ENVIRONMENTAL IMPACT ASSESSMENT

PETROJAM REFINERY UPGRADE PROJECT

Report Submitted to:

Petrojam Limited

96 Marcus Garvey Road, Kingston 11, Jamaica

Prepared by:

Claude Davis & Associates

141 Oakhampton Trail, Hamilton, ON L9B 0A3

In Association with

TEMN Ltd.

20 West Kings House Road, Kingston 10

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GLOSSARY

Abbreviation	Description
ACGIH	American Conference of Government Industrial Hygienists
APHA	American Public Health Association
API	American Petroleum Institute
API	American Petroleum Institute
API	American Petroleum Institute
ARB	Air Resources Board
asl	Above sea level
AWWA	American Water Works Association
b/sd	barrels per stream day
bbl	Barrel of oil
bgl	Below ground level
BOD	Biochemical Oxygen Demand
bpd	Barrels per day
CCCL	Caribbean Cement Company Ltd
CCRU	Continuous Catalytic Reforming Unit
Cd	Cadmium
CDCs	Community development committees
CMC	Criteria Maximum Concentrations
COD	Chemical Oxygen Demand
Cr	Chromium
CRU	Catalytic Reforming Unit
DDPH	Dissolved/Dispersed Petroleum Hydrocarbons
DO	Dissolved Oxygen
ECD	Environmental Control Division
ECD	Environmental Health Division
EIA	Environmental Impact Assessment
FCCU	Fluid Catalytic Cracking Unit
GC/MSD	Gas chromatography/mass spectrometry
GDP	Gross domestic product
gpm	Gallons per minute
ha	Hectares
HCDC	Hope for Children Development Corporation
HiVol	High volume
IDFC	Intensity-Duration-Frequency curves
ISBL	Inside the Battery Limit
ISPS	International Ship and Port Security Code Plan
JET	Jamaica Environment Trust
JNAAQS	Jamaican National Ambient Air Quality Standard

Abbreviation	Description
JPPC	Jamaica Private Power Company
JPS	Jamaica Public Service Company Ltd.
JSLC	Jamaica Survey of Living Conditions
KMA	Kingston Metropolitan Area
KSA	Kingston and St. Andrew
KSAC	Kingston and St. Andrew Corporation
kt	Knot
LPG	Liquefied petroleum gas
MDEA	Methyl Diethanol Amine
MMBTU	Million British Thermal Units
MPN	Most Probable Number
MTBE	Methytertiarybutylether
NHT	Naphtha Hydrotreating
NMIA	Norman Manley International Airport
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NSWMA	National Solid Waste Authority
NWC	National Water Commission
OEHHA	Office of Environmental Health Hazard Assessment
OSBL	Outside the Battery Limit
PAP	Priority Air Pollutant
PCJ	Petroleum Corporation of Jamaica
PIOJ	Planning Institute of Jamaica
PM_{10}	Particulate Matter with diameter less than 10 micrometres
PSA	Pressure swing absorption
RfC	Reference Concentration (RfC) - An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious non-cancer health effects during a lifetime. The inhalation reference concentration is for continuous inhalation exposures and is appropriately expressed in units of mg/m3 or ppm.
RfD	Reference Dose - An estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure of the human population to a potential hazard that is likely to be without risk of deleterious effects during a lifetime. The RfD is operationally derived from the no-observed-adverse-effect level (NOAEL-from animal and human studies) by a consistent application of uncertainty factors that reflect various types of data used to estimate RfDs and an additional modifying factor, which is based on a professional judgment of the entire database on the chemical. The RfDs are not applicable to non-threshold effects such as cancer.
RO	Reverse Osmosis

Abbreviation	Description
RTBS	Rose Town Benevolent Society
RUP	Refinery upgrade project
SDC	Social Development Commission
SIA	socioeconomic impact assessment
SMR	Steam methane reforming
SO_2	Sulphur Dioxide
SPAW	Specially Protected Areas and Wildlife
SRU	Sulphur Recovery Unit
TDS	Total dissolved Solids
TG CDC	Tivoli Gardens CDC
TGTU	Tail Gas Treating Unit
TLV	Threshold Limit Values
TOR	Terms of Reference
TSP	Total Suspended Particulate matter
TSS	Suspended Solids
TSS	Total Suspended Solids
UDC	Urban Development Corporation
UWI	University of the West Indies
VOC	Volatile Organic Compound
WRA	Water Resources Authority

Executive Summary

Petrojam Limited proposes to upgrade its refinery located at 96 Marcus Garvey Drive in Kingston, Jamaica. The upgrade would expand the capacity of the refinery from 35,000 barrels per day (bpd) to 50,000 bpd and will entail upgrading some existing processing units and adding new processing and waste treatment units. The upgrade will allow the production of higher value refined petroleum products and better treatment of effluents from the refinery.

The refinery upgrade project (RUP) is of national importance, as it is expected to achieve a number of technical and national objectives including:

- Reducing the importation of finished petroleum products;
- Re-aligning the refinery's process configuration and capacity to match product yields with market demand;
- Production of environmentally friendly petroleum products (low sulphur diesel and gasoline);
- Assuring continued ability to supply petroleum products at least cost, by increasing its profitability through use of cheaper, heavier crude oils and
- Production of proportionately higher valued products from the crude oil raw material.

The existing units that will be upgraded are:

- Crude Distillation Unit
- Gas Recovery Unit
- Kerosene Hydrotreater

The main new process units that will be added are:

- Distillate Hydrotreater
- Naphtha Hydrotreater
- Continuous Catalyst Regeneration Platformer Unit
- Vacuum Distillation Unit
- Delayed Coking Unit

The new effluent treatment units are:

- Sour Water Stripper
- Amine Absorber
- Sulphur Recovery Unit
- Tail Gas Treatment Unit
- Waste Water Treatment Plant (includes upgrading the existing wastewater plant)

The National Environment and Planning Agency (NEPA) determined that the refinery upgrade project (RUP) will require an EIA, the Terms of Reference (TOR) for which (see Appendix 1) were

finalised after consultation with and input by interested stakeholders. This EIA report addresses all of the items and aspects specified in the TOR. The EIA also conforms to the Equator Principles and the environmental, social standards of the International Financial Corporation (IFC), an institution of the World Bank Group that is responsible for transactions with the private sector.

Study Area

The various aspects of the EIA have potential impacts in areas that vary in size depending on the nature of the aspect. The various aspects and the study areas (ordered in increasing impact area) are as follows:

Occupational	On site
Marine ecology	200 m off shore the site inside Kingston Harbour
Water quality	
Marine	200 m off shore and inside Kingston Harbour
Wastewater	On-site and 50 m offshore (outfall)
Socio-economic	Within a 3km radius surrounding the site
Heritage sites	Within a 0.5 km radius surrounding the site
Geology	Onsite
Hydrology	Within a 2 km radius surrounding the site
Air quality & Human Health Effects	See Figure 1

The air quality study area (see entire Figure 1) is the largest because of the potential for the dispersion of airborne emissions from the facility. The general location of the refinery is shown in Figure 1.

Project Alternatives

The proposed project was selected from a number of alternatives. The three alternatives considered for the EIA were the do nothing (no upgrade), a terminalling option and the proposed RUP. The main features of these alternatives are summarised in Table 1.

Based on the economic viability (net present value) of the three options the Terminalling option is least attractive and the selected refinery upgrade option is the most attractive (See Table 1).

Public Consultation

Public consultation entailed an initial public meeting at which the proposed Terms of Reference for the EIA were presented and attendees provided valuable feedback. Additional meetings were held with representatives from four communities (Tivoli, Greenwich Town, Rose Town and Whitfield Town) at which formal presentations describing the project were made. Consultation with stakeholders took place as a component of the social impact assessment. Input was solicited from businesses in the Marcus Garvey Drive area, NGOs and from community leaders.

A second public meeting will be held to present the findings of the EIA.

