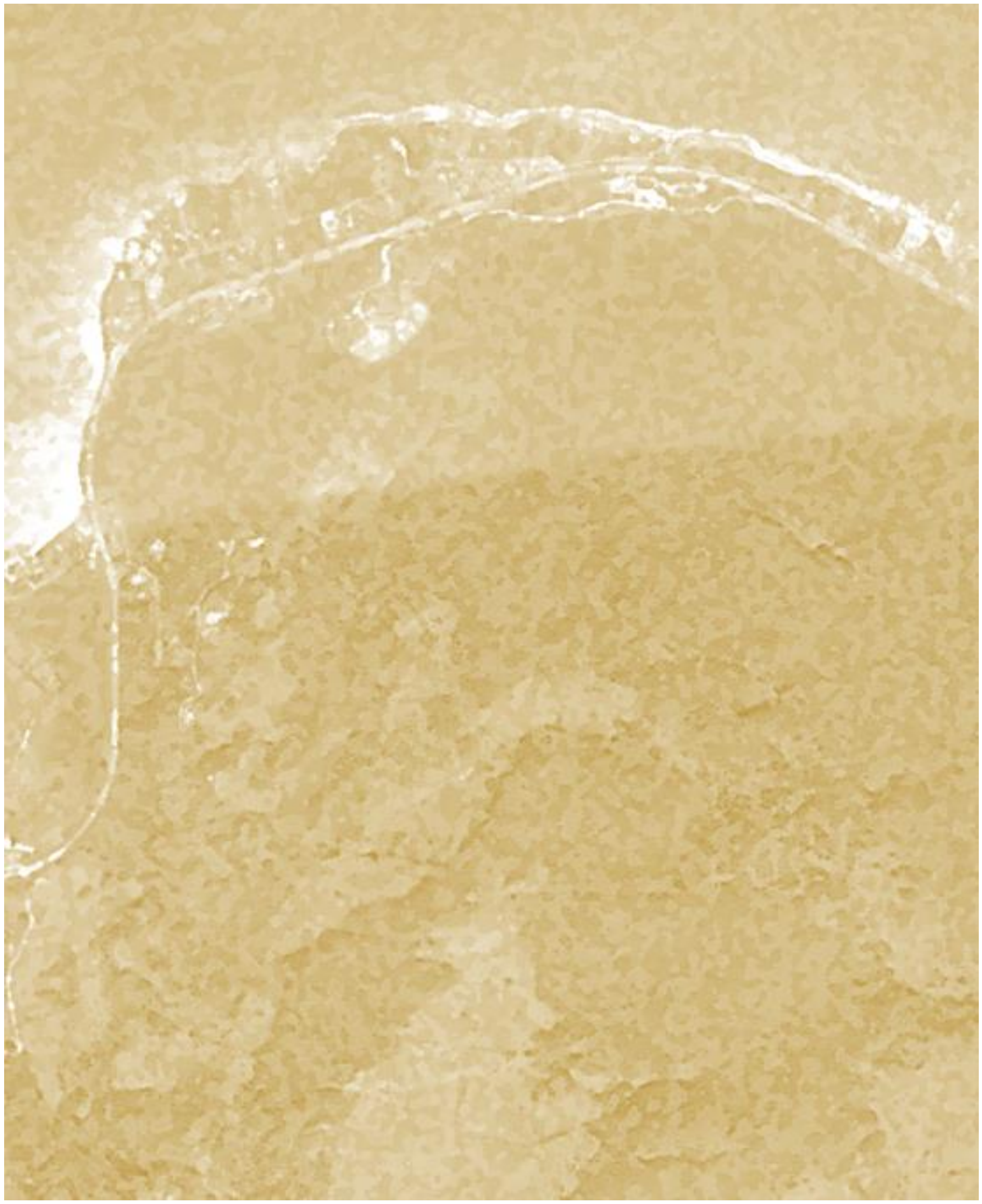


Environmental Impact Assessment

PROPOSED QUARRYING AND MINERAL PROCESSING AT RIO BUENO QUARRY, DRY HARBOUR MOUNTAIN, DISCOVERY BAY, ST. ANN

Report Version:	FINAL – Revised No.3
Date:	MAY 2019
Submitted by:	C.L. ENVIRONMENTAL CO. LTD. and FORREST & ASSOCIATES
Submitted to:	NATIONAL ENVIRONMENT & PLANNING AGENCY

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED QUARRYING AND MINERAL PROCESSING AT RIO BUENO QUARRY, DRY HARBOUR MOUNTAIN, DISCOVERY BAY, ST. ANN

Submitted to:
NATIONAL ENVIRONMENT & PLANNING AGENCY
10 and 11 Caledonia Avenue
Kingston 5

Submitted by:
C.L. ENVIRONMENTAL COMPANY LIMITED
20 Windsor Avenue
Kingston 5
&
FORREST AND ASSOCIATES
4 Chelsea Avenue
Kingston 10

MAY 2019

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ACRONYMS

A	AADT	Annual average daily traffic
	ACGIH	American Conference of Industrial Hygienists
	AMC	Antecedent moisture conditions
	amsl	Above mean sea level
B	BA	Basal area
C	C	Celsius
	CBD	Convention on Biological Diversity
	CDMP	Caribbean Disaster Mitigation Project
	CN	Curve number
	CO	Carbon Monoxide
	CO2	Carbon Dioxide
D	DAFOR	Dominant, Abundant, Frequent, Occasional, Rare
	dBA	A-weighted sound level (decibel)
	DBH	Diametre at breast height
	DEM	Digital elevation model
	DO	Dissolved oxygen
E	E	East/ Easting
	EIA	Environmental Impact Assessment
	EMP	Environmental Monitoring Programme
	ESRI	Environmental Systems Research Institute
	FOG	Fats Oil and Grease
F	ft	Feet
G	g/l	Grams per litre
	GIS	Geographic information system
	GOJ	Government of Jamaica
	GPS	Global Positioning System
H	HA	Hectares
	hr	Hour
	Hz	Hertz
I	IPCC	Intergovernmental Panel on Climate Change
	IUCN	International Union for Conservation of Nature
J	JAD 2001	Jamaica Grid 2001
	JGQ	Jamaica Gypsum and Quarries Limited
	JNHT	Jamaica National Heritage Trust
K	km	Kilometre
	Leq	Time-average sound level
	Lj	jth sound level
M	m	Metre
	m/s	Metres per second
	m3/sec	Cubic metres per second
	mg/l	Milligrams per litre
	mg/m^3	Milligrams per cubic metre
	min	Minute (s)
	mm	Millimetre

	mm/24 hr	Millimetres per 24 hour period
	mS/cm	milli Siemens per cm
	MSDS	Material Safety Data Sheets
N	N	North/ Northing
	NAAQS	National Ambient Air Quality Standards
	NEPA	National Environment and Planning Agency
	NMIA	Norman Manley International Airport
	NO2	Nitrogen Dioxide, Nitrite
	NO3	Nitrate
	NOx	Nitrogen Oxides
	NRCA	Natural Resources Conservation Act
	NSWMA	National Solid Waste Management Authority
	NTU	Nephelometric turbidity units
	NWA	National Works Agency
	NWC	National Water Commission
O	ODPEM	Office of Disaster Preparedness and Emergency Management
	OSHA	Occupational Safety and Health Administration
P	PCQ	Point-Centred Quarter
	PEL	Hearing Conservation and Permissible Exposure Limit
	PIF	Project Information Form
	PM10	Particulate matter smaller than 10 microns in diametre, respirable particulate matter
	PM2.5	Particulate matter smaller than 2.5 microns in diametre, fine particulate matter
	ppm	parts per million
	ppt	parts per thousand
Q	QSP II	Quest suite Professional II
S	s	Second
	SCS	US Soil Conservation Service
	SIA	Social Impact Area
	SO2	Sulfur Dioxide, sulfite
	SO4	Sulfate
	SOx	Sulfur Oxides
	STATIN	Statistical Institute of Jamaica
T	TCP Act	Town and Country Planning Act
	TDS	Total dissolved solids
	TSS	Total Suspended Solids
	TCL	Trinidad Cement Limited
U	USEPA	United States Environmental Protection Agency
W	WHO	World Health Organization
	WRA	Water Resources Authority
Y	yr	Year

EXECUTIVE SUMMARY

INTRODUCTION

The expanding tourism sector, with its accompanying need for worker accommodation and other amenities has led to a significant increase in demand for construction aggregates in the north-western end of the island. Unfortunately, the combination of lack of replenishment, uncontrolled harvesting, and distance from source means that the ability to meet this demand by the use of river shingles has been compromised and will not result in cost effective procurement of raw materials for this development. The use of limestone is therefore a resource imperative for the continued economic development of the tourism sector as presently envisioned in the development plan of Jamaica.

