Designation

Movements	Lane 1	Lane 2	Lane 3	Grade	Left Turn Channelized?
1,2,3	2,3	2		0%	N
4,5,6	5	4,5		0%	N
7,8,9	7,9			1%	N
10,11,12				0%	N

Flared Minor Street approach

Movement 9	Yes		No	N	Storage space	# of vehicles
Movement 12	Yes		No	N	Storage space	# of vehicles

Median Storage

Movements 7	Type if yes :	Y	No		Storage space	2 # of vehicles
Movement 10 & 11	Type if yes :		No	N	Storage space	# of vehicles

Upstream Signals - >0.4km

Worksheet 4

General Information

Project Description: Indistrial Terrace & Marcus Garvey Drive — Kingston

Critical Gap and Follow-Up time

$$t_c = t_{c,base} + t_{c,HV}P_{HV} + t_{c,G}G - t_{c,T} - t_{3,LT}$$

		Major RT		Minor LT		Minor TH		Minor RT	
Movement		**1**	**4**	**9**	**12**	**8**	**11**	**7**	**10**
$T_{c,base}$ (ex. 17-5)			4.1	6.2				7.1	
$t_{c,HV}$			1.0	1.0				1.0	
P_{HV} (fr WS 2)			9%	12%				17%	
$t_{c,G}$				0.1	0.1	0.2	0.2	0.2	0.2
G (from WS 3)		0	0	0.01	0	0.01	0	0.01	0
$t_{3,LT}$			0	0				0.7	
$t_{c,T}$	single stage		0	0				0	
	two stage								
$t_{c,(Eqn\ 17-1)}$	single stage		4.2	6.3				6.6	
	two stage								

$$t_f = t_{f,base} + t_{f,HV}P_{HV}$$

	Major RT		Minor LT		Minor TH		Minor RT	
Movement	**1**	**4**	**9**	**12**	**8**	**11**	**7**	**10**
$t_{f,base}$ (ex. 17-5)		2.2	3.3				3.5	
$t_{f,HV}$		0.9	0.9				0.9	
P_{HV} (fr WS 2)		9%	12%				17%	
t_f (eqn 17-2)		2.3	3.4				3.7	

Worksheet 6

General Information

Project Description Indistrial Terrace & Marcus Garvey Drive Kingston

Impedance and Capacity Calculation

Step 1: LT from Minor Street	v_9		v_{12}
Conflicting Flow s (Exibit 17-4)	$V_{c,9} =$	627	$V_{c,12} =$
Potential Capacity (Eqn 17-3 or 17-29)	$C_{p,9} =$	466	$C_{p,12} =$
Ped impedance factor (eqn17-12)	$P_{p,9} =$	1	$P_{p,12} =$
Movement Capacity (equation 17-4)	$C_{m,9} =$	466	$C_{m,12} =$
Prob of queue-free state (Eqn 17-5)	$P_{0,9} =$	0.8635	$P_{0,12} =$

Step 2: RT from Major Street	v_4		v_1
Conflicting Flow s (Exibit 17-4)	$V_{c,4} =$	657	$V_{c,1} =$
Potential Capacity (Eqn 17-3 or 17-29)	$C_{p,4} =$	900	$C_{p,1} =$
Ped impedance factor (eqn17-12)	$P_{p,4} =$	1	$P_{p,1} =$
Movement Capacity (equation 17-4)	$C_{m,4} =$	900	$C_{m,1} =$
Prob of queue-free state (Eqn 17-5)	$P_{0,4} =$	0.8644	$P_{0,1} =$

Step 5: RT from Major Street	v_7		v_{10}
Conflicting Flow s (Exibit 17-4)	$V_{c,7} =$	627	$V_{c,10} =$
Potential Capacity (Eqn 17-3 or 17-29)	$C_{p,7} =$	424	$C_{p,10} =$
Ped impedance factor (eqn17-12)	$P_{p,7} =$	1	$P_{p,10} =$
Movement Capacity (equation 17-4)	$C_{m,7} =$	424	$C_{m,10} =$
Prob of queue-free state (Eqn 17-5)	$P_{0,7} =$	0.8824	$P_{0,10} =$

Worksheet 9

General Information

Project Description	Indistrial Terrace & Marcus Garvey Drive	Kingston

Control Delay, Que length, Level of Service

	Lane 1			Lane 1			
	Movement 7	Movement 8	Movement 9	Movement 10	Movement 11	Movement 12	
Csep (WS 6)	424.0		466.3				
Volume (WS 2)	49.9		63.7				
delay	-7.9		-11.7				
Q_{sep}	-0.1		-0.2				
Q_{sep} + 1	0.9		0.8				
Round (Q_{sep} + 1)	1.0		1.0				
n_{max}	1						
C_{SH}	447						
C_{sep}	890						
n	2						
C_{act}	1334						

Worksheet 10

General Information

Project Description	Indistrial Terrace & Marcus Garvey Drive	Kingston

Control Delay, Que length, Level of Service

Lane	V(veh/h)	c_m (veh/h)	v/c	Que length (eqn 17-37)	Control delay (s)	LOS (EX 17-2)	Delay and LOS
1 (mov 7&9)	113.52	1334	0.085	0.28	7.9	A	7.9 A
2							
3							
Movement							
1							
4	122.00	900	0.136	0.47	9.6	A	9.6, A

Transportation within the SIA is achieved through buses, legal and illegal ("robot") taxis and private cars. Transportation to and from the site is adequate with workers having the option of taking a taxi or bus which travels along the Marcus Garvey main road. According to Community Profiles created by the SDC in April 2009, residents in Denham Town and Tivoli Gardens use several modes of transportation, with bus being the main mode, followed by licensed and unlicensed/robot taxis. Bicycle and motor cycle were the least utilized modes of transport.

4.13 Aesthetics

The area of the proposed development is an industrialized area with JPS Hunts Bay power plant, Seprod Ltd and Newport Mills Ltd (animal feed producers), in close proximity.

The proposed site is the location of the now defunct NWC Western Sewage works. The proposed development will improve the visual impact of the site.

The most identified environmental issues identified by households in the SDC profiles were blocked drains and illegal dumping. Indeed these environmental problems are also being considered aesthetically unpleasant.

5.0 Environmental Impacts

This Section will discuss the impacts associated with construction and operation of the proposed power plant project. Construction activities are mainly divided into site preparation (vegetation clearing and excavation) and construction of the facilities for the power plant. Operation activities will consider the power plant by itself. Section 6.0 will address cumulative impacts of the proposed project and other existing operations nearby.

An environmental impact is defined as any change to an existing condition of the environment. The nature of the impacts may be categorised in terms of:

o Direction (overall effect on the environment)	positive or negative
o Duration (length of time effect expected to occur)	long or short term
o Location (impact of effect on specific site area)	indirect or direct
o Magnitude (scale of predicted impact)	large or small
o Extent (range of predicted impact)	wide or local
o Significance (of predicted impact to developer and site)	large or small

To systematically identify the impacts associated with the proposed plant, an impact matrix was constructed which arrayed the main project activities against the relevant environmental factors. This matrix is shown in Table 56 and Table 57.

Table 56 Significant Site Preparation and Construction Phase Impacts

ACTIVITY/IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
1. Site Preparation												
Vegetation clearance		x	x		x			x		x		x
Excavation Works		x		x	x			x		x		x
Increased infiltration/runoff		x		x		x		x		x		x
Solid waste generation		x		x	x			x		x		x
Foundation Dewatering		x		x	x			x		x		x
Piling/Building Foundation		x		x	x			x		x		x
Air quality		x		x	x			x		x		x
Noise		x		x	x			x		x		x
Decreased water quality		x		x		x		x		x		x
Land use		x	x		x			x		x		x
2. Material Transport												
Dusting & spillage		x		x	x			x		x		x
Traffic congestion, road wear		x		x	x			x		x		x
3. Improper Material Storage												
Dusting		x		x	x			x		x		x
Suspended solid runoff		x		x	x			x		x		x
4. Construction Works												
Noise		x		x	x			x		x		x
Refuelling of vehicles and fuel storage onsite		x		x	x			x		x		x
Repair of vehicles onsite		x		x	x			x		x		x
5. Construction Crew												
Sewage/Wastewater generation		x		x	x			x		x		x
Solid waste generation		x		x	x			x		x		x
Emergency response		x		x	x			x		x		x
6. Socioeconomics												
Job creation	x			x	x		x			x	x	

Table 57 Significant Operation Phase Impacts

ACTIVITY/IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
1. Plant Maintenance												
Polluted run off from wash-down activities		x	x		x			x		x		x
2.Storm Water/Drainage												
Increased flow & siltation		x	x			x		x		x		x
3. Air Quality												
Increased pollutants in air shed		x	x		x		x			x	x	
4. Noise Pollution												
Increased noise pollution		x	x			x		x		x		x
5. Occupational Health and Safety												
Increased air emissions exposure		x	x		x			x		x		x
Increased noise exposure		x	x		x			x		x		x
Increased potential for accidents		x	x			x		x		x		x
6. Spills and Waste Disposal												
Increased potential for oil spills		x	x			x		x		x		x
Improper oily water disposal		x	x			x		x		x		x
Improper solid waste disposal		x	x			x		x		x		x
Improper black & grey water disposal		x	x			x		x		x		x
7. Occupational Health												
Increased noise exposure		x	x		x			x		x		x
Increase exposure to air pollutants		x	x		x			x		x		x
Increased accident potentials		x	x		x			x		x		x
8. Socioeconomics												
Job creation	x		x			x	x			x	x	
Stable electricity supply	x		x			x	x			x	x	
Increased worker productivity	x		x		x		x			x	x	
Economic growth nationally	x		x		x			x	x		x	

5.1 Potential Impacts of the Proposed Project during Site Preparation

5.1.1 Impact: Vegetation Clearance

The clearing and removal of trees and ground cover during site preparation will result in the loss of much of the existing vegetation and consequently a reduction in arboreal and other habitat for birds and other small fauna. Also, the removal of vegetation will expose soil, and hence runoff during heavy rainfall may carry sediments, bits of vegetation and particulates with it into the Tivoli Gully and ultimately the marine environment. However, the flora on the proposed site are not endemic, endangered, threatened or rare, and are commonly found around the island.

5.1.2 Impact: Excavation Works

Using the necessary machinery to conduct excavation on site may result in elevated noise levels and disturbance to surrounding businesses and communities.

5.1.3 Impact: Solid Waste Generation

Derelict NWC buildings on site to be demolished will result in solid waste creation in the form of broken building blocks, steel rebar and roofing material, the latter of which contains 20%-40% asbestos (the disposal of which will be dealt with in the Closure Plan).

5.1.4 Impact: Foundation Dewatering

Working in building and structure foundations subsurface may most likely encounter groundwater. To enable working in these areas dewatering of the foundation will have to be carried out.

5.2 Potential Impacts of the Proposed Project during Construction of the 60 MW Power Plant

5.2.1 Impact: Piling and Building Foundations

Inserting the piles with a pile driver will result in repeated clanging sounds which may be audible and a nuisance to surrounding businesses and communities.

5.2.2 Impact: Hydrology: Increase Particle suspension and Surface Runoff

During site preparation and construction activities, water quality is likely to be affected especially during rainfall events whereby site run-off will cause increased siltation and sedimentation of the marine environment via roads, drains and the Tivoli Gully.

Surface runoff from the newly paved asphaltic concrete has the potential of introducing hydrocarbons to the marine environment.

5.2.3 Impact: Air quality (Fugitive Dust and Noise)

Site preparation and construction has the potential to have a two-folded direct negative impact on air quality. The first impact is air pollution generated from the exhaust emissions of construction equipment and vehicles. 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 vegetation. Both types of impacts will be of high intensity but of relatively short duration, so no permanent, significant impacts are anticipated from these activities.

5.2.4 Impact: Noise

Site clearance and construction of the proposed development necessitates the use of heavy equipment to carry out the job. These equipment include bulldozers, backhoes, pile driving etc. They possess the potential to have a direct negative impact on the environment.

Noise directly attributable to construction activities should not result in noise levels in the residential areas to exceed 55dBA during day time (7am – 10 pm) and 45dBA 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.

It is anticipated that persons closest to the proposed construction area will be most affected by the construction activities for example driving of the piles (impulse noise) for the foundation.

The proposed project has the potential to be a noise nuisance during both the construction and the operation phases. However, with the proper mitigative steps the proposed project will have minimal if any impact on the surrounding community.

The proposed power plant construction will involve clearing of the land, earthwork, building construction and landscaping. It is anticipated that construction activities will take place seven (7) days per week.

The demolition of existing buildings and structures on the proposed site will be the first step. Excavation of the foundation will be the next step. Bulldozers and front-end loaders will excavate the soil and load it onto trucks for transport to the approved landfill for disposal or redistribute on-site. The proposed construction site is in close proximity of the coast and it is anticipated that excavation areas will have to be dewatered. This will involve the use of pumps to remove the water.

After the excavation works have been completed, concrete trucks will arrive at the site with pre-mixed concrete and pump it into the site to form the foundations. Foundation work will use equipment such as excavators, bulldozers, loaders, pumps to remove water (both storm and groundwater), backhoes, tractors, hammers, motorized concrete buggies, concrete pumps, jack hammers, pneumatic compressors, a variety of small (mostly hand-held) tools and concrete trucks. The project is slated to take 565 days.

Table 58 lists noise emissions from typical construction equipment. The data from this will be used to estimate the potential noise impact from the construction of the proposed power plant.

Table 58 Typical noise emission levels for construction equipment

Equipment	Noise Level at 15m (dBA)
Air Compressor	81
Asphalt Spreader (paver)	89
Asphalt Truck	88
Backhoe	85
Bulldozer	87
Compactor	80
Concrete Spreader	89
Concrete Mixer	85
Concrete Vibrator	76
Crane (derrick)	88
Delivery Truck	88
Diamond Saw	90
Dump Truck	88
Front End Loader	84
Hoist	76
Motor Crane	83
Jackhammer	88
Pump	76
Roller	80
Shovel	82
Truck	88

Sources: *Patterson, W.N., R.A. Ely, and S.M. Swanson, "Regulation of Construction Activity Noise," Bolt Beranek and Newman, Inc., Report 2887, for the Environmental Protection Agency, Washington, D.C., November 1974 and New York State Department of Environmental Conservation, "Construction Noise Survey," Report No. NC-P2, Albany, NY, April 1974.*

The types of noises emitted from the equipment are considered intermittent noise with the exception of noise from pumps, which is considered continuous noise.

The proposed construction activity will general generate intermittent noise within an estimated 85 dBA. A conservative estimate of noise level at the boundaries from the construction activity at the northern, southern, western and eastern boundaries are 69.3, 69.3, 72.0 and 82.5 dBA respectively. This assumes the worst case scenario that multiple equipment listed in Table 58 above are being operated simultaneously and continuously. This will not be the case and as stated above, the type of noise generated by most of the equipment used in the construction will emit intermittent noise.

Although the estimated noise levels at the western and eastern boundaries are not in compliance with the World Bank Guidelines of 70 dBA at the fence line. The fact that these areas are zoned for industrial purposes makes the potential negative impact from noise pollution low.

5.2.5 Impact: Biological: Vegetation Removal

The flora on the proposed site is not endemic, endangered threatened or rare and are commonly found around the island.

5.2.6 Impact: Land Use

There are no impacts as it relates to land use as the proposed location is already an industrial area and the location will have little visual impacts.

5.2.7 Impact: Solid Waste Generation and disposal

During the construction phase of the proposed project, solid waste generation may occur mainly from two points:

i. From the construction campsite.
ii. From construction activities such as site clearance and excavation.

The construction of the power plant facilities will generate large amounts of solid waste, comprised of mainly concrete blocks, timber, steel, used packaging, containers etc. Other lightweight waste such as styrofoam, paper and plastics has the potential to be blown into the nearby Tivoli Gully.

5.2.8 Impact: 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. No significant environmental impacts were identified from this activity.

5.2.9 Impact: Storage of Fuels and Chemicals

It is anticipated that refueling and maintenance of large machinery will take place on the construction site and that, correspondingly, there will be storage of fuel and lubricants on the site. With the storage of fuels and maintenance of construction equipment, there is the potential of leakage of hydraulic fuels, oils etc.

Spilled chemicals can contaminate soil, as well as pollute the groundwater.

5.2.10 Impact: Raw Material Storage and Stockpiling

Raw materials, for example sand, marl and asphaltic concrete used in the construction of the proposed development, will be stored onsite. There will be a potential for them to become air or waterborne.

5.2.11 Impact: Transportation of Raw Material and Equipment

The various materials required for construction and building (e.g. sand, marl, aggregate, steel, blocks, lumber, asphalt, cement, etc.) will be obtained from sources elsewhere and transported to the site. In the case of fine earth materials, dusting and spillages could occur on the roadways between source and site, particularly when materials are transported in uncovered or improperly sealed trucks. Dusting degrades local air quality and material spillages worsen driving conditions and increase the risk of road accidents.

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.

5.2.12 Construction Traffic

5.2.12.1 Construction Sequence

The sequence of construction is expected to adhere to the basic outline as shown:

1. Site Clearance
2. Construction of:

   a. Perimeter fencing
   b. Buildings
   c. Roads
   d. Tanks
3. Installation of fuel pipeline from Petrojam
4. Installation of Special Machinery and equipment

These general stages in the sequence will generate similar types of traffic on the roads. The trips generated will have a much higher percentage of heavy vehicles. This is because there will be delivery of materials and equipment to the site as well as removal of rubbish or debris from the site.

5.2.12.2 Construction Traffic

Scheduling

Construction traffic will be mostly trucks delivering materials to the site as well as removing rubbish (Table 59). This will vary somewhat for the different stages of construction, for example site clearance will have predominantly rubbish removal from site whereas infrastructure construction will have trucks delivering to site. The number of trips per day is not expected to exceed 50 during any of the phases. Construction traffic will be scheduled for off peak hours to avoid or minimise any congestion at the intersection.

Table 59 The construction stages showing what hour's construction traffic will be scheduled

Construction Stage	Vehicle types	Affected Roads	Time of Day
Site Clearance	Loaders/Excavators Dump trucks hauling rubbish from the site	MG, IT	OP 1
Onsite Infrastructure Construction	Trucks delivering materials and equipment to site	MG, IT	OP 1, OP2
Fuel pipeline construction	Excavators and trucks delivering materials	MG, IT	OP 1, OP2
Delivery and Installation of Machinery and Equipment	Trucks delivering equipment to site, inclusive of engine from the warf	MG, IT	OP 1, OP2

OP 1 - off peak period 9am to 1pm   OP 2 - off peak period after evening peak

Further analysis of traffic data at the intersection was conducted, adding the estimated construction traffic to the peak hours and off peak hours (10-11am). The results as outlined in cubic metres indicates addition of construction traffic will significantly change the LOS for the morning peak hour but will affect the off peak hour or the evening peak in a significant way (Table 60).

In the morning periods and even during the off peak periods, the high volumes of traffic in the eastbound lane provides less acceptable gaps for motorists exiting Industrial Terrace to cross the said lane to the west bound lane. It is however easier for them to merge with the eastbound lane.

Table 60 Comparison of the LOS for morning peak, off peak and evening peak traffic without construction traffic to the same with construction traffic

Parameter	Morning Peak	Morning Peak + construction traffic	Off peak -10am - 11 am	Off peak -10am - 11 am + construction traffic	Evening Peak	Evening Peak + construction traffic	Units
Marcus Garvey Drive to Industrial Terrace							
Control delay	18.9	26.6	11.35	13.8	9.6	9.6	sec
LOS	C	D	B	B	A	A	
Industrial Terrace to Marcus Garvey Drive							
Control delay	286	303.5	15.56	15.8	7.9	8.6	sec
LOS	F	F	C	C	A	A	

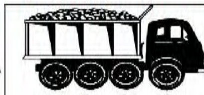
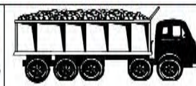
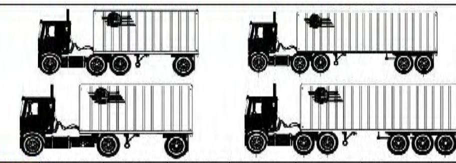
The actual routing (location) of the fuel pipeline has not been confirmed at the time of the writing of this report. The construction traffic management is however similar in approach as the other construction stages. The following precautions must be taken to ensure minimal disruption and potential danger to traffic:

- Construction traffic entering or leaving the site will be scheduled for off peak hours to minimize additional congestion at the intersection and/or disruptions in the regular traffic flow.
- Construction traffic will be directed to turn left at the intersection when exiting the site
- Construction traffic intending to head towards Three- Miles should utilize Spanish Town Road or turn left at the Marcus Garvey Drive intersection and turn around at Water Lane
- Adequate covering up of the works to minimize danger to passing traffic.
- Erection of signs ahead of the works warning motorists of the construction ahead

5.2.13 Weight Limits

All trucks are expected to adhere to the national works agency standard for the loads per axle they exert on the pavement (Figure 61). The Engines for the plant are expected to be one of the most difficult pieces of machinery to transport because of its size and weight. The Project Manager will need to write to the National Works Agency at least two (2) weeks in advance for a special permit to transport all 6 engines from the Wharf to the site.

SPECIAL PERMIT REQUIREMENTS vehicles exceeding Permit Column data can be issued ith a Special Permit once the vehicle does not exceed the relevant column etc

Maximum Allowable																			
	Permit	MAX Limit	Permit	MAX Limit	MAX Limit	Permit	MAX Limit	MAX Limit	Permit	MAX Limit	MAX Limit	Permit	MAX Limit	MAX Limit	MAX Limit	MAX Limit	MAX Limit	MAX Limit	MAX Limit
Overall Height (m)	3.6	4.15	3.6	4.15	4.15	3.6	4.15	4.15	3.6	4.15	4.15	3.6	4.15	4.15	4.15	4.15	4.15	4.15	4.15
Gross Weight (tons)	12.2	15	12.2	20	25	12.2	30	35	12.2	30	35	12.2	25	30	35	40	45	50	55
Length (m)	9.14	12.8	9.14	12.8	12.8	9.14	12.8	12.8	9.14	12.8	12.8	12.8	17.3	17.3	17.3	17.3	17.3	17.3	17.3
Width (m)	2.44	2.70	2.44	2.70	2.70	2.44	2.75	2.75	2.44	2.75	2.75	2.44	2.75	2.75	2.75	2.75	2.75	2.75	2.75
No. of Axles	2	2	3	3	3	4	4	4	5	5	5	3	3	4	4	5	5	6	6
No. of Tires	6	6	8	8	10	12	12	14	16	16	12	10	10	12	14	16	18	20	22

Please note that

1. Maximum allowable dual tire axle load is **10 tonnes** except super singles/ flotation
2. Maximum allowable single tire axle load is **5 tonnes** except super singles/ flotation
3. maximum allowances **must not exceed manufacturer ratings**, specifications for **vehicles and tires** etc
4. Special permits are required for tucks that exceed one or more of the following criteria:

   a. ***Overall Length of 9.14m (rigid) or 12.8 m (articulated/trailer)***

   b. ***Overall width of 2.44 m,***

   c. ***Gross weight of 12,273 kg,***

   d. ***overhang of 50% of wheelbase,***

   e. ***height of 3.6 m from ground***

Figure 61 National Works Agency weight limit requirements for heavy vehicles

5.2.14 Impact: Emergency Response

Construction of the proposed power plant has the potential for accidental injury, whether major or minor. Precautions will be taken to minimize the frequency and severity of construction accidents.

5.2.15 Impact: Employment

The major socio-economic impact during the construction is the potential direct positive benefit of employment opportunities. It is estimated that approximately 45 persons will be employed during the site clearance, demolition and preparation phase and an estimated 50 persons during the construction of the foundations.

5.2.16 Impact: Historical and Cultural Resources

No significant impacts identified as there are no historical or cultural resources located on the site.

5.2.17 Impact: Aesthetics

The construction of the proposed plant will improve the aesthetics of this area zoned for industrial purposes.

5.3 Operation of the 60 MW Power Plant

This section assesses the impacts of the proposed power plant by itself, while Section 6.0 will address the cumulative impacts in the project area.

5.3.1 Air Quality

This section addresses both the in-stack emission standards and guidelines for Jamaica and the World Bank as well as the ambient air quality standards and guidelines for Jamaica and the World Bank respectively.

5.3.1.1 In-Stack Emission Standards and Guidelines

The Minister, in exercise of the powers conferred by Section 38 of the NRCA, promulgated draft Air Quality Regulations in 2002 which was updated to the Natural Resources Conservation (Air Quality) Regulations 2006. These air quality regulations, among other things, contain in-stack air emission standards for new facilities (installed or commenced construction after September 1, 2001). Table 61 shows these in-stack air emission standards.

Table 61 Jamaican In-Stack Air Emission Standards

Pollutant	Standard
Sulphur Dioxide	A maximum of 2.2 percent sulphur in heavy fuel oil (No. 5 or 6 oil)
PM[(a)]	85 nanograms per Joule (ng/J) 100 milligrams (mg) per cubic meter at 15% oxygen[(b)]
NO_x[(a)]	2,981 ng/J 3,512 mg/normal cubic meter at 15% oxygen[(c)]

a) Liquid fuel fired internal combustion engines of 2-50 MW
b) It is not clear in the regulation whether this is normal cubic meters on a dry basis.
c) It is not clear in the regulation whether this is on a dry basis.

The following Table 62 provides the World Bank in-stack air quality guideline values for an internal combustion engine powered by liquid fuels(plant of >50 MWth to >300 MWth).

Table 62 World Bank In-Stack Air Quality Guidelines

Pollutant	**INTERNAL COMBUSTION ENGINES** [a]	
	Non Degraded Air shed (NDA)	**Degraded Air shed (DA)**
Nitrogen Oxides	1,850 milligrams/Nm^3	400 milligrams/Nm^3
Sulphur Dioxide	1,170 milligrams/Nm^3	0.5% Sulphur in fuel
Particulate Matter	50 milligrams/Nm^3	30 milligrams/Nm^3

a) These NO_x, PM, and SO_2 values are expressed on a dry basis at 15 percent oxygen.

Wärtsilä, the IC engine manufacturer, has supplied stack emissions data for the equipment, assuming the use of SCRs and 0.5% (by weight) sulphur content in the fuel oil. Table 63 provides a comparison of the manufacturer's data with the Jamaican in-stack air emission standards.

Table 63 Comparison of in-stack air emissions to Jamaican Standards

POLLUTANT	**ENGINE SPECIFICATION**	**JAMAICAN STANDARD**
SO_2	Maximum of 0.5% sulphur, by weight in fuel oil	Maximum of 2.2% sulphur by weight in No. 5 or 6 oil
PM	50 mg/$Nm^{3(a)}$	100 mg/$m^{3(b)}$
NO_2	400 mg/$Nm^{3(a)}$	3,512 mg/$Nm^{3(c)}$

a) This is a dry basis at 15% oxygen
b) This is specified at 15% oxygen, but not whether it is a dry basis, normal cubic meters;
c) This is not specified whether it is a dry basis, but it is at 15% oxygen.

As shown in Table 63, the engines will comply with the Jamaican in-stack standards for SO_2, PM, and NO_2.

Table 64 compares the proposed project in-stack emission rates, as provided by Wärtsilä, to the World Bank in-stack air quality guideline values for SO_2, PM, and NO_2. The PM emissions would be influenced by fuel quality.

Table 64 Comparison of in-stack emission levels to World Bank Guideline values

POLLUTANT	ENGINE SPECIFICATION[(a)]	DEGRADED	NON DEGRADED
		WORLD BANK GUIDELINE VALUE[(a)]	**WORLD BANK GUIDELINE VALUE[(a)]**
SO_2	Maximum of 0.5% sulphur (S), by weight in fuel oil.	0.5% or less sulphur fuel	2% or less sulphur fuel
NO_2	400 $mg/Nm^{3(a)}$	400 mg/Nm^3	1,850 $milligrams/Nm^3$
PM	50 $mg/Nm^{3(a)}$	30 mg/Nm^3	50 mg/Nm^3

a) All values are dry basis, 15% oxygen assuming degraded airshed

5.3.1.2 Evaluation Criteria

Significance Levels

NEPA has promulgated significant air quality impact levels (SILs) for SO_2, NO_2, and PM_{10} to limit the number of background sources that would be necessary to include in a detailed air quality analysis. If a facility's maximum predicted pollutant-specific impacts are below the SILs, the facility is considered to not pose a significant impact on the local air quality and additional detailed analyses with background sources need not be performed. The SILs for SO_2, NO_2, and PM_{10} are 20 and 80 micrograms per cubic meter ($\mu g/m^3$) for the annual and 24-hour averaging times, respectively. For this study, the predicted highest annual and highest 24-hour concentrations in 5 years were compared to the SILs. In accordance with the NRCA Guideline Document, compliance with the NO_2 Jamaican AAQS and SILs were determined by assuming that 75 percent of emitted nitrogen oxides (NO_x) emissions from the modeled sources are converted to NO_2.

Jamaican AAQS As Compared to Other International AAQS

A summary of the Jamaican AAQS, IFC/World Health Organization (WHO) Guidelines, and the USEPA AAQS are also included in Table 65. The WHO Guidelines are to be used in countries where adequate AAQS currently do not exist. A comparison of the Jamaican and USEPA AAQS demonstrates that the Jamaican standards are at least as adequate as the more internationally recognized USEPA standards in protecting human health. It is also noted that while the USEPA short-term AAQS permit one exceedance per year, the short-term Jamaican AAQS are based on the highest predicted short-term concentrations. As such, the Jamaican AAQS are considered to be adequate for use in this air quality study. For the proposed power plant and other sources, the highest predicted annual and short-term concentrations are the basis for determining compliance with the Jamaican AAQS.

Table 65 Jamaican significance levels, AAQS and other recognized international AAQS and guidelines

TABLE 2-1
JAMAICAN SIGNIFICANCE LEVELS, AAQS AND OTHER RECOGNIZED INTERNATIONAL AAQS AND GUIDELINES

Pollutant	Averaging Time	Concentration Rank	Jamaican Significance Levels ($\mu g/m^3$)	Jamaican AAQS ($\mu g/m^3$)	WHO[a] Guidelines ($\mu g/m^3$)	USEPA AAQS ($\mu g/m^3$)
SO_2	Annual	Highest	20	80 Primary; 60 Secondary	na	80
	24-Hour	Highest	80	365 Primary; 280 Secondary	20/125	365[b]
	3-Hour	Second Highest		na	na	1,300
	1-Hour	Highest		700	na	na
NO_2	Annual	Highest	20	100	40	100
	24-Hour	Highest	80	na	na	na
	1-Hour	Highest		400	na	na
TSP	Annual	Highest	na	60	20/35	na
	24-Hour	Highest	na	150	na	na
	24-Hour	99th-Percentile		NA	25/75	na
PM_{10}	Annual	Highest	20	50	20/35	50
	24-Hour	Highest	80	150	na	150[b]
	24-Hour	98th-Percentile		NA	25/75	na
CO	8-Hour	Highest	na	10,000	na	10,000[b]
	1-Hour	Highest	na	40,000	na	40,000[b]

na = not applicable

[a] World Health Organization Guidelines and Interim Target Levels, to be used if no AAQS exist for country.