Figure 1 Map of West Kingston - Jamaica, showing the Location of the Petrojam Limited Refinery Site

Table 1 Comparison of Project Alternatives

Factor Considered	Do Nothing	Terminalling	Proposed Refinery Upgrade Project
Ability to meet local demand	Refinery capacity cannot meet local demand for gasoline and diesel. Continued import of some finished products	Demand for all products met entirely by imports	Demand met by upgrade Imports of finished products would be eliminated
Ability to meet fuel quality (ultra low sulphur diesel & low sulphur gasoline) needs	Could not produce low sulphur diesel	Demand met entirely by imports	Will produce required ultra low sulphur diesel & low sulphur gasoline
Importation	Requires additional finished product importation	Demand met entirely by imports	Import of additional crude
Low (2.2%) sulphur heavy fuel oil	Requires continued importation	Demand met entirely by imports	Requires continued importation of 2.2% HFO
Crude quality	Requires higher quality crude	Not applicable	Allows lower quality crude to be used
Introduction of new products and by-products	None	Not applicable	Production of Pet coke for use in adjacent power generation station Export of intermediate products (vacuum gas oil (VGO) Production of sulphur for local use and for export
Employment	No change	Fewer employees (~30% of current work force)	Additional employment during construction and operation after the upgrade
Synergies	No change	Lost taxes and loss of ~US $10 million to economy	Pet coke used to generate electricity at an adjacent JPS generating station; sulphur by products used locally and

Factor Considered	Do Nothing	Terminalling	Proposed Refinery Upgrade Project
			excess exported
Capital cost	None	US $1 million for decommissioning	US $758 million as at November 2008[1]
Economic viability	Would incur decommissioning costs	Lower operational costs Elimination of current government-to-government crude oil agreements	Increased profit margin
Net Present values (@12%)	US $126.5 million	US $52.2 million	US $184.8 million

[1] As indicated by Front Engineering Design Contractors, SNC Lavalin Inc.

Description of the Existing Environment – Baseline Studies

Baseline studies were conducted to characterise the physical, biological, and sociological/socioeconomic features that are influenced by the existing refinery operations. The aspects covered in each of the three areas are as follows:

Physical	Geology, soils, hydrology, water resources, climate, air quality, occupational exposure, emergency response plans, waste management,
Biological	Terrestrial, avifauna, marine
Socioeconomic	Demography, infrastructure & services, housing, amenities, community fabric/cohesion, economic activities, public perception, land use, macroeconomic

Physical

The refinery site is located on reclaimed land whose geology is classified as Alluvium Aquifer. The site is suitable only for industrial use. The subsurface is made up of material classified as engineering fill. Because of this the site is susceptible to liquefaction[2] and ground failure during earthquakes.

Geology & hydrology

The site is located in the Liguanea alluvium aquifer. Groundwater in the aquifer is not suitable for drinking because of contamination by nitrate from sewage. Except for the coastal areas of the aquifer, groundwater is suitable for irrigation and industrial purposes. Near the coast groundwater is affected by saline intrusion and must be treated before it can be used for most industrial purposes.

The abstraction rates of water from wells on the Petrojam site are within the limits specified in the licences for the wells issued by the Water Resources Authority and do not affect nearby (within ~1 km of the site) wells.

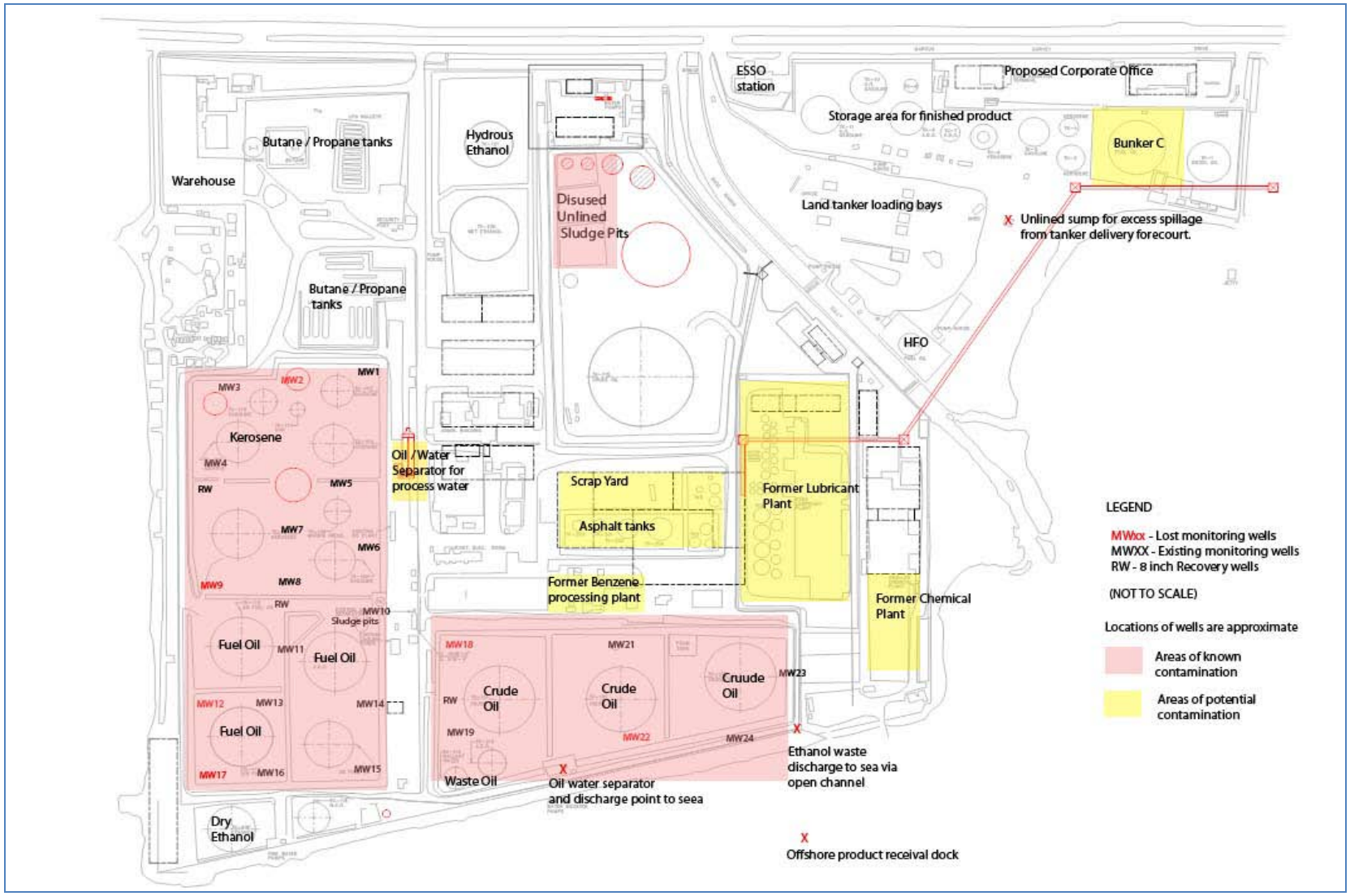
There is an ongoing program to assess the extent of previous leakage of petroleum products from storage tanks. Boreholes have been drilled to monitor ground water quality and recovery wells have been drilled to recover some of the leaked hydrocarbons. The extents of the known and potential contaminated areas (see Figure 2) have been determined and the remedial program is ongoing.

Oil Spills

There have been no reported ship oil spill incidents in Kingston Harbour since 2003. There have been minor spills (associated with coupling of hoses at the Petrojam marine dock) but their small amounts did not warrant any cleanup. Cleanup was required however as a result of a power failure incident during hurricane Ivan.

[2] Soil liquefaction occurs when soil loses its strength (shear resistance) for example because of shaking during an earthquake: this causes the soil to flow in a manner resembling a liquid.

Figure 2 Locations of Known and Potential Hydrocarbon Contamination to Soil and Water (Not To Scale)



Drainage and Storm Surge Assessment

The site is fully developed with extensive hard surface areas and consequently the run off potential during rainfall events is high. The site is well served by a system of drains and is flanked on the east by the Shoemaker Gully. No flooding of the site or overflowing of the Shoemaker Gully has been reported.

The storm surge analysis estimated highest wave heights for the worst case events that would occur once in 25 years and once in 100 years. The Petrojam Refinery site is sheltered from the Caribbean Sea by the Palisadoes. The presence of cays outside the harbour and the shallow areas inside the harbour serve to mitigate the impact of storm surges from the open sea (southwest). The storm surge analysis indicates that the highest waves at the eastern section of the refinery site (1.49 m for the 1-in-25 years and 1.73 m for the 1-in-100 years) would arise from the east-south-east as a result of waves generated inside the harbour. Storm surge impacts are therefore of minor concern.

Ambient Water Quality

Existing (baseline) water quality in the harbour was determined from monitoring data at four locations – three in the vicinity of the refinery's trade effluent outfalls and at a background site outside the harbour. The monitoring data were compared with the US EPA ambient standards for marine waters since there are no equivalent NRCA or NEPA standards. At all four stations, fecal coliform levels were below but nitrate and phosphate levels were above the corresponding standards. At the station east of the Petrojam outfall BOD and TSS levels were above and at the station near the API separator outfall the DO and BOD levels were above the corresponding standards.