It is with this in mind that Jamaica World Mining has identified the Bengal site in Trelawny to develop an environmentally friendly limestone processing operation, which will consider and mitigate as far as possible all environmental impacts. Jamaica World has partnered with EPSA, a global contract mining company who has a balance sheet of over US $900m. It is anticipated that the project will create between 50 and 100 jobs and is estimated to contribute over JMD$635,755,176 of tax dollars to the Jamaican Government via the Quarry tax.

Following the submission of the Permit Application to NEPA, it was decided that an EIA was required. The specific tasks outlined in the approved TORs were executed by CL Environmental Co. Ltd and Forrest and Associates; this document serves to compile and present the findings of the EIA undertaken.

PROJECT DESCRIPTION

Project Location

This site is in the area of Jamaica known as Rio Bueno and the proposed project is located at Bengal, St. Ann, off the north coast Queen's Highway east of Rio Bueno and to the west of Discovery. The proposed site is situated 4 kilometres from the Trelawny Parish border. The proponent Jamaica World Mining has put forward a quarry application on 50 hectares of land within this area.

Previous mining operations conducted on the project property by Jose Cartellone Civiles S.A. yielded material that was used for the construction of The Queens Highway leg of the North Coast Highway from Montego Bay to St. Ann's Bay. With its use in construction already illustrated, the proponent seeks to further extract material from this area for applications within this area and other value-added applications. The area proposed for a limestone quarry is based on the extent of limestone deposits, land ownership and the operational feasibility for the area of interest.

Proposed Operations

Rio Bueno will be an open-pit quarry with trucks and loading equipment. The proposed production fleet consists of two pieces of quarry loading equipment and three trucks and two-yard loaders. This equipment will feed a fixed plant, producing crushed stone, sand, and fines products. Material will be washed using fresh water from a pump established on site, with process water ponds established to minimize runoff, water will be re-used in the plant.

A 50-hectare block was the area applied for the establishment of a quarry operation. The area is further divided into three blocks, allowing for extraction moving south east extracting 2 million tonnes per annum. Extraction will occur with the objective's rehabilitation goals as one of the primary objectives. The slope angles to be achieved will ensure for future development plans for the proponent, Jamaica World Mining. Upon phased completion, reclamation for that phase will be completed, in conjunction with starting a new phase.

The initial phase (Phase I) is the pit development of the quarry based on expected zoning, property limits, buffers, and reclamation areas and the subsequent mining. During this phase the old plant site area on the north side of the property (along Queens Highway) will be rehabilitated. The new entrance will be in use, and the plant will be set up in the designated area. Mining will begin in the already exposed pit moving south ward. The already exposed pit will provide a suitable area for storage of the overburden removed, which will be used during the reclamation of the mined area.

The first and final phases covers a 15-hectare block and will extract approximately 11.295 million tonnes (yield tons are 7.9M with the 30% loss), which results in a duration of approximately 6 years for each Phase at an average output of 2M tonnes of per year. The second phase will produce a higher yield as it is a larger area for extraction. Located on 20 hectares the mined tonnage is calculated to be approximately 15M tonnes that should last for approximately 8 years. The quarry life is calculated to be 20 years but suspected to be more should the property be mined to sea level.

Project Components

Potable and process water will be trucked to the site, with electricity to be taken from the Jamaica Public Service Company grid serving the area. Solid waste generated from the quarry operators will be collected and taken by a private solid waste contractor when required and taken to the approved municipal dump site located at Tobalski or Hadden sites. No solid waste will be generated from quarrying, as all materials displaced during quarrying will either be sold or stored for reuse during rehabilitation of mined areas. The proposed processes for the wastewater effluent includes a grease trap (if kitchen facilities are contemplated), septic tank and evapotranspiration bed.

The sediment ponds used for storm water will be constructed in areas where the topography is conducive to water collection. The fixed assets and facilities shall be located on the base of each completed quarry phase. As this surface would have been already rehabilitated this is the best proposed location for equipment.

Site access from the North Coast Highway is proposed to be placed east of the previous site access used by the previous quarry operators.

Project Timeline

Phase 1 is estimated to be a five-year extraction programme.

- 2 months for preparation and equipment arrangement for the quarry operation.
- 56-month extraction programme (at 2 million tonnes every 12 months)
- 2-month timeline for decommission and commencement of phase 2.

Phase 2 would be a renewal of the quarry license. This would have been submitted 4 months before the license expiration date.

- 2 months for preparation and equipment set up for extraction
- 120-month operation. This is the largest area therefore the renewed license should expire before phase 2 is completely extracted. Phase 2 should be completed 24 months into the renewed license.

Phase 3 should take three years (36 months) for extraction to be completed.

IMPACTS

Significance scoring:

- ✓ 0: Negligible
- ✓ 1: Minot
- ✓ 2: Moderate
- ✓ 3: Significant

Site Preparation

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG	
Biological Impacts	Invertebrates	Land Clearance	Species loss, displacement and loss of habitat. *Marpesia chiron* in particular.	X				X	-2.33
		General Site Prep. Activity		X				X	-2.33
	Amphibians and Reptiles	Land Clearance	Displacement, loss of habitat and disruption of nesting. Noise Pollution.	X				X	-2
		General Site Prep. Activity	Displacement, loss of habitat and disruption of nesting. Noise Pollution.	X				X	-1.33
	Avifauna	Land Clearance	Displacement, loss of habitat and disruption of nesting. Noise pollution	X				X	-1.67
		General Site Prep. Activity	Increased noise pollution – displace sensitive fauna	X				X	-1
	Vegetation - Dry Limestone Forest	Land Clearance	Species Loss, Habitat Destruction	X				X	-2.33
			Soil erosion and land slippage		X			X	-2
		General Site Prep. Activity	Habitat loss. Dust pollution affecting remaining plants	X				X	-1
			Soil erosion and land slippage		X			X	-2

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG	
	Vegetation - Savannah	Land Clearance	Species Loss, Habitat Destruction	X				X	-2.33
		General Site Prep. Activity	Habitat loss. Dust pollution affecting remaining plants	X				X	-1
Physical Impacts	Air Shed	Land Clearance	Increased noise and dust pollution	X				X	-1.33
		General Site Prep. Activity	Increased noise and dust pollution	X				X	-1
	Hydrology and Water Resources	Land Clearance	Soil erosion and siltation from run-off and rainfall events	X				X	-1.67
			Increased Turbidity from run-off and rainfall events	X				X	-1.67
		General Site Prep. Activity	Soil erosion and siltation from run-off and rainfall events	X				X	-1.67
			Increased oil from vehicle and equipment maintenance	X					-1.67
			Increased Turbidity from run-off from run-off and rainfall events	X				X	-1
Social Impacts	Existing natural and social environment	Land Clearance	Increased solid waste generation	X				X	-1.33
			Aesthetic appeal	X			X		
		General Site Prep. Activity	Increased solid waste generation	X				X	-1.33
			Increased wastewater generation	X				X	-1
			Interrupted Traffic flow along main road	X				X	-1
	Labour Force/Local Economy	Land Clearance	Increased employment	X		X			2.33
			Increased accidental potential of labourers	X				X	-1.33
			Increased noise and dust exposure of labourers	X				X	-1.33
			Increased employment	X		X			2.33

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG	
		General Site Prep. Activity	Increased accidental potential of labourers	X				X	-1.33
			Increased noise and dust exposure of labourers	X				X	-1.33
	Users and Residents	Land Clearance	Noise and dust pollution	X				X	-1.33
		General Site Prep. Activity	Noise and dust pollution	X				X	-1.33
	Heritage and Cultural artefacts	Land Clearance	Potential for destruction of artefacts present	X				X	-1
		General Site Prep. Activity	Potential for destruction of artefacts present	X				X	-1

Operation

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG	
Biological Impacts	Invertebrates	Blasting and Quarrying	Disturbance and displacement	X				X	-2
		Transport & General Operations	Disturbance	X				X	-1.67
	Amphibians and Reptiles	Blasting and Quarrying	Disturbance and displacement	X				X	-2
		Transport & General Operations	Disturbance – vibration, noise and dust	X				X	-1.67
	Avifauna	Blasting and Quarrying	Disturbance – vibration, noise and dust	X				X	-2
		Transport & General Operations	Disturbance- vibration, noise and dust	X				X	-1.67
	Vegetation - Dry Limestone Forest	Blasting and Quarrying	Dust pollution	X				X	-2
		Transport & General Operations	Dust pollution	X				X	-1.67