[b] Can be exceeded not more than once per year.

Note: ($\mu g/m^3$) = micrograms per cubic meter.

5.3.1.3 Air Dispersion Modelling Analysis

General Description

Jamaica Energy Partners (JEP) is proposing to install a new facility, the West Kingston Power Plant, at Hunts Bay, consisting of six Wartsila 12V46 diesel engines with a total electric generating capacity of 60 megawatts (MW). An Air Dispersion Model is required for this project in order to ensure that the requirements of the National Environment & Planning Agency (NEPA) of Jamaica and the International Finance Corporation (IFC) are met. The National Environment & Planning Agency has established Ambient Air Quality Standards (AAQS) for sulphur dioxide (SO_2); nitrogen dioxide (NO_2); total suspended particulate (TSP) matter; particulate matter with aerodynamic diameters less than or equal to 10 microns (PM_{10}); and carbon monoxide (CO).

Golder Associates Inc. (Golder) has been contracted by JEP to perform an air quality impact analysis for the proposed power plant to determine compliance with the Jamaican AAQS. The modelling procedures for conducting the modelling analyses are based on procedures recommended in the NRCA Ambient Air Quality Guideline Document (Claude Davis & Associates, 2006) and subsequent technical discussions with NEPA (2008). Because of potential funding from the International Finance Corporation (IFC), the adequacy of the Jamaican AAQS and air modelling guidelines is demonstrated by comparison to the USEPA and other international evaluation criteria.

In accordance with recommendations in the Guideline Document, the modelling analysis was conducted using a 5-year meteorological data set consisting of hourly surface observations and daily upper air soundings from Kingston's Norman Manley International Airport (NMIA). The 5-year meteorological record was developed in conjunction with a recent air modelling study (Golder, 2008) and is based on the best data available and latest regulatory guidance.

The Jamaican AAQS are the primary criteria used for this study; the general modelling approach used; and the modelling inputs, results, and conclusions for the proposed power plant are presented in the following sections.

Model Selection and Modelling Techniques

This section outlines the dispersion models and modelling techniques that were utilized in performing the air dispersion modelling analysis

The most recent version of the American Meteorological Society/U.S. Environmental Protection Agency (USEPA) Regulatory Model (AERMOD), Version 07026 (USEPA, 2006a), was used to predict pollutant concentrations in the vicinity of the proposed JEP power plant. AERMOD is applicable for a variety of industrial applications because it is recognized as containing the latest scientific algorithms for simulating plume behaviour in all types of terrain. The NRCA Guideline Document recommends AERMOD as a detailed model that is suitable for use in both flat and complex terrain areas. For evaluating plume behaviour within the building wake of structures, AERMOD incorporates the Plume Rise Model Enhancement (PRIME) downwash algorithm developed by the Electric Power Research Institute (EPRI). AERMOD can predict pollutant concentrations for averaging times of annual and 24-, 8-, 3-, and 1-hour(s). For this modelling analysis, concentrations were predicted for each pollutant's specific averaging times of interest. For example, when predicting SO_2 concentrations for an AAQS analysis, the annual, 24-hour, and 1-hour averaging times were requested for comparing to the respective AAQS.

AERMOD was used in USEPA's regulatory default mode, which uses the following model options:

- Stack-tip downwash;
- Elevated terrain algorithms;
- Missing data processing routines;
- Calm wind processing routines; and
- A 4-hour half-life for exponential decay of SO2 for urban sources.

Based on communications with NEPA, the west Kingston area is considered urban, and a population of 96,052 from the 2001 census [Statistical Institute of Jamaica (STATIN), 2001] was input to AERMOD.

It is noted that the NEPA modelling guidelines recommend the model and modelling procedures that are currently used in the US for predicting maximum pollutant impacts for regulative applications.

Source Data

Maximum SO_2, NO_x, TSP, PM_{10}, and CO emission rates and stack parameter data for a Wartsila 12V46 diesel engine were developed by Wartsila. The proposed project consists of six identical engines with a total electric generating capacity of 60 MW. The location of each stack was determined by an AutoCAD site plan provided by JEP. The emission sources were modelled as point sources that discharge vertically with no rain caps. Because the six emission points are close together [i.e., located in a rectangular grid within 2 meters (m) of each other], the stacks were clustered to account for the plume entrainment from each source upon another source. Using this approach, the exhaust area from each stack was calculated, based on the stack diameter, and added together to estimate an effective stack diameter for the six engines combined. The exit velocity remained the same as that used for a single engine. This approach is consistent with recommendations for stacks that are located very close to one another (Electric Power Research Institute, 1984).

A summary of the proposed power plant's source locations and stack parameter data is presented in Table 66 and a summary of the plant's emission rates and basis of each emission rates is presented in Table 67. The locations of the proposed power plant stacks, key building structures, and fence line receptors are shown in Figure 62.

Building Data

All proposed key building structures and their dimensions were identified from the AutoCAD site plan and were incorporated into the air modelling analysis to account for any building downwash or wake effects on the proposed stacks. The heights of the key building structures were provided by JEP personnel for their inclusion in the air modelling analysis. A summary of the key building dimensions used in the modelling analysis for the proposed power plant is presented in Table 68.

A Good Engineering Practice (GEP) stack height was determined for each stack modelled to ensure that the stack heights are within the GEP stack height guidelines discussed in the NRCA Guideline Document. The NRCA GEP guidelines are totally consistent with the GEP guidelines of the USEPA and help determine a design stack height that will eliminate wake affects from nearby structures. A stack can be built that is below the GEP stack height. However, for a stack height that is below the GEP stack height, building dimension data needs to be included in a modelling analysis. Because the proposed JEP stacks are below the GEP stack height, the USEPA Building Profile Input Program-PRIME (BPIPPRM, Version 04274) (USEPA, 2004) was used to develop wind direction-specific building dimensions to input to the AERMOD model. The incorporation of the PRIME downwash algorithm in AERMOD makes a separate downwash cavity analysis unnecessary.

Table 66 Stack parameter data use for modelling analysis

TABLE 3-1

JEP WEST KINGSTON POWER PLANT STACK PARAMETER DATA USED FOR MODELING ANALYSIS

					Stack Parameters [a]					
		UTM Coordinates NAD83			Physical Data		Operating Data			
Source Description	Source ID	East (m)	North (m)	Elevation (m)	Height (m)	Diameter[b] (m)	Temperature (°F)	Temperature (K)	Velocity m^3/s	Velocity (m/s)
Engine 1	JEPHB1	308,743.8	1,988,076.9	4.0	32.5	1.3	183.6	362.5	39.0	29.38
Engine 2	JEPHB2	308,745.9	1,988,079.3	4.0	32.5	1.3	183.6	362.5	39.0	29.38
Engine 3	JEPHB3	308,746.3	1,988,074.8	4.0	32.5	1.3	183.6	362.5	39.0	29.38
Engine 4	JEPHB4	308,748.3	1,988,077.1	4.0	32.5	1.3	183.6	362.5	39.0	29.38
Engine 5	JEPHB5	308,748.7	1,988,072.6	4.0	32.5	1.3	183.6	362.5	39.0	29.38
Engine 6	JEPHB6	308,750.8	1,988,075.1	4.0	32.5	1.3	183.6	362.5	39.0	29.38

Note:

°F = degrees Farenheit

K = degrees Kelvin

m = meters

m/s = meters per second

m^3/s = cubic meters per second

[a] Based on site plan and source information provided by JEP.

[b] Because of their close proximity to one another, the 6 flue areas were merged for the modelng analysis and were modeled with an effective diameter of 3.18 m.

Table 67 Emissions used for modelling analysis

TABLE 3-2
JEP WEST KINGSTON POWER PLANT EMISSIONS USED FOR MODELING ANALYSIS

Source Description	Source ID	Emissions [a]						IFC EH&S Guidelines [d]	
		SO_2 [b]			NO_x			SO_2	NO_x
		(lb/hr)	(g/s)	(mg/Nm^3) [c]	(lb/hr)	(g/s)	(mg/Nm^3) [c]	wt%S[e]	(mg/Nm^3)
Engine 1	JEPHB1	50.4	6.35	254	79.4	10.00	400	0.5%	400
Engine 2	JEPHB2	50.4	6.35	254	79.4	10.00	400	0.5%	400
Engine 3	JEPHB3	50.4	6.35	254	79.4	10.00	400	0.5%	400
Engine 4	JEPHB4	50.4	6.35	254	79.4	10.00	400	0.5%	400
Engine 5	JEPHB5	50.4	6.35	254	79.4	10.00	400	0.5%	400
Engine 6	JEPHB6	50.4	6.35	254	79.4	10.00	400	0.5%	400

Note:
lb/hr = pounds per hour
g/s = grams per second

[a] Based on IFC requirements / information provided by Wartsila (2009).
[b] Based on maximum hourly fuel consumption of 2,285.7 kg/hr and maximum sulfur content of 0.5% by weight.
[c] Based on exhaust flow rate of 25 m^3 at 20 °C (39 m^3 at 183.6 °C).
[d] International Finance Corporation Environmental, Health, and Safety Guidelines for Thermal Power Plants burning liquid fuels (plant >50 MWth to <300 MWth, cylinder bore >400 mm) for a degraded air shed.
[e] Sulphur content of fuel used expresseed as percentage by weight (wt%)

Figure 62 Location of stacks, key building structures and fenceline receptors

Table 68 Dimensions of key buildings structures

TABLE 3-3

DIMENSIONS OF KEY BUILDING STRUCTURES - JEP WEST KINGSTON POWER PLANT

Structure Name	BPIP ID	Height (m)	Length (m)	Width (m)
Engine Hall	ENGINEHALL	13.15	57.7	29.8
Electrical Building	ELECTRICAL	5.7	27.8	11.0

Note: BPIP = Building Profile Input Program

Meteorological Data

In accordance with the NEPA Guideline Document, a 5-year meteorological data record was used for the modelling analysis. The AERMOD model's meteorological pre-processor program AERMET (USEPA, 2006b), Version 06341, was used to process the meteorological data. The 5-year data record consisted of hourly surface observations from 1999 to 2003 and upper air sounding data collected from NMIA for the same 5-year period. The upper air records were obtained from the NCDC's online database (NCDC, 2008). The meteorological record was developed for a prior air modelling study performed at Hunts Bay (Golder, 2008) and additional details concerning the development of the data are available from that document.

The wind speed and wind direction frequencies of the 5-year meteorological record can be viewed in Figure 63. As can be seen from this figure, winds occur from the east-southeast direction most of the year.

Receptors

A Cartesian receptor grid for the proposed power plant was used for the modelling analysis and consisted of the following receptor spacing:

- 50-m spacing on the fence line;
- 100-m spacing from the fence line to 2.5 kilometres (km); and

- 250-m spacing from 2.5 to 5 km.

The 5-km receptor grid was sufficient for capturing the maximum impacts for the proposed power plant. The location of the receptor grid is shown in Figure 64. For cumulative source modelling with background sources, the same receptor grid was used, except that the grid's receptors that were located inside the fence lines of nearby facilities owned by Jamaica Public Service and Petrojam were excluded.

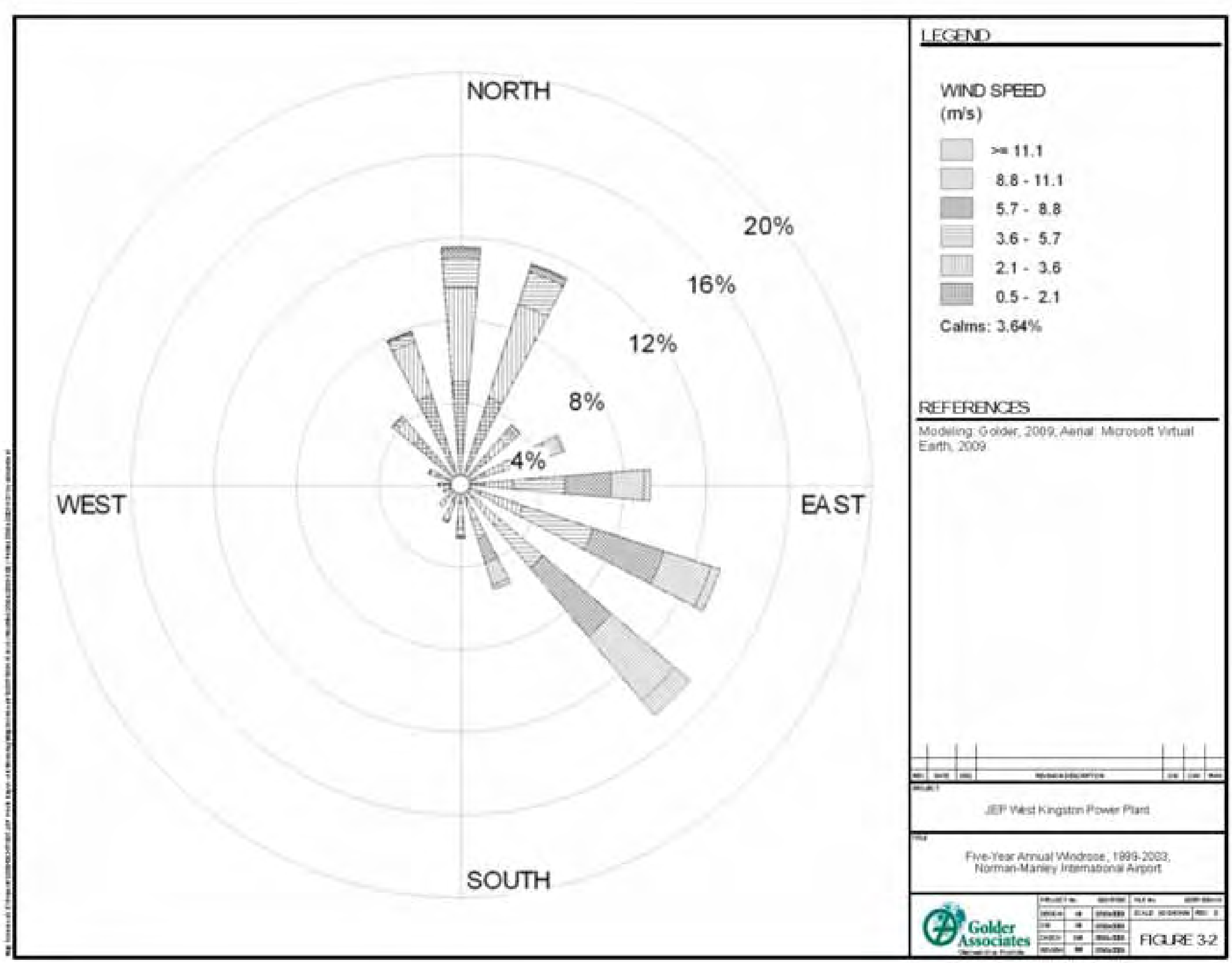


Figure 63 Five year annual wind rose

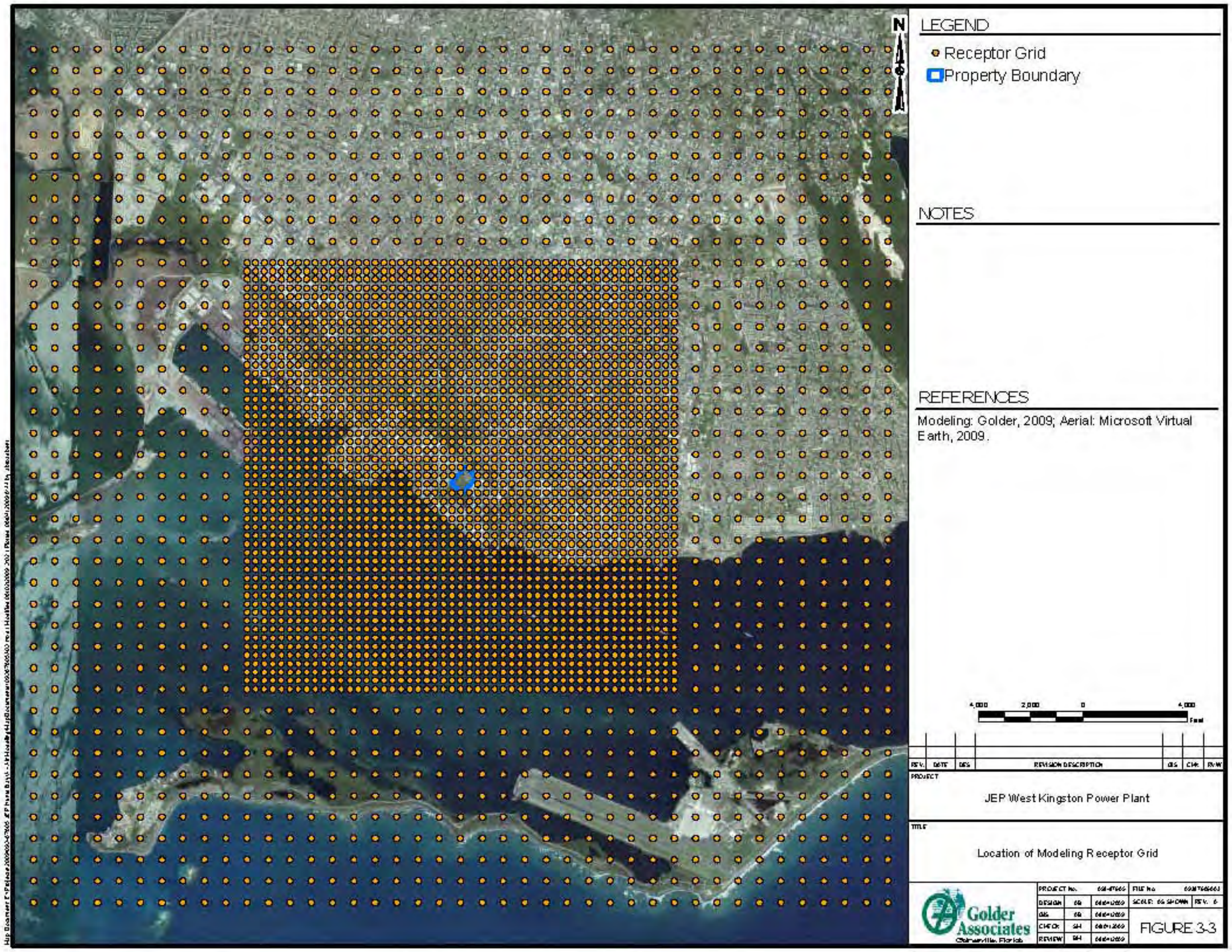


Figure 64 Location of modelling receptor grid

Elevations for all receptors were obtained from 30-m elevation maps developed by Mona GeoInformatics Institute (2008). Raster formatted maps were obtained and the elevations were extracted by overlaying the receptor locations for each site over the map. The GIS program ArcInfo Version 9.2 (ESRI, 2006) was used to extract the values from the raster and assign them as elevations. The values were then exported to a text file and formatted as inputs to the AERMOD control files.

Background Sources

Source inventories were obtained for SO_2 and NO_x background sources because the proposed power plant's maximum impacts were predicted to be greater than the Jamaican SILs for those pollutants. Because the proposed power plant's maximum predicted TSP, PM_{10}, and CO impacts were well below the Jamaican SILs and/or AAQS, cumulative source modelling analyses were not performed for these pollutants.

Current emission and stack parameter data for SO_2 and NO_x background sources in the Kingston airshed were available from a recently completed air modelling study (Claude Davis & Associates, 2009). A summary of the background source data is presented in Table 69. This table includes two SO_2 and NO_x source inventories for Petrojam: 1) the current plant configuration, and 2) the source configuration after a proposed Petrojam upgrade presented in that document. While cumulative source SO2 and NOx AAQS modelling analyses were performed for each Petrojam source configuration, it is noted that the timing of the implementation of the proposed expansion, if it happens, is not known. The locations of current background emission sources in the vicinity of the proposed power plant are shown in Figure 65. The location of future background emission sources after Petrojam's proposed upgrade is shown in Figure 66.

Table 69 Summary of background source data

TABLE 3-4
JEP WEST KINGSTON POWER PLANT PROJECT
BACKGROUND SO_2 AND NO_x SOURCE EMISSION AND STACK PARAMETER DATA USED FOR THE AAQS ANALYSES

Facility Name / Emission Unit Description	AERMOD ID Name	UTM Location X (m)	UTM Location Y (m)	Elevation (m)	Stack and Operating Parameters Height (m)	Diameter (m)	Temperature (K)	Velocity (m/s)	SO_2 Emission Rate (g/s)	NO_x Emission Rate (g/s)
Jamaica Ethanol Processing Ltd										
Unit 1	JETH2	315,203	1,987,788	18	6.10	0.60	358.7	10.00	15.03	1.50
JPS Hunts Bay										
B6	JPHB6	308,271	1,987,952	4	45.70	2.90	441.0	5.85	251.3	26.10
GT10	JPSGT10	308,364	1,987,948	4	11.54	4.20	689.0	15.80	18.2	38.34
GT5	JPSGT5	308,569	1,988,137	4	12.04	4.12	766.0	8.30	27.5	25.36
JPS Rockfort										
Unit 1	JPSR1	314,500	1,987,543	7	38.80	1.76	616.0	21.83	100.9	55.70
Unit 2	JPSR2	314,500	1,987,554	7	38.80	1.76	616.0	21.83	117.3	47.10
JPPC										
Engine 1	JPPC1	314,376	1,987,692	7	65.00	1.80	672.0	45.90	36.6	142.70
Engine 2	JPPC2	314,380	1,987,692	7	65.00	1.80	672.0	45.90	36.6	142.70
PetroJam (Current facility)										
Pipestill heater	PJAMF-1	307,496	1,988,255	4	45.72	3.05	699.8	4.19	45.8	5.28
Powerformer Feed Preheater F-234	PJAMF-234	307,505	1,988,264	4	45.72	2.90	624.8	3.71	13.93	1.17
Vacuum Furnace	PJAMF201	307,507	1,988,266	4	20.50	0.69	602.6	6.15	2.52	0.15
GTG High & Low Temp Coils	PJAMF6	307,464	1,988,146	1	18.30	1.83	673.0	32.06	1.42	4.96
Foster Wheeler Boiler	FWB	307,450	1,988,135	1	16.20	0.80	623.0	24.90	21.7	2.50
Cleaver Brooks Boiler (Standby)	CBB	307,518	1,988,227	4	17.37	0.80	602.6	80.41	17.1	0.04
Hurst Boiler (Standby)	HURST	307,496	1,988,255	4	18.29	3.05	699.8	4.19	8.54	0.02
Volcano Boiler (Standby)	VOLCANO	307,439	1,988,147	1	69.40	3.05	650.0	0.47	1.39	0.47
Flare	FLR	307,340	1,988,244	2	45.72	0.20	1473.0	20.00	0.315	0.03
F-401	F-400	307,544	1,988,096	1	45.70	2.90	483.0	0.37	1.64	0.14
Platform Charge Heater F-411	F-400	307,544	1,988,096	1	45.70	2.90	483.0	0.81	3.61	0.30
No. 1 Interheater F-412	F-400	307,544	1,988,096	1	45.70	2.90	483.0	1.03	4.6	0.39
No. 2 Interheater F-412	F-400	307,544	1,988,096	1	45.70	2.90	483.0	0.63	2.81	0.24
F-401 - 412 (combined sources)	F-400	307,544	1,988,096	1	45.7	2.90	483.0	1.03	12.66	1.06
Nebraska (Oil)	NBRSKA	307,523	1,988,224	4	20.50	2.06	602.6	6.15	37.6	0.09
PetroJam (Proposed upgraded facility)										
Vacuum Furnace	PJAMF201	307,507	1,988,266	4	20.5	0.61	683.0	3.71	2.52	0.15
Petrojam Sulfur C	45ME01	307,633	1,988,416	4	35.0	1.01	547.0	6.77	1.85	0.00
Petrojam DHT	22F01	307,591	1,988,366	4	35.0	1.16	645.0	6.40	0.00391	0.64
Petrojam CCR	31F04	307,563	1,988,336	4	35.0	1.52	539.0	7.19	0.00908	1.46
Petrojam NHT	21F01	307,520	1,988,314	4	35.0	0.76	615.0	2.99	0.00088	0.13
Petrojam DCU	13F01	307,658	1,988,157	4	35.0	1.68	422.0	6.55	0.0129	2.05
Petrojam VDU - Oil	11F01	307,538	1,988,298	4	60.0	2.44	628.0	6.58	57.6	0.14
Petrojam CDU - Oil	01F05	307,505	1,988,283	4	60.0	2.10	589.0	7.92	47.8	0.11
Petrojam H2 Plant	25F01	307,545	1,988,259	4	35.0	2.44	478.0	5.09	0.0373	2.80
Pterojam Utility Boiler	BNEW/650	307,658	1,988,425	4	60.0	2.53	616.0	4.72	71.6	0.17
Petrojam DCU 2	23F01	307,598	1,988,282	4	33.5	0.76	561.0	1.31	1.2	0.06
Petrojam Flare New	FLAREN	307,304	1,988,198	4	65.2	0.03	1273.0	20.00	0.315	0.07
Petrojam Boiler B2 #New Cleaver Brooks	B125#2	307,524	1,988,223	4	18.3	0.41	603.0	74.60	17.1	0.04
Petrojam Boiler #B3 Nebraska	B125#3	307,532	1,988,240	4	17.4	2.06	603.0	6.41	37.6	0.09
PJAM GTG High & Low Temp Coils	PJAMF6	307,464	1,988,146	1	18.3	1.83	673.0	32.06	1.42	4.96
PJAM Foster Wheeler Boiler	FWB	307,450	1,988,135	1	16.2	0.80	623.0	24.90	21.7	2.50
PJAM Volcano Boiler (Standby)	VOLCANO	307,439	1,988,147	1	69.4	3.05	650.0	0.47	1.39	0.47
PJAM F-401	F-401	307,544	1,988,096	1	45.7	2.90	483.0	0.37	1.64	0.14
PJAM Platformer Charge Heater F-411	F-411	307,544	1,988,096	1	45.7	2.90	483.0	0.81	3.61	0.30
PJAM No.1 Interheater F-412	F-412N1	307,544	1,988,096	1	45.7	2.90	483.0	1.03	4.6	0.39
PJAM No.2 Interheater F-412	F-412N2	307,544	1,988,096	1	45.7	2.90	483.0	0.63	2.81	0.24
Caribbean Cement Company										
Kiln 3 main stack	CCK3	316,433	1,987,235	40	44.00	2.60	433.0	9.40	42.23	38.11
Kiln 4 main EP	CCK4	316,592	1,987,318	15	44.00	2.60	363.0	13.00	4.38	28.03
Kiln 5 main fabric filter	CCK5	316,790	1,987,425	38	117.50	2.60	381.0	17.00	28.95	43.42
Other Sources										
D&G Boiler Stack East	DG1	305,923	1,991,542	11	45.72	0.72	533.0	12.00	9.81	0.98
D&G Boiler Stack West	DG3	305,905	1,991,557	11	18.00	0.60	523.0	11.90	6.85	0.68
D&G Boiler Stack	DG2	305,914	1,991,549	11	18.00	0.60	523.0	11.90	6.85	0.68
CCC Kiln 4 Dry 1300 tons/d	CCCLD	316,680	1,987,152	20	44.00	2.60	433.0	12.80	4.38	28.03
CCC Kiln 3 Wet 700 tons/d	CC3	316,543	1,987,325	71	44.00	2.60	433.0	9.40	42.23	38.11
Caribbean Products	CP1	305,581	1,991,871	9	14.60	0.56	477.0	1.00	7.85	0.02

Note:
m = meters
K = Kelvins
m/s = meters per second
g/s = grams per second
[a] Inventory based on Petrojam EIA (Claude Davis & Associates, 2009).