Climate and Air Quality

The main climatic features that contribute to potential environmental impacts from the refinery are the rainfall patterns, the wind regime and to a lesser extent temperature. The rainfall patterns were considered in the assessment of drainage. Similarly, hurricane climatology which is a specialised subset of the overall climatology was used in the storm surge analysis. Wind and temperature conditions are important in determining the dispersion of pollutants once released to the air.

Climatology

Jamaica is under the influence of prevailing north-east trade winds. For locations on the south coast of Jamaica (such as the Petrojam site) the mountains that lie along an east-west axis of the island deflect the north-east trade winds (and provide an easterly component) and together with sea breeze effects (north and south components) result in predominant winds from the east-south-east and south-east.

The temperature regime for period 1990 to 2001 ranged from a minimum of 22.6 °C to a maximum of 32.8 °C; the mean daily temperature over the period was 28.2 °C.

Air Pollutant Sources

The Annual emissions from major air pollution point sources in the Kingston airshed are summarised in Table 2. The existing Petrojam sources account for about 15.6% of sulphur dioxide (SO_2) emissions, 1.2% of nitrogen oxides (NOx) emissions, 12.7% of particulate matter (PM) emissions, 0.2% of carbon monoxide (CO) emissions and 0.2% of VOC emissions from major point sources. Other sources in the airshed are mobile sources (on-road vehicles, aircraft emissions during landings and take-offs) which emit mainly NOx, CO and non-methane volatile organic compounds (NMVOC) but much less SO_2 and smaller point and fugitive sources with emissions of SO_2 and PM. The NOx and CO emissions from the Petrojam refinery account for a small percentage of these emissions in the airshed and hence will have little impact on the ambient levels of CO and NOx. Petrojam's SO_2, PM and VOC emissions although relatively small have the potential to affect ambient levels of these pollutants at least in the vicinity of the refinery. It is for these reasons that ambient measurements of VOCs, PM and SO_2 were measured at sites near the refinery during the EIA and available historical ambient air quality data in the airshed were reviewed.

Existing Air Quality

In connection with their air quality licence applications, Petrojam and JPS – because of their close proximity to each other, proposed to conduct joint ambient air quality monitoring for SO_2, NOx and particulate matter with diameters less than 10 um (PM_{10}). It was anticipated that the equipment ordered for that program would have been available for the EIA but unforeseen delays prevented the establishment of the three monitoring stations in time for data from those stations to be included in the EIA.

Instead, total suspended particulate matter TSP was measured at two locations using a high volume (Hi-Vol) sampler and a Mini-Vol sampler (MVS). Passive sampling methods were used at six stations to measure SO_2 and NO_2. One of the six stations was at Kelly Pen near Old Harbour where continuous SO_2 and NOx analyzers are available so that the measurements from the passive samplers could be compared with those from the continuous analyzers. The comparisons will not allow any indication of hourly levels (since the exposure period for the passive samplers is ~10 days) but will provide some measure of ambient air quality over a 10 day and longer periods.

TSP levels from the Hi-Vol sampler at the Petrojam Boat House (BH) during the sampling period were in the range 4 to 91 $\mu g\, m^{-3}$ with an average of 47 $\mu g\, m^{-3}$. At the loading rack site the measurements made with the MVS sampler ranged from 12 to 143 $\mu g\, m^{-3}$ with an average of 68 $\mu g\, m^{-3}$. All values were well below the NRCA ambient air quality 24 hr standard for TSP (160 $\mu g\, m^{-3}$). The BH site also had a MVS sampler so that comparisons could be made with the Hi-Vol sampler (which is approved for use by NEPA) since the MVS sampler is not an approved instrument. NEPA allows use of such instruments once comparisons are available with approved instruments. The comparison between the two samplers was poor but the MVS on average showed higher measurements by a factor of 2.6. On this basis, although subject to

Table 2 Kingston Airshed Point Source Emissions

Description	Annual Emission Rates (tonne/y)				
	SO_2	NOx	PM	CO	VOC
Petrojam Flare	8.94	0.75	0.00	0.04	0.38
Petrojam Pipestill heater	1300	150	93.1	12.93	0.26
Petrojam Powerformer Feed preheater F-2/3/4	395	33.2	0.517	6.03	0.48
Petrojam Vacuum furnace	71.5	4.15	0.089	1.04	0.08
Petrojam Nebraska (Oil)	1067	2.54	70.5	11.33	0.22
Petrojam New Cleaver Brooks Boiler	485	1.15	32.0	5.14	0.10
Petrojam Hurst Boiler	242	0.576	16.0	2.57	0.05
D&G Boiler Stack East	278	27.8	17.3	2.96	0.06
D&G Boiler Stack West	194	19.4	15.5	2.06	0.04
D&G Boiler Stack	194	19.4	15.5	2.06	0.04
JPPC Engine 1	1039	4049	285	872	331
JPPC Engine 2	1039	4049	285	872	331
CCC Kiln 4 Dry 1300 tons/d	124	796	59.8	225	0.00
CCC Kiln 3 Wet 700 tons/d	1199	1082	67.2	1.70	0.00
JPS-Rockfort	2864	1581	79.5	3769	198
JPS-Rockfort	3329	1337	82.3	3769	198
JPS-Hunts Bay B6	7132	741	281	6409	0.54
JPS Hunts Bay GT (GT10)	517	1088	95.1	42.6	0.163
Jamaica Ethanol Processing Ltd.	427	42.6	20.4	4.53	0.06
Caribbean Products Company Ltd.	223	0.529	14.7	2.36	0.05
JPS Hunts Bay GT (A5)	781	720	63.0	25.5	0.00
Caribbean Cement Company Clinker cooler 3	0.00	0	19.9	0.00	0.00
Caribbean Cement Company Clinker cooler 4	0.00	0.00	31.3	0.00	0.00
D&G Grain handling	0.00	0.00	20.4	0.00	0.00
Total	**22,910**	**15,744**	**1,665**	**16,038**	1,060
Petrojam	3,570	192	212	39	1.57
Petrojam % of Total Point Sources	15.6	1.2	12.7	0.24	0.15

considerable uncertainty, the Loading Rack MVS measurements (which were all below the NRCA standard) are likely to be even lower than that reported by the Hi-Vol sampler.

Volatile Organic Compound (VOC) Measurements

VOCs are released from storage tanks at the refinery as well as from fugitive sources (valves, flanges, drains etc) in various refinery processes. VOCs are also released from motor vehicles because of evaporation of fuel and from the tailpipe. Ambient levels of VOCs were measured at five locations using passive devices (3M badges) that were exposed (two at each site) for 24 ± 0.2 h. The exposed badges were analysed for individual compounds. The compounds include 13 aromatic and saturated hydrocarbons released from refinery operations and motor vehicles, two compounds released from vegetation and some consumer products and two chlorinated solvents one of which is used at the refinery and in dry cleaning. Some of these compounds are included in the Priority Air Pollutant (PAP) list specified in the Air Quality Regulations and for which there are ambient air guideline concentrations.

Benzene is the only compound whose measured concentrations are above the NRCA Guideline limit. The measured concentrations for the remaining compounds were lower (by factors ranging from 7 to 3300) than the corresponding limits[3].

The concentrations of tetrachloroethylene, trichloroethylene, 2,2-dimethylbutane, a-pinene, decane and d-Limonene showed no variation across the five monitoring sites hence indicating no nearby sources for these compounds. The highest concentrations of the other compounds (benzene, xylenes, toluene, n-pentane) were at the loading rack (LR) site which is located within 50 m of the loading rack where gasoline, kerosene, and diesel fuel are loaded on to tankers. These compounds are also expected to be emitted from traffic sources (evaporative and exhaust emissions) and because of this it is not feasible to distinguish between the exhaust and evaporative emissions from traffic and those from the refinery operations.

The second highest concentrations were at the Boat House (BH) site and the concentrations decreased as the distance downwind (towards the west) from the refinery increased. It is therefore clear that the refinery is a source for the VOCs. The potential impact of benzene was addressed in the health risk assessment.

Historical Ambient Air Quality Data

There are limited ambient air quality data available for the Kingston airshed. NEPA only reported monthly average SO_2 and NO_2 concentrations measured at Cross Roads for limited periods between April 2006 and 2007 although continuous analysers (three minute averages) were used to take measurements. The monthly average SO_2 concentrations which ranged from 30 to 37 $\mu g\, m^{-3}$ suggest that the annual mean SO_2 concentration would be well below the

[3] For compounds with no limits for a 24 h averaging period, the measured 24 h average values were extrapolated to an annual average which was then compared to the annual limit.