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG	
	Vegetation - Savannah	Blasting and Quarrying	Dust pollution	X				X	-2
		Transport & General Operations	Dust pollution	X				X	-1.67
Physical Impacts	Water Column	Blasting and Quarrying	Groundwater contamination-sedimentation, pollutants from site etc.		X			X	-2.66
	Air Shed	Blasting and Quarrying	Noise and dust pollution	X				X	1.67
		Transport & General Operations	Noise and dust pollution	X				X	-1.67
Social Impacts	Existing natural and social environment	Blasting and Quarrying	Noise and dust pollution	X				X	-1.67
			Solid waste generation	X				X	-1.67
		Transport & General Operations	Wastewater generation	X				X	-1.67
			Solid waste generation	X				X	-1.67
			Noise and dust pollution	X				X	-1.67
			Traffic congestion	X				X	-1
	Users and Residents	Blasting and Quarrying	Noise and dust pollution	X				X	-1.67
			Aesthetic appeal	X			X		
			Damage to property from rockfall	X				X	-1.67
			Vibration	X				X	-1.67
		Transport & General Operations	Noise and dust pollution	X				X	-1.67
			Aesthetic appeal				X		
			Vibration				X		
	Local Economy/Labour Force	Blasting and Quarrying	Noise and dust exposure	X				X	-2
			Increased employment	X		X			3
			Increased accident potential	X				X	-2.33
		Transport & General Operations	Noise and dust exposure	X				X	-2
			Increased employment	X		X			3
			Increased accident potential	X				X	-2.33

MITIGATION

Site Preparation

Drainage and Hydrology

i. Storm water pollution prevention practices include: silt fence, rock check dams, and vegetation used to control erosion from storm water run-off.
ii. Sedimentation and erosion control practices will be implemented on site to lessen the erosion potential of exposed soil surfaces. Additional and regular site maintenance and housekeeping procedures will also minimize erosion and the adverse impacts of storm water runoff.
iii. Within the storage areas for overburden, if deemed necessary, diversion ditches will be constructed to collect storm water run-off and direct it into sediment ponds.
iv. Storm water will be treated as necessary by means of sedimentation in settling ponds. Also, used process water will be treated by means of sedimentation in settling ponds and recirculated through the processing plant after it is treated. If necessary, pit water will be pumped to a settling pond for treatment and ultimate discharge.
v. Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin.

Air Quality

i. Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.
ii. Minimize cleared areas to those that are needed to be used.
iii. Cover or wet construction materials such as marl to prevent a dust nuisance.
iv. Ensure that haul roads are graded and properly maintained
v. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.
vi. Being prepared to suspend or downgrade operations if winds are high and dust plumes become unavoidable.
vii. Utilizing dust screens to minimize dust blow from quarry site to surrounding residences and roads.

Noise

i. Use equipment that has low noise emissions as stated by the manufacturers.
ii. Use equipment that is properly fitted with noise reduction devices such as mufflers.
iii. Operate noise-generating equipment during regular working hours (e.g. 7 am – 7 pm) to reduce the potential of creating a noise nuisance during the night.
iv. Construction workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.

Water Supply

A 150,000 gallon (567811.768 litres) water storage tank will be installed on property within the crushing area. The use of a water tank on-road truck, with an approximate capacity of 20,000 litres to control the dust in the working areas and haulage roads will be a scheduled part of daily operations.

Wastewater Generation and Disposal

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

Solid Waste Generation

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

Storage of Raw Material and Equipment

i. A central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of chemicals into the sediment.
ii. Raw materials that generate dust should be covered or wetted.
iii. Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.
iv. Raw material should be placed on hardstands surrounded by berms.
v. Equipment should be stored on impermeable hard stands surrounded by berms.
vi. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage.
vii. Minor spills will be immediately cleaned or contained.
viii. All deteriorating equipment (pipes, valves, drums etc.) will be immediately replaced. Spill prevention structures will be implemented on site, for example; curbs, grading, elevated pads, drip pans, will be installed at servicing areas.
ix. All employees will be trained in spill prevention and response procedures. This is done to provide immediate response to spills and clean-up may commence whenever identified.

Transportation of Raw Material and Equipment

i. Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
ii. Adequate and appropriate road signs should be erected to warn road users of the activities. For example reduced speed near the entrance to the site.
iii. Raw materials should be adequately covered within the trucks to prevent any y.

iv. The trucks should be parked on the proposed site until they are off loaded.
v. Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
vi. The use of flagmen should be employed to regulate traffic flow.

Habitat Destruction

i. Establish a site rehabilitation plan for the site.
ii. A buffer zone of minimal to no activity should be established surrounding the proposed area. The vegetation in this area may then become a natural seed-source to the mined-out lands after closure. If considered, seedlings may also be actively transplanted from this area as well.
iii. The staged and sequential clearing of vegetation over the life of the quarry.
iv. Monitoring of indirect impacts on threatened plant species surrounding the site.
v. All staff on site should be made aware of the mitigation plans to be implemented.
vi. Ensure that all endemic, rare and threatened species as best as possible will be removed to the adjoining dry limestone forest area which would act as an pseudo ex situ site. This however is very difficult because of the substrate which renders the removal of some of these species without damage and loss impossible. This action would require much patience and meticulous removal for species rooted in the limestone substrate. The substrate would have to be removed with the species in most cases.
vii. Ensure that the remaining dry limestone forests are preserved and not mined out in the future. This would allow also the loss of habitat as well as species within the core dry limestone forest of the proposed site. The justification of this would be the assumption and that the species within the proposed site are also within the adjoining dry limestone forest and in similar healthy numbers and populations.

Increased Soil/Substrate Erosion

i. Remove trees only as necessary.
ii. A site preparation plan should be developed prior to project initiation.
iii. Leaving or planting strips of vegetation on steep slopes may help to prevent erosion.
iv. A phased approach to mining activities is recommended.

Fauna

i. A study should be carried out to ascertain the status of *Marpesia chiron*:
   (a) Is there a resident population?
   (b) If the answer to (a) is yes, then is there a breeding population in the study site?
ii. A study should be conducted to determine if the area is a breeding site of the Blue Swallowtail Butterfly. This study should be carried out at the next swarming (likely after the rains of April-May) when breeding is taking place.
iii. The Jamaican Boa or Coney must be relocated if encountered. However, it will be difficult since both species are very secretive in nature and they are also nocturnal.
iv. Attempts should be made to rehabilitate the soil of the mined out areas followed by replanting of vegetation. This could be done for the floor regions, but might not be possible for the almost vertical walls; these vertical areas will be recolonized naturally over time. The high diversity of

animals in the present abandoned mine is an indication that these areas have the potential to return to being sites of high biodiversity.

Health and Safety Concerns

i. Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.
ii. Construction workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.
iii. Adequate communication with workers and signage should be put in place to alert/inform workers of potential dangers. Personal Protective Equipment (Hard hat, steel-toe shoes, reflective vests, safety glasses etc.) should be worn by all workers.

Heritage

i. Care should be taken during land clearance and the site preparation stages so that any historical artefacts observed can be recovered by the JNHT.

Operation

Air Quality

i. Ensure that equipment are properly maintained so as to reduce air emissions.
ii. Haul trucks must maintain speeds at 25 km/h or less.
iii. Quarry areas and roadways should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.

Noise Pollution

i. Ensuring that equipment used are properly fitted with noise reduction devices.
ii. Reduce unnecessary revving of vehicular engines.
iii. Use equipment that has low noise emissions as stated by the manufacturers.
iv. Use equipment that is properly fitted with noise reduction devices such as mufflers.
v. Operate noise-generating equipment during regular working hours (e.g. 7 am – 7 pm) to reduce the potential of creating a noise nuisance during the night.
vi. Workers operating equipment that generates noise should be equipped with noise protection.

The following mitigations were employed to reduce noise levels to within the NEPA Day Time standards:

1. Semi enclose the Primary Impactors (enclosed the sides and tops)
2. Installing noise walls to the north of the facility.

Rock Blasting

These blasting practices will be kept to a minimum and will involve directional, controlled blasts, using mats where possible. The following procedures are also recommended to mitigate or minimize the potential for dangers including:

i. Conducting pre-blast crack surveys which documents the existing status of structures (homes and residences).
ii. Executing pre-blast tests to monitor effects, measure attenuation characteristics and minimize vibration impacts. Predictions are evaluated using actual data and adjustments are made during the blasting program. This is monitored using instruments placed at the nearest structure in every direction.
iii. Implementing rockfall catchment fences. These mechanisms help to contain fragmented pieces of stones (fly-rock) from impacting nearby settlements.

<u>Vibration</u>

i. Avoid night time activities. People are more aware of vibration in their homes during the night time hours.
ii. Have regular community meetings or devise a communication strategy to inform the residents of dates and times which blasting is scheduled to occur, as well as the duration.
iii. Conduct pre-project crack surveys at residences in the area so that the existing status of structures (homes and residences) is documented.
iv. Execute pre-blast tests to monitor effects, measure attenuation characteristics and minimize vibration impacts. Predictions are evaluated using actual data and adjustments are made during the blasting program. This is monitored using instruments placed at the nearest structure in every direction.

<u>Wastewater Generation and Disposal</u>

i. A wastewater treatment facility will be located on site.