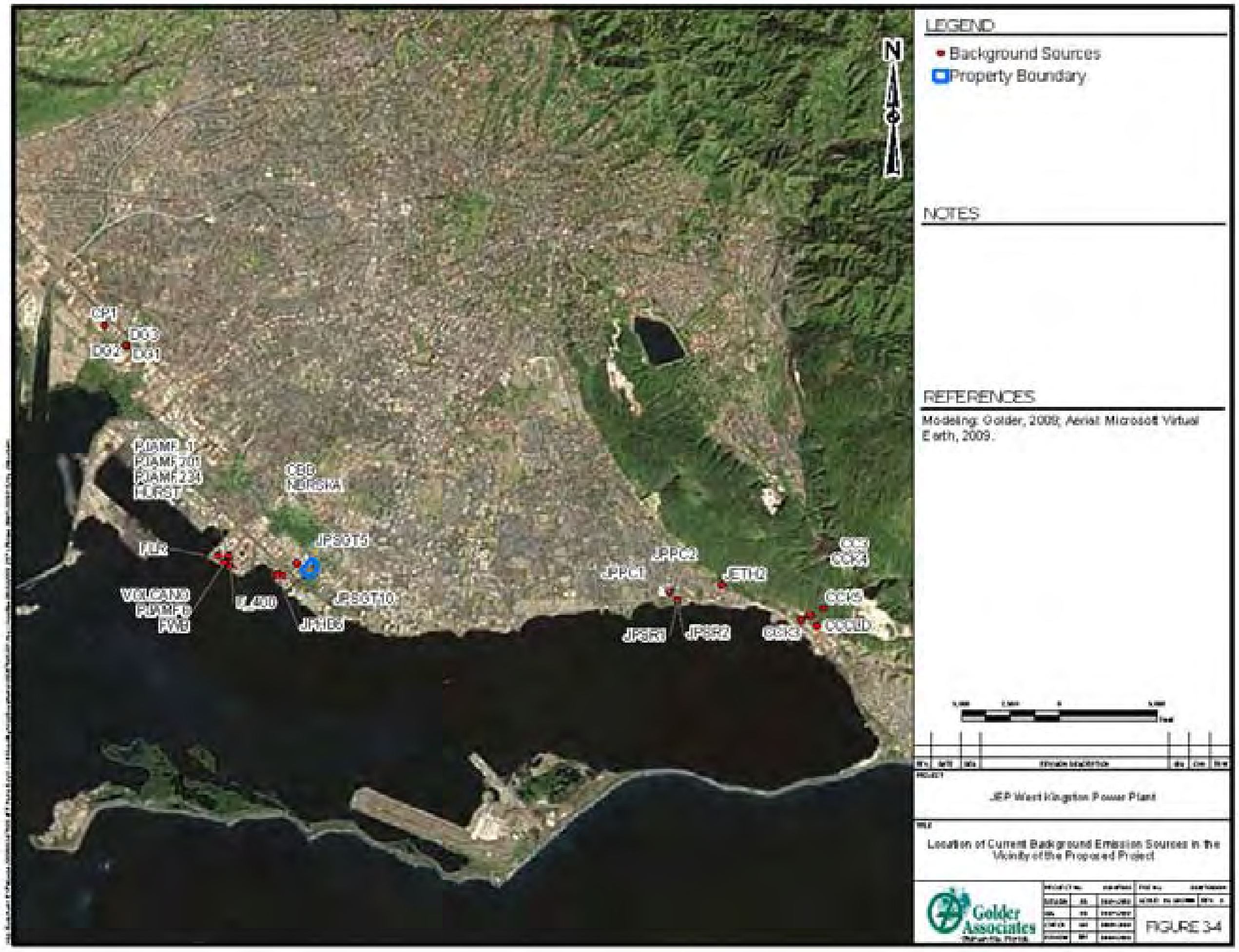


Figure 65 Location of current background emission source in the vicinity of the proposed project

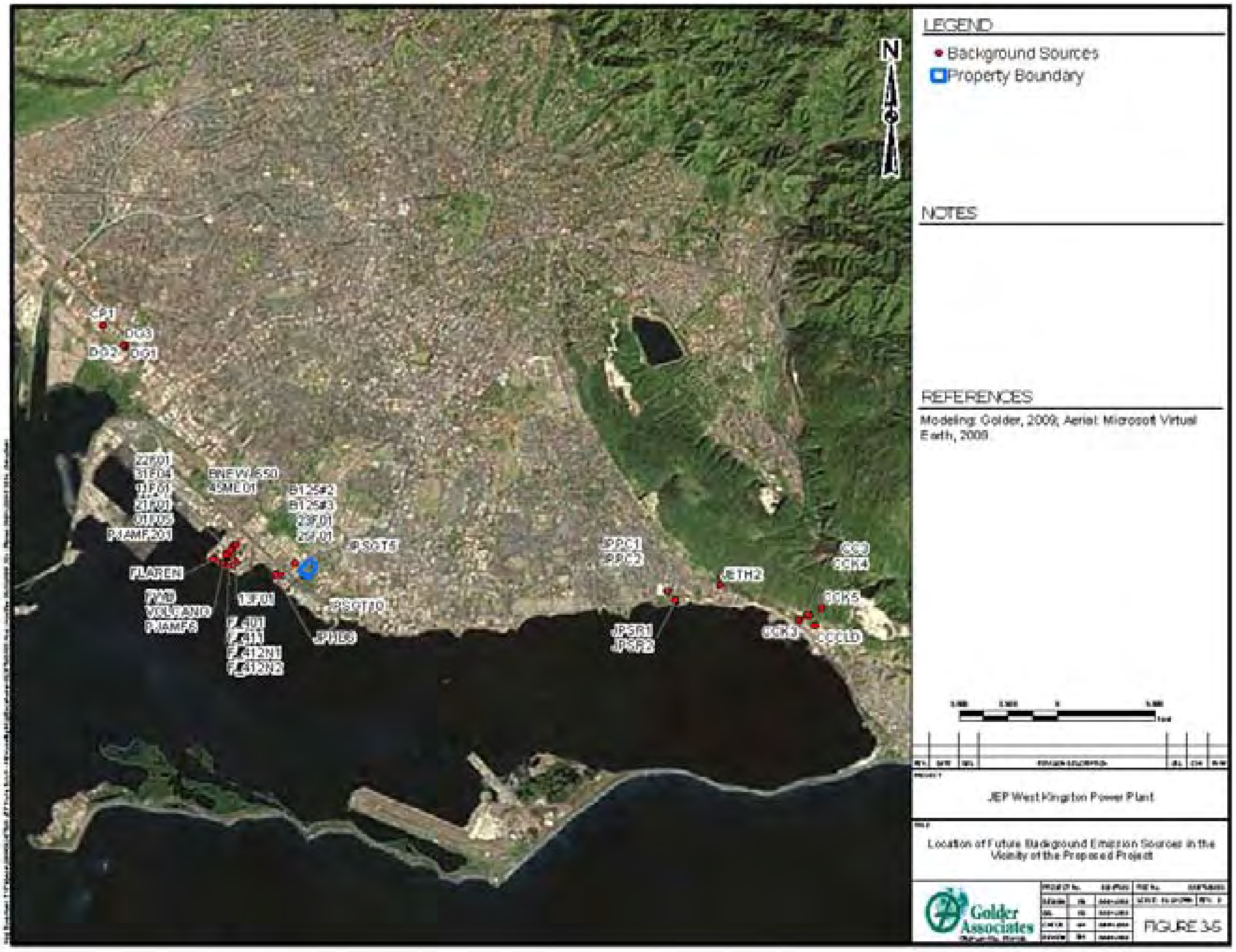


Figure 66 Location of future background emission sources in the vicinity of the proposed project

The emission rates used in the air modelling analysis are based on maximum heat input rates and available data for sulphur content in the fuel oil (2.3% for JPS and Petrojam and 2% for JPPC). The fuel used by Petrojam and JPS (both Hunts Bay and Rockfort plants) would be similar to the fuel used at the JPS Old Harbour plant (i.e. 3% sulphur fuel). However, based on historical data for the JPS Old Harbour Plant, the actual sulphur content varied between a minimum of 1.97%wt and a maximum of 2.29%wt in 2006 and a minimum of 2.20%wt and a maximum of 2.4%wt in 2007. It should also be noted that all sources in the area applied for air pollutant discharge license in 2008, which involves a polluter pay emission system which will encourage all plants in the air shed to decrease emissions since they would pay fees proportional to the quantity of pollutants emitted to the air shed. The JPPC power plant uses heavy fuel oil with a sulphur content of 2%wt.

Non-Modelled Background Concentrations

Non-modelled background concentrations are those concentrations from sources not explicitly modelled. The NRCA Guidance Document does not provide non-zero background concentrations for SO2 and NO2. Therefore, in order to account for background concentrations of SO2 and NO2 from sources not included in the modelling analysis, available ambient air monitoring data in the area were reviewed. NEPA's Cross Roads monitor site (NEPA, 2007) was selected, since it is relatively remote from the major industrial areas in Kingston and is, therefore, a good representative location for background air quality. The average SO2 and NO2 background concentrations from the monitoring site were used as background concentrations for the cumulative source modelling impact assessments. The background concentrations were added to the modelled source impacts for comparison to the Jamaican AAQS.

Modelling Results

Proposed Power Plant Impacts Only

The maximum predicted SO_2, NO_2, TSP, PM10, and CO concentrations for the proposed power plant only are summarized in Table 70. Because the maximum predicted TSP/PM10 and CO concentrations were below the SILs and AAQS, respectively, additional detailed modelling for these pollutants with background sources was not performed. The maximum predicted annual average and 24-hour average SO_2 concentrations for the project were less than both the SILs and the AAQS. The maximum predicted 1-hour average SO_2 concentration was less than the 1-hour AAQS. Figure 67 to Figure 69 show the spatial distribution of the predicted highest annual, 24-hour and 1-hour average concentrations due to the proposed power plant.

The maximum predicted annual average NO_2 concentration for the project was less than both the SILs and the AAQS concentrations. The maximum predicted 1-hour average NO_2 concentration was less than the 1-hour AAQS. Figure 70 and Figure 71 show the spatial distribution of the predicted highest annual and 1-hour average concentrations due to the proposed power plant.

Discussion

The modelling analysis shows that the proposed power plant-only impacts are in compliance with all Jamaican AAQS. Cumulative source modelling analyses conducted for SO_2 and NO_2 have indicated offsite maximum concentrations that, except for the annual NO_2 AAQS, are greater than the Jamaican AAQS. From Table 71, it can be seen that the highest contributors to the maximum predicted SO_2 concentrations are JPS Hunts Bay Power Plant and Petrojam. JEP's contribution varies from 1.9 percent of the maximum predicted annual average concentration to 7.4 percent of the maximum predicted 1-hour average concentration. The JPPC power plant is the major contributor to the maximum predicted 1-hour NO_2 concentration in the area.

To obtain a better understanding of the existing air quality in the vicinity of the proposed power plant, JEP has implemented an ambient air monitoring and air model validation program that will measure the baseline air quality in the vicinity of the maximum impact areas of the proposed project and compare to modelling predictions. A more detailed discussion of these programs is presented in Section 6.0

Table 70 Maximum predicted concentrations for JEP only

TABLE 4-1
MAXIMUM PREDICTED CONCENTRATIONS FOR THE PROPOSED JEP WEST KINGSTON POWER PLANT ONLY

Pollutant	Averaging Time	Concentration Rank	Concentrations[a] (µg/m³)	Jamaican SIL (µg/m³)	Jamaican AAQS (µg/m³)
SO_2	Annual	High	6.29	20	80
(0.5%S)	24-Hour	High	34.3	80	365
	1-Hour	High	213	na	700
NO_2[b,c]	Annual	High	7.5	20	100
	1-Hour	High	269	80	400
TSP	Annual	High	1.2	na	80
	24-Hour	High	7.1	na	150
PM_{10}	Annual	High	1.2	20	50
	24-Hour	High	7.1	80	150
CO	8-Hour	High	20	10,000	10,000
	1-Hour	High	57	40,000	40,000

na = not applicable

[a] Concentrations are based on highest predicted concentrations from AERMOD using 5 years of meteorological data for 1999 to 2003 consisting of surface and upper air data from Kingston/Norman Manley International Airport.

[b] NO_x to NO_2 conversion factor of 0.75 applied to modeled NO_x impacts based on Jamaican Modeling Guidelines.

[c] NO_X emissions based on 400 mg/Nm³

Table 71 Source contributions to peak modelled concentrations

TABLE 4-3
SOURCE CONTRIBUTIONS TO PEAK MODELED CONCENTRATIONS

	Concentrations ($\mu g/m^3$)[a]				
Plant	**1-Hour NO_2**	**Annual NO_2**	**1-Hour SO2**	**24-Hour SO_2**	**Annual SO_2**
JEP	2	0.3	142	12	2
JPS Hunts Bay	3	0.3	912	127	28
Petrojam	1	0.1	624	252	67
JPS Rockfort	434	11	119	12	2
JPPC	1,235	15	37	2	1
Other	349	6	89	7	6
Totals	2,024	33	1,923	412	106

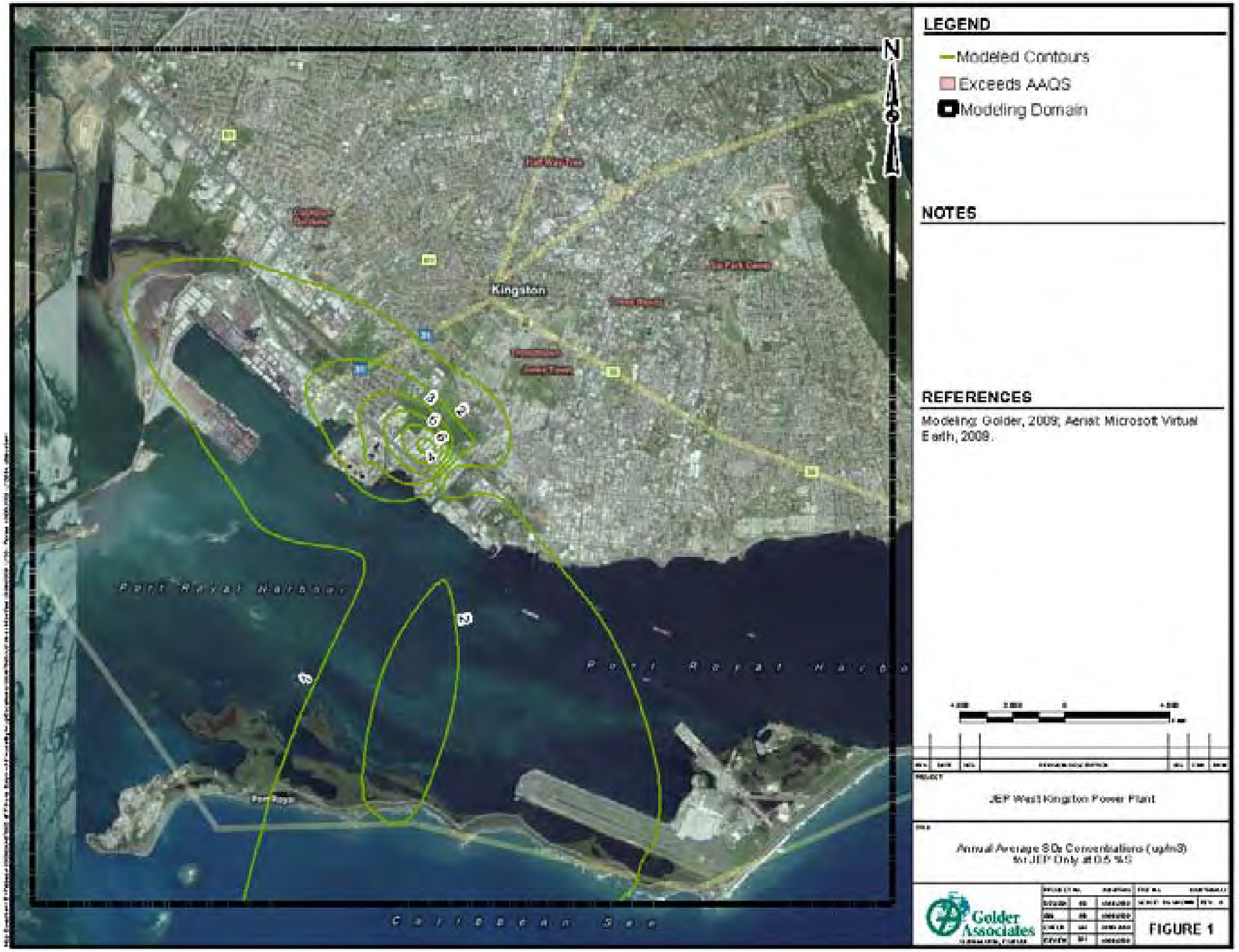


Figure 67 Predicted annual average SO_2 concentrations – JEP plant only

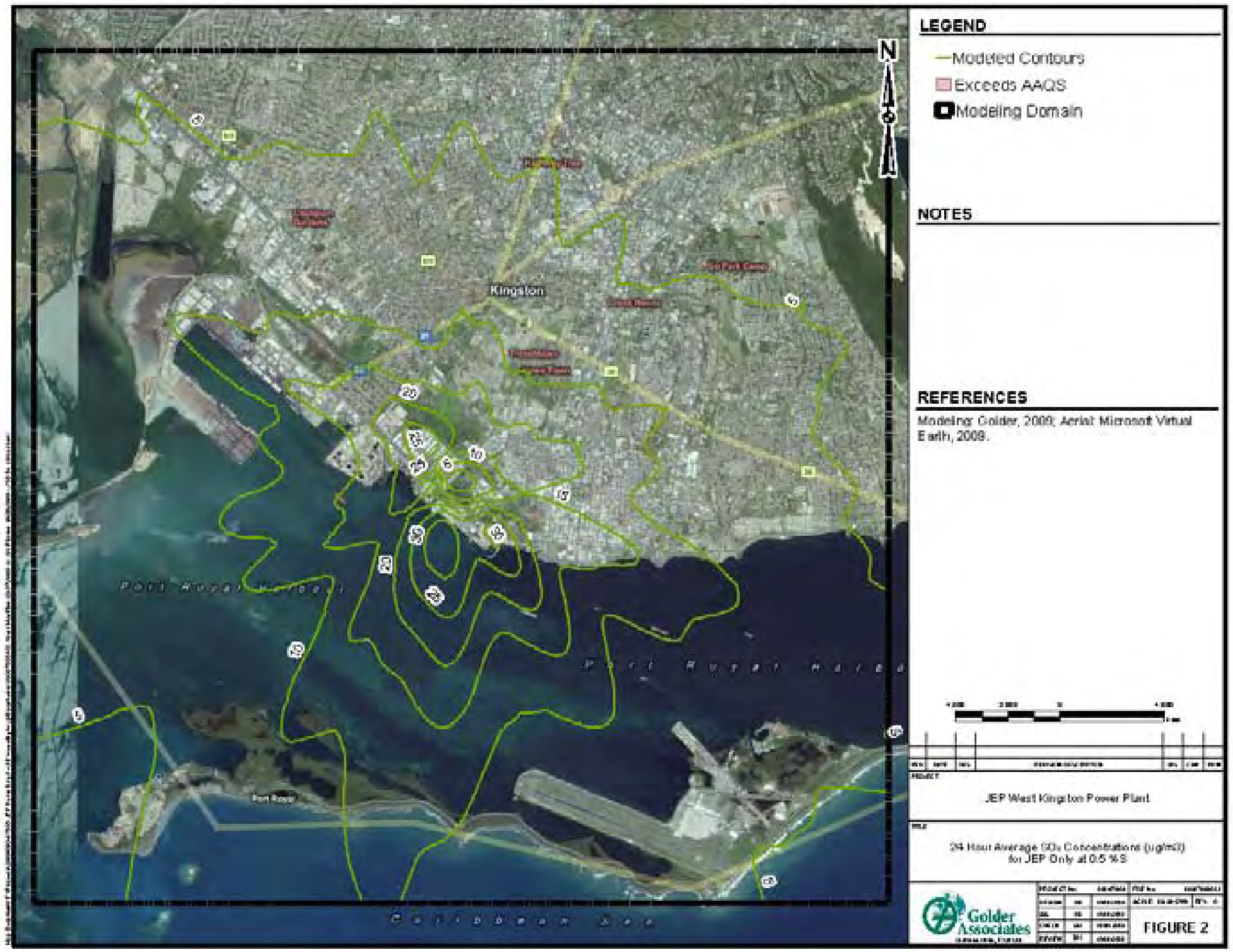


Figure 68 Predicted 24 hour average SO_2 concentrations – JEP plant only

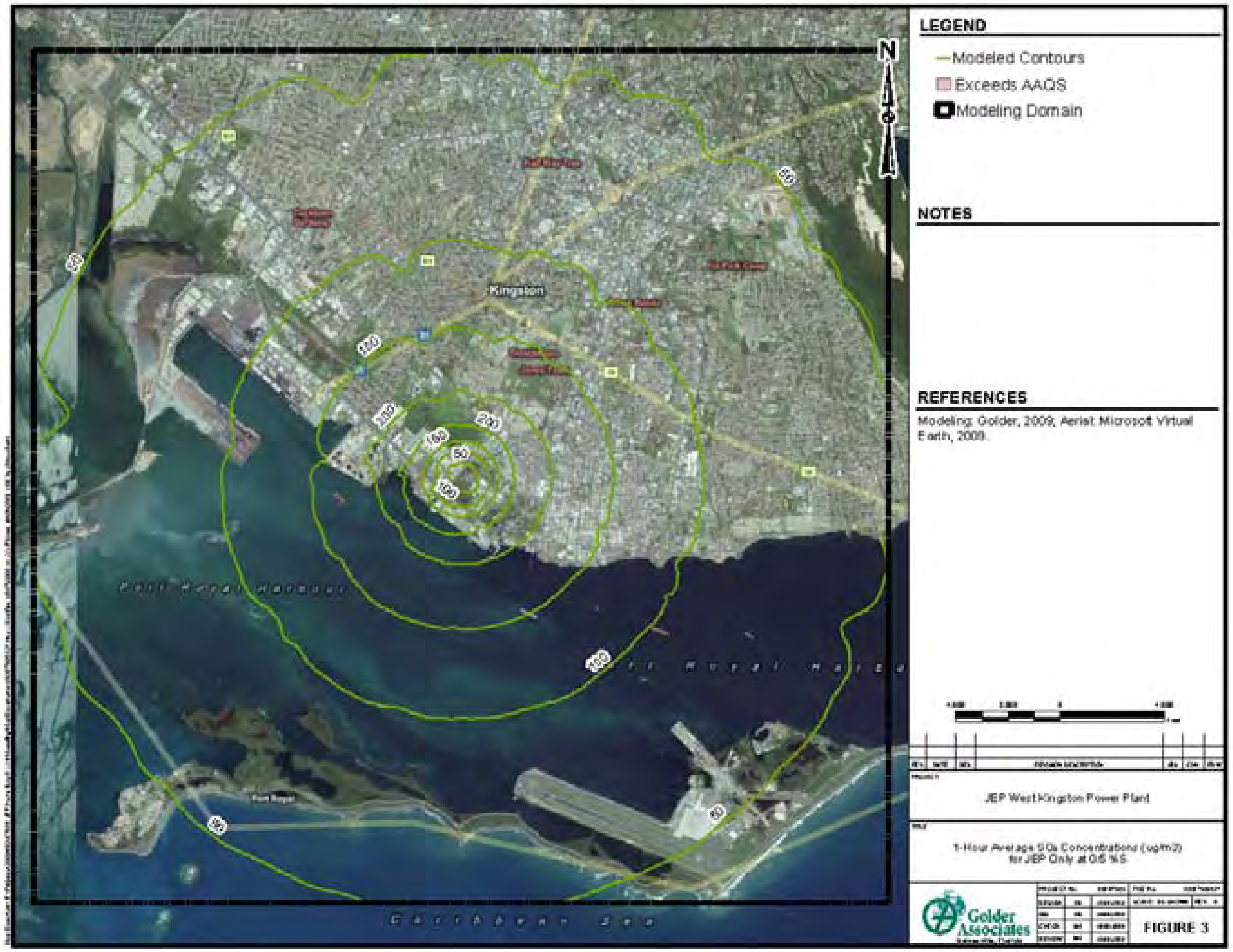


Figure 69 Predicted 1 hour average SO_2 concentrations – JEP plant only

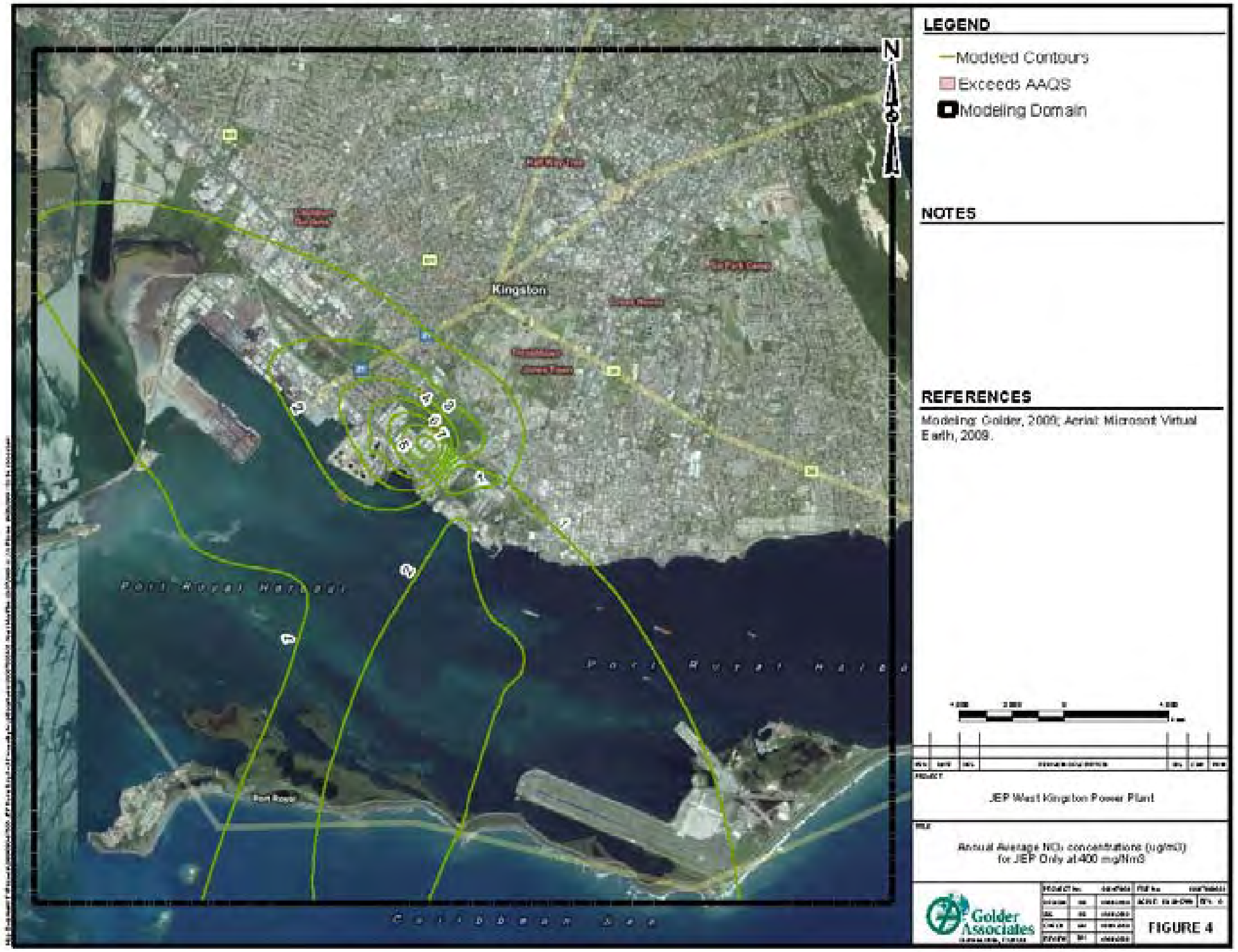


Figure 70 Predicted annual average NO_2 concentrations – JEP plant only

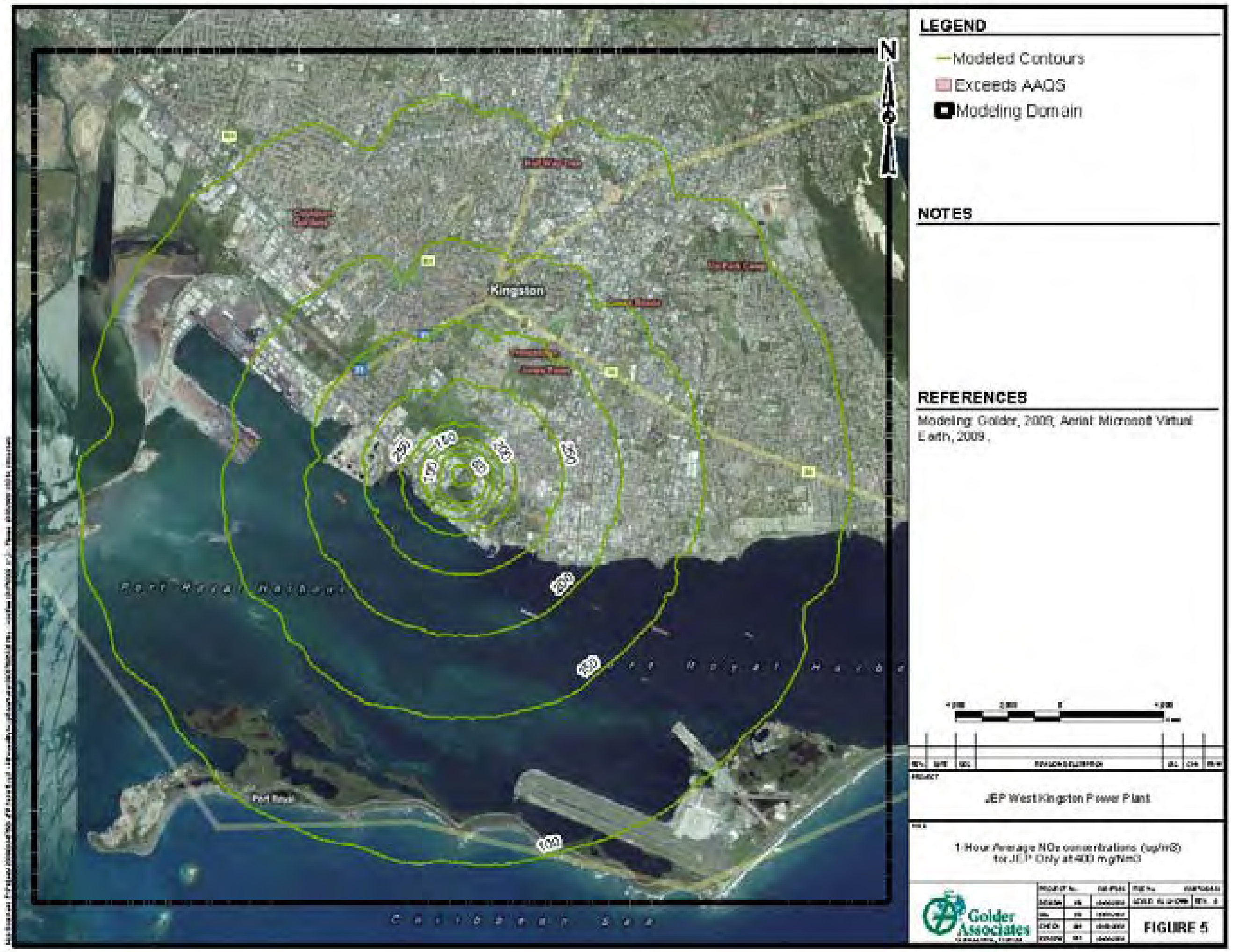


Figure 71 Predicted 1 hour average NO_2 concentrations – JEP plant only

5.3.2 Biological Resources

The proposed project will not have significant impact on the terrestrial flora. The species identified were not significantly important, ecologically or commercially. The low species diversity and numbers of birds seen are testament of the disturbed nature of the area and its small importance as a habitat for birds.

5.3.3 Hydrology

The operation of the power plant is not expected to have significant impact on the surface and ground water in the Project Area. The power plant will receive its drinking water from the National Water Commission's domestic supply and private bottled water suppliers. The project will have curbed and diked areas to minimize surface water runoff to the surrounding area and an oil water separator.

5.3.4 Land Use

The proposed project will not have significant impact on the existing land use as the project location is already an industrialized area.

5.3.5 Noise Impacts

5.3.5.1 Noise from Proposed Power Plant

The predicted noise from the proposed power plant was determined by using SoundPlan version 6.5. The model was calibrated to give the manufacturers' guaranteed noise output of 67 dBA at perimeter wall of the plant. The noise spectrum from the engines of Dr. Bird II in Old Harbour was used as these engines are similar to the one to be used in the proposed 60 MW power plant. Once the model was calibrated then structures such as the perimeter wall, auxiliary buildings, tank farms, 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 below in Table 72 and depicted in Figure 72.

Comparison with NEPA Guidelines

Stations 1, 2, 3, 4, 5 and 8 will be compliant with the NEPA day time guidelines. However, the baseline noise levels at stations 6 and 7 exceeded the NEPA day time guidelines. Stations 1, 2, 3, 5 and 8 will be compliant with the NEPA night time guidelines. The baseline noise levels for Stations 6 and 7 all exceeded NEPA night time guidelines.