JNAAQS for the annual average SO_2 concentration (60 µg m^{-3}). The NEPA report indicated that the highest hourly average NO_2 concentration was 77 µg m^{-3} – which is well below the NRCA Guideline concentration of 400 µg m^{-3} for a 1-hour average.

TSP and PM_{10} concentrations measured by NEPA at three locations (NEPA Office at Cross Roads [XRDS], NEPA Laboratory at 191 Old Hope Road [OHR] and at Harbour View [HV]) were well below the 24 h JNAAQS. None of these sites is near the refinery.

NO_2 concentrations measured using passive monitors at up to 19 locations in the Kingston & St Andrew airshed at various times during 2001, 2004 and 2006 gave mean weekly averaged NO_2 concentrations ranging from 10 to 46 µg m^{-3}. The lowest weekly average NO_2 concentrations were at sites to the north of the study area (Chancery Hall, Norbrook Heights, and Constant Spring Golf Club). The highest measured NO_2 concentrations were at the Cross Roads, Half Way Tree and Matilda's Corner sites which were located near high traffic road intersections. The weekly average NO_2 concentrations at a site located on Marcus Garvey Drive between the Refinery and the JPS Hunts Bay station were in the range 20 to 39 µg m^{-3}.

Two-week average SO_2 concentrations made using the passive SO_2 monitors at up to six sites during April to July 2007 ranged from 7 to 42 µg m^{-3}. The highest values were measured at Camperdown High School which is located near to the power stations and a cement plant in the Rockfort area. None of the monitoring sites were located near the refinery.

Occupational Health

Noise

Eight sets of sound level measurements over entire work shifts were made at six locations near the refinery between September 4 and 23, 2008. The measurements were made twice at two locations (maintenance workshop and laboratory) since sound levels were expected to vary. Continuous equivalent A-weighted sound level (LA) measured at the main work stations ranged from a high of 93.4 dbA at the Process Unit to a quiet 48.1dbA in the lobby of the Administration building. Measurements at the Process Unit location had a level above the OSHA Action Level. The main source on the Process Unit as well as at the Smoke Shed was Furnace F-1. At the Smoke Shed and the Maintenance Workshop the noise levels approached but did not exceed the Action Level. Petrojam uses signs to advise workers of high noise level areas and requires the use of personal protective equipment (ear plugs or ear muffs) in high noise areas.

VOC Measurements

Passive devices were also deployed at seven (7) locations on the refinery site to measure VOC concentrations over a 12 hour shift. The concentrations of the individual compounds (the same set as used in the ambient measurements) were all below the NIOSH occupational standards (8 h time weighted average concentration) or Threshold Limit Values (TLV).

Emergency Response Plans

Petrojam has developed and documented a comprehensive Health, Safety, and Environmental Management (HSEM) program that includes emergency response plans. The program is based on Process Safety Management (PSM) and is based on voluntary compliance with the United States Occupational Health and Safety Administration (OSHA) regulations 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals. The OSHA regulations are more comprehensive and stringent than the applicable Jamaican legislation that governs Petrojam's operations.

The emergency response plans fall under the following headings:

Fire Emergency Plan

Oil Spill Response Plan

International Ship and Port Security Code Plan (ISPS) Plan

Evacuation Plan

Civil Unrest

Hurricane Preparedness and Response

Earthquake Response Plan

An integral part of the emergency response plans are protocols for notification of relevant national emergency agencies (Police, Fire Brigade, Ambulance, NEPA, Port Authority, Coast Guard) and communication with nearby residents and businesses. Petrojam has instituted a Community Outreach Committee and an outreach program that includes regular meetings with community members. However, it was noted at the initial EIA public meeting that there was need for improvement in the communication/warnings

Waste Management

Liquid Wastes

Two separate waste water streams are discharged from the refinery. Rejected water from the reverse osmosis treatment plant and blowdown water from a cooling tower are discharged into the storm water drain. The other stream comprises waste water from various processing units which is treated in an oil/water API separator before discharge to the harbour. Over the 1 year period ending April 2008, at both outfalls the levels for conductivity, total dissolved solids (TDS) and total suspended solids (TSS) were always below (100% compliance) the corresponding NRCA Trade Effluent Standards. For the other parameters, the compliance percentages with the standards at the storm drain outfall were 58% (Temperature), 51% (oil and grease), 68% (pH) and 10% (sulphide); at the API separator effluent the compliance percentages were 66% (Temperature), 41% (oil & grease), 98% (pH), and 37%(sulphide).

Processing Solid Waste

Solid waste from processing units (e.g., spent hydrofiner catalysts and chloride adsorbents) are placed in drums, held on site in a designated area and accumulated into batches until the size is suitable for shipment overseas to recycling companies. In the case of UOP R86 platforming catalyst, it is shipped to the vendor for recovery of metallic platinum. Used inert silica balls are stored on site in drums and incorporated in concrete mix used mainly in the bund walls of the tank farm.

Hydrocarbon sludge generated on site and from off-site sources is treated in the sludge reprocessing plant. Solids from this process are stored in drums and held on site in a designated area while hydrocarbon liquids are sent to crude tanks and oily water is sent to the API separator. Since there is no hazardous waste disposal site in Jamaica, hence Petrojam stores the waste onsite.

Domestic Solid Waste

Domestic wastes are sent to the municipal solid waste management site by a contracted garbage disposal service. All domestic sewage generated on the site is discharged to the National Water Commission (NWC) sewer.

Biological

Terrestrial

Since the refinery site has been a well developed industrial site for over 40 years biodiversity is very low and there are no rare or endemic plant (or other faunal) species on the site. Plant species on the site were catalogued.

Avifauna

During the site visit the few birds seen were engaged in foraging activities. The longstanding industrial nature of the site and the pollution of the harbour make the marine environment immediately offshore the facility unattractive for birds.

Marine

An assessment and classification of the relevant pelagic and benthic marine communities was made to determine the presence of ecologically or commercially important marine species.

Two dives were conducted along east-west transects parallel to the southern shore line of the Petrojam property. No benthic or mobile resources were noted during either transect swims. Few organisms (stingray, green sea urchin, bivalves and empty bivalve shells) were found and no fish were seen, presumably because of the turbid water. The substrates tended to change in composition from the muddy silt sampled on the west to the calcareous fragments sampled to the east. The presence of the mud was regarded as being the result of proximity to the Hunts Bay discharges, with increasing distances from this discharge (progressing eastward) resulting in less mud. Macro-algae were observed on any available hard surface.

Sociological/Socioeconomic

Demography

The population within 0.5 km of the Petrojam site was 8,891 while between 0.5 and 2 km from the site, the population was 75,456. Survey results conducted within the Socioeconomic Impact Assessment (SIA) study area showed that the average household size is 4 individuals with ranges from 1 to 11 persons per household. This average is consistent with that of the Social Development Commission (SDC) data. The average household size in the study area exceeds the national average of 3.3. The figure also represents an increase from the 2002 Parish average of 3.2. Eighty four percent (84%) of respondents to the SIA survey conducted for the EIA are the head of their households. Of these, 60% were males while 40% were females. The majority (76%) of the household heads were between the ages of 30 and 59, 17% were aged 18-29 years and 7% were over 60.

Infrastructure and Services

The modes of travel to work or school were taxis (40%), minibuses (23%), own private vehicles (9%) and public transportation (by the Jamaica Urban Transit Company (JUTC)) (24%). Survey respondents reported the distances travelled to work or school as follows: less than 1.6 km (51%), 1.6 to 8 km (33%), more than 8 km (14%) and varying distances (2%).

The SIA study area is served by 9 health centres and two hospitals (Kingston Public Hospital and Victoria Jubilee Hospital). One health facility is within 0.5 km of the Petrojam site. There are at least 83 schools serving the area of which 65% are basic and infant schools, 19% are Primary schools, 11% high schools and 5% vocational schools. The Ministry of Education's 2006/2007 Directory of Public Educational Institutions lists 1 Community College, 3 Teachers Colleges, a Multi-disciplinary and 2 Universities within Kingston Metropolitan Area (KMA). A skills training facility, Garmex which is operated by HEART Trust NTA is located close to the proposed project site across Marcus Garvey Drive.

Housing

Housing and land tenure data were available for only two of the 17 communities in the SIA study area. In these communities the percentages of persons who reportedly owned their homes were ~ 65% in one (Denham Town) and 9% in the other (Greenwich Town/Newport West). Twenty eight percent (28%) of Denham Town residents lived "free" while 4.4% rented. In contrast only 7.5% of Denham Town residents reported owning the land on which their homes are located and 2.5% leased. This implies that approximately 55% of residents may be squatting. In Greenwich Town/Newport West, 60% of residents reported renting their homes while 30% "captured" them and 10% own or lease their homes.