<u>Storage of Raw Material and Equipment</u>

i. A central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of chemicals into the sediment.
ii. Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne.
iii. Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.
iv. Raw material should be placed on hardstands surrounded by berms.
v. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff.
vi. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage.
vii. Minor spills will be immediately cleaned or contained, this is to ensure fuel and oils do not come in contact with storm water and other surface runoff. Inspections to identify area that require maintenance will be done to mitigate leaks and spills.

viii. All deteriorating equipment (pipes, valves, drums etc.) will be immediately replaced. Spill prevention structures will be implemented on site, for example; curbs, grading, elevated pads, drip pans, will be installed at servicing areas.
ix. All employees will be trained in spill prevention and response procedures. This is done to provide immediate response to spills and clean-up may commence whenever identified.

<u>Transportation of Material</u>

i. Adequate and appropriate road signs should be erected to warn road users of the activities. For example, reduced speed near the entrance to the site.
ii. Raw materials should be adequately covered within the trucks to prevent any escaping into the air and near the roadway.
iii. The trucks should be parked on the proposed site until they are ready to go to port.
iv. The use of flagmen should be employed to regulate traffic flow where necessary
v. It should also be considered that the crushed material be transported by conveyor to the plant or to key points and not by trucks. These measures should substantially reduce the traffic as well as dust emissions.

<u>Flora</u>

i. It should be investigated if the mechanical crusher to be employed can accommodate a filter-system.
ii. It should also be considered that the crushed material be transported by conveyor to the plant or to key points and not by trucks. These measures should substantially reduce the dust emissions; however, it is understood that some vehicular movement around the site will be necessary.
iii. Water (recycled if possible) should also be used for dust suppression where required.
iv. Vegetation and soil should be removed together (mixed) so that the plant matter helps to hold the soil. Alternatively, vegetation can be stripped and stockpiled and then spread over the newly made stockpiles of soil.
v. Where practical, rehabilitation of the quarry should be progressive: proceeding after the closure of mined out sections.
vi. In terms of aesthetics, natural vegetation surrounding the quarry should be retained (such as in a buffer area) so as to help minimise dust emissions.
vii. Vegetation should only be cleared where it is absolutely necessary for operation.
viii. As the quarry expands, the time between clearing and quarrying should not be protracted.
ix. When trucking material it should be covered for the duration of the trip and when idle.

<u>Fauna</u>

Due to its rare sightings and conservation significance, signage showing photographs of the butterfly *Marpesia chiron* should be placed at various locations around the site so that it can be identified easily and if observed, it can be reported to the biodiversity branch at NEPA. Sensitization and education of employees on site re *Marpesia chiron* should be conducted by qualified personnel (from NEPA or other).

Aesthetics

To maintain the scenic value of the western section of the corridor the quarry operators will also have to be careful with the height and location of the infrastructure they may deploy in the old quarry area and verify that there is no view shed infringement for potential receptor in the highway corridor and the Bengal subdivision. Appropriate camouflage techniques could be used when infringement is unavoidable.

Health and Safety Concerns

i. Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.
ii. Consideration should be given to putting in place a conveyor system. This would transport material from the site to the port that is located less than a kilometre away: Further reducing traffic congestion and the risk of traffic accidents.
iii. Workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.
iv. Where unavoidable, workers working should be provided and fitted with N95 respirators.

ENVIRONMENTAL MANAGEMENT AND MONITORING

As part of the Environmental Management System (EMS), it is recommended that several parameters be monitored before, during and after the project implementation to record any negative impacts and to propose corrective or mitigation measures. The suggested parameters include but not limited:

1) Water quality
2) Noise
3) Dust
4) Traffic
5) Solid Waste Generation and Disposal
6) Sewage Generation and Disposal
7) Equipment Maintenance

CONCLUSIONS

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. The project team and the consulting scientists worked together, utilizing findings of these impacts to analyse possible options for the final project. The implementation of recommended mitigation measures will assist in further reducing the environmental impact of the project.

The preferred alternative is the Project as proposed with conversion into a renewable energy source upon decommissioning.

1.0 INTRODUCTION

1.1 CONTEXT AND RATIONALE

Traditionally, the use of crushed river aggregates has been the preferred raw material choice of concrete manufactures due to the combined factors of hardness, angularity, availability and relative ease of mining. In Jamaica, the river sources for this material are located largely in the eastern section of the island. The exploitation of these reserves, with their replenishment being retarded by the relatively long dry periods experienced over the past 5 -10 years, has resulted in it becoming more difficult to easily harvest and manufacture construction aggregates from this resource. Limestone aggregates have consequently gained acceptance as an alternative material for use in the construction sector, provided the challenges of "chemical purity", hardness and availability are successfully navigated. Limestone deposits are found all over the island, accounting for > 60% of all naturally occurring minerals in Jamaica.

The expanding tourism sector, with its accompanying need for worker accommodation and other amenities has led to a significant increase in demand for construction aggregates in the north-western end of the island. This demand will see the need for some 4 million metric tons of construction aggregates over the next 5 years. Unfortunately, the combination of lack of replenishment, uncontrolled harvesting, and distance from source means that the ability to meet this demand by the use of river shingles has been compromised and will not result in cost effective procurement of raw materials for this development. The use of limestone is therefore a resource imperative for the continued economic development of the tourism sector as presently envisioned in the development plan of Jamaica. Construction aggregates from properly constituted and hardened limestone must be the preferred raw material for the building sector in this area.

It is with this in mind that the Jamaica World Mining has identified the Bengal site in Trelawny to develop an environmentally friendly limestone processing operation, which will consider and mitigate as far as possible all environmental impacts that are related to the following areas of interaction with the natural environment:

1. Facility location
2. Pre-operation (plant construction/erection)
3. Operation
4. Sales and administration

Jamaica World will create between 50 and 100 jobs and is estimated to contribute over JMD$635,755,176 of tax dollars to the Jamaican Government via the Quarry tax.

1.2 PROJECT LOCATION

The project site is located at Bengal in the parish of St. Ann, east of Rio Bueno and west of Discovery Bay (Figure 1-1 and Figure 1-2). The proposed site is situated 4 kilometres from the Trelawny Parish border. The proponent Jamaica World Mining has put forward a quarry application on 50 hectares of land within this area. Please refer to section 3.1.2 for further detail on the study area.