Comparison with World Bank Guidelines

Stations 1, 2, 3, 5 and 8 will be compliant with the World Bank day and night time guidelines

Table 72 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 THE PLANT*	*NEPA STD.*	*WORLD BANK GUIDELINE*	*BASELINE*	*PREDICTED NOISE FROM THE PLANT*	*NEPA STD.*	*WORLD BANK GUIDELINE*
1	Railway	Industrial	55.7	60.0	75	70	53.8	60.0	70	70
2	Seprod Wall	Industrial	53.9	68.7	75	70	55.6	68.7	70	70
3	Marcus Garvey Drive	Industrial	57.2	63.6	75	70	57.6	63.6	70	70
4	Industrial Terrace	Industrial	61.6	72.5	75	70	59.9	72.5	70	70
5	Tivoli Gardens High School	Institutional	59.5	39.9	50	55	51.9	39.9	40	45
		2nd Floor		41.3				41.3		
		3rd Floor		44.9				44.9		
6	Charles Chinloy Preschool & Day Care	Institutional	58.1	59.9	50	55	53.3	59.9	40	45
7	Tivoli Gardens Community	Residential	61.9	58.4	55	55	58.0	58.4	50	45
		2nd Floor		58.0				58.0		
		3rd Floor		58.0				58.0		
		4th Floor		56.3				56.3		
8	Factories Corporation of Jamaica	Industrial	62.4	61.7	75	70	57.0	61.7	70	70

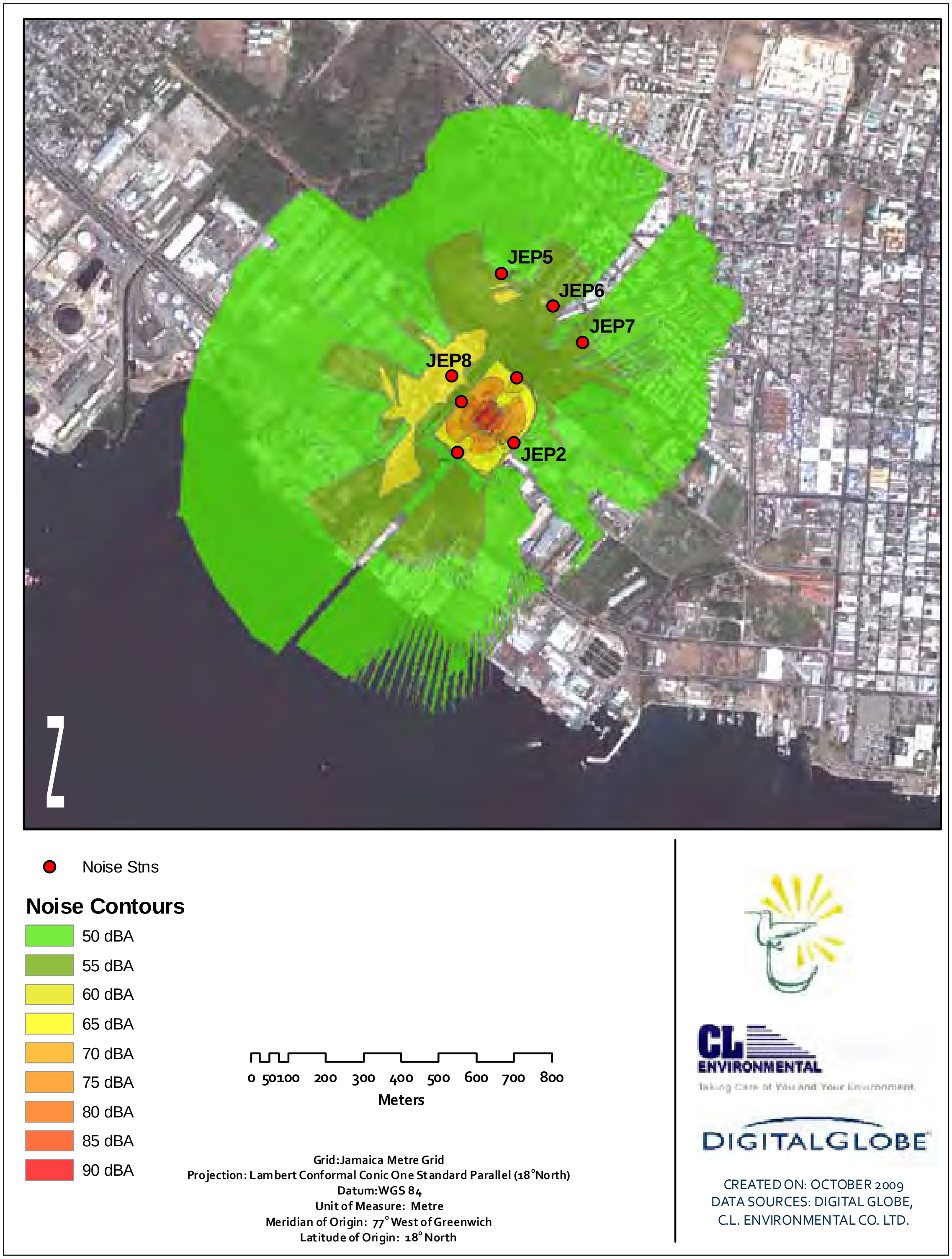


Figure 72 Modelled noise results

5.3.5.2 Occupational Noise

Individual worker noise exposure on the existing barge ('Dr. Bird II") was measured for the annual worker noise exposure survey (December 23rd and 24th, 2008) by using Quest Technologies Noise Pro DLX dosimeters in the data logging mode. The exposure (dose) was calculated by the Noise Pro DLX internally using a complex formula.

Six (6) job categories were investigated with selected employees in each category wearing a dosimeter over their work shift. These were:

i. Maintenance Supervisor,
ii. Operations Manager,
iii. Control Room Operator,
iv. Assistant Planner,
v. Mechanic; and
vi. Plant Technician

The results from the dosimeter were compared with OSHA standards for hearing conservation and permissible level (PEL) for engineering controls.

The results from the exercise are listed in Table 73 to Table 78.

Table 73 Dosimeter results for the Maintenance Supervisor – Dr Bird 2 (8am-4pm) shift

PARAMETERS	MINIMUM (dBA)	MAXIMUM (dBA)	TWA (dBA)	DOSE (%)	PEAK (dBA)
OSHA HEARING	65.0	113.1	91.3	119.5	
OSHA ENGINEERING	65.0	113.1	90.6	109.2	142.9

Table 74 Dosimeter results for the Operations Manager (8am-4pm) shift

PARAMETERS	MINIMUM (dBA)	MAXIMUM (dBA)	TWA (dBA)	DOSE (%)	PEAK (dBA)
OSHA HEARING	65.0	113.7	84.6	47.2	144.0
OSHA ENGINEERING	65.0	113.7	84.2	44.8	

Table 75 Dosimeter results for the Control Room Operator – Barge 2 (8am-4pm) shift

PARAMETERS	MINIMUM (dBA)	MAXIMUM (dBA)	TWA (dBA)	DOSE (%)	PEAK (dBA)
OSHA HEARING	65.0	128.7	69.5	5.8	144.7
OSHA ENGINEERING	65.0	128.7	63.4	2.5	

Table 76 Dosimeter results for the Assistant Planner (8am-4pm) shift

PARAMETERS	MINIMUM (dBA)	MAXIMUM (dBA)	TWA (dBA)	DOSE (%)	PEAK (dBA)
OSHA HEARING	69.9	116.3	81.1	29.2	143.5
OSHA ENGINEERING	69.9	116.3	80.4	26.3	

Table 77 Dosimeter results for the Mechanic – Barge 2 (8am-4pm) shift

PARAMETERS	MINIMUM (dBA)	MAXIMUM (dBA)	TWA (dBA)	DOSE (%)	PEAK (dBA)
OSHA HEARING	65.0	120.4	108.3	1,263.7	144.4
OSHA ENGINEERING	65.0	120.4	108.3	1,260.9	

Table 78 Dosimeter results for the Plant Technician – Barge 2 (8am-4pm) shift

PARAMETERS	MINIMUM (dBA)	MAXIMUM (dBA)	TWA (dBA)	DOSE (%)	PEAK (dBA)
OSHA HEARING	69.9	120.9	105.8	888.7	147.3
OSHA ENGINEERING	69.9	120.9	105.7	886.1	

The results indicated that three (3) of the job categories (Maintenance Supervisor, Mechanic and Plant Technician) were in non compliance with both OSHA hearing conservation and engineering controls.

In terms of the OSHA hearing conservation threshold, the noise exposure for these employees at these doses means that the OSHA Hearing Conservation comes into play. The Hearing Conservation Amendment (1983) calls for a hearing conservation program to be put in place as the 8-hour TWA exceeds 85dB (50% dose). Jamaica Energy Partners have such a programme in place and the workers are outfitted with personal protective equipment (ear muffs and plugs).

The highest instantaneous peak sound level recorded for all job categories exceeded the OSHA regulation which states that unprotected workers may not be exposed to peak sound levels greater than 140dBA.

5.3.6 Wastewater

5.3.6.1 Bund

Bunds are the structures that enclose the oil tanks, effectively isolating them from other areas of the plant. All bunds should be capable of containing the full capacity of the tanks enclosed plus a safety factor of approximately 10 to 20 percent.

The bund walls should be made of reinforced concrete and the insides should be lined with impervious non-slip material such that maintenance works can be carried out without the risk of a worker slipping.

Bunds, tanks and pipe work should be inspected regularly for signs of damage and should be checked at least weekly. Any accumulated rainwater, oil or debris should be removed and any defects to the bund wall or lining should be repaired promptly using the appropriate technique to ensure the bund retains its integrity.

5.3.6.2 Pipe Work

All pipe work should be sited above ground where possible, in order to make inspection and repair easier. The pipe work should also be protected against corrosion; insulated to guard against frost; be effectively supported and safeguarded against damage. Where a pipeline has to be laid underground it should be resistant to corrosion and placed in a protective sleeve or duct with open grating covers for inspection purposes.

The route of underground pipe work should be clearly marked and protected from mechanical damage, excessive surface loading and ground movement or disturbance. Such pipelines should be subjected to regular inspection and periodic pressure tests to check their integrity.

Separate fill pipes should be provided for each tank unless the tanks are interconnected by a balance pipe of greater flow capacity than the fill pipe. The fill pipes should have a 50mm diameter threaded connection and should be clearly marked with the product type, tank capacity and a tank number where more than one tank is involved. They should also be located within the confines of the bund and be fitted with a suitable lockable fill cap with chain and an overfill alarm should be fitted.

Surface drainage from such areas should pass through a suitably sized oil separator of an approved design.

Air vent pipes should, where possible, be positioned so they can be seen easily during delivery. They should not be smaller than the inlet pipe, should be well supported and directed so that any discharge from them (eg. in the event of the tank being overfilled) passes into the bund.

5.3.7 Traffic

Staffing on the site is not expected to exceed 30 persons at any one time. A worst case scenario could be that seventy percent (21) of the workers leave the site during the evening peak hour and use the intersection with the same modal split as presently exists. This increase in traffic only increases the control delay for vehicles exiting Industrial Terrace by 0.1 second. This will not affect the level of service at the intersection – which is presently at LOS A during the evening peak.

For the morning peak, the increase in traffic will increase the control delay by 9.6 and 0.8 seconds while the level of service remains constant at F and C for movements from Industrial Terrace and Marcus Garvey Drive respectively.

Overall post construction traffic will not in any significant way affect the delay waiting time or level of service experienced by motorists at the intersection.

5.3.8 Historical and Cultural Resources

Of the eight (8) historic sites listed within the SIA, the Kingston Railway Station (1845) is the closest, approximately 800m east of the proposed power plant site. It is not anticipated that the operation of the proposed project will have a potential negative impact on this site.

5.3.9 Socioeconomic Impacts

The proposed project will employ sixty one (61) persons on a permanent basis during its operation. They will be broken down into three (3) main groups, which are detailed in Table 79 to Table 81 below.

Table 79 Composition of the Operations Department

OPERATIONS DEPARTMENT	
Operations Manager	1
Operation Analyst	1
Shift Supervisor	4
Systems Administrator	1
Control Room Operator	4
Plant Technicians	8
Trainee Plant Technicians	4
Laboratory Technician	1
TOTAL	**24**

Table 80 Composition of the Maintenance Department

MAINTENANCE DEPARTMENT	
Maintenance Manager	1
Maintenance Supervisor	1
Workshop/Facility Supervisor	1
Maintenance Planner	1
Lead Instrumental and Electrical Technician	1
Instrumental and Electrical Technician	2
Lead Mechanical Technicians	3
Mechanical Technicians	8
Mechanical Assistants	4
Machinist	2
Welder/Fitter	1
Trainee Welder/Fitter	1
Stores /Tool Crib	2
TOTAL	**28**

Table 81 Composition of the Business Management and Administration Department

BUSINESS MANAGEMENT AND ADMINISTRATION	
Plant Manager	1
Business Manager	1
Accountant	1
Purchasing Officer	1
Human Resource/Payroll Officer	1
Environmental Health and Safety Specialist	1
Administrative Assistant	1
Office Assistant/Receptionist	1
Driver/Bearer	1
TOTAL	**8**

Casual workers are employed on a rotational basis so as to enable a wider cross section of the community to benefit.

The project will result in a more reliable and constant supply of electricity to the national power grid, which, will increase worker productivity and economic growth for the island of Jamaica.

5.3.10 Aesthetics

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.

6.0 Cumulative Impacts

The two areas of primary concern for cumulative impacts are air quality and noise. Each of these areas will be described below.

6.1 Air Quality

The maximum predicted SO_2 and NO_2 concentrations due to all existing sources and the proposed JEP 60 MW Power Plant (0.5% sulphur fuel and 400mg/Nm^3 NO_x) are presented in Table 82. Figure 73 to Figure 75 shows the spatial distribution of the predicted highest annual, 24-hour and 1-hour average SO_2 concentrations due to all existing sources and the proposed JEP 60 MW Power Plant. Figure 76 and Figure 77 show the spatial distribution of the predicted highest annual and 1-hour average NO_2 concentrations due to all existing sources and the proposed JEP 60 MW Power Plant. Source contributions to the peak modelled SO_2 and 1-hour NO_2 concentrations are presented in Table 83.

Cumulative source modelling analyses conducted for SO2 and NO2 have indicated offsite maximum concentrations that, except for the annual NO2 AAQS, are greater than the Jamaican AAQS.

Table 82 Maximum predicted concentrations for the AAQS analyses with current Petrojam Sources

TABLE 4-2

MAXIMUM PREDICTED CONCENTRATIONS FOR THE AAQS ANALYSES WITH CURRENT PETROJAM SOURCES

Pollutant	Averaging Time	Concentration Rank	Concentrations (µg/m³)[a] Modeled Sources	Background[c]	Total	UTM Coordinate East (m)	North (m)	Jamaican AAQS (µg/m³)
SO_2	Annual	High	106	7.6	114	307262	1988390	80
	24-Hour	High	412	7.6	420	307183	1988257	365
	1-Hour	High	1923	7.6	1931	306850	1988200	700
NO_2[b]	Annual	High	33	16.3	49	308350	1988400	100
	1-Hour	High	2024	16.3	2040	307801	1988119	400

NA = not applicable

[a] Concentrations are based on highest predicted concentrations from AERMOD using 5 years of meteorological data for 1999 to 2003 consisting of surface and upper air data from Kingston/Norman Manley International Airport.

[b] NO_x to NO_2 conversion factor of 0.75 applied to modeled NO_x impacts based on Jamaican Modeling Guidelines.

[c] Based on average measurements from NEPA's Cross Roads monitor, 2007.

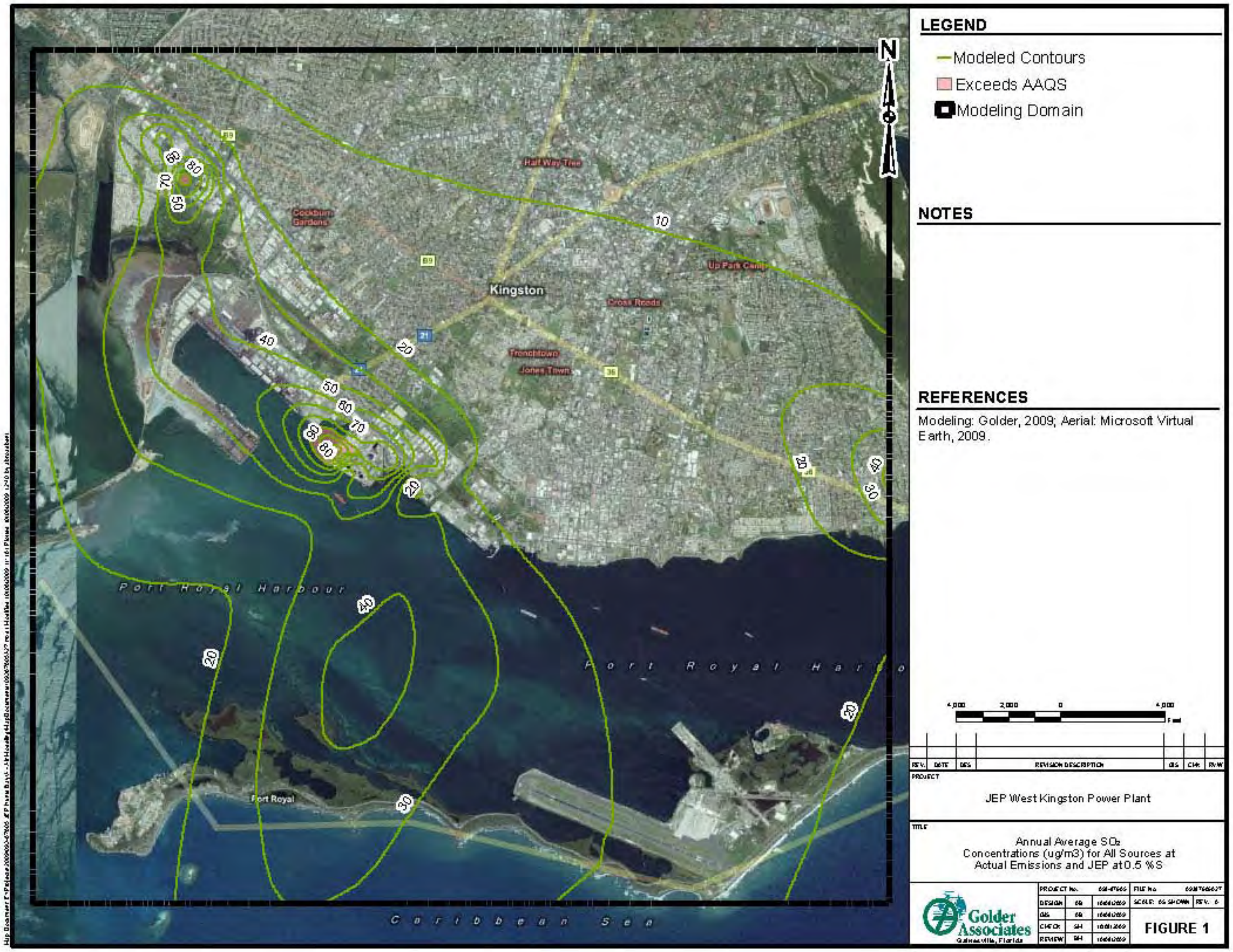


Figure 73 Predicted annual average SO_2 concentrations – All existing sources

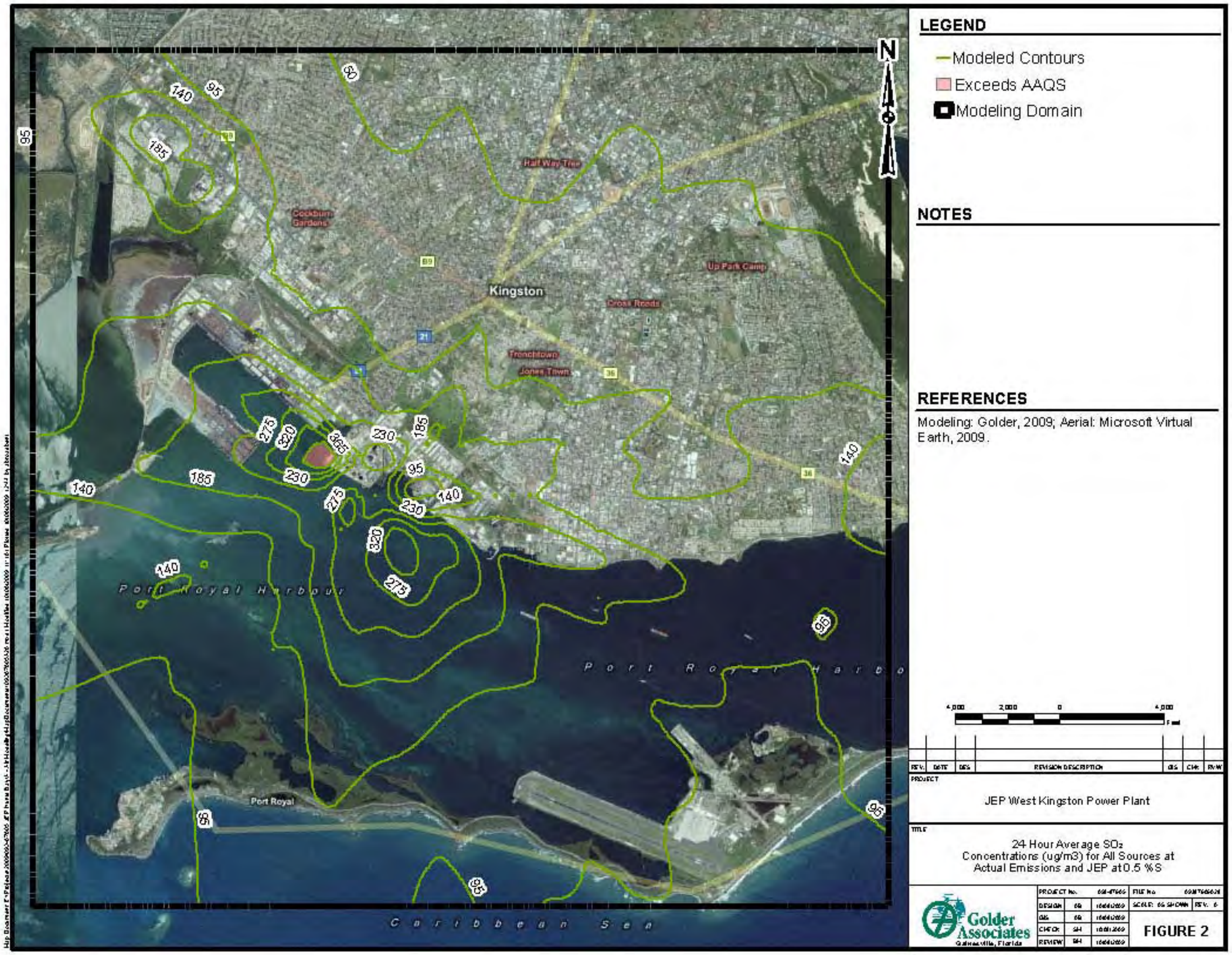


Figure 74 Predicted 24 hour average SO_2 concentrations – All existing sources

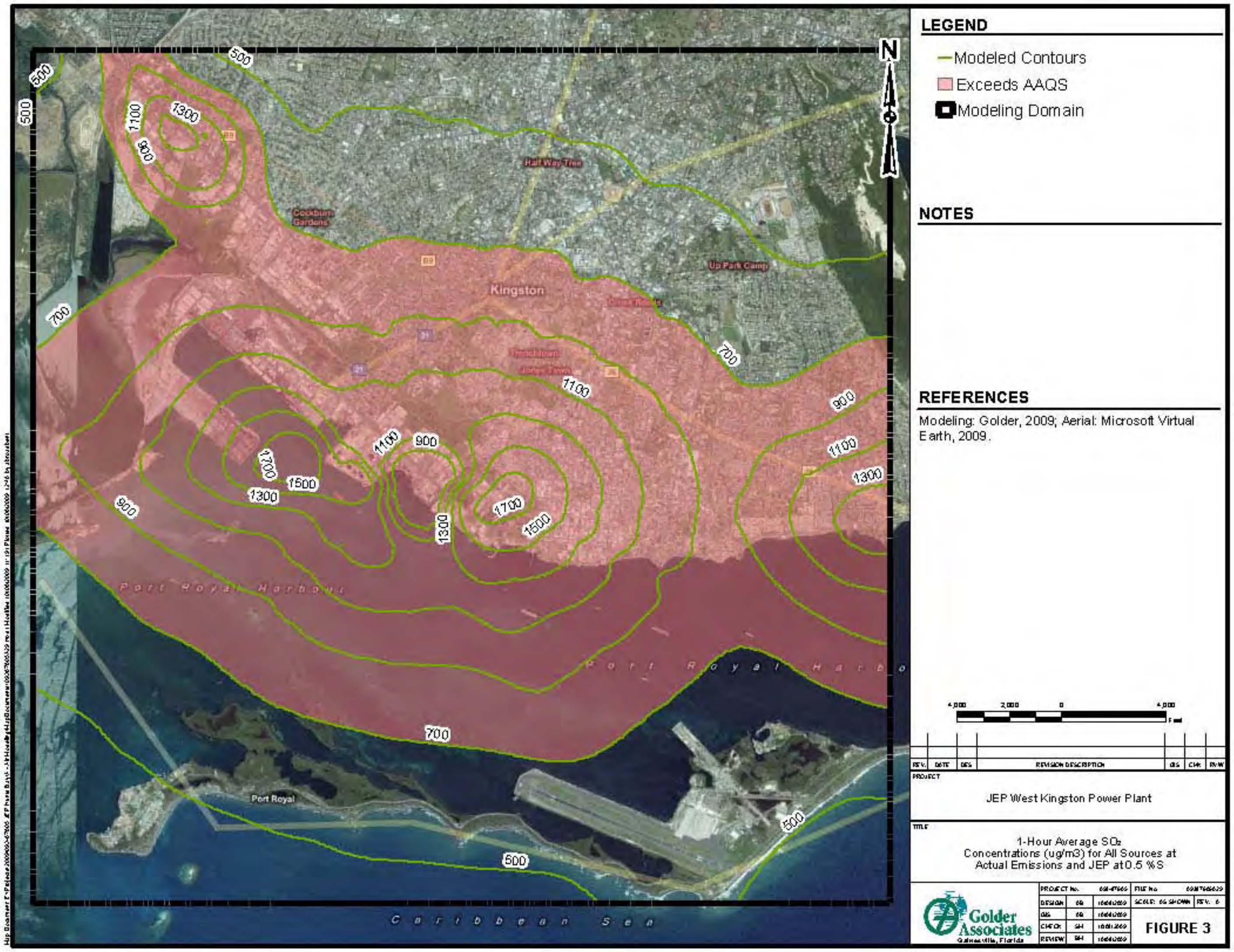


Figure 75 Predicted 1 hour average SO_2 concentrations – All existing sources

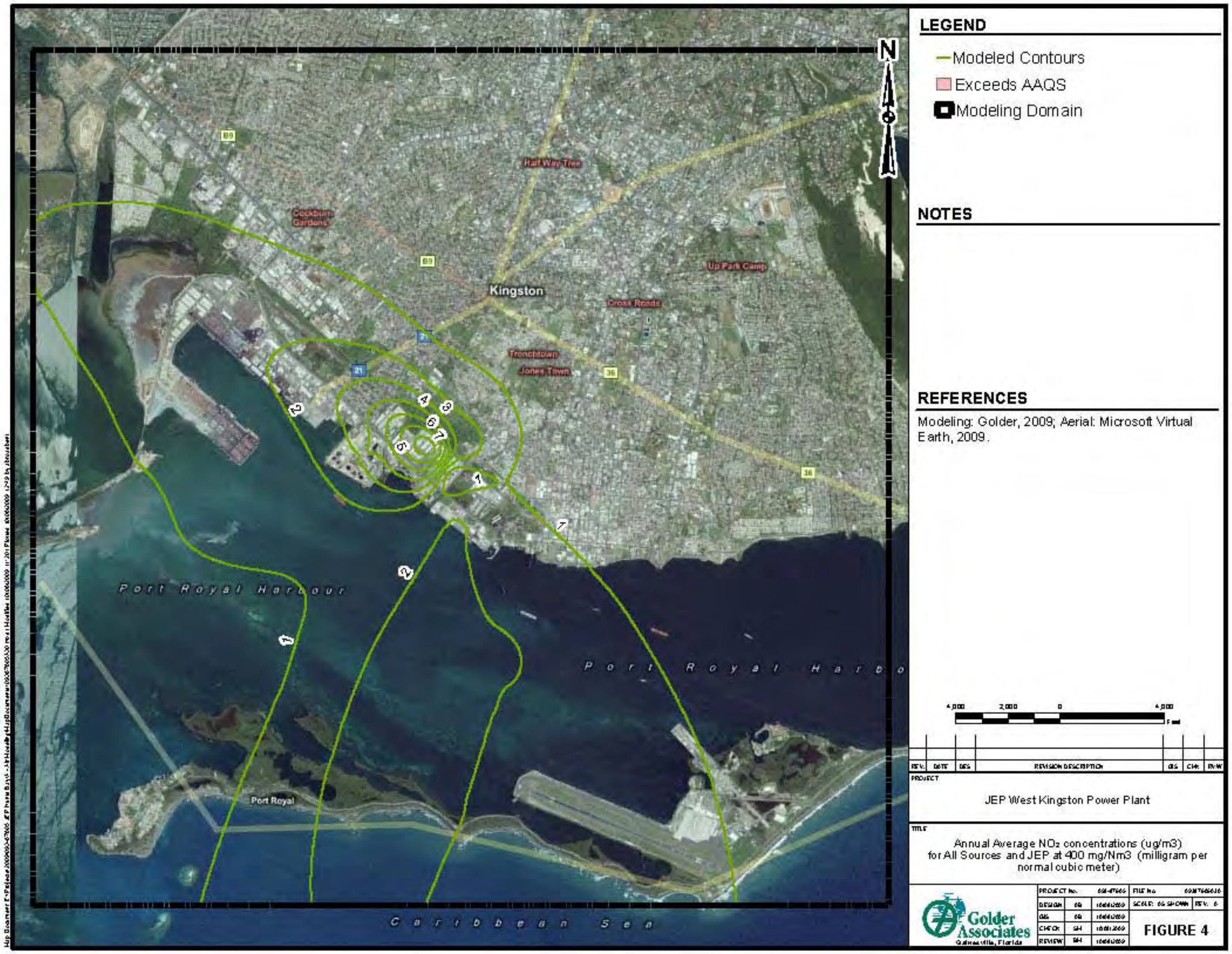


Figure 76 Predicted annual average NO_2 concentrations – All existing sources

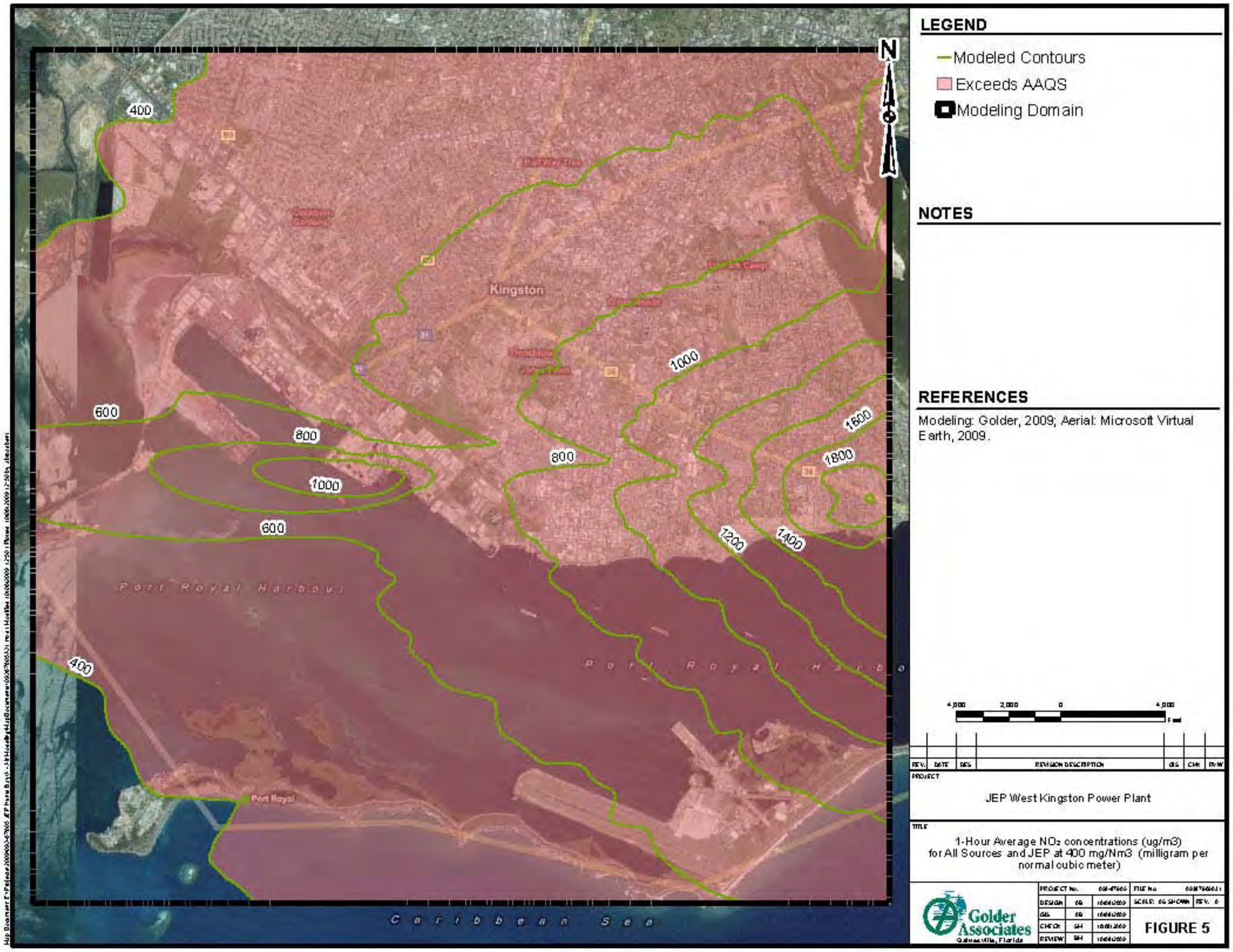


Figure 77 Predicted 1 hour average NO_2 concentrations – All existing sources

Table 83 Source contributions to peak modelled concentrations

TABLE 4-3
SOURCE CONTRIBUTIONS TO PEAK MODELED CONCENTRATIONS

	Concentrations ($\mu g/m^3$)[a]				
Plant	**1-Hour NO_2**	**Annual NO_2**	**1-Hour SO2**	**24-Hour SO_2**	**Annual SO_2**
JEP	2	0.3	142	12	2
JPS Hunts Bay	3	0.3	912	127	28
Petrojam	1	0.1	624	252	67
JPS Rockfort	434	11	119	12	2
JPPC	1,235	15	37	2	1
Other	349	6	89	7	6
Totals	2,024	33	1,923	412	106

6.2 Noise

The operation of the proposed 60 MW power plant will result in an increase in the existing noise level (cumulative) (Table 84 and Table 85).