Land ownership ranged from 7.5% to 43% in selected communities. Other reported tenure types were rent, lease, family and capture. The SDC reported a total of 18 squatter settlements in four of the 17 communities within the SIA study area.

The SIA survey results for the types of construction materials used in housing in the SIA were block and steel 70%, wood 11% and the remaining 19% declined to respond. This is consistent with the 2006 JSLC figure for the KMA. The most popular materials for roofs were zinc (54.5%) and concrete (10%) and for fencing were zinc (24.5%) and block and steel (14.5%).

Amenities

Access to amenities (toilet facilities, piped water in dwellings, electricity, fuel for cooking and telephone, lighting and telephone) were deduced from data for the KMA derived in the Jamaica Survey of Living Conditions (JSLC), the SDC Community Profile and the most recent (2007) Jamaica Socioeconomic Survey published by the Planning Institute of Jamaica (PIOJ). In 2006, the percentages of households in the KMA with these amenities were: flushed toilet - 89.9%; pit latrines -8.6%; and cell phones – more than 50%. The main source of fuel for cooking was liquefied petroleum gas (LPG) and lighting was electricity. Collection of municipal waste is by the National Solid Waste Management Authority (NSWMA) 97% of households or by private contractor (3%).

Community Fabric Cohesion

Community fabric and cohesiveness is considered very strong within the communities in the study area although some communities have divisions within them and there is little or no interaction between communities. The SDC community profiles indicate that there are active community-based organizations (CBOs), non-government organizations (NGOs), sports clubs and church groups in most of the communities within the study area. There are also numerous social interventions geared at skills training, maintaining peace, homework programs and community development. The majority of the communities also have a community centre that is in fair to good condition.

Petrojam established a Community Outreach Committee which liaises with the Greenwich Town community representatives and Petrojam staff. The terms of reference include evaluating and recommending the most cost-effective community related projects; developing appropriate projects and initiatives to enhance the well being of the community; identifying specific projects such as adopt-a-school, home work program etc. and making recommendations for consideration by Petrojam Management. To date, one project was successfully completed, the community centre and basic school was upgraded in Greenwich Town. Additionally, there is an annual health fair at Petrojam that is open to all residents within the surrounding areas. Petrojam also provides two scholarships to high school students annually.

Residents of many communities perceive crime as being low to moderate. This is reflected in the proportion of them indicating that they felt safe. Residents expressed moderate to high fear in two communities namely, Maxfield Park and Greenwich Town/Newport West. There was fear of gangs and warfare including reprisal killings and drive by shootings. The community

liaison officer at the Hunts Bay Police Station was contacted for an interview but unfortunately it was not possible to conduct the interview.

National heritage sites

The Jamaica National Heritage Trust indicated that there are no Historical Sites within the 0.5 km of the study site.

Economic

The entire southern portion of the area consists of an industrial and commercial corridor which includes the Petrojam Limited Refinery (study site), Kingston Wharves and associated shipping terminals, warehouses and offices of brokerage firms, the Jamaica Public Service (JPS) Hunts Bay Power Plant and the Greenwich Town Fishing village among others. Economic activities within the residential communities are mainly small enterprises – shops and bars.

The Greenwich Town Fishing Beach is located immediately west of the study site. A 2002 study indicated that there were an estimated 350 fisher folk operating from the fishing beach with 200 owning or controlling beach structures. At that time there were 218 structures on the beach, 72 of which were structures and gear sheds belonging to the Fisheries Division. The 146 privately owned structures included 60% of which were "lived in" and 16% were shops and stalls for vendors, some of which were actually lived in. The remaining 24% (35 structures) were reportedly not lived in but were net- or boat/tackle-related structures. The estimated catch for the week was 100,000 lbs of fish with 112 active boats.

During the SIA survey for this EIA, there were fewer structures on the beach than was observed in 2002. This was largely due to the destruction by Hurricanes Ivan in 2004. Approximately 80 structures were observed, 62 of which were concrete gear sheds. The remaining structures were wood and zinc structures that were lived-in, shops or equipment sheds.

Employment and Income

Seventy five percent (75%) of the 110 participants surveyed reported being employed. Of those employed, 46% were self-employed, 39% had full time jobs, 12% had part-time, while 4% had seasonal jobs or other employment. The main occupation types included construction workers, business owners, fisher folk, vendors, shopkeepers, teachers, pastors and trade workers (painters, mechanics, tailors and dressmakers). Fisher folk accounted for the largest occupation type interviewed as a result of their concentration at the Greenwich Town Fishing Beach.

Sixty five percent (65%) of survey respondents agreed to give income information. Of these 69% reported earning $3,000-$10,000 per week, 16% less than $3,000, 8% earned $10,0001 - $20,000, and 7% over $20,000. The survey findings are consistent with the SDC community profiles which identified high unemployment levels as a characteristic of the study area. The SDC survey reported 37% of household heads were unemployed. Among the youths (15-24), unemployment was reported at 40%. The high levels of unemployment may be related to the low skills level and educational attainment of the communities within the study area.

Public Perception

Public perception of the project was derived from interviews with members of various communities and with stakeholders (four community development committees, two NGOs, one business and the Kingston and St Andrew Corporation (KSAC). Requests for interviews with other business along Marcus Garvey Drive were unanswered.

The main positive comments from the communities were that the proposed development would be good for employment and training opportunities and would contribute to economic development in the area. They further commented that the opportunities should be made available in all communities within the area. Their main concerns were the possibility of the project not being implemented or if implemented that the people in the surrounding communities would not benefit. They were also concerned about the increased potential for exposure to hazards and the lack of emergency response plans that fully engaged the community.

The CDCs all felt that the upgrade project would have a positive impact on employment in nearby communities. Some were urging that appropriate training programs targeted at residents in these communities be put in place early in order to develop some of the skills needed at the refinery. Concerns were expressed about potential negative environmental and health impacts but felt that Petrojam and the EIA process would minimise such impacts.

For the sole business that responded (JPS) most survey respondents also felt that the project would have positive impacts on employment and on the adjacent communities. With regard to impacts on their company, respondents felt that the availability of lower cost fuel and the diversification of the fuels used for electricity generation would have national benefits (lower cost of imported fuel, lower electricity costs).

The survey completed by the Jamaica Environmental Trust (JET) - the sole non-government organisation NGO that completed the survey - noted that the availability of low sulphur fuels that the refinery will produce will be beneficial to the environment since it will help to improve air quality across Jamaica. They looked forward to "a thorough assessment of all pollution control alternatives that are available to Petrojam and a full, quantitative assessment of the air and water quality impacts of the facility before and after the upgrade".

Land Use

The lands to the north and east of the refinery site have heavy industrial, light industrial, commercial and residential uses. The southern boundary of the site borders Kingston Harbour.

The Down Town Kingston area is to the east of the site while to the north are the communities of Whitfield Park and Delacree Pen. Immediately adjacent to the site is the Greenwich Town Fishing beach and further west is New Port West. Land use within these areas is varied. The western portions are mainly commercial with some residential and light and heavy industrial. Lands to the north are mainly residential communities with commercial and open spaces. Several schools, a cemetery and other government facilities are also located within this area.

The lands to the west are commercial, light industrial and an aerodrome. Some residential areas are also located within this area

Macroeconomic

The role that Petrojam plays in Jamaica's economic development is important because of the energy intensive bauxite and alumina industry, the increasing demand for fuel to generate electricity and for transportation. With minimal indigenous sources of fuel, Jamaica is heavily dependent on imported fuel to meet its energy demand. The rapid increase in oil prices in 2007 and 2008 lead to increased foreign exchange needed to purchase petroleum products. Although crude oil prices have declined since the peak in July 2008 the effects of the surge in oil prices remain and have been compounded by the global recession. The availability of stable, adequate and diversified energy supplies is desirable in order to minimise external influences such as fluctuations in prices or supplies.

Jamaica has been adversely impacted by several hurricanes over the past two decades and one of the predicted climate change impacts is an increase in the frequency and intensity of weather systems such as tropical storms and hurricanes which have inflicted billions of dollars in damages and losses especially to coastal areas. Of immediate concern is the need to continue putting in place measures that will reduce our vulnerability to hurricanes (and other natural disasters) and in the longer term to protect coastal assets and/or otherwise mitigate the longer term impacts of climate change. In response to climate change concerns, international conventions such as the Kyoto Protocol (to which Jamaica is a signatory) are attempting to secure voluntary commitments to reduce global greenhouse gas emissions from energy related and other activities.