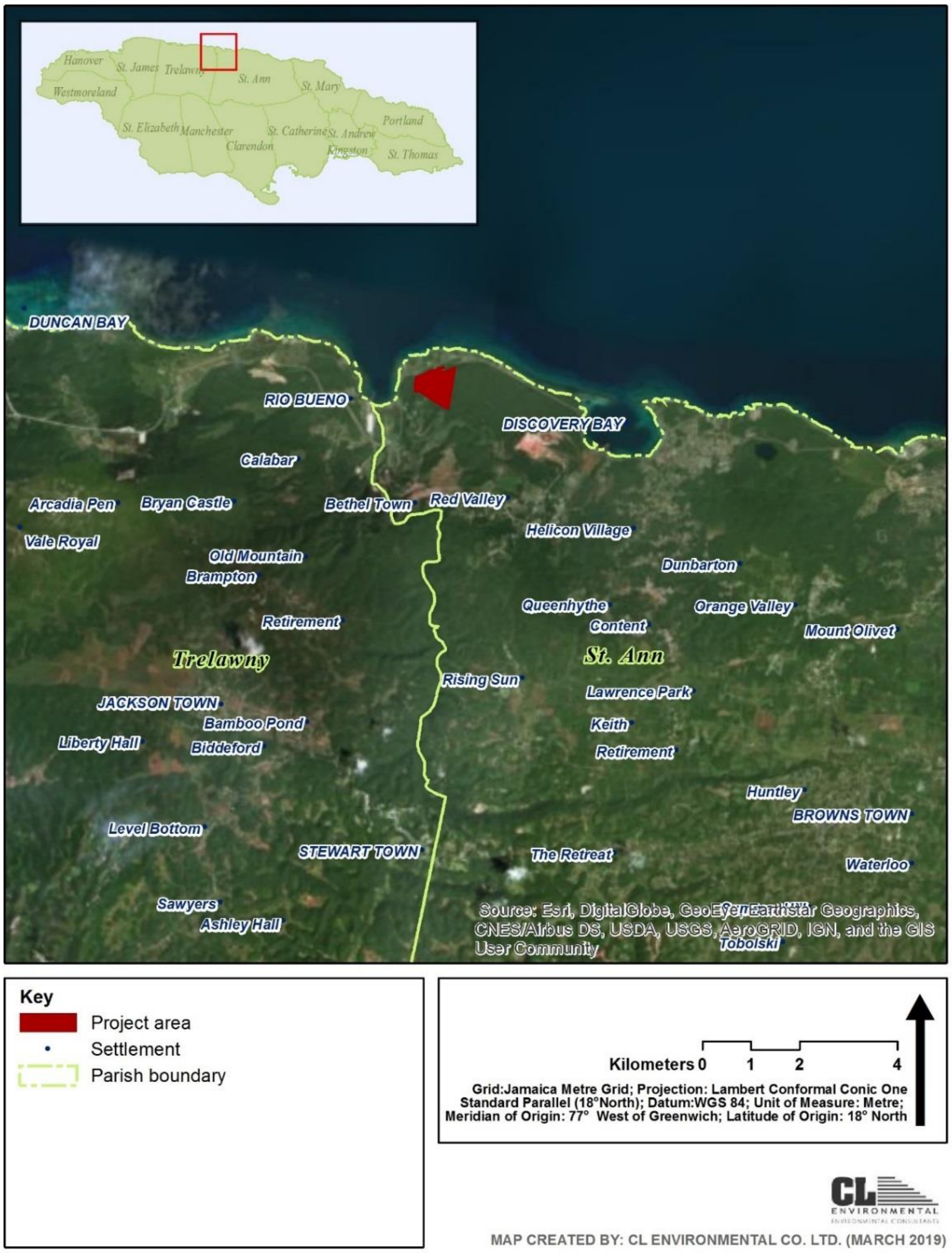


Figure 1-1 Project location, Bengal, St. Ann

Figure 1-2 Project Location and basic facilities

1.3 THE PROPONENT

Jamaica World is an industrial development start-up company that envisions operating in the Mining, Real Estate, and Renewable Energy sectors. The company currently owns one asset: 572 acres of land in Jamaica, W.I. Jamaica World has had many land and mineral valuation analysis completed on the property. The most notable valuation was completed by Continental Placer Geology Firm, which discovered that the land asset potentially contains up to 335,300,000 tons of limestone, of which 156,400,000 tons are proven (proven being defined by US geologists as having been actually discovered during excavation exercises). The land asset was mined by from 2001 to 2007 by Cartelone Construction company, which extracted 2 million tons of aggregate from the site to construct the north coast corridor of the Queens highway in Jamaica. Jamaica World's core business will be the mining, manufacturing, processing, and distribution of the aggregate and limestone affiliated products. The company plans to extract high-quality limestone from its open-pit quarries and then process it for sale as aggregate, pulverized limestone, quicklime, hydrated lime and lime slurry.

Jamaica World has partnered with **EPSA**, a global contract mining company who has a balance sheet of over US $900m. EPSA has over 20 years of specialization in earthmoving, and works in various countries across Europe, Africa, America, Australia and Asia Pacific. Services include mining, civil works, special works (ports and airports), hydraulic works and levelling works. EPSA is committed towards the environment and is certified by ISO 14001. In addition to completing implementation deliverables, their project outcomes include occupational health and safety, environment and community efforts.

1.4 SCOPE OF WORK

1.4.1 Purpose of EIA and Terms of Reference

Environmental impacts from the preparation and operation of the proposed quarry will potentially arise and it was considered imperative to evaluate these likely impacts, recommend mitigation strategies and potentially viable alternatives to the proposed project. The Permit Application for the proposed project, the *Environmental Impact Assessment for the Proposed Quarrying and Mineral Processing at Rio Bueno Quarry, Dry Harbour Mountain, Discovery Bay, St. Ann* was submitted to the National Environment and Planning Agency (NEPA) and it was decided that an Environmental Impact Assessment (EIA) was required. The Terms of Reference (TORs) (Appendix 1) were established by the National Environment and Planning Agency (NEPA) in order to outline the various aspects of the EIA. This report serves to compile and present the findings of the EIA and ultimately provide a comprehensive evaluation of the proposed project.

1.4.2 Project Consultant and Study Team

The specific tasks outlined in the approved TORs were executed by **CL Environmental Co. Ltd** and **Forrest and Associates**; the study team may be seen in Appendix 2.

C. L. Environmental Company Limited has been incorporated in Jamaica as a Limited Liability Company since August 2000. The Company provides consultancy services to both governmental and non-governmental agencies, local and overseas. The company comprises a range of professional skills and includes environmental scientists, marine ecologists, environmental engineers, waste management specialists, planners, industrial hygienists, environmental management systems specialists, environmental educators and quality Consultants. The team of Consultants and Scientists associated with C.L Environmental Company have over the years, worked on numerous environmental projects of which some were of national importance such as the Highway 2000 North South Link: Caymanas to Linstead and Moneague to Ocho Rios legs, National Programme of Action for Land Based Sources and Activities that Impact the Marine Environment, the Remediation of the American Airlines Flight 331 Accident Site at Norman Manley International Airport, the Ausjam Gold Mine Cyanide Spill in Clarendon, Environmental Assessment Road Rehabilitation Works for the Moneague Lake Flooding in St. Ann for Bouygues Travaux Publics and the Environmental Monitoring of the Falmouth Cruise Pier Development in Falmouth, Trelawny for the National Environment and Planning Agency (NEPA) to name a few.

The environmental impact assessment capabilities of the company are built on a multidisciplinary group of professional associates who collectively have over eighty years of experience in environmental management. In addition, to their experience, the depth and diversity of the team provides us with strengths in policy development, organisational evaluation operational management, project management, noise modelling, water quality assessments, solid waste and medical waste management and waste treatment design and implementation. The combined inter disciplinary strength of this team and their regional and international experience, makes them highly suitable to undertake the proposed project.

1.4.3 General Methodology, Assumptions and Constraints

Modelling software used for this EIA make certain assumptions when running various scenarios. Some of the models used and their assumptions are shown in Table 1-1.

Table 1-1 Modelling software used and their assumptions/limitations/constraints

Modelling Software	Parameter Modelled	Assumptions/Limitations/Constraints/Improvements
SoundPLAN 8.0	Noise	The ISO 9613-2 standard is the world-wide accepted and applied engineering method to predict the noise from industrial sites and also from other types of sources. It has been shown that this standard has provided reasonable results for mid-range distances and in case the meteorological conditions are not of dominating influence within the assessment interval. Although it is widely accepted and used, the ISO 9613-2 standard has some limitations as outlined by (Economou and Charalampous 2012). Limitations include user decision whether vertical diffraction paths are important or not, material reflection properties, the user has to interpret and decide how to use foliage, site and housing attenuation factors and uneven grounds cannot be properly modelled. ISO 9613-2 implicitly assumes that wind blows from each source to each receiver. Each receiver cannot be downwind simultaneously as such actual

Modelling Software	Parameter Modelled	Assumptions/Limitations/Constraints/Improvements
		levels can be lower than predicted, because each receiver cannot be downwind of each source at the same time (Brittain and Hale 2008). The CONCAWE standard assumes that all calculations are based on octave bands. It has one advantage in that it is one of the few standards that allow meteorological influence (e.g., wind and stability) to be used in the calculation. The CONCAWE standard has three major shortcomings. One is that the formulae for the ground effect and the meteorological correction are only valid from distances of greater than 100 meters. What if the source is closer to the receiver? In this case, SoundPLAN takes the value for the 100-meter calculation and extrapolates the effect between the 100-meter mark and 0.0 dB. This is certainly not correct, but what is? It is not defined in the standard. Another shortcoming is that the standard does not have any formula for screening, it just states to use the approach from Maekawa. The third shortcoming is the missing definition concerning how to modify the ground effect when significant screening is present. (SoundPlan 2012).
AERMOD Air Dispersion Model 9.1	Air Emissions	An air quality dispersion model is a computer software tool used to assess potential ambient pollutant concentration impacts. With any modelling analyses, there is a degree of uncertainty. The accuracy of ambient air pollutant concentrations predicted using an air quality dispersion model (such as the AERMOD software) depends on the quality of model input data (meteorological data, source characterizations and emissions rates), as well as the model algorithms. For this project, prognostic meteorological data were obtained using the Mesoscale Model (version 5) to provide high resolution, representative meteorological data for the project site location, and emission rates were determined using USEPA emission factors and supplied project data. Numerous tracer release field study data sets have been used in model evaluation studies of AERMOD (USEPA, 2003). The results of these studies indicated good agreement with the observed concentrations for point source releases. However, accurate simulations of volume and area sources are more challenging and the AERMOD model has not been adequately evaluated for these source types. The AERMOD modeling of the Bengal Quarry site included volume and area sources and any uncertainties in the model predictions may be due to conservative assumptions made while characterizing the sources and their emission rates, and because many of the material handling activities are fugitive sources of emissions of particulate matter. The non-point source release characteristics and the unsteady nature of the emitting activities make them challenging to simulate with a steady state model such as AERMOD. AERMOD assumes that the emitting activities are steady state whereby predicted concentrations for each hour from an emission rate and meteorological conditions are uniform across the modelling domain, which may lead to an over estimation of maximum predicted impacts by the model.

2.0 LEGISLATION AND REGULATORY CONSIDERATION

2.1 EIA FRAMEWORK

2.1.1 Rationale and Basis

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

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

2.1.2 Development Application and the EIA Process

2.1.2.1 General Procedures

The National Environment and Planning Agency (NEPA) [1] has been given responsibility for environmental management in Jamaica under the Natural Resources Conservation Authority Act (NRCA) Act of 1991. Since the promulgation of the NRCA Act, it has been strengthened by various supporting regulations that became effective in January 1997. The Environmental Permit and License

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

System (P&L) is administered by NEPA through the Applications Section. It was introduced in 1997 to ensure that all developments meet required standards and negative environmental impacts are minimized. Under the NRCA Act of 1991, the NRCA has the authority to issue, suspend and revoke environmental permits and licenses, as well as the power to request EIAs for a permit or for any activity in a prescribed area (entire island of Jamaica) where it is of the opinion that the environment is likely to have adverse effects due to the activities.