The cumulative noise impact takes into account all the existing background noise sources which include the Jamaica Public Service power plant, the Factories Corporation of Jamaica Garmex Freezone, and the existing noise within the community (Tivoli). Noise from the new noise source (the proposed 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.

Table 84 Results of noise measurements during (19:00 hrs Tuesday 28th, to 7:00 hrs Thursday 30th, July 2009)

STATION			DAY TIME (7 am. – 10 pm.) (dBA)				NIGHT TIME (10 pm. – 7 am.) (dBA)			
No.	*LOCATION*	*CATEGORY*	*BASELINE*	*CUMM*	*NEPA STD.*	*WORLD BANK GUIDELINE*	*BASELINE*	*CUMM*	*NEPA STD.*	*WORLD BANK GUIDELINE*
1	Railway	Industrial	55.7	61.4	75	70	53.8	61.0	70	70
2	Seprod	Industrial	53.9	68.7	75	70	55.6	68.7	70	70
3	Marcus Garvey Drive	Industrial	57.2	64.5	75	70	57.6	64.6	70	70
4	Industrial Terrace	Industrial	61.6	72.5	75	70	59.9	72.5	70	70
5	Tivoli Gardens High School	Institutional	59.5	59.5	50	55	51.9	51.9	40	45
		2nd Floor		59.5				51.9		
		3rd Floor		59.5				52.7		
6	Charles Chinloy Preschool & Day Care	Institutional	58.1	62.1	50	55	53.3	60.8	40	45
7	Tivoli Gardens Community	Residential	61.9	63.6	55	55	58.0	61.2	50	45
		2nd Floor		63.4				61.0		
		3rd Floor		63.4				61.0		
		4th Floor		63.0				60.2		

NB: Numbers in red indicate non-compliance with both NEPA and World Bank guidelines. Numbers in green indicate non-compliance with NEPA guidelines but compliance with World Bank guidelines when the 3 dBA rule is applied. The number in blue is non-compliant only with World Bank guidelines.

Table 85 Results of noise measurements during (19:00 hrs Saturday 1st, to 7:00 hrs Tuesday 4th, August 2009)

STATION			**DAY TIME (7 am. – 10 pm.) (dBA)**				**NIGHT TIME (10 pm. – 7 am.) (dBA)**			
No.	LOCATION	CATEGORY	BASELINE	CUMM	NEPA STD.	WORLD BANK GUIDELINE	BASELINE	CUMM	NEPA STD.	WORLD BANK GUIDELINE
1	Railway	Industrial	56.2	61.6	75	70	51.2	60.5	70	70
2	Seprod	Industrial	53.3	68.7	75	70	51.5	68.7	70	70
3	Marcus Garvey Drive	Industrial	56.3	64.3	75	70	51.7	63.6	70	70
4	Industrial Terrace	Industrial	59.5	72.5	75	70	53.7	72.5	70	70
5	Tivoli Gardens High School	Institutional	57.0	57.0	50	55	48.0	48.6	40	45
		2nd Floor		57.0				48.9		
		3rd Floor		57.0				49.8		
6	Charles Chinloy Preschool & Day Care	Institutional	58.0	62.0	50	55	55.9	61.4	40	45
7	Tivoli Gardens Community	Residential	61.9	63.6	55	55	58.0	61.2	50	45
		2nd Floor		63.4				61.0		
		3rd Floor		63.4				61.0		
		4th Floor		63.0				58.2		
8	Factories Corporation of Jamaica	Industrial	62.4	65.1	75	70	57.0	63.0	70	70

NB: Numbers in red indicate non-compliance with both NEPA and World Bank guidelines. Numbers in green indicate non-compliance with NEPA guidelines but compliance with World Bank guidelines when the 3 dBA rule is applied. The number in blue is non-compliant only with World Bank guidelines.

6.2.1 Comparison with NEPA Guidelines

6.2.1.1 28th – 30th July, 2009

Stations 5, 6 and 7 would exceed the NEPA day and night time guidelines and station 4 (night time) when the cumulative noise levels are calculated, but the NEPA Guidelines were being exceeded at these locations prior to the addition of the proposed project.

6.2.1.2 1st – 4th August, 2009

Stations 5, 6 and 7 would exceed the NEPA day and night time guidelines and Station 4 (night) when the cumulative noise levels are calculated, but the NEPA Guidelines were being exceeded these locations prior to the addition of the proposed project.

6.2.2 Comparison with World Bank

6.2.2.1 28th – 30th July, 2009

Stations 4, 5, 6, 7 would exceed the World Bank day and night time guidelines when the cumulative noise levels are calculated. Stations 5 and 7 would comply with the 3dBA rule, thus compliance with World Bank guidelines.

Station 4 is located close to where the radiators will be located and although the noise exceeds the guideline (due to its closeness to the noise source), the fact that it is in an industrial area and that the influence on the noise climate at the closest receptor (Factories Corporation of Jamaica Complex) is minimal, the potential negative impact is negligible.

Station 6 (daytime) will exceed the 3 dBA rule the guideline by 1 dBA, however it is not at the level (5 dBA above baseline) that would cause a community reaction. Although it exceeds the night time guideline at this station, the fact that during those hours the school would not be in operation suggest that the potential negative impact would be minimal.

6.2.2.2 1st – 4th August, 2009

Stations 4, 5, 6 and 7 would exceed the World Bank day and night time guidelines when the cumulative noise levels are calculated. Stations 5 and 7 would comply with the 3dBA rule, thus compliance with World Bank guidelines.

6.3 Outline Emergency Plan

Jamaica Energy Partners has developed an Emergency Response Plan for their facility at Old Harbour Bay. While this facility is sea based and the one being proposed is land based the elements are similar. It is therefore proposed that the existing plan be updated to reflect the realities of land based issues.

The key elements of this plan include and are not limited to;

i. Earthquake,

ii. Hurricane,

iii. Flooding,

iv. Explosion,

v. Oil /Hazardous Material Spill

vi. Community and Outside Liaison

vii. Unrest and Riots,

viii. Act of Terrorism and Armed Attack,

ix. Bomb Threats and Acts of Sabotage,

x. Serious or Multiple Injury; and

xi. Illegal Trespassing

The plan also includes emergency call lists of persons on and offsite, building plans, site maps and evacuation routes.

7.0 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 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 noted by scientific experts. The JEP project team and the consulting scientists worked together, utilising findings of these impacts to analyse possible options for the final development.

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
- The proposed Development as described in the EIA but with increased noise insulation of the power house building
- The proposed Development as described in the EIA but situated approximately 6km east of the proposed site on lands at Rockfort
- The proposed Development as described in the EIA but situated approximately 5km east of the proposed site on lands at Bournemouth
- The proposed Development as described in the EIA but using liquified natural gas or coal as fuel.

7.1 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.

In light of the fact that the proposed site was used for sewage treatment works the "no action" alternative will have a minimal effect on the physical environment. In terms of the social 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.

7.2 The Proposed Development as described in the EIA

The 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.

This project has the potential to adversely impact the air quality of the air shed surrounding the proposed development and increase noise pollution of the surrounding area. These impacts will be properly mitigated.

7.3 The Proposed Development as described in the EIA with Increased Noise Insulation of the Power House Building

The same project as in section 7.2 but with increase noise insulation of the power house walls to attenuate noise emitted hence reducing the noise impact to the surrounding community.

7.4 The Proposed Development as described in the EIA but situated approximately 6km East of The Proposed Site on Lands at Rockfort

Locating the proposed power plant approximately 6km east of the proposed site (Figure 78) is not more environmentally sound as it is situated along the coastline and would be more prone to storm surge flooding. In addition land defence structures would have to be built and refuelling infrastructure at sea would also have to be built. The cost of the land would be more expensive than the proposed location.

The reasons given above would result in increase costs to the project and ultimately to the customers.

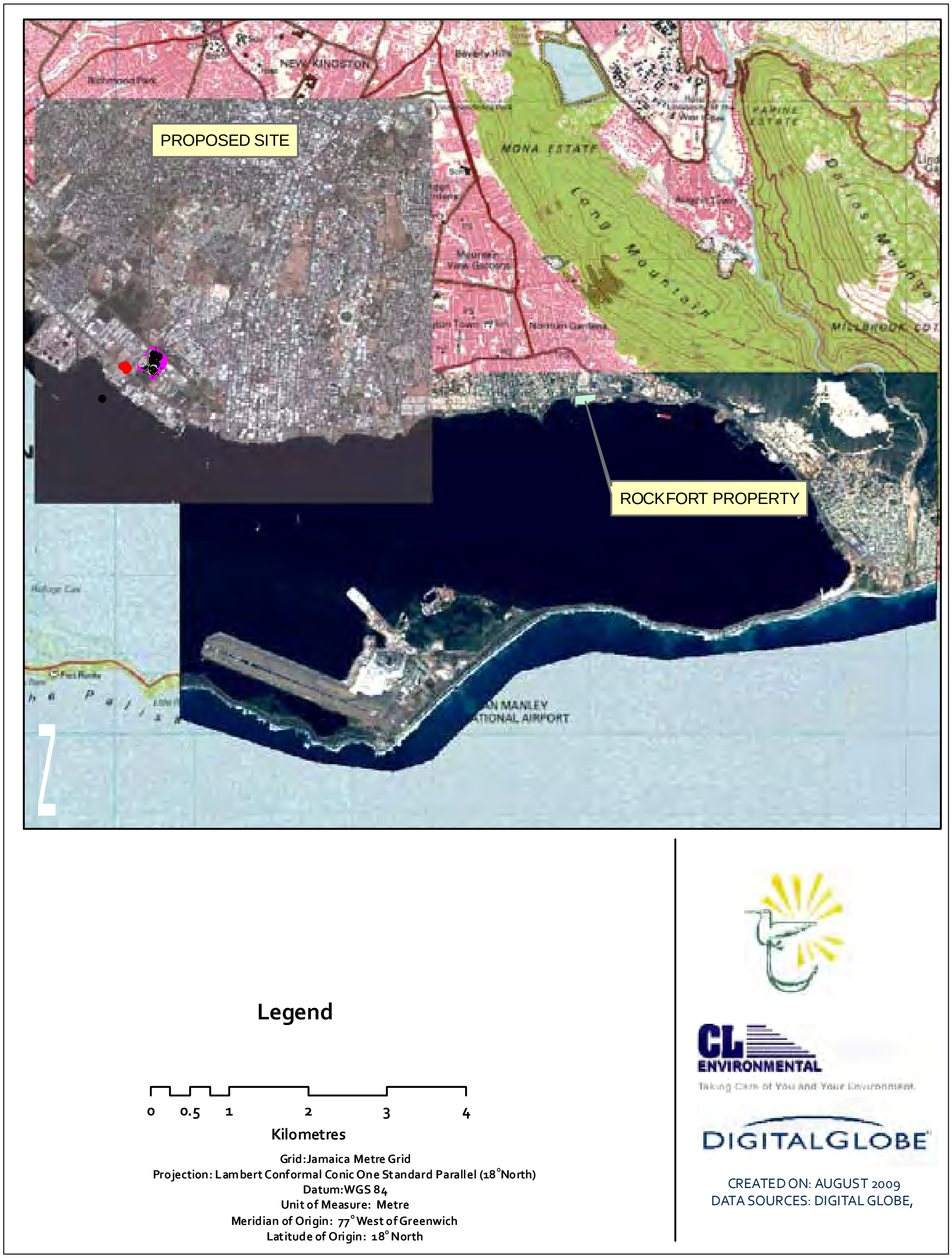


Figure 78 Location of the Rockfort site

7.5 The Proposed Development as described in the EIA but situated approximately 5km East of The Proposed Site on Lands at Bournemouth

Locating the proposed power plant approximately 5km east of the proposed site (Figure 79) is not more environmentally sound as it is situated along the coastline and would be more prone to storm surge flooding. Land defence structures would have to be built and refuelling infrastructure at sea would also have to be built. The power plant would be approximately 50m from the Bournemouth Bath (recreational area) and approximately 70m from residences in Bournemouth Gardens.

The cost of the land would be more expensive than at the proposed location.

The reasons given above would result in increase costs to the project and ultimately to the customers and also has the potential to cause social conflicts.

7.6 The Proposed Development as described in the EIA but using Liquefied Natural Gas (LNG) or Coal as Fuel

Alternate types of fuel types to diesel (oil) were investigated. These were LNG and coal. LNG is increasingly becoming a popular alternative source of fuel. It produces less air emissions and pollutants than either coal or oil.

Although LNG would have been an excellent alternative, the short timeframe for this project (urgent need for power generation), the preparation (construction of specialized storage and infrastructure) and negotiations for supply would result in approximately a three (3) year delay. This would result in not meeting the timeframe for provision of additional power generation.

Using coal as the fuel would also result in a delay in installation of power generating capacity. In addition, the environmental impact of using coal is potentially more significant and would require more mitigation. The proximity to populated areas would also negate the use of coal due to the emissions from such a plant.

7.7 Overview of Alternative Analyses

Based on the above, the most environmentally sound and most economical alternative is the development as proposed in the EIA (Section 7.3). This option will result in the shortest possible time for the provision of the needed additional power generating capacity with reduced potential negative impacts which can be mitigated.

Figure 79 Location of the Bournemouth property

8.0 Environmental Action Plan

This section discusses appropriate mitigation measures for the proposed project during construction and operation. Also, ambient monitoring measures are described in Section 8.2 and Reporting requirements are discussed in Section 8.3.

8.1 Mitigation

8.1.1 Site Preparation Phase

8.1.1.1 Dewatering of Building and Structure foundations

Water should be discharged to a settling pond (precipitation pool) which should be constructed. This will settle out solids from the foundation dewatering process. The supernatant water will be decanted and dispose of in the Tivoli Gully. The sludge will be removed from time to time, dried and transported by trucks to the Riverton dump for disposal.

8.1.1.2 Stockpile of Removed Topsoil

Ensure that the stockpile is bermed and situated away from drainage channels.

8.1.1.3 Air Quality

1. Site roads should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.
2. Minimize cleared areas to those that are needed to be used.

8.1.1.4 Solid Waste Generation

1. Bins should be strategically placed around the construction site.
2. The bins at the construction site should be adequately designed and covered to prevent access by vermin and minimise odour.
3. The bins at both the construction site should be emptied regularly to prevent overfilling.

8.1.2 Construction Phase

8.1.2.1 Noise Pollution

1. Use equipment that has low noise emissions as stated by the manufacturers.
2. Use equipment that is properly fitted with noise reduction devices such as mufflers.
3. Construction workers operating equipment that generates noise should be equipped with noise protection. 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.

8.1.2.2 Vegetation Removal

No mitigation required as the vegetation that will be removed is neither endemic, rare or of commercial value.

8.1.2.3 Air Quality

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

8.1.2.4 Solid Waste Generation

1. Skips and bins should be strategically placed within the campsite and construction site.
2. The skips and bins at the construction campsite should be adequately designed and covered to prevent access by vermin and minimise odour.
3. The skips and bins at the construction site should be adequately covered to prevent a dust nuisance.
4. The skips and bins at both the construction campsite and construction site should be emptied regularly to prevent overfilling.

5. Disposal of the contents of the skips and bins should be done at an approved disposal site. The Riverton dump in St. Andrew is recommended. Appropriate permission should be sought.

8.1.2.5 Wastewater Generation and Disposal

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.

8.1.2.6 Storage of Raw Material and Equipment

1. Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne.
2. Raw material should be placed on hardstands surrounded by berms.
3. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff.
4. 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 berms to contain the volume being stored in case of accidental spillage.

8.1.2.7 Transportation of Raw Material and Equipment

1. 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.
2. Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
3. As much as possible, transport of construction materials should be scheduled for off-peak traffic hours which are the periods between 9am and 1pm as well as the periods after the evening peak. This will reduce the risk of traffic congestion and accidents on the roads leading to the site.
4. Appropriate traffic warning signs, informing road users of a construction site entrance ahead and instructing them to reduce speed, should be placed along the main road in the vicinity of the intersection of Marcus Garvey Drive and Industrial Terrace on all three road legs for the duration of the construction period.

5. Flagmen should be employed to control traffic and assist construction vehicles as they enter and exit the project site as well as the intersection
6. The Project Manager should hire a company that already has licensed/ special permit issued for heavy haulage vehicles etc. For over dimension loads (width, height, length etc) the subcontractor is to submit a letter with the attached specifications and schematics/ drawings of the loaded vehicle to the Director of Island Traffic Authority or the Director of the National Works Agency.

8.1.2.8 Flood Mitigation

1. Filling the Site

A power plant is a major utility and should be designed to avoid any possible flooding of the critical units of the power plant during an extreme event. Some of these components are:

- the Control Room,
- the Engine/Generator, and
- any other electrical equipment important for the running of the plant

It is therefore recommended that the critical design elevation of critical components be at a minimum elevation of 0.3 m above the expected flood level for the return period chosen by the designer and or the developer.

The 100-year return storm surge of 2.20 m obtained is consistent with the findings of other local storm surge analyses studies done for the immediate shoreline. This storm surge was therefore chosen above the OAS/Toas predicted flood water surface elevation of 6.941 m. This is also consistent with the anecdotal evidence which indicates the area has not been observed to flood in the last 41 years. Table 5 shows the proposed floor elevations for the corresponding rainfall return periods.

2. Routine Monitoring and Cleaning of the Drain and Culvert

In order to avoid flooding of the drain and surrounding areas, it is imperative that the concrete U-drain be monitored. The responsible authorities should monitor the drain and culvert on a monthly basis. A cleaning schedule should be implemented which requires that the drain and culvert be cleaned every 3 to 6 months to avoid build up of debris which could lead to the blocked culvert scenario analysed earlier.

8.1.2.9 Emergency Response

1. 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.
2. The JEP construction management team should have onsite first aid kits and make arrangements for the nurse and doctor on call for the construction site.
3. Make prior arrangements with health care facilities such as the Kingston Public Hospital or the Denham Town Health Centre to accommodate any eventualities.
4. Arrange with health practitioners to be on call during the construction period.
5. Material Safety Data Sheets (MSDS) should be stored onsite.

8.1.2.10 Employment

During this phase, an average of 50 professionals, trades men and labourers will be utilized. This represents a significant level of employment within the study area. This has the potential to be a significant positive impact.

Mitigation

Not required

8.1.3 Operation

8.1.3.1 Air Quality

The latest modeling data (conducted by Golder) shows that the airshed likely exceeds Jamaican (National Environment & Planning Agency [NEPA]) standards and World Bank guidelines for SO_2 and NO_2. Operation of the New Plant without compensating mitigation would exacerbate this situation.

The modeling data represents a conservative scenario and actual monitoring data (Table 2) has so far presented more favorable data. JEP proposal considers the following:

- *JEP will ensure that at least 2 ambient monitoring stations are in place and operational for a minimum of 6 months before COD.*
- *JEP to provide IFC with an Ambient Air Quality Monitoring & Verification Plan.*
- *The information gathered from the ambient monitoring stations shall be the Baseline data, which shall be used in conjunction with revised modeling data to give, before COD, a more accurate projection of Air shed after expansion.*
- *For the project to be approved, JEP must develop a mitigation plan for SO2 and NO2 emissions at the proposed 60 MW plant. The Mitigation plan will be implemented after the Commercial Operation Date of the Expansion ("COD") unless and until JEP demonstrates that either:*
  - *(a) The Air shed will be in compliance with Jamaican (NEPA) SO_2 and NO_2 standards after the New Plant is in Operation; or*
  - *(b) The Airshed will not be made worse than the existing situation (the Baseline) after the commissioning of the new capacity.*

If ambient air quality monitoring confirms that the air shed is degraded with respect to NO_x, then JEP proposes to install Selective Catalytic Reducers (SCRs) (Figure 80) on each engine to reduce NO_x to 400 mg/Nm^3 (IFC guidelines for degraded air shed).

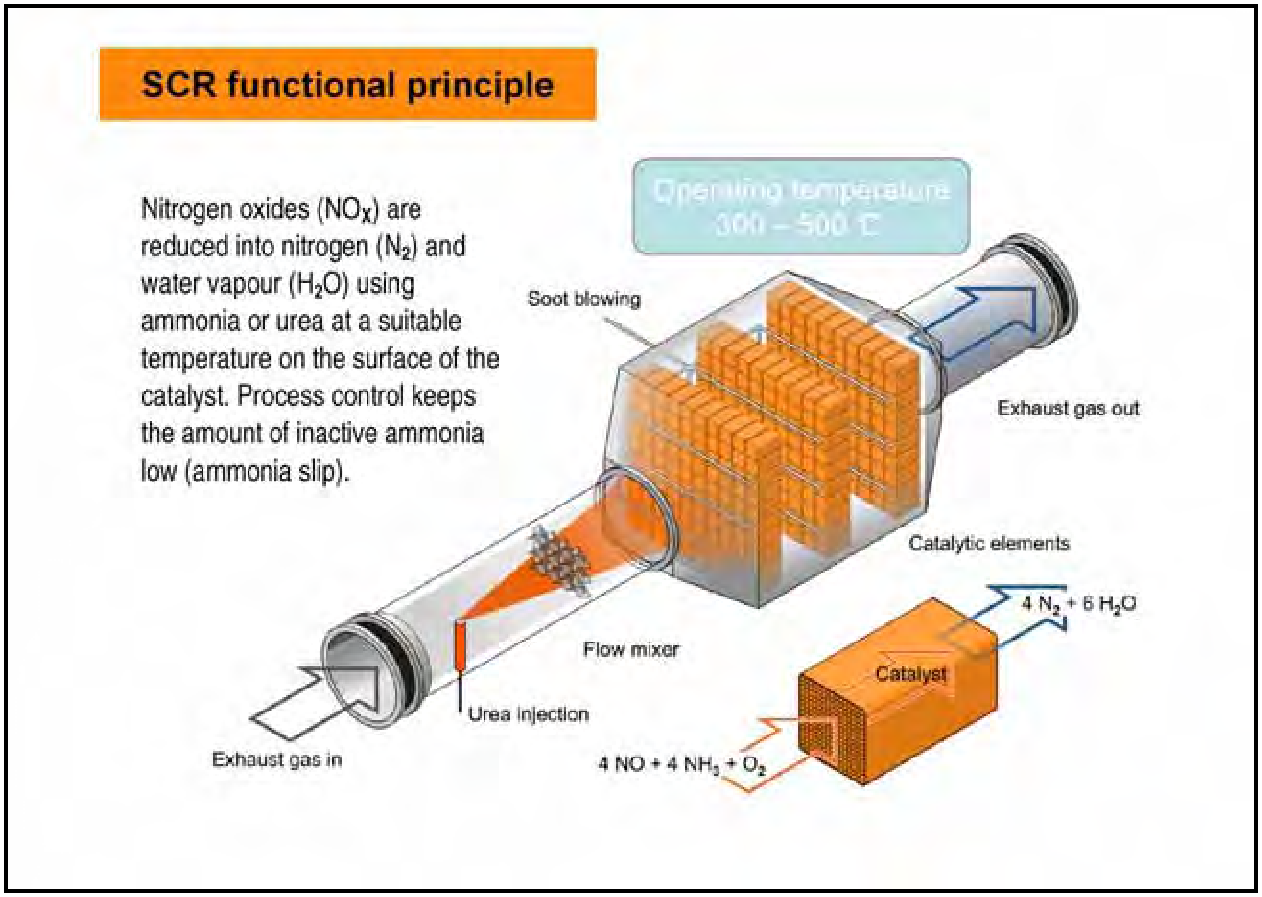
If the air shed is found to be degraded with respect to SO2, JEP proposes switch to the use of fuel with a sulphur content of 0.5% by weight or less.

It will be an event of default if JEP fails to implement the mitigation plan after failure to demonstrate compliance with the Jamaican (NEPA) Ambient Air Quality Monitoring standards.

Based on our latest available information, the Operating and Maintenance cost for the SCR will be approximately US$8/MWh.

8.1.3.2 Natural Hazards

1. Ensure that the new structures can withstand hurricane and earthquake impacts.
2. Ensure that the new structures are designed to withstand a 50 –100 year flood event.
3. Develop an emergency response plan and/or update the existing emergency response plan.



Source: Wärtsilä

Figure 80 SCR functional principle

8.1.3.3 Noise

The noise mitigation measures to be employed are;

i. Changing the existing radiators to low noise version,

ii. Equip the ventilation outlet fans that are used to expel hot air from the power generation building with 2000 mm silencers; and

iii. The installation of two 35 dBA charge air silencers in series for each engine.

These mitigation measures are estimated to cost EUR$ 500,000.00 (≈ US$743,905.36).

8.1.3.4 Power Plant Maintenance

1. The use of lead based paints should be prohibited. If this is unavoidable care should be taken to prevent inhalation by the persons applying the paint and to minimize the potential for the paint to enter the ecosystem.
2. Oily rags should be properly stored and disposed.
3. Hazardous waste should be properly identified and the most appropriate and environmentally friendly methods should be used to dispose the waste.

8.1.3.5 Overland Drainage

Drainage from the paved surface should not directly discharge to the perimeter gullies such as the Tivoli Gully. Instead drains should be designed so as to provide some treatment before disposal (e.g. silt trap and or oil/water separators).

8.1.3.6 Occupational Health and Safety

1. Provision of Personal Protective Equipment (PPE) e.g. noise muffs, plugs, helmets and Personal fall arrest systems (PFAS).
2. Establish a hearing conservation programme.
3. Ensure adequate ventilation within the work area.
4. A programme to monitor the thermal comfort of workers will be implemented.
5. Lighting levels (illumination) should be area specific and will be a function of the nature of activity that is being conducted. It should be adequate to enable a safe, comfortable and productive workers environment.
6. A confined space policy will be developed and implemented.
7. Use the Occupational Safety and Health Administration (OSHA) standard 1910 as a guide to Occupational Health and Safety maters.

8.1.3.7 Solid Waste Generation and Disposal

1. Provision of solid waste storage bins and skips.
2. Contracting a private contractor to collect solid waste in a timely fashion to prevent a build up.

3. Ensure that the solid waste collected is disposed in an approved dumpsite such as the Riverton dump in Kingston.

8.1.3.8 Wastewater Generation and Disposal

1. All run-offs from potential contamination sources within the power plant (power house floor drains, workshops etc.) will be pumped to a contaminated water tank and an oily water separator. This will be collected by a private contractor to be disposed in an environmentally friendly fashion or dispose of in the NWC sewer line.
2. Ensure that the sewage system is connected to the NWC sewer line.
3. Ensure that the trade effluent system is connected to the NWC sewer line.

8.1.3.9 Emergency Response

1. Have first aid kits located in various sections of the power plant.
2. Make prior arrangements with health care facilities such as the Denham Town Health Centre or the Kingston Public hospital to accommodate any eventualities.
3. Arrange with health practitioners to be on call.
4. Design and implement an emergency response plan or update the existing plan to reflect the issues of the new power plant.
5. Staff should be trained in Cardio Pulmonary Resuscitation (CPR).
6. Coordinate with mutual aid organisations/agencies such as with the local fire brigade (Trench Town).

8.1.3.10 Traffic

Post construction traffic will not in any significant way affect the delay waiting time or level of service experienced by motorists at the intersection. Therefore there is no need for mitigation.

8.2 Monitoring

8.2.1 Monitoring During Site Preparation for the Proposed Power Plant

- 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 JEP may perform this exercise.
  No additional cost is anticipated for 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 JEP may perform this exercise.
  No additional cost is anticipated for this exercise.

8.2.2 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 KSAC.
  Person(s) appointed by JEP may perform this exercise.
  No additional cost is anticipated for this exercise.
- Undertake monthly water quality monitoring to ensure that the construction works are not negatively impacting the Tivoli Gully and indirectly the marine environment quality. The parameters that should be monitored are **conductivity**, **dissolved oxygen**, **nitrates**, **phosphates**, **turbidity, total suspended solids and faecal coliforms**.
  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.
  This is estimated to cost approximately **J$ 66,950** per monitoring exercise.

- A noise survey should be undertaken to determine workers exposure and construction equipment noise emission.

  The noise survey is estimated to cost approximately **J$45,000**.
- 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.
- 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 JEP may perform this exercise.

  No additional cost is anticipated for 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 JEP may perform this exercise.

  No additional cost is anticipated for 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 JEP may perform this exercise.

  No additional cost is anticipated for 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 JEP may perform this exercise.