Key policy initiatives have been the development of the Energy Sector Plan – a component of the *Draft Vision 2030 Jamaica - National Development Plan* and the *Green Paper: The Energy Sector Policy 2006 - 2020*. The policy objectives of the Green Paper include ensuring stable and adequate energy supplies, protecting the economy from energy price volatility and minimising the adverse environmental effects from the production, storage, transport and use of energy. The refinery upgrade project addresses and is consistent with these policy initiatives and in fact will help to implement them.

Policy, Legislative and Regulatory Regime

Responsibility for implementing and enforcing the instruments associated with the regime lies with several government entities (ministries, executive agencies) as mandated by various Acts, regulations and policies.

The National Environment and Planning Agency (NEPA) is the principal agency responsible for implementing the Natural Resources Conservation Authority Act and its regulations as well as the Beach Control Act and the Land Development and Utilization Act. NEPA also has responsibilities under The Town and Country Planning Act, the Watersheds Protection Act and the Wildlife Protection Act.

The provisions of these acts as well as others that affect Petrojam's operations (The Petroleum Act, The Draft Occupational Health and Safety Act, the Public Health Act, the Petroleum and Oil Fuel (Landing and Storage) Act, the Factories Act and the Harbours Act) are described in the EIA report.

The Jamaica Energy Policy (Green Paper) and the Draft Energy Sector Plan under Vision 2030 which help to guide Petrojam's long term plans are described. Other national policies (National Industrial Policy, National Land Policy and the policy for National System of Protected Areas) and international treaties that are relevant to Petrojam's activities are also described.

Identification and Assessment/Analysis of Potential Impacts

Methodology

A quantitative assessment of the overall project alternatives and analyses of the potential environmental (physical/chemical and biological) and socioeconomic (sociological, economic/macroeconomic) impacts during construction and after the upgrade was done.

The Rapid Impact Assessment Method (RIAM) was the tool used to make the assessment. The RIAM method provides an overall assessment where there are multi-disciplinary factors since the method allows data from different disciplines to be analysed against common important criteria within a common matrix, thereby providing a clear assessment of the major impacts. Such an assessment can be done for each project alternative and in the present case will be done for the "do nothing" case and for the preferred alternative (during construction and operation). The RIAM is based on two groups of assessment criteria and the means by which semi-quantitative values for each of these criteria can be assigned for the impacts in the four environmental components and then consolidated to give an overall assessment. The two groups of assessment criteria (A and B) are those that are of importance to the condition (group A scores are multiplicative to give total aT), and which can individually change the score obtained and those that are of value to the situation, but individually should not be capable of changing the score obtained (group B scores that are additive to give a total bT). The overall assessment ES is the product of the additive and the multiplicative sores (aTxbT)

Overall Assessment

The various ES values were grouped into ranges and assigned alphabetic or numeric codes so they may be more easily compared.

The methodology was applied to two of the three project alternatives – the "do nothing" alternative i.e., the existing situation as described and characterised in the baseline studies (Section 4), and the preferred alternative – the refinery upgrade project including the period during construction. Since the terminalling alternative is the least attractive and will not receive any consideration for implementation, it was not considered.

ASSESSMENT OF THE IMPACTS DURING CONSTRUCTION

It should be noted that all refinery activities will continue during the construction for the upgrade since the new processing units will be located mainly north of the existing processing area.

Physical and Chemical

Groundwater

Licences will be sought from the Water Resources Authority to drill new wells during the construction period. These wells will also serve water requirements after the upgrade). No adverse impact on ground water is likely since the licensed abstraction rate would take into consideration the overall capacity of the aquifer and its wells.

There will be ongoing recovery and cleanup of the leaked hydrocarbons from some of the tanks in the tank farm.

Construction (site preparation, demolition and construction) activities have the potential to affect surface water runoff, dust emissions/air quality and vibration.

Since the site is fully developed there will be minimal if any changes in the surface characteristics that would affect the quantity (i.e., flooding and drainage) of runoff during rainfall events. The magnitude of wave heights from storm surges would not be affected by construction activities.

Site preparation for foundation and other excavation activities may mobilise surface contaminants and sediment during rainfall events. The RUP processing area includes areas designated as potentially contaminated and hence excavation in this area could unearth soils contaminated with petroleum products. Since the degree of contamination is unknown it is recommended that a site assessment be done to determine the nature and extent of contamination in areas that would be excavated and the need for mitigative measures (e.g., remediation, safe management of contaminated excavated soils). Management of excavation and demolition piles will be necessary to mitigate the mobilisation and entrainment of suspended particles in runoff during precipitation events.

Site preparation, demolition, excavation and general construction activities have the potential to generate dust and noise. Control and protective measures will be put in place to mitigate dust emissions and noise and, where necessary, to monitor occupational noise exposure. It is anticipated that the ambient monitoring network established as a condition of Petrojam's air quality licences will be fully operational well before construction starts.

The potential vibration impacts during construction are from pile driving, excavation and compacting of soil. Typical vibration levels do not have the potential to cause structural damage. Some construction activities, such as pile driving can produce vibration levels

that may have the potential to damage some vibration sensitive structures if performed within 30 m (100 ft) of the structure.

Annoyance from vibration often occurs when vibration levels exceed the human perception thresholds. These perception thresholds are at least 10 times lower than the damage threshold for normal buildings and are well below vibration levels at which damage could occur.

The refinery will continue to operate the existing processing units during the upgrade and no changes in the emergency response plans with respect to processing will be needed. The construction activities are governed by standard safety procedures. All staff engaged in construction activities will be required to undergo Petrojam's Health and Safety orientation and training. The training/orientation will include familiarisation with emergency response plans.

Biological Impacts

Potential terrestrial impacts during construction are negligible since the site is a well developed industrial site and no changes in the habitat are likely. Potential marine impacts due to construction activities can arise from runoff water that contains construction related sediment and hydrocarbon contaminants. The construction related discharges are not likely to be significant once mitigative housekeeping measures to reduce runoff affected by construction activities are put in place.

Socioeconomic Impacts

Land Use and Community Development

Land use by the proposed project will be limited to the existing Petrojam property and hence there will be neither land use impacts nor will there be any direct impacts on land use in surrounding areas. Construction activities will be concentrated in the central and eastern sections of the Petrojam site which is at least 0.5 km from the Greenwich Town Fishing Beach which is on the western boundary of the Petrojam site.

There will be indirect impacts on community development through employment opportunities for persons from the communities. This would reduce unemployment and increase residual income.

Public Perception

Survey results indicate generally very positive public perception about the construction phase although there were concerns about specific aspects (air pollution, hazardous waste) and in some cases indifference (proposed project would not affect them).

Employment and Income

Employment and income would be impacted positively by the proposed development. Petrojam has estimated that approximately 1,200 to 2,000 skilled jobs will be required

during the construction phase of the project. Training programs especially within the communities adjacent to the refinery between now and when construction starts will be an important initiative to help secure employment opportunities for Petrojam's needs as well as for the spin off industries and services. A joint Petrojam/HEART program will provide such training.

Traffic

Increased traffic due to the increase in the construction work force and delivery of materials can easily be accommodated by the recently upgraded Marcus Garvey Drive. Where feasible the larger pieces of construction and process equipment will be moved by barge from the port to the Petrojam loading dock. When movement of such equipment by road is required mitigative measures will be put in place.

Heritage Sites and Community Activities

Since there are no heritage sites located within 0.5 km of the site there can be no impact on the heritage sites. The regular activities of the surrounding communities will not be affected by the construction activities for the upgrade.

Macroeconomic Impacts During Construction

The total project cost is estimated at US $758 million of which 25 -30% may be financed locally. The macroeconomic impacts will derive from increases in imports of construction and process equipment, in the supply of local construction materials and in wages earned by construction workers. The technical knowledge transfer for the design and construction will build local capacity that will be useful for other projects and industries.

IMPACTS AFTER THE UPGRADE

Physical and Chemical

Stormwater and Drainage and Wastewater

Process related wastewater from floor drains, process areas, chemical storage areas and equipment drains will be collected and routed to the wastewater treatment plant. The drains in the new process area will be designed to handle a 1 in 10 year storm event before overflow to the storm drains.

There will be negligible change in the amount of runoff to storm drains because of the upgrade so there will be negligible change in the runoff or potential for flooding (which does not occur at the site) or storm surge related impacts.

The upgrade will include a new wastewater treatment plant. The plant will incorporate and upgrade the existing API separator and will include secondary treatment to meet NEPA trade effluent standards.