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

The NRCA requires that the EIA include the following:

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

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

As deemed necessary by the NRCA, Public Meeting(s) are then held (see Appendix 3 for the full guidelines on public participation in EIAs), 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.

2.1.2.2 Project-specific Progress

Following the submission of the Permit Application to NEPA, it was decided that an EIA was required and for which the final TORs (Appendix 1) were used to guide the EIA approach. This document serves to compile and present the findings of the EIA.

2.2 NATIONAL LEGISLATION

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

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

2.2.1 Development Control

Several development and planning related laws and regulations may affect the Project. The applicability of these laws is dependent on the location of the development chosen, social and socio-economic issues as well as the availability of land for acquisition.

2.2.1.1 Town and Country Planning Act (TCP Act) 1957 (Amended 1987)

The Town and Country Planning Act (TCP Act) 1957 (Amended 1987) provides the statutory requirements for the orderly development of land through planning, as well as guidelines for the preparation of Development Orders. A Development Order is a legal document which is used to guide development in the area to which it applies and the TCP Act is only applicable in an area where a Development Order exists. It constitutes land use zoning map/s, policy statements and standards relating to land use activities. Additionally, tree Preservation Areas and Conservation Areas (as specified areas the gazetted Development Orders) are two types of protected areas associated this Act. As seen in Figure 2-1, the Development Order relevant to this proposed is the Town and Country Planning (St. Ann Parish) Provisional Development Order 1998 (Confirmed January 2000). Section 4.3.2.2 provides further detail regarding zoning.

The Local Planning Authority (LPA) for this project is the St. Ann Parish Council. All development applications are made through the LPA which include enquiries, planning, building and subdivision approvals. The TCP Act establishes the Town and Country Planning Authority, which in conjunction with the LPA, are responsible for land use zoning and planning regulations as described in their local Development Orders. The TCP Act is administered by the National Environment and Planning Agency.

Town and Country Planning (St. Ann Parish) Provisional Development Order 1998 (Confirmed January 2000)

This order defines all rules and regulations for development within the bounds of the parish of St. Ann, with further specifications for various planning areas. Objective 8 (c) of this order speaks to mining, and specifically "to disperse the economy and diversify the employment base in the rural area…through the exploitation of mineral resources". Additionally, Objectives 11 and 12 are as follows:

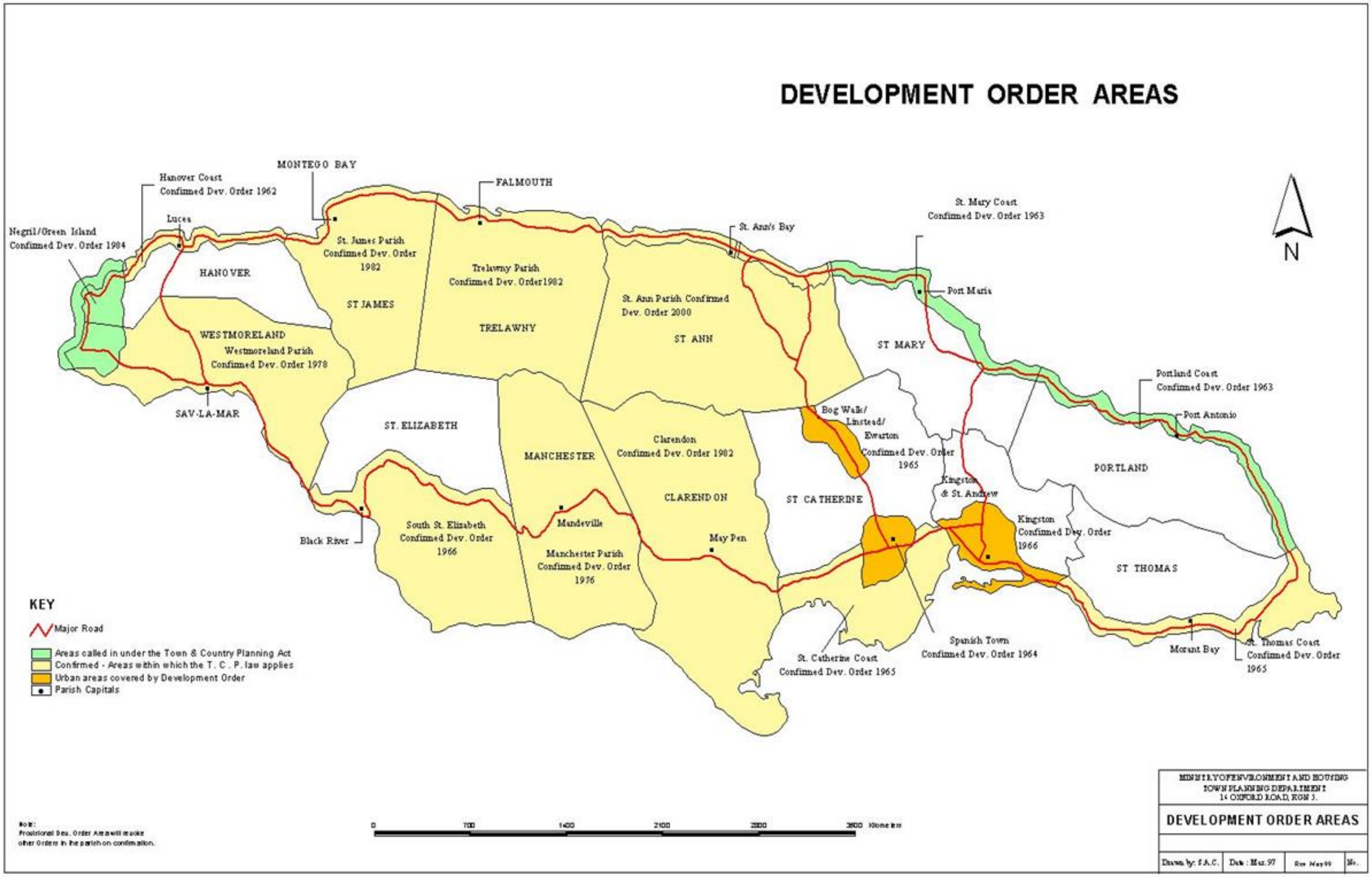
- To guard lands of significant mineral wealth against encroachment by other uses or development which would prevent their exploitation.
- To guard against all forms of pollution resulting from mining activities.

It is stated that the parish is rich in mineral deposits such as Bauxite and Whiting, and apart from sand, gravel and aggregates used in the local construction industry, other minerals are virtually untapped. Because such activities can have positive and negative effects on the development of the parish it is important that proper guidance and monitoring be carried out. Policies specific to Minerals and relevant to this project include:

- Policy M 3 Mining and quarrying plans should be submitted to the appropriate authorities before mining or quarrying commences.
- Policy M 5 All mined out lands are to be restored to a level satisfactory to the planning authorities and be properly re-vegetated.
- Policy M 6 Quarries must be located in quarry zones and will not be permitted in anv other location.
- Policy M 8 Plant sites should be located as close as possible to mineral deposits

Specific to the section of the "Undeveloped Coast" from Rio Bueno to Discovery Bay, and within which the project land is located (Figure 4-73), two policies are stipulated (UC 4 and UC 5). The area is said to consist of vegetation of scenic value, and owing the predominant limestone out-crop, the type of vegetation existing would have established itself over a period of many years and would take a long time to be re-established if destroyed. The following policies are listed:

- Policy UC 4 Only those forms of development which will not result in any significant alteration to the existing topography or any reduction in significant stands of vegetation will be permitted.
- Policy UC 5 No development will be allowed in these wooded areas which would adversely affect the homogeneity or integrity of these areas.



Source: National Environment and Planning Agency (http://www.nepa.gov.jm/symposia_03/Laws/Maps/Map_of_Development_Orders.htm)

Figure 2-1 Development Order Areas in Jamaica

2.2.1.2 Parish Councils Act 1901 (Amended 2007)

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

2.2.1.3 Local Improvement Act 1944

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

2.2.1.4 Land Acquisition Act 1947

The Land Acquisition Act was passed in 1947. As stipulated under Section 3 of this Act, any officer authorized by the Minister may enter and survey land in any locality that may be needed for any public purpose. This may also involve:

- Digging or boring into the sub-soil;
- Cutting down and clearing away any standing crop, fence, bush or woodland;
- Carrying out other acts necessary to ascertain that the land is suitable for the required purpose.

2.2.1.5 Land Development and Utilization Act 1966

This act specifies conditions pertaining to the development and utilization of land, dispossession of owners or occupiers and the Land Development and Utilization Commission as it pertains to agricultural and unused land. The Land Development and Utilisation Act is administered by the National Environment and Planning Agency.