  No additional cost is anticipated for 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 JEP 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.

  Person(s) appointed by JEP may perform this exercise.

  No additional cost is anticipated for this exercise.

8.2.3 Monitoring During the Operational 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 JEP 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$200,000** 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 JEP may perform this exercise.

  No additional cost is anticipated for this exercise.
- During the operation of the proposed power plant project, there will be two ambient air quality monitoring stations which will monitor sulphur dioxides and nitrogen oxides on a continuous basis. These monitors will be located to provide a representative picture of the proposed operations at the power plant.

  Person(s) appointed by JEP may perform this exercise.

8.3 Reporting Requirements

8.3.1 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, JPS 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.

8.3.2 Air Emissions

A quarterly report will summarize the results of the two (2) ambient air quality monitoring stations. This report will provide information relative to SO_2, NO_x, CO and PM_{10} concentrations in the project area.

9.0 Appendices

Appendix 1 Approved Terms of Reference

TERMS OF REFERENCE (TORs) FOR AN ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR JAMAICA ENERGY PARTNERS WEST KINGSTON POWER PLANT

Project Brief

In a response to the Office of Utilities Regulation request for proposals to supply up to 60MW of generating capacity on a Build, Own and Operate (BOO) Basis, the Jamaica Energy Partners submitted a bid and was successful.

Jamaica Energy Partners (JEP) has been a private supplier of electricity to the Jamaican power grid since 1995, as a result of an agreement with the Jamaica Public Service Company Limited (JPS). JEP operates two power barges, namely Dr. Birds I and II, with a combined generating capacity of approximately 124MW; this is approximately 15% of Jamaica's power demand. Their first power barge, Dr. Bird I, a 74 MW power barge was installed and commissioned in 1995 whilst the most recent addition was a 50 MW power barge, which was commissioned in 2006. Both these barges have medium speed diesel generating sets. JEP, over the last twelve years has established a track record of reliability and efficiency. With the addition of this 60MW generating capacity, JEP,s total generating capacity will be increased to approximately 184 MW making it one of the major suppliers of electricity in Jamaica.

The facility will provide electricity using six (6) diesel generators operating at 11 kV at the generator terminals. Each generator will have an active power rating of 11,349 kW and will have an automatic speed governor and an automatic voltage regulator to facilitate operation in parallel with existing generating sets on the national grid. The generators will supply power to an internal 11 kV electrical bus from which power will be exported to the grid. Power for facility auxiliary equipment will also be supplied from this electrical bus. The primary fuel for the engines will be low sulphur (<1.8 % by volume), #6 residual (heavy) fuel oil. They will also be able to operate on #2 or #3 diesel fuel. These engines are capable of being converted in the future to also operate on Natural Gas.

The diesel engines to be used will be manufactured by Wartsila and will be of model type 12V46. This model designation represents a twelve (12) cylinder engine with the cylinders in two banks in a 60° "V" configuration with a cylinder bore of 460 mm and a gross power output per cylinder of 975 kW. These engines use forced induction in the form of turbo-charging to increase the volumetric efficiency and hence the power density of the engine. Electronically controlled common rail fuel injection will be used to provide improved fuel efficiency and lower exhaust emissions.

The engines are designed to use the Miller combustion cycle and this will result in further gains in efficiency over the "standard" Otto cycle diesel engines as pumping losses are reduced in the intake and exhaust strokes and the thermal efficiency is improved.

As the factor that has the most significant influence on NOx formation is the temperature during combustion and the most successful approach to lower NOx emissions is to reduce the peak temperatures during the combustion. The Miller cycle, as implemented for the Wartsila engines, achieves such a reduction in NOx formation through:

- Efficient cooling of the air leaving the turbocharger using a two-stage heat exchanger.
- Higher charge air pressures.
- Compression ratio of 16:1 implemented in the engine design.
- Intake valves timed to close before bottom dead center (BDC) on the intake stroke.
- Exhaust valves timed to close before bottom dead center (BDC) on the power/combustion stroke.

The engines will use radiators for primary heat exchange. Waste heat recovery systems will be installed in the exhaust stacks of some engines in the form of economizers. The heat energy recovered by the economizers will be used to apply heat to the facility thermal oil system. This system will be used as the energy transfer medium for transferring heat energy through heat exchangers throughout the facility for processes such as:

- The preparation of the fuel oil for combustion
- The pre-heating of the cooling water systems for the diesel engines in preparation for starting.

The expected gross electrical efficiency of each these engines will be 44.3%.

A #2 diesel oil fired standby system will be provided for the heating of the thermal oil when all the DG sets with economizers are offline.

A fresh water treatment system will be developed for the facility. It will involve taking water from the existing NWC municipal supply. This water will be converted for use by the facility by using a reverse osmosis plant.

Heavy fuel oil for the facility will be supplied by a pipeline to be built during the construction phase of this project. This pipeline will carry fuel from the nearby Petrojam facility to the storage tanks on site. Heavy Fuel Oil will be processed prior to being piped to the main diesel engines. This process will entail heating and pumping the fuel from the storage tank(s) to a settling tank (Buffer Tank). After settling to remove dirt/sludge and water from the fuel, it will be further heated and then pumped to centrifugal separators for further removal of heavy particles and water from the fuel before being pumped to a holding tank (Day Tank) for engine ready fuel.

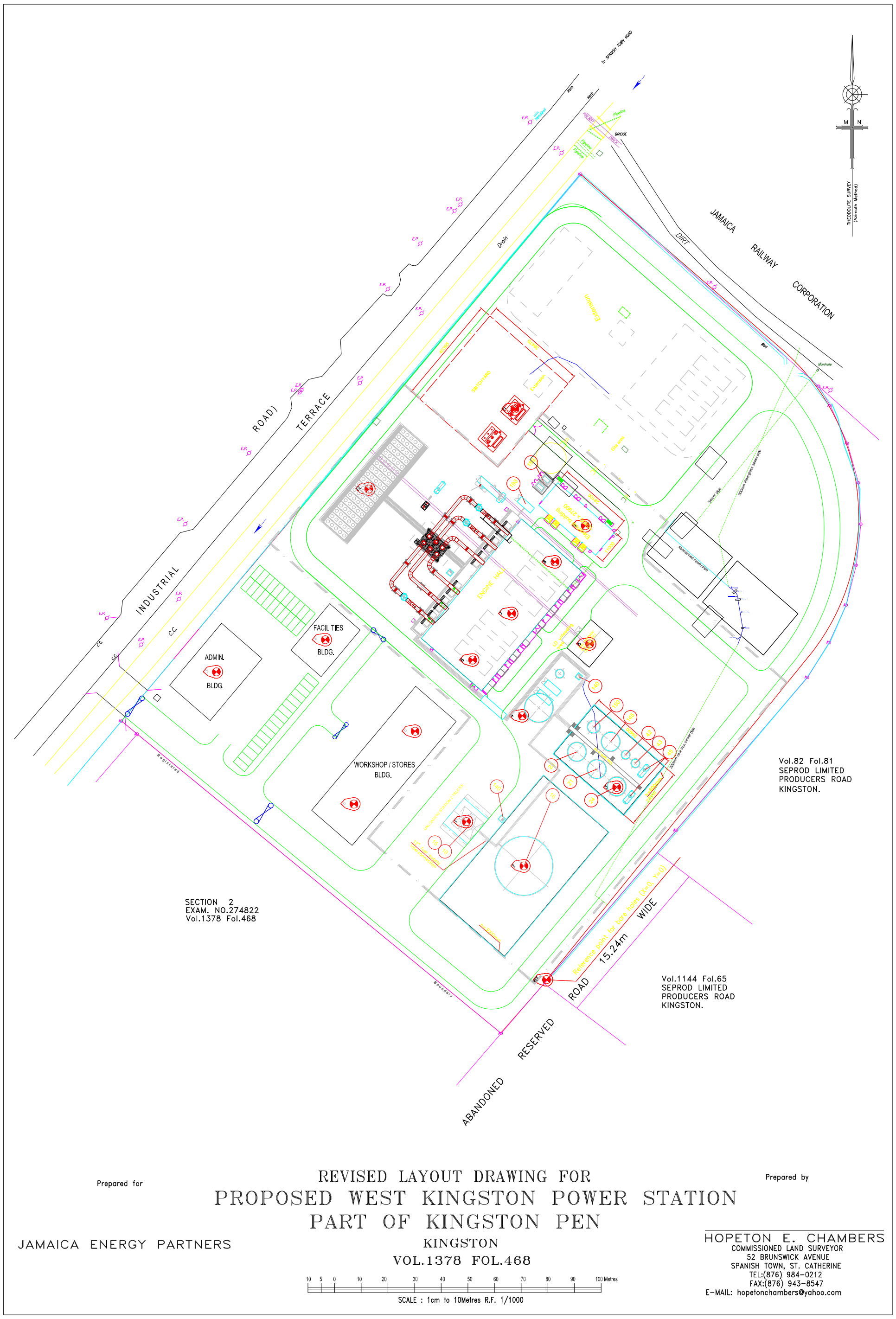
Auxiliary systems for the facility will include centrifugal separators for fuel oil purification and compressors for pneumatic instrumentation and control systems. Waste oil generated will be treated to remove water, reducing the total volume of waste oil produced. The waste oil/sludge will then be loaded on trucks for processing and disposal at the Petrojam refinery. It is proposed that waste water from the facility will be sent to the existing NWC sewer main.

Two 45 MVA power transformers will be used to transfer the power delivered from the generator bus to the 69 kV transmission grid for delivery to the Hunt's Bay substation for further transmission and distribution. Power for facility auxiliary systems will be provided through two 11 kV/380 V transformers connected to the generator electrical bus. A 110 V DC system will provide power for electrical switchgear, automation systems and protective relaying systems.

A standby "Black Start" generator will be installed to provide emergency power for the start up of the facility and its main diesel generator sets in the event of separation of the facility from the grid or the absence of power on the transmission grid.

General facility operation and control will be through a Supervisory Control and Data Acquisition System (SCADA) utilising workstations in the Control Room providing the human machine interface (HMI). Programmable Logic Controllers (PLCs) will be installed throughout the facility for engine and auxiliary systems interface and control. Microprocessor based protective relays will be installed to provide high speed protection for the generators, transformers and transmission lines. Telecommunication equipment will be installed to interconnect with the grid tele-protection and data collection systems.

The fire suppression system will consist of hydrants and hose stations installed throughout the facility along with automatic and manually activated sprinkler systems. These will be supplied with water from a tank dedicated to supplying water for this purpose. The fire water mains will be kept in a pressurised state and any drop in pressure will automatically start the pumps installed to feed this system. A small electrical “Jockey” water pump will be installed to maintain normal line pressure. When the pressure in the line cannot be maintained by this pump, a second high flow “Main” electrical water pump will be started to supply the system. A diesel engine powered pump will also be installed as the third stage pump in the event that the electrical pumps fail to maintain the line water pressure. The operation of all pumps will be monitored by the fire detection system as well as by the facility Supervisory Control and Data Acquisition (SCADA) system.



Proposed site layout

Site location

The proposed site is located along Marcus Garvey Drive on what is known as the Hunts Bay lands, just east of Universal Freight Handlers. The proposed site is bordered to the north by the old Western Wastewater Treatment Facility, east by Seprod Jamaica Limited and west by the minor road, Industrial Terrace.

It is located approximately 1.5 km west of downtown Kingston and approximately 1.0 km east of Petrojam.

Proposed site map

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

Collaborating with project's design, installation and management teams, to ensure that the design criteria are implemented in the most environmentally sound manner possible.

To provide a comprehensive description of the project, its existing setting including project objectives and information on the nature, location/ existing setting, timing, duration, frequency, general layout and size of facility including ancillary buildings, pre-construction activities (closure plan of sewage plant), construction methods, works and duration, and post construction plans. This involves noting areas to be reserved for construction, 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. This should involve the use of maps, site plans, aerial photographs and other graphic aids and images, as appropriate, and include information on location, general layout and size, as well as pre-construction, construction, and post construction plans.

The sewage treatment system will be described including the disposal of treated effluent as well as solid waste disposal option. In addition, plans for storm water collection and disposal as well as plans for providing utilities and other services will be clearly stated. This will involve the use of maps at appropriate scales, site plans, satellite imagery and other graphic aids and images, as appropriate.

Task #2 –Description of the Environment/Baseline Studies Data Collection and Interpretation

This task involves the generation of baseline data which is used to describe the study area/ geographical boundaries 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 and the length of the study will be clearly detailed.

Baseline data should include:

(A) Physical

i) A detailed description of the existing **geology** and **hydrology.** Special emphasis should be placed on storm water run-off, drainage patterns, effect on groundwater and availability of potable water.

ii) **Water quality** of any existing wells, rivers, ponds, streams or coastal waters in the vicinity of the development. Quality Indicators should include but not necessarily be limited to nitrates, phosphates, faecal coliform, and suspended solids.

iii) The **hazard vulnerability** of the site and proposed project will be assessed. This will include but not be limited to; hurricanes, earthquake, flood and fire

iv) Climatic conditions and air quality in the area of influence including particulate emissions from stationary or mobile sources, NO_x, SO_x, wind speed and direction, precipitation, relative humidity and ambient temperatures,

v) Noise levels of undeveloped site and the ambient noise in the area of influence.

vi) Obvious sources of pollution existing and extent of contamination.

vii) Availability of solid waste management facilities.

(B) Biological

Present a detailed description of the flora and fauna (terrestrial) of the area, with special emphasis on rare, endemic, protected or endangered species and wild food crops. The community structure and health will be determined. Migratory species will also be considered. Generally, species dependence, niche specificity, community structure and diversity ought to be considered.

The presence of alien, invasive alien, nuisance or pest species should also be reported.

(C) Socio-economic & cultural

Present and projected population; present and proposed land use; planned development activities, issues relating to squatting and relocation, community structure, employment, distribution of income, goods and social services; recreation; public health, emergency response and safety; cultural peculiarities, aspirations and attitudes should be explored. The physical carrying capacity of the local infrastructure and public service will be investigated. This will be conducted within 2km of the proposed site.

The historical importance of the area will also be examined. While this analysis is being conducted, an assessment of public perception of the proposed development will be conducted. This assessment may vary with community structure and may take multiple forms such as public meetings or questionnaires.

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, Watershed Protection Act, the NRCA Air Quality Regulations, the National Solid Waste Management Act, Water Resources Act**,** Office of Utilities Regulation (OUR) Act, the Town and Country Planning Act, Building Codes and Standards, Kingston and Urban St. Andrew Development Order and Plans and the appropriate international convention/protocol/treaty where applicable. An example would be World Bank Environmental

Guidelines -Pollution Prevention and Abatement Handbook especially (Appendix 4) Relevant sections of the – Thermal Power: Guidelines for New Plants.

Task #4 – Identification and Assessment/Analysis of Potential Impacts

Identify the significant environmental and public health/safety issues of concern and indicate their relative importance to the design of the power plant.

Identify the nature, severity, size and extent of potential direct, indirect and cumulative impacts (for terrestrial and aquatic environments) during the pre-construction, construction and operational phases of the development as they relate to, (but are not restricted by) the following:

- change in drainage patterns
- flooding potential
- visual impact
- landscape impacts of excavation and construction
- loss of and damage to geological features
- loss of species and natural features
- habitat loss and fragmentation species
- biodiversity/ecosystem functions
- pollution of potable, surface and ground water
- routing including, right of way (ROW), pipeline construction and pipeline integrity of the fuel pipeline
- air pollution
- capacity and design parameters of proposed sewage treatment facility
- socio-economic and cultural impacts.
- Impact of flooding, loss of natural features, excavation and construction on the historic landscape, architecture and archaeology of the site.
- risk assessment (e.g. spontaneous combustion and fluid and/or chemical spills)
- disposal of hazardous waste
- noise
- solid waste
- carrying capacity of the proposed site

Identify the interaction between different impacts and impacts of other projects will also be considered. In addition, the impacts that have occurred and those impacts which could still occur as a consequence of the clearing works that were conducted on the site prior to the preparation of the TORs should also be identified and analysed

Distinguish between significant positive and negative impacts, reversible or irreversible direct and indirect, long term and immediate impacts as well as avoidable and irreversible impacts.

Characterize the extent and quality of the available data, explaining significant information deficiencies, assumptions and any uncertainties associated with the predictions of impacts. Project activities and impacts will be represented in matrix form with separate matrices for pre and post mitigation scenarios.

Task #5 - Cumulative Impact

This section will deal with the potential cumulative effects of past, present and reasonable foreseeable actions. Cumulative impact is the impact on the environment from incremental impact of action. It can result from individually minor but collectively significant actions taking place over a period of time.

This may include noise, air emissions etc.

Task #6 – Drainage Assessment

An assessment of Storm Water Drainage will be conducted. The EIA Report will cover, but not be limited to:

i. Drainage for the site during construction, to include mitigation for sedimentation to the aquatic environment
ii. Drainage for the site during operation, to include mitigation for sedimentation to the aquatic environment
iii. Drainage control for gully traversing the perimeter of the property, to include impacts that this drain will have on the aesthetics, water quality and sedimentation of the coastal area, etc.

Task #7 – Reverse Osmosis Plant

The EIA report will include a description of RO unit inclusive of estimated volumes for water going into and coming out of the unit, expected quality with respect to pH, Total Dissolved Solids, Total Hardness, Silica, Iron and Suspended solids of the streams leaving the unit (based on specified water input). Options for the management of the reject water from the RO unit as well as the management of used membranes and chemicals used in the water treatment process will be presented and discussed. The recommended options will be specified with explanation of reasons for the selection(s).

Task #8 –Mitigation

Prepare guidelines for avoiding or reducing (e.g. restoration and rehabilitation), as far as possible, any adverse impacts due to proposed usage of the site and utilising of existing environmental attributes for optimum development. Quantify and assign financial and economic values to mitigating methods.

Task #9 – Environmental 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 site clearance and preparation, construction and occupation/operation and decommissioning of the power plant and facility. An Environmental Management Plan and Historic Preservation Plan (if necessary) for the long term operations of the site should also be prepared.

An outline monitoring programme should be included in the EIA, and a detailed version submitted to NEPA for approval after the granting of the permit and prior to the commencement of the development. At the minimum the monitoring programme and report should include:

- Introduction outlining the need for a monitoring programme and the relevant specific provisions of the permit and/or licence(s) granted.
- The activity being monitored and the parameters chosen to effectively carry out the exercise.

- 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

The Monitoring report should also include, at minimum:

- Raw data collected. Tables and graphs are to be used where appropriate
- Discussion of results with respect to the development in progress, highlighting any parameter(s) which exceeds the expected standard(s).
- Recommendations
- Appendices of data and photographs if necessary.

Task #11 – Emergency Response Plan

An emergency response plan will be developed for the facility in collaboration with the Office of Disaster Preparedness and Emergency Planning and the Fire Department to deal with any eventualities such as natural disasters and for operational emergencies such as fires and oil spills. The outline of this plan will be documented in the EIA and the detailed document will be submitted to NEPA.

Task #12 - Project Alternatives

Alternatives to the project will be examined including the no-action alternative. This examination of project alternatives will incorporate the use history of the overall area in which the site is located and previous uses of the site itself. It will also include an analysis of reasonable alternatives to meet the ultimate project objective (providing 60MW of much needed electricity power to the National Power Grid).

Task #13 –Public Participation/Consultation Programme

Conduct a public presentation on the findings of the EIA to inform, solicit and discuss comments from the public on the proposed development.

- 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 (NGOs (Non-Governmental Organizations such as the Jamaica Environment Trust (JET), CBOs (Community Based Organizations), Citizens Associations and special interest groups such as the Private Sector Organization of Jamaica (PSOJ) and Jamaica Manufacturers Association (JMA).
- 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.

Task #14 –Statement of Energy Conservation

The energy conservation methods that will be incorporated in the design of the facility, together with recommended energy conservation measures for the operational phase will be described as a part of the EIA.

Task #15 –Health Impact Assessment

A health impact assessment will be conducted to provide empirical data for evidence-based decision making and informed intervention (should this be necessary), by quantifying hazards and risks important to the public's health.

Task #16 –Client Representation

The Consultants will maintain regular contact with the Client, the National Environmental Planning Agency (NEPA) and other Regulatory Agencies such as the National Works Agency, Water Resources Authority, the Environmental Health Unit of the Ministry of Health and Office of Disaster Preparedness and Emergency Management to ensure that all problems are rectified as quickly as possible in an environmentally sound manner. Additionally, the Consultants undertake to represent the Client at meetings with NEPA and other relevant Government bodies as necessary.

Appendix 2 Environmental Impact Assessment Team

• Dale Webber, PhD.	Vegetation
• Carlton Campbell, M. Phil., CIEC	Noise and Socio-economics
• Matthew Lee, M.Sc.	Water Quality
• Janette Manning, M.Phil.	Water Quality
• Professor Edward Robinson	Geology
• Shakira Khan-Butterfield	Geology
• Richard Coutou	Geology
• CEAC Solutions Ltd.	
o Christopher Burgess M.Sc. Eng., PE	Environmental Engineering
o Carlnenus Johnson	Traffic Impact Statement and Wastewater
o Kwesi Falconer	Drainage Review and Flood Risk
• Golder Associates Inc.	
o Steve Marks	Air Quality Modelling
o Sal Mohammad	Air Quality Modelling

Appendix 3 Guidelines for Public Presentation – EIA

NATURAL RESOURCES CONSERVATION AUTHORITY

GUIDELINES FOR CONDUCTING PUBLIC PRESENTATIONS

1997-01-08

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 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 NRCA 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 who did the EIA study and prepared the EIA report and the public.

Section 2: Specific Guidelines for Public Presentations/Meeting

2.1 Requirements

When a decision is taken by the Authority that a pubic presentation is required, the developer and consultant will be notified by the NRCA. [See Appendix 1] On receipt of the notification arrangements must be made for the public presentation in consultation with the NRCA in respect of date, time, venue and participants.

2.2 Public Notification

The developer/consultants must in addition to specific invitation letters, put a notice in the press advertising the event. Specific notice to relevant local NGOs should be made by the developer/consultants. The notice should indicate where the EIA report is available. A typical notice is in Appendix 2.

2. 3 Responsibility of Developer/Consultant Team

The consultant is responsible for distribution of copes of the EIA report to ensure that they are available to the public in good time for the meeting. A summary of the project components and the findings of the EIA in non-technical language should be prepared for distribution also in good time for the meeting. Three (3) to four (4) weeks in advance of the meeting is recommended. Copies should be placed in the Local Parish Library and the Parish Council office as well as at the nearest NRCA Regional Coordinator's office and other locations in the community.

The consultant is also responsible for making the arrangements to document the proceedings of the meeting. A permanent record of the meeting is required and one can consider tape recording from which a written record can be made.

2.4 Conduct of the Meeting

With respect to the conduct of the meeting, the NRCA will advice on the selection of a Chairman and will make arrangements to document the concerns of the audience for its own records. The Chairman should be "neutral", that is, not have a direct interest in the project. NRCA staff may on occasion be responsible to chair the meeting. The role and responsibilities of the chairmen are in Appendix 4.

The technical presentation by the proponent and the consulting team should be simple, concise and comprehensive. The main findings of the EIA with respect to impacts identified and analysed should be presented both adverse and beneficial.

The 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 construction and operational phases of the project (if it is approved) bearing in mind that the public and NGO 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 up to 30-60 minutes for questions.

Please note that the public will be given a period of thirty (30) days after the meeting to send in written comments.

A typical agenda for a meeting is given in Appendix 3

APPENDIX 1

Date

Name of Organization Submitting EIA

Address of the Organization

Attention: Responsible Party

Dear

Subject: Notification of Requirement of Public Presentation / Meeting

The Natural Resources Conservation Authority (NRCA) has determined that a public meeting is required to adequately assess the potential environmental impacts associated with the following proposed activity:

____

____

____

NRCA guidelines for conducting public meetings are attached. As noted in the guidelines, a Notification of Public Meeting must be issued by you once the date, time, venue and programme has been established in consultation with the NRCA. Please note that further processing of your application will halt until the public meeting be carried out by the developer and consulting team and that the public will be allowed a period of thirty (30) days after the meeting to send in written comments.

Questions regarding the public presentation process should be directed to:

____

____

Signature__________________________

Name ______________________________

Title______________________________

Date______________________________

cc: other government agencies

APPENDIX 2

NOTIFICATION OF

P U B L I C M E E T I N G

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 REORT MAY BE CONSULTED AT THE

____________________ PARISH LIBRARY

____________________ PRAISH COUNCIL OFFICE

____

For further information contact:

APPENDIX 3

A G E N D A

1. WELCOME AND INTRODUCTION

2. PRESENTATION OF EIA FINDINGS AND MEASURES TO MINIMIZE IMPACTS

3. QUESTION AND ANSWER SESSION

4. CLOSING REMARKS

APPENDIX 4

ROLE AND RESPONSIBLITIES OF THE CHAIRMAN

The Chairman 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 consultants/ proponent.

The responsibilities of the Chairman include explaining the NRCA approval process, that is, the steps involved and the role of the NRCA at these public presentations. In other words, the Chairman should explain the context within which the meeting is taking place.

The Chairman 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 Chairman is responsible for introducing the presenters.

The Chairman should contribute but not monopolize the meeting.

Appendix 4 Relevant Sections of the Pollution Prevention and Abatement Handbook WORLD BANK GROUP Effective April 2007

Environmental, Health, and Safety Guidelines for Thermal Power Plants

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)[1]. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/sustainability.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, based on environmental assessments and/or environmental audits as appropriate, with an appropriate timetable for achieving them. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Applicability

This document includes information relevant to combustion processes fueled by gaseous, liquid and solid fossil fuels and biomass and designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type (except for solid waste which is covered under a separate Guideline for Waste Management Facilities), with a total rated heat input capacity above 50 Megawatt thermal input (MWth) on Higher Heating Value (HHV) basis.[2] It applies to boilers, reciprocating engines, and combustion turbines in new and existing facilities. Annex A contains a detailed description of industry activities for this sector, and Annex B contains guidance for Environmental Assessment (EA) of thermal power projects. Emissions guidelines applicable to facilities with a total heat input capacity of less than 50 MWth are presented in Section 1.1 of the **General EHS Guidelines**. Depending on the characteristics of the project and its associated activities (i.e., fuel sourcing and evacuation of generated electricity), readers should also consult

[1] Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

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

the EHS Guidelines for Mining and the EHS Guidelines for Electric Power Transmission and Distribution.

Decisions to invest in this sector by one or more members of the World Bank Group are made within the context of the World Bank Group strategy on climate change.

This document is organized according to the following sections:

Section 1.0 – Industry Specific Impacts and Management
Section 2.0 – Performance Indicators and Monitoring
Section 3.0 – References and Additional Sources
Annex A – General Description of Industry Activities
Annex B – Environmental Assessment Guidance for Thermal Power Projects.

1.0 Industry-Specific Impacts and Management

The following section provides a summary of the most significant EHS issues associated with thermal power plants, which occur during the operational phase, along with recommendations for their management.

As described in the introduction to the **General EHS Guidelines**, the general approach to the management of EHS issues in industrial development activities, including power plants, should consider potential impacts as early as possible in the project cycle, including the incorporation of EHS considerations into the site selection and plant design processes in order to maximize the range of options available to prevent and control potential negative impacts.

Recommendations for the management of EHS issues common to most large industrial and infrastructure facilities during the construction and decommissioning phases are provided in the **General EHS Guidelines**.

1.1 Environment

Environmental issues in thermal power plant projects primarily include the following:

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

Air Emissions

The primary emissions to air from the combustion of fossil fuels or biomass are sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter (PM), carbon monoxide (CO), and greenhouse gases, such as carbon dioxide (CO_2). Depending on the fuel type and quality, mainly waste fuels or solid fuels, other substances such as heavy metals (i.e., mercury, arsenic, cadmium, vanadium, nickel, etc), halide compounds (including hydrogen fluoride), unburned hydrocarbons and other volatile organic compounds (VOCs) may be emitted in smaller quantities, but may have a significant influence on the environment due to their toxicity and/or persistence. Sulfur dioxide and nitrogen oxide are also implicated in long-range and trans-boundary acid deposition.

The amount and nature of air emissions depends on factors such as the fuel (e.g., coal, fuel oil, natural gas, or biomass), the type and design of the combustion unit (e.g., reciprocating engines, combustion turbines, or boilers), operating practices, emission control measures (e.g., primary combustion control, secondary flue gas treatment), and the overall system efficiency. For example, gas-fired plants generally produce negligible quantities of particulate matter and sulfur oxides, and levels of nitrogen oxides are about 60% of those from plants using coal (without emission reduction measures). Natural gas-fired plants also release lower quantities of carbon dioxide, a greenhouse gas.

Some measures, such as choice of fuel and use of measures to increase energy conversion efficiency, will reduce emissions of multiple air pollutants, including CO_2, per unit of energy generation. Optimizing energy utilization efficiency of the generation process depends on a variety of factors, including the nature and quality of fuel, the type of combustion system, the operating temperature of the combustion turbines, the operating pressure and temperature of steam turbines, the local climate conditions, the type of cooling system used, etc. Recommended measures to prevent, minimize, and control air emissions include:

- Use of the cleanest fuel economically available (natural gas is preferable to oil, which is preferable to coal) if that is consistent with the overall energy and environmental policy of the country or the region where the plant is proposed. For most large power plants, fuel choice is often part of the national energy policy, and fuels, combustion technology and pollution control technology, which are all interrelated, should be evaluated very carefully upstream of the project to optimize the project's environmental performance;
- When burning coal, giving preference to high-heat-content, low-ash, and low-sulfur coal;
- Considering beneficiation to reduce ash content, especially for high ash coal;[3]
- Selection of the best power generation technology for the fuel chosen to balance the environmental and economic benefits. The choice of technology and pollution control systems will be based on the site-specific environmental assessment (some examples include the use of higher energy-efficient systems, such as combined cycle gas turbine system for natural gas and oil-fired units, and supercritical, ultra-supercritical or integrated coal gasification combined cycle (IGCC) technology for coal-fired units);
- Designing stack heights according to Good International Industry Practice (GIIP) to avoid excessive ground level concentrations and minimize impacts, including acid deposition;[4]
- Considering use of combined heat and power (CHP, or co-generation) facilities. By making use of otherwise wasted heat, CHP facilities can achieve thermal efficiencies of 70 – 90 percent, compared with 32 – 45 percent for conventional thermal power plants.
- As stated in the General EHS Guidelines, emissions from a single project should not contribute more than 25% of the applicable ambient air quality standards to allow additional, future sustainable development in the same airshed.[5]

Pollutant-specific control recommendations are provided below.

Sulfur Dioxide

The range of options for the control of sulfur oxides varies substantially because of large differences in the sulfur content of different fuels and in control costs as described in Table 1. The choice of technology depends on a benefit-cost analysis of the environmental performance of different fuels, the cost of controls, and the existence of a market for sulfur control by-products[5]. Recommended measures to prevent, minimize, and control SO_2 emissions include:

[3] If sulfur is inorganically bound to the ash, this will also reduce sulfur content.