Air Quality

The upgrade will require new process heaters for various process units, a new boiler (and associated new stacks) and a new flare. The existing vacuum furnace and three existing boilers will be retained. Because of the increased throughput of the refinery, maximum capacity emissions of SO_2, NOx, CO, PM and VOC will increase by 89%, 17%, 107%, 252% and 400% respectively. Although the percentage increase in VOC emissions from point sources is large the absolute VOC emissions from point sources is small relative to the other contaminant emissions. VOC emissions from storage tanks and loading operations will be similar before and after the upgrade since the total amounts of finished products loaded and/or stored will be similar. This is because the reduced imports of finished products will be offset by products made in the refinery. The percentages of Petrojam's emissions in the Kingston airshed's point source emissions before and after the upgrade are shown in Table 3. After the upgrade greenhouse gas emissions will increase by 84% for CO_2, 138% for CH_4 and 173% for N_2O.

Although the percentage increases in Petrojam's emissions for the various gases are large (they will nearly double or more several cases) the emissions should be viewed relative to other emissions in the Kingston airshed in order to get an indication of overall air quality impact. Air dispersion modelling provides a means to predict the overall impact as well as the impact from Petrojam's future (and existing) emissions.

The model predictions show that predicted SO_2 concentrations due to Petrojam sources alone are of potential concern both for the existing situation and after the upgrade since the highest predicted concentrations exceed the corresponding NRCA air quality standards. Predictions for CO and TSP are well below all of the corresponding NRCA standards and therefore are not of concern. In the case of NO_2, the prediction for Petrojam sources alone are well below the standards but when all sources in the airshed are considered the 1 hour Guideline Concentrations is predicted to be exceeded but this would be due to another source or sources in the airshed.

Table 3 Summary of Petrojam's Emissions Share of Point Sources in the Kingston Airshed

	SO_2	**NOx**	**PM**	**CO**	**VOC**
Petrojam's Share (%) Existing	16	1.2	13	0.2	15
Petrojam's Share (%) After Upgrade	26	1.4	24	0.9	1

Unfortunately there are very limited ambient monitoring data with which model predictions can be compared. Based on the monitoring data obtained at sites near the Petrojam refinery during the EIA, it is clear that the model over-predicts the SO_2 concentrations. In any event, as one of the conditions of the air quality licences for the Petrojam and JPS Hunts Bay station, ambient monitoring for SO_2, NOx, and PM_{10} will

take place at three stations near the facilities. The monitoring data from these stations will provide continuous and reliable information on air quality in the vicinity of the two facilities.

Another way of examining the impact of the upgrade is to determine whether or not the predicted change in air quality is "significant". The Guideline Document provides the definition of "significant". The dispersion model results in relation to the test of significant impact are shown in Table 4. If the increase in the model prediction as a result of the upgrade is below the criterion the impact is deemed not significant. The data are somewhat inconclusive since the SO_2 and NO_2 results for the 24 hour (shaded cells) show that the changes are significant but the results for the annual average indicate that the impacts of the upgrade are not significant.

Table 4 Summary of Dispersion Modelling Results to Test Significance of Air Quality Impacts

Pollutant	**Averaging Period**	**Maximum Predicted ($\mu g\ m^{-3}$)**		**Increment ($\mu g\ m^{-3}$)**	**Significance Criterion ($\mu g\ m^{-3}$)**
		Existing	After Upgrade		
SO_2	24 hr	551	704	153	80
	Annual	97	110	13	21
TSP	24 hr	36	44	8	80
	Annual	6	6.5	1.5	21
NO_2	1 hr	86	233		
	24 hr#	50	135	85	80
	Annual	1	5	4	21
CO	1 hr	25	122	97	2000
	8 hr	10	17	7	500

Estimated from the 1 hr results based on equation 9-1.

Health Risk Assessment

The Terms of Reference for the EIA required a health risk assessment to identify human health risks due to the existing refinery operations and to determine any incremental risks due to the refinery upgrade. The health risk assessment was based on the methodology indicated in the NRCA *Guideline Document* which is an integral component of the NRCA Air Quality Regulations. A screening process identified benzene as the only compound of potential concern since a) it has the lowest limit of the compounds included in ambient VOC measurements; and b) some of the 24 h average concentrations that were measured in the vicinity of the Petrojam site were higher than the 24 h limit).

Risks associated with emissions from the refinery were estimated by comparing the exposure rates predicted by the model at a number (146) of special receptors with established toxicity reference values (TRVs). Since the benzene emissions will be similar before and after the upgrade it was necessary to make only one set of model predictions. The special receptors included schools, hospitals, the nearest residences and ambient monitoring stations. TRVs are established by regulatory agencies (e.g., US EPA, California Air Resources Board, Health Canada or the Ontario Ministry of the Environment) and are based on animal toxicity tests or human epidemiological studies. These TRVs are rates of exposures to which the persons can be exposed without harmful human health effects. Risks are estimated by directly comparing the rate of exposure to the TRV. The TRVs used in this report were taken from the USEPA's Integrated Risk Information System (IRIS) and the California Air Resources Board. The reference concentration (RfC) was used to assess non-carcinogenic inhalation effects and inhalation unit risk (IUR) provided on IRIS and ARB to assess carcinogenic effects. Since IRIS (US EPA) and ARB provided TRV values, the lower (more stringent) value was used to evaluate the hazard quotient. Acute effects were assessed by comparing the highest predicted 1 hr benzene concentration to the acute reference value.

The hazard quotient (HQ), which is the ratio between the concentration to which a person is exposed and the RfC, is used to assess non-cancer hazards. Regulatory agencies agree that a hazard quotient value below one (1) is not significant – that is no adverse health effects would be expected. A HQ greater than one indicates that there is a potential for adverse health effects.

Estimates of the exposure were made at 146 receptors which included monitoring stations used in the EIA, the residences nearest to the refinery, schools, hospitals and health centres in the airshed. At the special receptors, non-cancer health risks associated with acute exposure to benzene remained significantly below the target HQ of 0.6 except for one of the monitoring stations NW1. Similarly for chronic exposure – based on the highest predicted daily average benzene concentration, two monitoring station receptors have hazard quotients greater than 0.6.

Six of the 146 receptors – namely five monitoring stations as well as at the nearest residence to the northwest (NRNW) had incremental lifetime cancer risks (ILCR) that were greater than 1 in 1,000,000: the ILCR values at the remaining 123 non-occupational receptors (i.e., excluding those within Petrojam's property) are less than 1 in 1,000,000 and hence the exposures at these receptors were considered negligible.

At 1×10^{-5} (1-in-100,000), Health Canada considers the risk to be essentially negligible. Five receptors NW1, NW2 and BH have incremental cancer risks between 10^{-5} and 10^{-6}. Only at the loading rack – which is on Petrojam's property was the incremental lifetime cancer risk greater than 10^{-5}.

The frequencies with which exceedances of the 1h and 24 h limits occur at the five receptors range from 0.05% of the time to 2.0% of the time. This low frequency of occurrence would be likely to require much less urgent action in other jurisdictions e.g., Ontario for example especially if the frequencies were based on measured values.

It is prudent to err on the side of caution and we recommend that the risks due to benzene exposure by the existing refinery should be examined further at receptors in the vicinities of the nearest residences, the loading rack and also at the monitoring stations near the refinery. The first step in such examination is to conduct additional ambient monitoring for benzene. In making the recommendation we are discounting a) the conservative (high) emission rates used in the model, b) the likelihood that the model over predicts, c) the loading rack site should be treated in an occupational exposure context and d) the conservative nature of the unit cancer risk factor.

It is clear however that since the benzene emissions will be similar before and after the upgrade that the upgrade will not pose any additional risks.

Vibration Impacts

Vibration impacts that can arise from spinning or vibrating equipment (e.g., pumps, compressors, motors) are also unlikely to affect adjacent properties since such equipment will be located almost exclusively in the processing area. It is only feasible to determine these impacts from manufacturers' specifications and these are not yet available. The potential impact of vibration on Petrojam's structures will be an important aspect of the design and will be taken into consideration in due course.

Emergency Response Plans

Petrojam's existing Process Safety Management program and the philosophy and objectives of the Health, Safety, and Environmental Management (HSEM) program will be retained but the various plans will be adapted to reflect the physical changes as well as to introduce measures that are required for the new processing units.

Biological Impacts

Potential terrestrial and marine impacts because of the upgrade are negligible since the site is a well developed industrial site and no changes in the habitat are likely. After the upgrade the potential will remain for entry of petroleum products to an already impacted harbour ecosystem. While the possible impacts of petroleum product toxicity and sedimentation / turbidity may not be as severe as would be the case with healthier reefs the relative impacts on these systems have the potential to be of critical importance to the survival of both harbour and reef systems.