2.2.1.6 Registration of Titles Act 1989

The Registration of Titles Act was passed in 1989 and speaks to the legalities associated with land registration in Jamaica.

2.2.1.7 Quarries Control Act 1983

The Quarries Control Act is administered by the Mines and Geology Division. It regulates the extraction of material such as sand, marl, gypsum, and limestone for construction purposes. Quarry zones and licenses, quarry tax, enforcement, safety, Quarry Advisory Committee, fines for illicit quarrying and bonds for restoration are addressed in this act.

Under this act, the Quarries Advisory Committee, which advises the Minister on general policy relating to quarries as well as on applications for licenses, was established. On the recommendation of the Quarries Advisory Committee, the Minister may declare an area in which quarry zones are to be established and establish quarry zones within any such specified area. A license is required for establishing or operating a quarry, unless the Minister decides to waive this requirement based on the volume of material to be extracted (if the mineral to be extracted is less than 100 cubic metres, a license may not be required).

2.2.1.8 Petroleum and Oil Fuel (Landing & Storage) Act 1925

This extends to the storage of petroleum in quantities greater than one hundred and twenty imperial gallons in a building specially appointed for this purpose by the Minister.

2.2.1.9 The Office of Disaster Preparedness and Emergency Management Act 1998

This Act was established by the Office of Disaster Preparedness and Emergency Management (ODPEM) to develop and implement policy and programmes to achieve and maintain an appropriate state of national and sectoral preparedness for coping with emergency situations.

2.2.2 Environmental Conservation

2.2.2.1 Protected Areas System Master Plan: Jamaica 2013 – 2017

The Protected Areas System Master Plan (PASMP) sets out guidelines for establishing and managing a comprehensive system of protected areas that supports national development by contributing to long-term ecological viability; maintaining ecological processes and systems; and protecting the country's natural and cultural heritage (National Environment and Planning Agency, n.d.). The PASMP is consistent with several national policies and plans, including the Policy for Jamaica's System of Protected Areas 1997 (section 2.2.2.2), the National Strategy and Action Plan on Biological Diversity in Jamaica (2003) and Vision 2030 Jamaica: National Development Plan (2009) (section 2.3.1). It is also a requirement under the Convention for Biological Diversity's (CBD's) Programme of Work for Protected Areas (PoWPA).

Existing protected area categories in Jamaica are listed in Table 2-1, Table 2-2 and Table 2-3. The NRCA/NEPA is responsible for areas declared/designated under the acts it administers, including the Natural Resources Conservation Authority Acts and Wild Life Protection and (Sections 2.2.2.2 and 2.2.2.4 respectively). In addition, a number of other government entities (such as the Forestry Department, Fisheries Division and Jamaica National Heritage Trust), local management entities, non-governmental entities, private sector and individuals are outlined as important role players as well. Indeed, responsibility for protected area management has been a shared endeavour and this collaborative approach to protected area management will continue under the PASMP (National Environment and Planning Agency, n.d.).

Table 2-1 Existing categories of protected areas in Jamaica (January 2012) - protected area system categories

Source: (National Environment and Planning Agency, n.d.)

CATEGORY	RESPONSIBLE AGENCY	LAW
Protected Area	Forestry Department: Water, Land, Environment and Climate Change (MWLECC)	Forest Act, 1996 and Forest Regulations
	National Environment and Planning Agency: MWLECC	NRCA Act, 1991
	NEPA: MWLECC	Beach Control Act, 1956

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

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

Source: (National Environment and Planning Agency, n.d.)

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

Table 2-3 Existing categories of protected areas in Jamaica (January 2012) - international designations

Source: (National Environment and Planning Agency, n.d.)

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

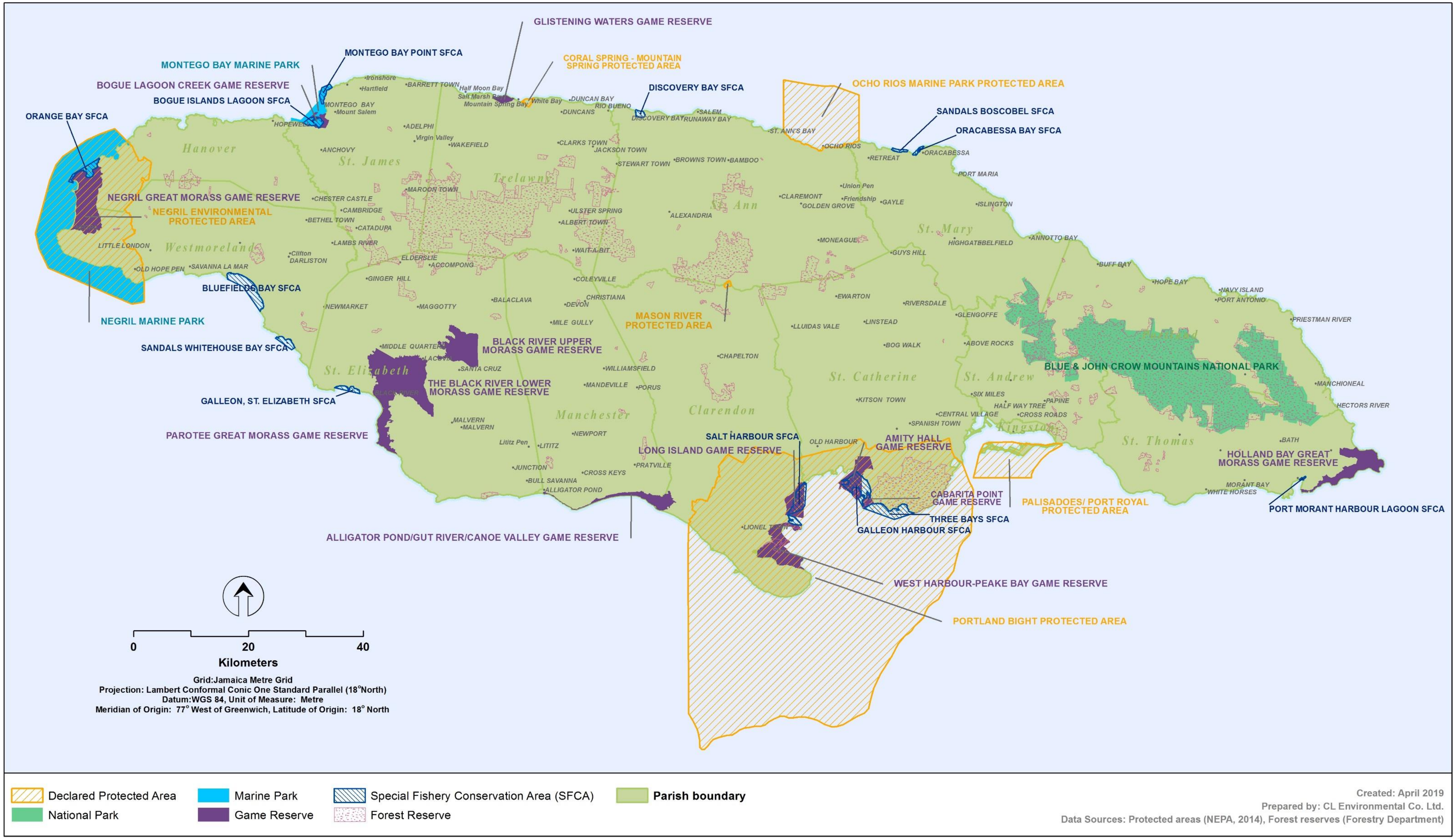


Figure 2-2 Protected areas system in Jamaica (excluding designations under the Jamaica National Heritage Trust and proposed protected areas not yet declared)

2.2.2.2 Policy for the National System of Protected Areas 1997

This legislative instrument is a White Paper and essentially proposes a comprehensive protected areas system for Jamaica. Six types of protected areas are proposed in order to encompass the diverse natural resources and landscape, and are comparable to those of the IUCN (International Union for Conservation of Nature) [2]:

1) National Nature Reserve/Wilderness Area (Equivalent to IUCN Category I)
2) National Park, Marine Park (Equivalent to IUCN Category II).
3) Natural Landmark/National Monument (Equivalent to IUCN Category III)
4) Habitat/Species Management Area (Equivalent to IUCN Category IV)
5) National Protected Landscape, or Seascape (Equivalent to IUCN Category V)
6) Managed Resource Protected Area (Equivalent to IUCN Category VI)

2.2.2.3 Natural Resources Conservation Authority Act 1991

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

The Act also gave power of enforcement of a number of environmental laws to the NRCA, namely the *Beach Control Act*, *Watershed Act* and the *Wild Life Protection Act*, as well as a number of regulations and orders including:

- *The Natural Resources (Permit and Licences) Regulations 1996 and* (Amendment) Regulations *2015;*
- *Natural Resources (National Parks) Regulations 1993 and (Amendment) Regulations 2003;*
- *The Natural Resources (Marine Parks) Regulations 1992, (Amendment) Regulations 2003,* and *(Amendment) Regulations, 2015;* and
- *The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order 1996* and *(Amendment) Order 2015.*

<u>The Natural Resources Conservation (Permit and Licences) Regulations 1996 and (Amendment) Regulations 2015</u>

A permit and licencing system was established under these regulations in order to control the undertaking of any new construction or development of a prescribed nature in Jamaica and the

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

handling of sewage or trade effluent and poisonous or harmful substances discharged into the environment.