[4] For specific guidance on calculating stack height see Annex 1.1.3 of the General EHS Guidelines. Raising stack height should not be used to allow more emissions. However, if the proposed emission rates result in significant incremental ambient air quality impacts to the attainment of the relevant ambient air quality standards, options to raise stack height and/or to further reduce emissions should be considered in the EA. Typical examples of GIIP stack heights are up to around 200m for large coal-fired power plants, up to around 80m for HFO-fueled diesel engine power plants, and up to 100m for gas-fired combined cycle gas turbine power plants. Final selection of the stack height will depend on the terrain of the surrounding areas, nearby buildings, meteorological conditions, predicted incremental impacts and the location of existing and future receptors.

[5] For example, the US EPA Prevention of Significant Deterioration Increments Limits applicable to non-degraded airsheds provide the following: SO_2 (91 $\mu g/m^3$ for 2nd highest 24-hour, 20 $\mu g/m^3$ for annual average), NO_2 (20 $\mu g/m^3$ for annual average), and PM_{10} (30 $\mu g/m^3$ for 2nd highest 24-hour, and 17 $\mu g/m^3$ for annual average).

- Use of fuels with a lower content of sulfur where economically feasible;
- Use of lime (CaO) or limestone ($CaCO_3$) in coal-fired fluidized bed combustion boilers to have integrated desulfurization which can achieve a removal efficiency of up to 80-90 % through use of Fluidized Bed Combustion[7, 8];
- Depending on the plant size, fuel quality, and potential for significant emissions of SO_2 , use of flue gas desulfurization (FGD) for large boilers using coal or oil and for large reciprocating engines . The optimal type of FGD system (e.g., wet FGD using limestone with 85 to 98% removal efficiency, dry FGD using lime with 70 to 94% removal efficiency, seawater FGD with up to 90% removal efficiency) depends on the capacity of the plant, fuel properties, site conditions, and the cost and availability of reagent as well as by-product disposal and utilization.[9]

Table 1 - Performance / Characteristics of FGDs

Type of FGD	Characteristics	Plant Capital Cost Increase
Wet FGD	• Flue gas is saturated with water • Limestone ($CaCO_3$) as reagent • Removal efficiency up to 98% • Use 1-1.5% of electricity generated • Most widely used • Distance to limestone source and the limestone reactivity to be considered • High water consumption • Need to treat wastewater • Gypsum as a saleable by-product or waste	11-14%
Semi-Dry FGD	• Also called "Dry Scrubbing" – under controlled humidification. • Lime (CaO) as reagent • Removal efficiency up to 94% • Can remove SO_3 as well at higher removal rate than Wet FGD • Use 0.5-1.0% of electricity generated, less than Wet FGD • Lime is more expensive than limestone • No wastewater • Waste – mixture of fly ash, unreacted additive and $CaSO_3$	9-12%
Seawater FGD	• Removal efficiency up to 90% • Not practical for high S coal (>1%S) • Impacts on marine environment need to be carefully examined (e.g., reduction of pH, inputs of remaining heavy metals, fly ash, temperature, sulfate, dissolved oxygen, and chemical oxygen demand) • Use 0.8-1.6% of electricity generated • Simple process, no wastewater or solid waste.	7-10%

Sources: EC (2006) and World Bank Group.

Nitrogen Oxides

Formation of nitrogen oxides can be controlled by modifying operational and design parameters of the combustion process (primary measures). Additional treatment of NO_X from the flue gas (secondary measures; see Table 2) may be required in some cases depending on the ambient air quality objectives. Recommended measures to prevent, minimize, and control NO_X emissions include:

- Use of low NO_X burners with other combustion modifications, such as low excess air (LEA) firing, for boiler plants. Installation of additional NO_X controls for boilers may be necessary to meet emissions limits; a selective catalytic reduction (SCR) system can be used for pulverized coal-fired, oil-fired, and gas-fired boilers or a selective non-catalytic reduction (SNCR) system for a fluidized-bed boiler;
- Use of dry low-NO_X combustors for combustion turbines burning natural gas;
- Use of water injection or SCR for combustion turbines and

[6] Regenerative Flue Gas Desulfurization (FGD) options (either wet or semi-dray) may be considered under these conditions.
[7] EC (2006)
[8] The SO2 removal efficiency of FBC technologies depends on the sulfur and lime content of fuel, sorbent quantity, ratio, and quality.
[9] The use of wet scrubbers, in addition to dust control equipment (e.g. ESP or Fabric Filter), has the advantage of also reducing emissions of HCl, HF, heavy metals, and further dust remaining after ESP or Fabric Filter. Because of higher costs, the wet scrubbing process is generally not used at plants with a capacity of less than 100 MWth (EC 2006).

reciprocating engines burning liquid fuels;[10]

- Optimization of operational parameters for existing reciprocating engines burning natural gas to reduce NOx emissions;
- Use of lean-burn concept or SCR for new gas engines.

Table 2 - Performance / Characteristics of Secondary NOx Reduction Systems

Type	Characteristics	Plant Capital Cost Increase
SCR	• NOx emission reduction rate of 80 – 95% • Use 0.5% of electricity generated • Use ammonia or urea as reagent. • Ammonia slip increases with increasing NH_3/NOx ratio may cause a problem (e.g., too high ammonia in the fly ash). Larger catalyst volume / improving the mixing of NH_3 and NOx in the flue gas may be needed to avoid this problem. • Catalysts may contain heavy metals. Proper handling and disposal / recycle of spent catalysts is needed. • Life of catalysts has been 6-10 years (coal-fired), 8-12 years (oil-fired) and more than 10 years (gas-fired).	4-9% (coal-fired boiler) 1-2% (gas-fired combined cycle gas turbine) 20-30% (reciprocating engines)
SNCR	• NOx emission reduction rate of 30 – 50% • Use 0.1-0.3% of electricity generated • Use ammonia or urea as reagent. • Cannot be used on gas turbines or gas engines. • Operates without using catalysts.	1-2%

Source: EC (2006), World Bank Group

Particulate Matter

Particulate matter[11] is emitted from the combustion process, especially from the use of heavy fuel oil, coal, and solid biomass. The proven technologies for particulate removal in power plants are fabric filters and electrostatic precipitators (ESPs), shown in Table 3. The choice between a fabric filter and an ESP depends on the fuel properties, type of FGD system if used for SO_2 control, and ambient air quality objectives. Particulate matter can also be released during transfer and storage of coal and additives, such as lime. Recommendations to prevent, minimize, and control particulate matter emissions include:

- Installation of dust controls capable of over 99% removal efficiency, such as ESPs or Fabric Filters (baghouses), for coal-fired power plants. The advanced control for particulates is a wet ESP, which further increases the removal efficiency and also collects condensables (e.g., sulfuric acid mist) that are not effectively captured by an ESP or a fabric filter;[12]
- Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors;
- Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments;
- Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust;
- For solid fuels of which fine fugitive dust could contain vanadium, nickel and Polycyclic Aromatic Hydrocarbons (PAHs) (e.g., in coal and petroleum coke), use of full enclosure during transportation and covering stockpiles where necessary;
- Design and operate transport systems to minimize the generation and transport of dust on site;
- Storage of lime or limestone in silos with well designed, extraction and filtration equipment;
- Use of wind fences in open storage of coal or use of enclosed storage structures to minimize fugitive dust.

[10] Water injection may not be practical for industrial combustion turbines in all cases. Even if water is available, the facilities for water treatment and the operating and maintenance costs of water injection may be costly and may complicate the operation of a small combustion turbine.

[11] Including all particle sizes (e.g. TSP, PM_{10}, and $PM_{2.5}$)

[12] Flue gas conditioning (FGC) is a recommended approach to address the issue of low gas conductivity and lower ESP collection performance which occurs when ESPs are used to collect dust from very low sulfur fuels. One particular FGC design involves introduction of sulfur trioxide (SO_3) gas into the flue gas upstream of the ESP, to increase the conductivity of the flue gas dramatically improve the ESP collection efficiency. There is typically no risk of increased SOx emissions as the SO_3 is highly reactive and adheres to the dust.

emissions where necessary; applying special ventilation systems in enclosed storage to avoid dust explosions (e.g., use of cyclone separators at coal transfer points).

See Annex 1.1.2 of the **General EHS Guidelines** for an additional illustrative presentation of point source emissions prevention and control technologies.

Table 3 – Performance / Characteristics of Dust Removal Systems

Type	Performance / Characteristics
ESP	• Removal efficiency of >96.5% (<1 µm), >99.95% (>10 µm) • 0.1-1.8% of electricity generated is used • It might not work on particulates with very high electrical resistivity. In these cases, flue gas conditioning (FGC) may improve ESP performance. • Can handle very large gas volume with low pressure drops
Fabric Filter	• Removal efficiency of >99.6% (<1 µm), >99.95% (>10 µm). Removes smaller particles than ESPs. • 0.2-3% of electricity generated is used • Filter life decreases as coal S content increases • Operating costs go up considerably as the fabric filter becomes dense to remove more particles • If ash is particularly reactive, it can weaken the fabric and eventually it disintegrates.
Wet Scrubber	• Removal efficiency of >98.5% (<1 µm), >99.9% (>10 µm) • Up to 3% of electricity generated is used. • As a secondary effect, can remove and absorb gaseous heavy metals • Wastewater needs to be treated

Sources: EC (2006) and World Bank Group.

Other Pollutants

Depending on the fuel type and quality, other air pollutants may be present in environmentally significant quantities requiring proper consideration in the evaluation of potential impacts to ambient air quality and in the design and implementation of management actions and environmental controls. Examples of additional pollutants include mercury in coal, vanadium in heavy fuel oil, and other heavy metals present in waste fuels such as petroleum coke (petcoke) and used lubricating oils[13]. Recommendations to prevent, minimize, and control emissions of other air pollutants such as mercury in particular from thermal power plants include the use of conventional secondary controls such as fabric filters or ESPs operated in combination with FGD techniques, such as limestone FGD, Dry Lime FGD, or sorbent injection.[14] Additional removal of metals such as mercury can be achieved in a high dust SCR system along with powered activated carbon, bromine-enhanced Powdered Activated Carbon (PAC) or other sorbents. Since mercury emissions from thermal power plants pose potentially significant local and transboundary impacts to ecosystems and public health and safety through bioaccumulation, particular consideration should be given to their minimization in the environmental assessment and accordingly in plant design.[15]

Emissions Offsets

Facilities in degraded airsheds should minimize incremental impacts by achieving emissions values outlined in Table 6. Where these emissions values result nonetheless in excessive ambient impacts relative to local regulatory standards (or in their absence, other international recognized standards or guidelines, including World Health Organization guidelines), the project should explore and implement site-specific offsets that result in no net increase in the total emissions of those pollutants (e.g., particulate matter, sulfur dioxide, or nitrogen dioxide) that are responsible for the degradation of the airshed. Offset provisions should be implemented before the power plant comes fully on stream. Suitable offset measures could include reductions in emissions of particulate matter, sulfur dioxide, or nitrogen dioxide, as necessary through (a) the installation of new or more effective controls at other units within the same power plant or at other power plants in

[13] In these cases, the EA should address potential impacts to ambient air quality for such heavy metals as mercury, nickel, vanadium, cadmium, lead, etc.

[14] For Fabric Filters or Electrostatic Precipitators operated in combination with FGD techniques, an average removal rate of 75% or 90 % in the additional presence of SCR can be obtained (EC, 2006).

[15] Although no major industrial country has formally adopted regulatory limits for mercury emissions from thermal power plants, such limitations where under consideration in the United States and European Union as of 2006. Future updates of these EHS Guidelines will reflect changes in the international state of

the same airshed, (b) the installation of new or more effective controls at other large sources, such as district heating plants or industrial plants, in the same airshed, or (c) investments in gas distribution or district heating systems designed to substitute for the use of coal for residential heating and other small boilers. Wherever possible, the offset provisions should be implemented within the framework of an overall air quality management strategy designed to ensure that air quality in the airshed is brought into compliance with ambient standards. The monitoring and enforcement of ambient air quality in the airshed to ensure that offset provisions are complied with would be the responsibility of the local or national agency responsible for granting and supervising environmental permits. Project sponsors who cannot engage in the negotiations necessary to put together an offset agreement (for example, due to the lack of the local or national air quality management framework) should consider the option of relying on an appropriate combination of using cleaner fuels, more effective pollution controls, or reconsidering the selection of the proposed project site. The overall objective is that the new thermal power plants should not contribute to deterioration of the already degraded airshed.

Energy Efficiency and GHG Emissions

Carbon dioxide, one of the major greenhouse gases (GHGs) under the UN Framework Convention on Climate Change, is emitted from the combustion of fossil fuels. Recommendations to avoid, minimize, and offset emissions of carbon dioxide from new and existing thermal power plants include, among others:

- Use of less carbon intensive fossil fuels (i.e., less carbon containing fuel per unit of calorific value – gas is less than oil and oil is less than coal) or co-firing with carbon neutral fuels (i.e., biomass);
- Use of combined heat and power plants (CHP) where feasible;
- Use of higher energy conversion efficiency technology of the same fuel type / power plant size than that of the country/region average. New facilities should be aimed to be in top quartile of the country/region average of the same fuel type and power plant size. Rehabilitation of existing facilities must achieve significant improvements in efficiency. Typical CO_2 emissions performance of different fuels / technologies are presented below in Table 4;
- Consider efficiency-relevant trade-offs between capital and operating costs involved in the use of different technologies. For example, supercritical plants may have a higher capital cost than subcritical plants for the same capacity, but lower operating costs. On the other hand, characteristics of existing and future size of the grid may impose limitations in plant size and hence technological choice. These tradeoffs need to be fully examined in the EA;
- Use of high performance monitoring and process control techniques, good design and maintenance of the combustion system so that initially designed efficiency performance can be maintained;
- Where feasible, arrangement of emissions offsets (including the Kyoto Protocol's flexible mechanisms and the voluntary carbon market), including reforestation, afforestation, or capture and storage of CO_2 or other currently experimental options[16];
- Where feasible, include transmission and distribution loss reduction and demand side measures. For example, an investment in peak load management could reduce cycling requirements of the generation facility thereby improving its operating efficiency. The feasibility of these types of off-set options may vary depending on whether the facility is part of a vertically integrated utility or an independent power producer;
- Consider fuel cycle emissions and off-site factors (e.g., fuel

practice regarding mercury emissions prevention and control

[16] The application of carbon capture and storage (CCS) from thermal power projects is still in experimental stages worldwide although consideration has started to be given to CCS-ready design. Several options are currently under evaluation including CO_2 storage in coal seams or deep aquifers and oil reservoir injection for enhanced oil recovery

supply, proximity to load centers, potential for off-site use of waste heat, or use of nearby waste gases (blast furnace gases or coal bed methane) as fuel. etc).

Table 4 - Typical CO_2 Emissions Performance of New Thermal Power Plants

Fuel	Efficiency	CO_2 (gCO_2 / kWh – Gross)
Efficiency (% Net, HHV)		
Coal (*1, *2)	Ultra-Supercritical (*1): 37.6 – 42.7 Supercritical: 35.9-38.3 (*1) 39.1 (w/o CCS) (*2) 24.9 (with CCS) (*2) Subcritical: 33.1-35.9 (*1) 36.8 (w/o CCS) (*2) 24.9 (with CCS) (*2) IGCC: 39.2-41.8 (*1) 38.2–41.1 (w/o CCS) (*2) 31.7–32.5 (with CCS) (*2)	 676-795 756-836 763 95 807-907 808 102 654-719 640 – 662 68 – 86
Gas (*2)	Advanced CCGT (*2): 50.8 (w/o CCS) 43.7 (with CCS)	 355 39
Efficiency (% Net, LHV)		
Coal (*3)	42 (Ultra-Supercritical) 40 (Supercritical) 30 – 38 (Subcritical) 46 (IGCC) 38 (IGCC+CCS)	811 851 896-1,050 760 134
Coal and Lignite (*4, *7)	(*4) 43-47 (Coal-PC) >41(Coal-FBC) 42-45 (Lignite-PC) >40 (Lignite-FBC)	(*6) 725-792 (Net) <831 (Net) 808-866 (Net) <909 (Net)
Gas (*4, *7)	(*4) 36–40 (Simple Cycle GT) 38-45 (Gas Engine) 40-42 (Boiler) 54-58 (CCGT)	(*6) 505-561 (Net) 531-449 (Net) 481-505 (Net) 348-374 (Net)
Oil (*4, *7)	(*4) 40 – 45 (HFO/LFO Reciprocating Engine)	(*6) 449-505 (Net)
Efficiency (% Gross, LHV)		
Coal (*5, *7)	(*5) 47 (Ultra-supercritical) 44 (Supercritical) 41-42 (Subcritical) 47-48 (IGCC)	(*6) 725 774 811-831 710-725
Oil (*5, *7)	(*5) 43 (Reciprocating Engine) 41 (Boiler)	(*6) 648 680
Gas (*5)	(*5) 34 (Simple Cycle GT) 51 (CCGT)	(*6) 594 396

Source: (*1) US EPA 2006, (*2) US DOE/NETL 2007, (*3) World Bank, April 2006, (*4) European Commission 2006, (*5) World Bank Group, Sep 2006, (*6) World Bank Group estimates

Water Consumption and Aquatic Habitat Alteration

Steam turbines used with boilers and heat recovery steam generators(HRSG) used in combined cycle gas turbine units require a cooling system to condense steam used to generate electricity. Typical cooling systems used in thermal power plants include: (i) once-through cooling system where sufficient cooling water and receiving surface water are available; (ii) closed circuit wet cooling system; and (iii) closed circuit dry cooling system (e.g., air cooled condensers).

Combustion facilities using once-through cooling systems require large quantities of water which are discharged back to receiving surface water with elevated temperature. Water is also required for boiler makeup, auxiliary station equipment, ash handling, and FGD systems.[17] The withdrawal of such large quantities of water has the potential to compete with other important water uses such as agricultural irrigation or drinking water sources. Withdrawal and discharge with elevated temperature and chemical contaminants such as biocides or other additives, if used, may affect aquatic organisms, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of aquatic life. Aquatic organisms drawn into cooling water intake structures are either impinged on components of the cooling water intake structure or entrained in the cooling water system itself. In the case of either impingement or entrainment, aquatic organisms may be killed or subjected to significant harm. In some cases (e.g., sea turtles), organisms are entrapped in the intake canals. There may be special concerns about the potential impacts of cooling water intake structures located in or near habitat areas that support threatened, endangered, or other protected species or where local fishery is active.

Conventional intake structures include traveling screens with relative high through-screen velocities and no fish handling or

[17] The availability of water and impact of water use may affect the choice of FGD

return system.[18] Measures to prevent, minimize, and control environmental impacts associated with water withdrawal should be established based on the results of a project EA, considering the availability and use of water resources locally and the ecological characteristics of the project affected area. Recommended management measures to prevent or control impacts to water resources and aquatic habitats include[19]:

- Conserving water resources, particularly in areas with limited water resources, by:
  - Use of a closed-cycle, recirculating cooling water system (e.g., natural or forced draft cooling tower), or closed circuit dry cooling system (e.g., air cooled condensers) if necessary to prevent unacceptable adverse impacts. Cooling ponds or cooling towers are the primary technologies for a recirculating cooling water system. Once-through cooling water systems may be acceptable if compatible with the hydrology and ecology of the water source and the receiving water and may be the preferred or feasible alternative for certain pollution control technologies such as seawater scrubbers
  - Use of dry scrubbers in situations where these controls are also required or recycling of wastewater in coal-fired plants for use as FGD makeup
  - Use of air-cooled systems
- Reduction of maximum through-screen design intake velocity to 0.5 ft/s;
- Reduction of intake flow to the following levels:
  - For freshwater rivers or streams to a flow sufficient to maintain resource use (i.e., irrigation and fisheries) as well as biodiversity during annual mean low flow conditions[20]
  - For lakes or reservoirs, intake flow must not disrupt the thermal stratification or turnover pattern of the source water
  - For estuaries or tidal rivers, reduction of intake flow to 1% of the tidal excursion volume
- If there are threatened, endangered, or other protected species or if there are fisheries within the hydraulic zone of influence of the intake, reduction of impingement and entrainment of fish and shellfish by the installation of technologies such as barrier nets (seasonal or year-round), fish handling and return systems, fine mesh screens, wedgewire screens, and aquatic filter barrier systems. Examples of operational measures to reduce impingement and entrainment include seasonal shutdowns, if necessary, or reductions in flow or continuous use of screens. Designing the location of the intake structure in a different direction or further out into the water body may also reduce impingement and entrainment.

Effluents

Effluents from thermal power plants include thermal discharges, wastewater effluents, and sanitary wastewater.

Thermal Discharges

As noted above, thermal power plants with steam-powered generators and once-through cooling systems use significant volume of water to cool and condense the steam for return to the boiler. The heated water is normally discharged back to the source water (i.e., river, lake, estuary, or the ocean) or the nearest surface water body. In general, thermal discharge should be designed to ensure that discharge water temperature does not result in exceeding relevant ambient water quality temperature standards outside a scientifically established mixing zone. The mixing zone is typically defined as the zone where initial dilution of a discharge takes place within which relevant water quality

system used (i.e., wet vs. semi-dry)

[18] The velocity generally considered suitable for the management of debris is 1 fps [0.30 m/s] with wide mesh screens; a standard mesh for power plants of 3/8 in (9.5 mm).

[19] For additional information refer to Schimmoller (2004) and USEPA (2001).

[20] Stream flow requirements may be based on mean annual flow or mean low flow. Regulatory requirements may be 5% or higher for mean annual flows and 10% to 25% for mean low flows. Their applicability should be verified on a site-specific

temperature standards are allowed to exceed and takes into account cumulative impact of seasonal variations, ambient water quality, receiving water use, potential receptors and assimilative capacity among other considerations. Establishment of such a mixing zone is project specific and may be established by local regulatory agencies and confirmed or updated through the project's environmental assessment process. Where no regulatory standard exists, the acceptable ambient water temperature change will be established through the environmental assessment process. Thermal discharges should be designed to prevent negative impacts to the receiving water taking into account the following criteria:

- The elevated temperature areas because of thermal discharge from the project should not impair the integrity of the water body as a whole or endanger sensitive areas (such as recreational areas, breeding grounds, or areas with sensitive biota);
- There should be no lethality or significant impact to breeding and feeding habits of organisms passing through the elevated temperature areas;
- There should be no significant risk to human health or the environment due to the elevated temperature or residual levels of water treatment chemicals.

If a once-through cooling system is used for large projects (i.e., a plant with > 1,200MWth steam generating capacity), impacts of thermal discharges should be evaluated in the EA with a mathematical or physical hydrodynamic plume model, which can be a relatively effective method for evaluating a thermal discharge to find the maximum discharge temperatures and flow rates that would meet the environmental objectives of the receiving water.[21]

Recommendations to prevent, minimize, and control thermal discharges include:

- Use of multi-port diffusers;
- Adjustment of the discharge temperature, flow, outfall location, and outfall design to minimize impacts to acceptable level (i.e., extend length of discharge channel before reaching the surface water body for pre-cooling or change location of discharge point to minimize the elevated temperature areas);
- Use of a closed-cycle, recirculating cooling water system as described above (e.g., natural or forced draft cooling tower), or closed circuit dry cooling system (e.g., air cooled condensers) if necessary to prevent unacceptable adverse impacts. Cooling ponds or cooling towers are the primary technologies for a recirculating cooling water system.

Liquid Waste

The wastewater streams in a thermal power plant include cooling tower blowdown; ash handling wastewater; wet FGD system discharges; material storage runoff; metal cleaning wastewater; and low-volume wastewater, such as air heater and precipitator wash water, boiler blowdown, boiler chemical cleaning waste, floor and yard drains and sumps, laboratory wastes, and backflush from ion exchange boiler water purification units. All of these wastewaters are usually present in plants burning coal or biomass; some of these streams (e.g., ash handling wastewater) may be present in reduced quantities or may not be present at all in oil-fired or gas-fired power plants. The characteristics of the wastewaters generated depend on the ways in which the water has been used. Contamination arises from demineralizers; lubricating and auxiliary fuel oils; trace contaminants in the fuel (introduced through the ash-handling wastewater and wet FGD system discharges); and chlorine, biocides, and other chemicals used to manage the quality of water in cooling systems. Cooling tower blowdown tends to be very high in total dissolved solids but is generally classified as non-contact cooling water and, as such,

basis taking into consideration resource use and biodiversity requirements.
[21] An example model is CORMIX (Cornell Mixing Zone Expert System) hydrodynamic mixing zone computer simulation, which has been developed by the U.S. Environmental Protection Agency. This model emphasizes predicting the site- and discharge-specific geometry and dilution characteristics to assess the environmental effects of a proposed discharge.

is typically subject to limits for pH, residual chlorine, and toxic chemicals that may be present in cooling tower additives (including corrosion inhibiting chemicals containing chromium and zinc whose use should be eliminated).

Recommended water treatment and wastewater conservation methods are discussed in Sections 1.3 and 1.4, respectively, of the **General EHS Guidelines**. In addition, recommended measures to prevent, minimize, and control wastewater effluents from thermal power plants include:

- Recycling of wastewater in coal-fired plants for use as FGD makeup. This practice conserves water and reduces the number of wastewater streams requiring treatment and discharge[22];
- In coal-fired power plants without FGD systems, treatment of process wastewater in conventional physical-chemical treatment systems for pH adjustment and removal of total suspended solids (TSS), and oil / grease, at a minimum. Depending on local regulations, these treatment systems can also be used to remove most heavy metals to part-per-billion (ppb) levels by chemical precipitation as either metal hydroxide or metal organosulfide compounds;
- Collection of fly ash in dry form and bottom ash in drag chain conveyor systems in new coal-fired power plants;
- Consider use of soot blowers or other dry methods to remove fireside wastes from heat transfer surfaces so as to minimize the frequency and amount of water used in fireside washes;
- Use of infiltration and runoff control measures such as compacted soils, protective liners, and sedimentation controls for runoff from coal piles;
- Spraying of coal piles with anionic detergents to inhibit bacterial growth and minimize acidity of leachate;[23]
- Use of SO_x removal systems that generate less wastewater, if feasible; however, the environmental and cost characteristics of both inputs and wastes should be assessed on a case-by-case basis;
- Treatment of low-volume wastewater streams that are typically collected in the boiler and turbine room sumps in conventional oil-water separators before discharge;
- Treatment of acidic low-volume wastewater streams, such as those associated with the regeneration of makeup demineralizer and deep-bed condensate polishing systems, by chemical neutralization in-situ before discharge;
- Pretreatment of cooling tower makeup water, installation of automated bleed/feed controllers, and use of inert construction materials to reduce chemical treatment requirements for cooling towers;
- Elimination of metals such as chromium and zinc from chemical additives used to control scaling and corrosion in cooling towers;
- Use the minimum required quantities of chlorinated biocides in place of brominated biocides or alternatively apply intermittent shock dosing of chlorine as opposed to continuous low level feed.

Sanitary Wastewater

Sewage and other wastewater generated from washrooms, etc. are similar to domestic wastewater. Impacts and management of sanitary wastewater is addressed in Section 1.3 of the **General EHS Guidelines.**

Solid Wastes

Coal-fired and biomass-fired thermal power plants generate the greatest amount of solid wastes due to the relatively high percentage of ash in the fuel.[24] The large-volume coal

[22] Suitable wastewater streams for reuse include gypsum wash water, which is a different wastewater stream than the FGD wastewater. In plants that produce marketable gypsum, the gypsum is rinsed to remove chloride and other undesirable trace elements.

[23] If coal pile runoff will be used as makeup to the FGD system, anionic detergents may increase or create foaming within the scrubber system. Therefore, use of anionic surfactants on coal piles should be evaluated on a case-by-case basis.

[24] For example, a 500 MWe plant using coal with 2.5% sulfur (S), 16% ash, and 30,000 kilojoules per kilogram (kJ/kg) heat content will generate about 500 tons of

combustion wastes (CCW) are fly ash, bottom ash, boiler slag, and FGD sludge. Biomass contains less sulfur; therefore FGD may not be necessary. Fluidized-bed combustion (FBC) boilers generate fly ash and bottom ash, which is called bed ash. Fly ash removed from exhaust gases makes up 60–85% of the coal ash residue in pulverized-coal boilers and 20% in stoker boilers. Bottom ash includes slag and particles that are coarser and heavier than fly ash. Due to the presence of sorbent material, FBC wastes have a higher content of calcium and sulfate and a lower content of silica and alumina than conventional coal combustion wastes. Low-volume solid wastes from coal-fired thermal power plants and other plants include coal mill rejects/pyrites, cooling tower sludge, wastewater treatment sludge, and water treatment sludge.

Oil combustion wastes include fly ash and bottom ash and are normally only generated in significant quantities when residual fuel oil is burned in oil-fired steam electric boilers. Other technologies (e.g., combustion turbines and diesel engines) and fuels (e.g., distillate oil) generate little or no solid wastes. Overall, oil combustion wastes are generated in much smaller quantities than the large-volume CCW discussed above. Gas-fired thermal power plants generate essentially no solid waste because of the negligible ash content, regardless of the combustion technology.

Metals are constituents of concern in both CCW and low-volume solid wastes. For example, ash residues and the dust removed from exhaust gases may contain significant levels of heavy metals and some organic compounds, in addition to inert materials.

Ash residues are not typically classified as a hazardous waste due to their inert nature.[25] However, where ash residues are expected to contain potentially significant levels of heavy metals, radioactivity, or other potentially hazardous materials, they should be tested at the start of plant operations to verify their classification as hazardous or non-hazardous according to local regulations or internationally recognized standards. Additional information about the classification and management of hazardous and non-hazardous wastes is presented in Section 1.6 of the **General EHS Guidelines.**

The high-volume CCWs wastes are typically managed in landfills or surface impoundments or, increasingly, may be applied to a variety of beneficial uses. Low-volume wastes are also managed in landfills or surface impoundments, but are more frequently managed in surface impoundments. Many coal-fired plants co-manage large-volume and low-volume wastes.

Recommended measures to prevent, minimize, and control the volume of solid wastes from thermal power plants include:

- Dry handling of the coal combustion wastes, in particular fly ash. Dry handling methods do not involve surface impoundments and, therefore, do not present the ecological risks identified for impoundments (e.g., metal uptake by wildlife);
- Recycling of CCWs in uses such as cement and other concrete products, construction fills (including structural fill, flowable fill, and road base), agricultural uses such as calcium fertilizers (provided trace metals or other potentially hazardous materials levels are within accepted thresholds), waste management applications, mining applications, construction materials (e.g., synthetic gypsum for plasterboard), and incorporation into other products provided the residues (such as trace metals and radioactivity) are not considered hazardous. Ensuring consistent quality of fuels and additives helps to ensure the CCWs can be recycled. If beneficial reuse is not feasible, disposal of CCW in permitted landfills with environmental controls such as run-on/run-off controls, liners, leachate collection systems, ground-water monitoring, closure controls, daily (or other operational) cover, and fugitive dust controls is recommended;

solid waste per day.
[25] Some countries may categorize fly ash as hazardous due to the presence of arsenic or radioactivity, precluding its use as a construction material.