The new wastewater treatment plant is designed to meet NEPA's trade effluent standards (including oil and grease) and will dramatically reduce the potential for oil

from the upgraded refinery reaching the harbour. Because of this marine impacts from hydrocarbons after the upgrade would be reduced.

Socioeconomic Impacts

Employment

It is estimated that over 185 new, permanent skilled positions will be needed after the upgrade and there will also be increased demand for skilled and unskilled contract workers. Members of the local community will need to take advantage of the training opportunities in order to help secure such job opportunities.

Land Use, Traffic and Community Development After the Upgrade

There will be no change in land use after the upgrade since the project will be entirely within the current property boundaries.

The quantity of finished products that will leave the site via tank trucks or ship (barges) should not change because of the upgrade. However, there will be increased marine traffic for the importation of larger amounts of crude oil and for the export of vacuum gas oil as well as sulphur. The new product petcoke will be transported to the JPS Hunts Bay Plant, which is located immediately east of the site, via a dedicated conveyor belt system, and will therefore not impact any road or marine transportation networks.

The upgrade should result in positive impacts on the community/community development because of the potential for increased employment opportunities at Petrojam for persons in the nearby communities. This in turn would positively affect other economic activities such as providing services and spending on consumer goods. The upgrade should not affect the normal community activities in adjacent nearby communities.

Public Perception

The public perception (based on survey and other data) was generally very positive about the project although there were concerns about specific aspects (air pollution, hazardous waste) and in some cases indifference (proposed project would not affect them).

Macroeconomic Impacts

The upgrade will allow the use of heavier lower cost crude oils thus adding flexibility (and hence security) in the sources of crude. It will diversify the sources of finished products and eliminate the need to import higher cost gasoline and diesel. The upgrade will also produce vacuum gas oil, diesel and sulphur in excess of local demand and these will be exported – earning additional foreign exchange. The net foreign exchange savings were estimated at US $100 million, although this will depend on regional prices for petroleum products. .

The upgrade will allow the production of petcoke which will be used by JPS in a 120 MW electricity generating station. The use of petcoke is expected to lower the overall cost of electricity generation. The petcoke electricity generating plant will require limestone from local quarries and will also produce ash which can be used in road construction or as an additive for cement further enhancing the national benefits of the project.

Other Cumulative Impacts

The production of low sulphur diesel for use in newer technology diesel engines as well as existing engines will reduce tailpipe emissions from these engines. The reduced emissions will have positive impacts on air quality and human health.

The improved wastewater treatment plant will allow Petrojam to meet and even exceed NEPA trade effluent standards and should have a positive impact on the water quality in Kingston Harbour.

Quantitative Impact Assessment

Quantitative assessment of the impacts in all study disciplines were assessed for the current situation, during construction and after the Refinery Upgrade using the rapid impact assessment matrix (RIAM) method.

The overall assessments for the three scenarios (Existing, during construction and after the upgrade) are presented in Table 5. The assessment shows that the most positive impacts are from the sociological and economic aspects (the ES or RV values are more positive than the existing situation); there is no significant change in terrestrial or physical impacts but there is deterioration in the marine aspect. The negative impacts for marine impacts are due to the increased marine traffic and the greater potential for marine accidents. These point to greater vigilance in preventive measures for shipping (loading/unloading of raw materials (crude) and products or intermediates that are shipped.

Mitigation and Monitoring

The assessments for the existing and upgraded refinery indicate the need for mitigation and or monitoring during construction and after the upgrade in the following areas:

- Seismic and hurricane impacts
- Ambient Air Quality
- Occupational Exposure
- Vibration
- Surface and groundwater
- Biological
- Socioeconomic

Table 5 Summary of Quantitative Impact Assessment

Activity/Discipline	Existing		During Construction		After the Upgrade	
Parameter	**ES**	**RV**	**ES**	**RV**	**ES**	**RV**
Physical and Chemical Components	***-174***	***-5***	***-251***	***-5***	***-113***	***-5***
Hydrology (Ground and Surface water)	-24	-3	-78	-5	-48	-4
Storm Surge	-5	-1	-5	-1	-5	-1
Marine Water Quality Impacts	-96	-5	-108	-5	0	0
Gaseous emissions	-42	-4	-42	-4	-52	-4
Occupational	-7	-1	-18	-2	-8	-1
Noise	0	0	0	0	0	0
Solid Waste Management	-6	-1	-30	-3	-6	-1
Biological and Ecological Component	***-14***	***-2***	***-14***	***-2***	***-28***	***-3***
Terrestrial	0	0	0	0	0	0
Marine	-14	-2	-14	-2	-28	-3
Sociological and Cultural Components	***20***	***2***	***60***	***3***	***96***	***4***
Economic and Operational components	***-22***	***-3***	***30***	***2***	***94***	***4***

Mitigation and Monitoring

The mitigation and monitoring during construction and after the upgrade are summarised in Table 6.

Environmental Management and Monitoring

Petrojam has a formal, documented and well established environmental management system and industrial hygiene program. In both cases the purpose is to ensure sound practices and to meet applicable local and international standards and guidelines.

Reporting

Quarterly monitoring reports will contain the results of all monitoring, photographic or other observations that are made in the reporting period as well as recommendations for action, if required, for improving the construction process from an environmental perspective and adjustment of the frequency of monitoring.

Table 6 Summary of Mitigation and Monitoring

Activity/Aspect	Mitigation	Monitoring
Physical and Chemical		
Seismic and hurricane impacts	Structural designs will conform to the National Building Code including seismic design criteria of 40% g consistent with a high risk earthquake area and to withstand 3 second wind gusts of 155 mile/hr.	Not applicable
Ambient Air Quality	No point source mitigation until data from continuous monitoring is evaluated – since comparison of EIA monitoring data and model predictions indicate that the model over-predicts	During construction: Establish 3 ambient monitoring stations for hourly averaged SO_2, NOx, wind speed & direction, daily averaged PM_{10} every 6th day: one station with hourly averaged total reduced sulphur (TRS).
Occupational Exposure	Reducing dust (e.g., wetting unpaved areas, cleaning and wetting if necessary paved areas) from general construction activities. Wearing of protective hearing devices, eye protection and breathing devices and also adherence to good housekeeping practices.	Two additional on-site TSP monitoring stations – every 3rd day adjusted based on constructions activities. Two speciated VOC monitoring surveys using passive samplers at (at least) 6 sites including nearest residences & loading rack. Continue monitoring of total hydrocarbons, SO_2 using Drager tubes. Monitor noise levels in the vicinities of where noise generating activities take place and at three perimeter locations during construction.
Vibration	Survey buildings within 100 m of pile driving. Limit times when pile driving etc take place	Monitor input from occupants of buildings in adjacent properties.
Surface and groundwater	The abstraction rate of water from additional wells will be closely monitored and test wells and monitoring the level of the water table will be carried out to ensure the abstraction rate is sustainable and within the licensed rate. Good housekeeping (removal of debris, minimising sizes of earth piles, maintenance/clearing of storm water drains, avoiding concrete washings from reaching storm drains) to minimise surface water runoff from construction/demolition debris and earth excavation piles and concrete mixing will be minimised by good housekeeping practices	Monitor abstraction rate and water table Introduce measurements of effluent flows for storm water and trade effluent and composite sampling to monitor various trade effluent parameters (Total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO), conductivity, oil and grease, sulphide, pH, chemical oxygen demand (COD) and phenol). The samples frequency would be initially every other day and adjusted based on wastewater treatment plant performance.

Activity/Aspect	Mitigation	Monitoring
Biological	Protocols for maintenance activities associated with cleaning of tanks will be revised to ensure that sandy/sediment containing wash water is collected so that the sediment/sandy material is allowed to settle before treatment and discharge of the supernatant. The sediment/sandy material will be disposed of in a landfill or other suitable/approved method.	Marine/Ecological Monitoring of marine water quality (monthly at outfalls and background sites) and the composition of marine, (benthic, pelagic) species (quarterly) during construction. The monitoring frequency would be adjusted based on monitoring results.
Socioeconomic Training/Employment Traffic Communication/Emergency response	 Implement training programs for persons in adjacent communities so they could take advantage of jobs during construction and after the upgrade. Movement of large and/or heavy pieces of equipment from the wharf to the site by barge where possible. When movement by road is required traffic impacts will be mitigated by making traffic management and other arrangements with various authorities (KSCA, JPS, Police, NWA etc.) and schedule such movements at night or other low traffic (week end) periods. Expand the Terms of Reference for the existing Community Outreach Committee to include engagement of the surrounding communities in emergency response planning in order to improve communication about emergency response and appropriate involvement of the community in emergency response.	None