- Dry collection of bottom ash and fly ash from power plants combusting heavy fuel oil if containing high levels of economically valuable metals such as vanadium and recycle for vanadium recovery (where economically viable) or disposal in a permitted landfill with environmental controls;
- Management of ash disposal and reclamation so as to minimize environmental impacts – especially the migration of toxic metals, if present, to nearby surface and groundwater bodies, in addition to the transport of suspended solids in surface runoff due to seasonal precipitation and flooding. In particular, construction, operation, and maintenance of surface impoundments should be conducted in accordance with internationally recognized standards.[26, 27]
- Reuse of sludge from treatment of waste waters from FGD plants. This sludge may be re-used in the FGD plant due to the calcium components. It can also be used as an additive in coal-fired plant combustion to improve the ash melting behavior

Hazardous Materials and Oil

Hazardous materials stored and used at combustion facilities include solid, liquid, and gaseous waste-based fuels; air, water, and wastewater treatment chemicals; and equipment and facility maintenance chemicals (e.g., paint certain types of lubricants, and cleaners). Spill prevention and response guidance is addressed in Sections 1.5 and 3.7 of the **General EHS Guidelines**.

In addition, recommended measures to prevent, minimize, and control hazards associated with hazardous materials storage and handling at thermal power plants include the use of double-walled, underground pressurized tanks for storage of pure liquefied ammonia (e.g., for use as reagent for SCR) in quantities over 100 m^3; tanks of lesser capacity should be manufactured using annealing processes (EC 2006).

Noise

Principal sources of noise in thermal power plants include the turbine generators and auxiliaries; boilers and auxiliaries, such as coal pulverizers; reciprocating engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers. Thermal power plants used for base load operation may operate continually while smaller plants may operate less frequently but still pose a significant source of noise if located in urban areas.

Noise impacts, control measures, and recommended ambient noise levels are presented in Section 1.7 of the **General EHS Guidelines**. Additional recommended measures to prevent, minimize, and control noise from thermal power plants include:

- Siting new facilities with consideration of distances from the noise sources to the receptors (e.g., residential receptors, schools, hospitals, religious places) to the extent possible. If the local land use is not controlled through zoning or is not effectively enforced, examine whether residential receptors could come outside the acquired plant boundary. In some cases, it could be more cost effective to acquire additional land as buffer zone than relying on technical noise control measures, where possible;
- Use of noise control techniques such as: using acoustic machine enclosures; selecting structures according to their noise isolation effect to envelop the building; using mufflers or silencers in intake and exhaust channels; using sound-absorptive materials in walls and ceilings; using vibration isolators and flexible connections (e.g., helical steel springs and rubber elements); applying a carefully detailed design to prevent possible noise leakage through openings or to minimize pressure variations in piping;

[26] See, for example, U.S. Department of Labor, Mine Safety and Health Administration regulations at 30 CFR §§ 77.214 - 77.216.

[27] Additional detailed guidance applicable to the prevention and control of impacts to soil and water resources from non-hazardous and hazardous solid waste disposal is presented in the World Bank Group EHS Guidelines for Waste Management Facilities.

- Modification of the plant configuration or use of noise barriers such as berms and vegetation to limit ambient noise at plant property lines, especially where sensitive noise receptors may be present.

Noise propagation models may be effective tools to help evaluate noise management options such as alternative plant locations, general arrangement of the plant and auxiliary equipment, building enclosure design, and, together with the results of a baseline noise assessment, expected compliance with the applicable community noise requirements.

1.2 Occupational Health and Safety

Occupational health and safety risks and mitigation measures during construction, operation, and decommissioning of thermal power plants are similar to those at other large industrial facilities, and are addressed in Section 2.0 of the **General EHS Guidelines**. In addition, the following health and safety impacts are of particular concern during operation of thermal power plants:

- Non-ionizing radiation
- Heat
- Noise
- Confined spaces
- Electrical hazards
- Fire and explosion hazards
- Chemical hazards
- Dust

Non-ionizing radiation

Combustion facility workers may have a higher exposure to electric and magnetic fields (EMF) than the general public due to working in proximity to electric power generators, equipment, and connecting high-voltage transmission lines. Occupational EMF exposure should be prevented or minimized through the preparation and implementation of an EMF safety program including the following components:

- Identification of potential exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities;
- Training of workers in the identification of occupational EMF levels and hazards;
- Establishment and identification of safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting access to properly trained workers;
- Implementation of action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the Institute of Electrical and Electronics Engineers (IEEE).[28] Personal exposure monitoring equipment should be set to warn of exposure levels that are below occupational exposure reference levels (e.g., 50 percent). Action plans to address occupational exposure may include limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, or the use of shielding materials.

Heat

Occupational exposure to heat occurs during operation and maintenance of combustion units, pipes, and related hot equipment. Recommended prevention and control measures to address heat exposure at thermal power plants include:

- Regular inspection and maintenance of pressure vessels and piping;
- Provision of adequate ventilation in work areas to reduce heat and humidity;

[28] The ICNIRP exposure guidelines for Occupational Exposure are listed in Section 2.2 of this Guideline.

- Reducing the time required for work in elevated temperature environments and ensuring access to drinking water;
- Shielding surfaces where workers come in close contact with hot equipment, including generating equipment, pipes etc;
- Use of warning signs near high temperature surfaces and personal protective equipment (PPE) as appropriate, including insulated gloves and shoes.

Noise

Noise sources in combustion facilities include the turbine generators and auxiliaries; boilers and auxiliaries, such as pulverizers; diesel engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers. Recommendations for reducing noise and vibration are discussed in Section 1.1, above. In addition, recommendations to prevent, minimize, and control occupational noise exposures in thermal power plants include:

- Provision of sound-insulated control rooms with noise levels below 60 dBA[29];
- Design of generators to meet applicable occupational noise levels;
- Identify and mark high noise areas and require that personal noise protecting gear is used all the time when working in such high noise areas (typically areas with noise levels >85 dBA).

Confined Spaces

Specific areas for confined space entry may include coal ash containers, turbines, condensers, and cooling water towers (during maintenance activities). Recommend confined space entry procedures are discussed in Section 2.8 of the **General EHS Guidelines**.

Electrical Hazards

Energized equipment and power lines can pose electrical hazards for workers at thermal power plants. Recommended measures to prevent, minimize, and control electrical hazards at thermal power plants include:

- Consider installation of hazard warning lights inside electrical equipment enclosures to warn of inadvertent energization;
- Use of voltage sensors prior to and during workers' entrance into enclosures containing electrical components;
- Deactivation and proper grounding of live power equipment and distribution lines according to applicable legislation and guidelines whenever possible before work is performed on or proximal to them;
- Provision of specialized electrical safety training to those workers working with or around exposed components of electric circuits. This training should include, but not be limited to, training in basic electrical theory, proper safe work procedures, hazard awareness and identification, proper use of PPE, proper lockout/tagout procedures, first aid including CPR, and proper rescue procedures. Provisions should be made for periodic retraining as necessary.

Fire and Explosion Hazards

Thermal power plants store, transfer, and use large quantities of fuels; therefore, careful handling is necessary to mitigate fire and explosion risks. In particular, fire and explosion hazards increase as the particle size of coal is reduced. Particle sizes of coal that can fuel a propagating explosion occur within thermal dryers, cyclones, baghouses, pulverized-fuel systems, grinding mills, and other process or conveyance equipment. Fire and explosion prevention management guidance is provided in Section 2.1 and

[29] Depending on the type and size of the thermal power plants, distance between control room and the noise emitting sources differs. CSA Z107.58 provides design guidelines for control rooms as 60 dBA. Large thermal power plants using steam boilers or combustion turbines tend to be quieter than 60 dBA. Reciprocating engine manufacturers recommend 65 to 70 dBA instead of 60 dBA (Euromot Position as of 9 May 2008). This guideline recommends 60 dBA as GIIP, with an understanding that up to 65 dBA can be accepted for reciprocating engine power plants if 60 dBA is economically difficult to achieve.

2.4 of the **General EHS Guidelines**. Recommended measures to prevent, minimize, and control physical hazards at thermal power plants include:

- Use of automated combustion and safety controls;
- Proper maintenance of boiler safety controls;
- Implementation of startup and shutdown procedures to minimize the risk of suspending hot coal particles (e.g., in the pulverizer, mill, and cyclone) during startup;
- Regular cleaning of the facility to prevent accumulation of coal dust (e.g., on floors, ledges, beams, and equipment);
- Removal of hot spots from the coal stockpile (caused by spontaneous combustion) and spread until cooled, never loading hot coal into the pulverized fuel system;
- Use of automated systems such as temperature gauges or carbon monoxide sensors to survey solid fuel storage areas to detect fires caused by self-ignition and to identify risk points.

Chemical Hazards

Thermal power plants utilize hazardous materials, including ammonia for NO_x control systems, and chlorine gas for treatment of cooling tower and boiler water. Guidance on chemical hazards management is provided in Section 2.4 of the **General EHS Guidelines.** Additional, recommended measures to prevent, minimize, and control physical hazards at thermal power plants include:

- Consider generation of ammonia on site from urea or use of aqueous ammonia in place of pure liquefied ammonia;
- Consider use of sodium hypochlorite in place of gaseous chlorine.

Dust

Dust is generated in handing solid fuels, additives, and solid wastes (e.g., ash). Dust may contain silica (associated with silicosis), arsenic (skin and lung cancer), coal dust (black lung), and other potentially harmful substances. Dust management guidance is provided in the Section 2.1 and 2.4 of the **General EHS Guidelines.** Recommended measures to prevent, minimize, and control occupational exposure to dust in thermal power plants include:

- Use of dust controls (e.g., exhaust ventilation) to keep dust below applicable guidelines (see Section 2) or wherever free silica levels in airborne dust exceed 1 percent;
- Regular inspection and maintenance of asbestos containing materials (e.g., insulation in older plants may contain asbestos) to prevent airborne asbestos particles.

1.3 Community Health and Safety

Many community health and safety impacts during the construction, operation, and decommissioning of thermal power plant projects are common to those of most infrastructure and industrial facilities and are discussed in Section 3.0 the **General EHS Guidelines**. In addition to these and other aspects covered in Section 1.1, the following community health and safety impacts may be of particular concern for thermal power plant projects:

- Water Consumption;
- Traffic Safety.

Water Consumption

Boiler units require large amounts of cooling water for steam condensation and efficient thermal operation. The cooling water flow rate through the condenser is by far the largest process water flow, normally equating to about 98 percent of the total process water flow for the entire unit. In a once-through cooling water system, water is usually taken into the plant from surface waters, but sometimes ground waters or municipal supplies are used. The potential effects of water use should be assessed, as discussed in Section 3.1 of the **General EHS Guidelines**, to ensure that the project does not compromise the availability of water for personal hygiene, agriculture, recreation, and other community needs.

Traffic Safety

Operation of a thermal power plant will increase traffic volume, in particular for facilities with fuels transported via land and sea, including heavy trucks carrying fuel, additives, etc. The increased traffic can be especially significant in sparsely populate areas where some thermal power plants are located. Prevention and control of traffic-related injuries are discussed in Section 3.4 of the **General EHS Guidelines**. Water transport safety is covered in the **EHS Guidelines for Shipping**.

2.0 Performance Indicators and Monitoring

2.1 Environment

Emissions and Effluent Guidelines

Effluent guidelines are described in Table 5. Emissions guidelines are described in Table 6. Effluent guidelines are applicable for direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the **General EHS Guideline.** Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in standards of countries with recognized regulatory frameworks. These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels due to specific local project conditions should be justified in the environmental assessment.

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.

Emissions levels for the design and operation of each project should be established through the EA process on the basis of country legislation and the recommendations provided in this guidance document, as applied to local conditions. The emissions levels selected should be justified in the EA.[39] The maximum emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems. In contrast, poor operating or maintenance procedures affect actual pollutant removal efficiency and may reduce it to well

[39] For example, in cases where potential for acid deposition has been identified as a significant issue in the EA, plant design and operation should ensure that emissions mass loadings are effectively reduced to prevent or minimize such impacts.

below the design specification. Dilution of air emissions to achieve these guidelines is unacceptable. Compliance with ambient air quality guidelines should be assessed on the basis of good international industry practice (GIIP) recommendations.

As described in the General EHS Guidelines, emissions should not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards[31] by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines[32], or other internationally recognized sources[33]. Also, emissions from a single project should not contribute more than 25% of the applicable ambient air quality standards to allow additional, future sustainable development in the same airshed.[34]

As described in the General EHS Guidelines, facilities or projects located within poor quality airsheds[35], and within or next to areas established as ecologically sensitive (e.g., national parks), should ensure that any increase in pollution levels is as small as feasible, and amounts to a fraction of the applicable short-term and annual average air quality guidelines or standards as established in the project-specific environmental assessment.

Environmental Monitoring

Environmental monitoring programs for this sector are presented in Table 7. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Examples of emissions, stack testing, ambient air quality, and noise monitoring recommendations applicable to power plants are provided in Table 7. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

[31] Ambient air quality standards are ambient air quality levels established and published through national legislative and regulatory processes, and ambient quality guidelines refer to ambient quality levels primarily developed through clinical, toxicological, and epidemiological evidence (such as those published by the World Health Organization).

[32] Available at World Health Organization (WHO). http://www.who.int/en

[33] For example the United States National Ambient Air Quality Standards (NAAQS) (http://www.epa.gov/air/criteria.html) and the relevant European Council Directives (Council Directive 1999/30/EC of 22 April 1999 / Council Directive 2002/3/EC of February 12 2002).

[34] US EPA Prevention of Significant Deterioration Increments Limits applicable to non-degraded airsheds.

[35] An airshed should be considered as having poor air quality if nationally legislated air quality standards or WHO Air Quality Guidelines are exceeded significantly.

Table 6 (A) - Emissions Guidelines (in mg/Nm³ or as indicated) for Reciprocating Engine

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 (%)
Reciprocating Engine	NDA	DA	NDA	DA	NDA	DA	
Natural Gas	N/A	N/A	N/A	N/A	200 (Spark Ignition) 400 (Dual Fuel) (a)	200(SI) 400 (Dual Fuel / CI)	15%
Liquid Fuels (Plant >50 MWth to <300 MWth)	50	30	1,170 or use of 2% or less S fuel	0.5% S	1,460 (Compression Ignition, bore size diameter [mm] < 400) 1,850 (Compression Ignition, bore size diameter [mm] ≥ 400) 2,000 (Dual Fuel)	400	15%
Liquid Fuels (Plant >/=300 MWth)	50	30	585 or use of 1% or less S fuel	0.2% S	740 (contingent upon water availability for injection)	400	15%
Biofuels / Gaseous Fuels other than Natural Gas	50	30	N/A	N/A	30% higher limits than those provided above for Natural Gas and Liquid Fuels.	200 (SI, Natural Gas), 400 (other)	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 the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack. 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.
- (a) Compression Ignition (CI) engines may require different emissions values which should be evaluated on a case-by-case basis through the EA process.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008)

- Natural Gas-fired Reciprocating Engine – NOx
  - Guideline limits: 200 (SI), 400 (DF)
  - UK: 100 (CI), US: Reduce by 90% or more, or alternatively 1.6 g/kWh
- Liquid Fuels-fired Reciprocating Engine – NOx (Plant >50 MWth to <300 MWth)
  - Guideline limits: 1,460 (CI, bore size diameter < 400 mm), 1,850 (CI, bore size diameter ≥ 400 mm), 2,000 (DF)
  - UK: 300 (> 25 MWth), India: 1,460 (Urban area & ≤ 75 MWe (≈ 190 MWth), Rural area & ≤ 150 MWe (≈ 380 MWth))
- Liquid Fuels-fired Reciprocating Engine – NOx (Plant ≥300 MWth)
  - Guideline limits: 740 (contingent upon water availability for injection)
  - UK: 300 (> 25 MWth), India: 740 (Urban area & > 75MWe (≈ 190 MWth), Rural area & > 150 MWe (≈ 380 MWth))
- Liquid Fuels-fired Reciprocating Engine – SO2
  - Guideline limits: 1,170 or use of ≤ 2% S (Plant >50 MWth to <300 MWth), 585 or use of ≤ 1% S (Plant ≥300 MWth)
  - EU: Use of low S fuel oil or the secondary FGD (IPCC LCP BREF), HFO S content ≤ 1% (Liquid Fuel Quality Directive), US: Use of diesel fuel with max S of 500 ppm (0.05%), EU: Marine HFO S content ≤ 1.5% (Liquid Fuel Quality Directive) used in SOx Emission Control Areas; India: Urban (< 2% S), Rural (< 4% S), Only diesel fuels (HSD, LDO) should be used in Urban

Source: UK (S2 1.03 Combustion Processes: Compression Ignition Engines, 50 MWth and over), India (SOx/NOx Emission Standards for Diesel Engines ≥ 0.8 MW), EU (IPCC LCP BREF July 2006), EU (Liquid Fuel Quality Directive 1999/32/EC amended by 2005/33/EC), US (NSPS for Stationary Compression Ignition Internal Combustion Engine – Final Rule – July 11, 2006)

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 6 (C) - Emissions Guidelines (in mg/Nm³ or as indicated) for Boiler

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 (%)
Boiler	NDA	DA	NDA	DA	NDA	DA	
Natural Gas	N/A	N/A	N/A	N/A	240	240	3%
Other Gaseous Fuels	50	30	400	400	240	240	3%
Liquid Fuels (Plant >50 MWth to <600 MWth)	50	30	900 – 1,500[a]	400	400	200	3%
Liquid Fuels (Plant >/=600 MWth)	50	30	200 – 850[b]	200	400	200	3%
Solid Fuels (Plant >50 MWth to <600 MWth)	50	30	900 – 1,500[a]	400	510[c] Or up to 1,100 if volatile matter of fuel < 10%	200	6%
Solid Fuels (Plant >/=600 MWth)	50	30	200 – 850[b]	200			6%

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; CFB = circulating fluidized bed coal-fired; PC = pulverized coal-fired; Nm³ is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack. 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.
- a. Targeting the lower guidelines values and recognizing issues related to quality of available fuel, cost effectiveness of controls on smaller units, and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant). b. Targeting the lower guidelines values and recognizing variability in approaches to the management of SO_2 emissions (fuel quality vs. use of secondary controls) and the potential for higher energy conversion efficiencies (FGD may consume between 0.5% and 1.6% of electricity generated by the plant). Larger plants are expected to have additional emission control measures. Selection of the emission level in the range is to be determined by EA considering the project's sustainability, development impact, and cost-benefit of the pollution control performance. c. Stoker boilers may require different emissions values which should be evaluated on a case-by-case basis through the EA process.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):

- Natural Gas-fired Boiler – NOx
  - Guideline limits: 240
  - EU: 150 (50 to 300 MWth), 200 (> 300 MWth)
- Solid Fuels-fired Boiler - PM
  - Guideline limits: 50
  - EU: 50 (50 to 100 MWth), 30 (> 100 MWth), China: 50, India: 100 - 150
- Solid Fuels-fired Boiler – SO_2
  - Guideline limits: 900 – 1,500 (Plant > 50 MWth to < 600 MWth), 200 – 850 (Plant ≥ 600 MWth)
  - EU: 850 (50 – 100 MWth), 200 (> 100 MWth)
  - US: 180 ng/J gross energy output OR 95% reduction (≈ 200 mg/Nm3 at 6% O_2 assuming 38% HHV efficiency)
  - China: 400 (general), 800 (if using coal < 12,550 kJ/kg), 1,200 (if mine-mouth plant located in non-double control area of western region and burning low S coal (<0.5%))

Source: EU (LCP Directive 2001/80/EC October 23 2001), US (NSPS for Electric Utility Steam Generating Units (Subpart Da), Final Rule – June 13, 2007), China (GB 13223-2003)

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.

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),[36] the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),[37] Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),[38] Indicative Occupational Exposure Limit Values published by European Union member states,[39] or other similar sources.

Additional indicators specifically applicable to electric power sector activities include the ICNIRP exposure limits for occupational exposure to electric and magnetic fields listed in Table 8. Additional applicable indicators such as noise, electrical hazards, air quality, etc. are presented in Section 2.0 of the **General EHS Guidelines**.

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)

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. The accident and fatality rates of the specific facility may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g., US Bureau of Labor Statistics and UK Health and Safety Executive)[40].

Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals[41] as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

[36] http://www.acgih.org/TLV/[36] Available at: http://www.acgih.org/TLV/ and http://www.acgih.org/store/

[37] Available at: http://www.cdc.gov/niosh/npg/

[38] Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992

[39] Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/

[40] Available at: http://www.bls.gov/iif/ and http://www.hse.gov.uk/statistics/index.htm

[41] Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

Appendix 5 Noise Calibrator Certificate

QUEST TECHNOLOGIES
a 3M company

Certificate of Calibration

Certificate Number: 231647QII050083

Model: QC-10

Date Issued: 2-June-2009

S/N: QII050083

Quest Technologies, Inc. certifies that the above listed product meets or exceeds the requirements of the following standard(s):

ANSI S1.40-1984 - Standard For Sound Calibrators

IEC 942-1988 For Sound Calibrators

Test Procedure: 5056-981

Subassemblies: N/A

Test Conditions:

Temperature: 18-25°C

Humidity: 20-80% R.H.

Barometric Pressure: 950-1050 mBar

Reference Standard(s):

Device	Cal Due Date	Uncertainty - Estimated at 95% Confidence Level (k=2)
Fluke 45	3-March-2011	+/- 1.4% AC Voltage, +/-0.1% DC Voltage
NI PXI-4071	4-February-2010	0.012% Frequency
B&K Ensemble	3-July-2009	+/- 2.2% Acoustic (0.19dB)

Calibrated By: Cathy Vieth
Cathy Vieth Assembler

In order to maintain best instrument performance over time and in the event of inspection, audit or litigation, we recommend the instrument be recalibrated annually. Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired.

All equipment used in this test is traceable to NIST, and applies only to the unit identified above.

058-387 Rev F

QUEST TECHNOLOGIES
a 3M company
1060 Corporate Center Drive • Oconomowoc WI 53066 • USA • Toll Free 800.245.0779 • Tel 262.567.9157 • Fax 262.567.4047
An ISO 9001 Registered Company • ISO 17025 Accredited Calibration Laboratory
www.questtechnologies.com

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Appendix 6 A Copy of the Community Survey Questionnaire

JEP WEST KINGSTON 60 MW POWER PLANT EIA

COMMUNITY QUESTIONNAIRE

DATE:___________________ INTERVIEWER:_______________

LOCATION:___________________

EMPLOYMENT & INCOME

1 Who is the head of the household? (i) father (ii) mother (iii) grandparents (iv) uncle (v) aunt (vi) other______________

2 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

3 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 ___________

4 What is the trade of the household head? ____________________________________

5 What is the trade of the partner? ____

6 How many persons in the household are presently employed? ____________________

7 Are you currently (i) employed (ii) unemployed (iii) retired

8 If employed do you work (i) part time, (ii) seasonally, (iii) full time (vi) self employed (v) other ___________

9 If employed, what do you do? __________________________________ (i) casual labour (ii) semi - skilled (iii) skilled (iv) artisan (v) professional

10 Where do you work? _________________________

11 How far is your work from home? (i) less than a km, (ii) 1- 5km, (iii) 6- 15km (iv) >15km.

** Use Table 1 to answer questions 9 - 11.

1. Below $500	6. $3001 - $4000
2. $ 501 - $1000	7. $4001 - $5000
3. $1001 - $1500	8. $5001 - $6000
4. $1501 - $2000	9. $6001 - $7000
5. $2001 - $3000	10.Over $7000

12 What is the average weekly income of the household head? ______________________

13 What is the average weekly income of the partner? ___________________________________

14 What is the average weekly income of the household? (All sources)

____

15 Do you depend on the proposed power plant location and adjoining land area for business?

____

EDUCATION

1 Which school do members of your household attend?

Basic [ ] Primary [ ] All Age [ ] Junior High [ ] New Secondary [ ] Secondary High [ ] Comprehensive High [ ] Technical High [ ] Vocational Agricultural [ ] Community College [ ] Teachers College [ ] University [ ] HEART [ ] Other [ ] ____

NAME / TYPE OF SCHOOL	DISTANCE FROM HOME (Km)	# OF PERSONS

HOUSING & SOCIAL AMENITIES

1 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. [ ]

2 How long have you (household) been living here?

0 - 5 yrs. [ ] 6 - 11 yrs. [ ] 12 - 17 yrs. [ ] 18 - 24 yrs. [ ] Over 24 yrs. [ ]

3 Number of bedrooms? __________

4 Do you have telephone? (i) Yes (ii) No (iii) Cellular phone (iv) Cables are being laid

NATURAL HAZARDS

Are there problems with frequent flooding? (i) Yes (ii) No

2 How frequently does flooding occur?

3 Where are the affected areas?

4 How high does the water level rise?

5 Are there problems with frequent earthquakes? (i) Yes (ii) No

6 Are there problems with frequent fires?

7 During Hurricane Ivan or Gilbert were you affected by storm surge or sea level rise? (i) Yes (ii) No

SERVICES, COMMUNITY COHESIVENESS & DEVELOPMENT

1 How do you travel? (i) Bus (ii) Personal vehicle (iii) Taxi (iv) Other ___________________

2 How much do you pay to travel? ____

3 Where do you normally shop for the household? ___________________________

4 Where do you go to market? ____

5 Where do you go for health care when you are sick? ______________________

6 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?

7 If yes how often? ____________________________

8 Are there any church groups in your area? (i) Yes ___________________(ii) No

9 Are there any environmental groups in your area? (i) Yes ___________
(ii) No

10 Are there any other organizations in your area? (i) Yes ___________________
(ii) No

11 How active are these organizations? ___________________________________

12 Are you actively involved in any of these groups? (i) Yes (ii) No (iii) Used to be
____

RECREATION & CONSERVATION

1 Are there any recreational facilities nearby? (i) Yes (ii) No

2 If yes, name and location of facility ____________________________________

3 Are you aware of any historic or cultural areas / sites in your community or nearby?
(i) Yes ____ (ii) No

4 If yes, what do you know about the site? ________________________________

5 Are you aware of any nature reserves in your community or nearby? (i) Yes (ii) No

If yes, where is the site? ____

PERCEPTION

1 Are you aware that the Jamaica Energy Partners (JEP) intends to install a power plant at Industrial Terrace? (i) Yes (ii) No

2 If yes, how were you informed? ____

3 Do you think this type of facility is suitable for this location?
____

4 If not, which location would you suggest?
____

5 Does the presence of the existing facility (JPS) impact on your lifestyle in any way? (i) Yes (ii) No
If yes how? ____

6 How would the installation of another power plant affect your lifestyle?
____

7 Is there anything in particular about your area that you would like to tell us?
____

8 Any other comments:

Signature: ....
Interviewer

Appendix 7 NWC Water supply and acceptance of wastewater letter

NATIONAL WATER COMMISSION
Water is Life

☐ 28-48 Barbados Avenue
P.O. Box 65, Kingston 5
Tel: (876) 929-5430-5
Fax: (876) 926-1329

☐ 4 Marescaux Road
Kingston 5
Tel: (876) 929-3540-5
Fax: (876) 960-0582

☐ 2A Manhattan Road
Kingston 5
Tel: (876) 929-3540-
Fax: (876) 968-8247

☐ 18 Oxford Road
Kingston 5
Tel: (876) 926-5825-7
Fax: (876) 926-7121

☐ 231A Old Hope Road
Kingston 6
Tel: (876) 977-4998-9
977-5000
Fax: (876) 927-1870

☐ 231B Old Hope Road
Kingston 6
Tel: (876) 977-2496
977-9330
Fax: (876) 977-2708

March 12, 2009

General Manager
Jamaica Energy Partners
3rd Floor RKA Building
10 Grenada Way
Kingston 5.

Attention: Mr. McKenzie

Dear Sir

Re: Jamaica Energy Partners Power Generating Facility, Industrial Terrace, Kingston Pen - Request for Acceptance of Trade Effluent into the Kingston Metropolitan Sewerage System

We write to acknowledge receipt of your letter dated March 06, 2009 and note that you are in the process of applying for and an Environmental Permit for your proposed 60MW Power Facility. This facility is to be constructed on the property of the retired Western Wastewater Treatment, Industrial Terrace, Kingston.

As indicated in our letter dated August 21, 2008, National Water Commission (NWC) is in a position to provide water supply and sewerage services for the proposed development.

We have set out below some of the influent standards for discharge into our sewer network. We will not accept any discharge into our sewerage facilities that will adversely impact our sewer network or the performance of the wastewater treatment facilities.

Item No.	Parameter	Concentration mg/l
1	BOD - Biochemical Oxygen Demand	250mg/l
1	TSS - Total Suspended Solids TSS	240 mg/l
3	Total Nitrogen	50.0 mg/l
4	Alkalinity/Acidity - PH	6 – 9
5	Sulphate	250 mg/l
6	Phosphate	8 mg/l
7	Temperature	No waste water discharge shall have a temperature in excess of 35^0 C

Please also note that:

- Pre-treatment of the discharge from the proposed Power Facility, which is deemed necessary prior to discharge into NWC's sewerage system, will be the responsibility of Jamaica Energy Partners (JEP).
- JEP will be required to maintain compliance with established influent standards and other stipulations made by NWC regarding the quality of discharges into our sewer network.
- The contents of the discharge from the facility should be free from all fat, oil and grease materials - FAT and chemicals.
- JEP will be required to perform at least weekly sampling/monitoring of the effluent discharged into the NWC's sewerage system to determine its compliance with the above NWC's parameters. The routine Sampling Report of the analysis of the effluent from the Power Generation Facility should be submitted to the NWC within (6) six days following the sampling event.
- The NWC will undertake ad-hoc sampling and monitoring via 'grab sampling' of JEP's effluent.
- If there are any temporary or unexpected impacts on the quality of the effluent that is discharge into NWC sewerage, which may necessitate special monitoring requirements until normal operation of the proposed power plant has commenced.
- It is mandatory that JEP notify and obtain the consent of the NWC of any process changes or the introduction or planned introduction of new wastewater constituents that would cause a substantial change in the volume or character of the waste water effluent to be discharged into the NWC's sewer network.

JEP will be required to inform the NWC of the progress of the construction and startup operation/commissioning of the Power Generation Facility. During this period, JEP will undertake sampling of its effluent discharge if a connection is made to the Commission's system.

Your application to the National Environment & Planning Agency should be followed with a detailed submission to the NWC. This submission should include, but not limited to the following items:

1. A complete set of the design drawings of the power facilities (i.e. site plan, drawing of facilities and its layout in relation to the existing NWC's sub-surface & surface facilities). A site plan of the power facilities in relation to other adjoining lands is to be submitted. The design document should be inclusive of details of the on site/pre-treatment facility. The design should clearly illustrate the proposed point of connection for water and waste water discharge (inclusive of the direction of flows for each conveyance pipe).

2. Technical specifications for item No.1;

3. Expected daily water requirement;

4. Expected rate of wastewater discharge of trade effluent from the proposed facility;

5. Type of chemicals/reagents to be utilized in the operation and maintenance of the Power Generation Facility.

The NWC remains available to assist with any additional information and clarification to assist with the implementation of this development.

Yours truly

VERNON BARRETT
Vice President, Corporate & Strategic Planning

Copy: E G Hunter - President
Franklyn Williams - Senior Vice President /Chief Engineer
Kevin Williams - Legal Counsel
Michael Dunn - VP, Eastern Division
Lewis Lakeman - AVP, SD&P

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