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

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

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

The Wild Life Protection Act of 1945 is mainly concerned with the protection of specified faunal species and is the only statute in Jamaica specifically designated to this. This Act protects several rare and endangered faunal species and the Wild Life Protection (Amendment of Second and Third Schedules) Regulations 2016 provides substitutions for the Second and Third Schedules of the principal Act which lists these species. For these reasons, biological assessments were included as part of the biological surveys (section 1.1). Please see Sections 6.0 and 7.0 for further detail regarding potential impacts mitigation measures recommended to ensure compliance with respective legislation.

The establishment of two types of protected areas, namely Game Sanctuaries and Game Reserves is authorized under this Act. There are no game reserves or sanctuaries falling within the study area.

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

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

- First schedule: Endangered Species threatened with extinction and which may be affected by trade therein
- Second schedule: Species which could become extinct or which have to be effectively controlled

- Third schedule: Species which any contracting party regulates within its own jurisdiction for the purpose of preventing or restricting over-exploitation and require the cooperation of other parties for the control of trade in such species
- Fourth schedule: Species in Jamaica the trade of which is to be controlled to prevent or restrict exploitation and which require the cooperation of other Parties in the control of trade in such species.

2.2.2.6 Water Resources Act 1995

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

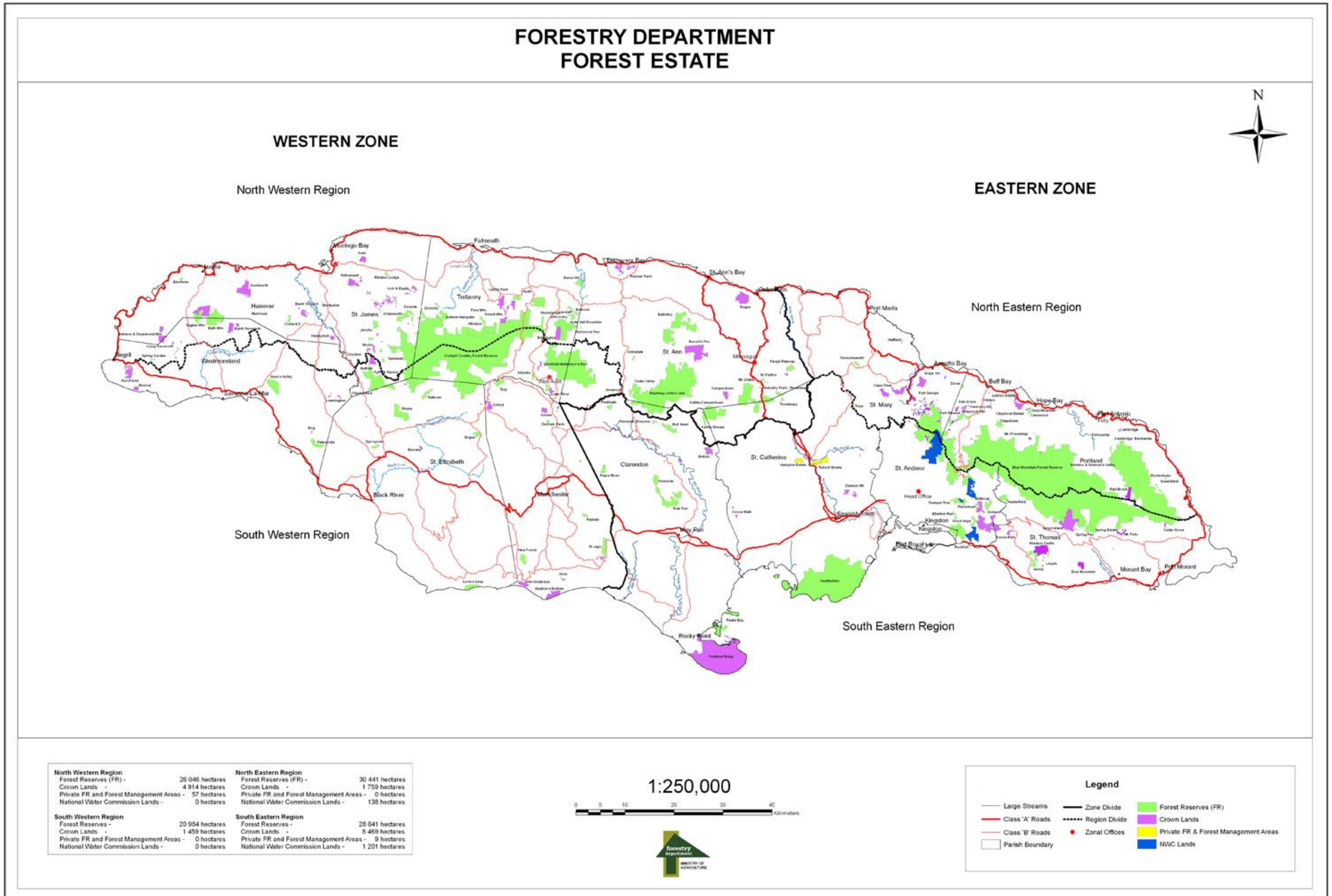
2.2.2.7 The Forest Act 1996

The 1996 Forest Act repealed the 1937 legislation and was the legal basis for the organization and functioning of the Forestry Department. The Forestry Department is the lead agency responsible for the management and conservation of the forest resources in Jamaica. A "Forest Reserve" is defined to be any area of land declared by or under this Act to be a forest reserve. In 1938, the Forest Branch gazetted some 78,800 hectares of Crown Lands as forest reserves, this making up more than 75% of the present-day forest reserves (Figure 2-3).

2.2.2.8 The Jamaica National Heritage Trust Act 1985

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

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



Source: Forestry Department (http://www.forestry.gov.jm/images/res250k_bg.jpg)

Figure 2-3 Map showing forest estates across the island, including reserves, crowned lands, private areas and NWC lands

2.2.3 Public Health & Waste Management

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

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

According to the Natural Resources Conservation Authority (Air Quality) Regulations, 2006:

> "significant impact", in relation to the impacts of sources on ambient air quality, means –:
>
> (a) the increment in the predicted average concentration of sulphur dioxide (SO_2), total suspended particulates (TSP), particulate matter less than ten microns (PM_{10}) or nitrogen dioxide (NO_2) is greater than an annual average of 20 μg/m^3 or a 24-hour average concentration of 80 μg/m^3; or
>
> (b) the increment in the predicted average concentration of CO is greater than 500 μg/m^3 as an 8-hour average or 2000 μg/m^3 as a 1-hour average.
>
> when such predictions are made using an approved air dispersion model.

Table 2-4 summarizes the Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations (GC).

Table 2-4 Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations (GC) for air quality

Pollutant	Avg. Period	Jamaican NAAQS or GC (μg/m^3)	Significant Impact Concentration (μg/m^3)
PM_{10}	24-hr	150	80
	Annual	50	20
TSP	24-hr	150	
	Annual	60	
NO_2	1-hr	400	
	24-hr	N/A	80
	Annual	100	20
SO_2	1-hr	700	
	24-hr	280	80
	Annual	60	20
CO	1-hr	40000	2000
	8-hr	10000	500
1,3 Butadiene	1-hr	0.04	
Acetaldehyde	1-hr	1250	
	24-hr	500	
Acrolein	1-hr	58.75	
	24-hr	23.5	
Benzene	Annual	1	
Benzo (a) pyrene	1-hr	0.00275	
	24-hr	0.0011	

Pollutant	Avg. Period	Jamaican NAAQS or GC (µg/m³)	Significant Impact Concentration (µg/m³)
Carbon Tetrachloride	1-hr	6	
	24-hr	2.4	
Chloroform	1-hr	1250	
	24-hr	500	
Ethylene Dibromide	1-hr	7.5	
	24-hr	3	
Formaldehyde	1-hr	162.5	
	24-hr	65	
Methylene Chloride	1-hr	550	
	24-hr	220	
Styrene	1-hr	2500	
	24-hr	1000	
Xylenes	1-hr	5750	
	24-hr	2300	
Vinyl Chloride	24-hr	1	
	Annual	0.2	
Arsenic	1-hr	0.75	
	24-hr	0.3	
Beryllium	Annual	0.0013	
Cadmium	1-hr	5	
	24-hr	2	
Chromium	1-hr	3.75	
	24-hr	1.5	
Cobalt	24-hr	0.12	
Copper	1-hr	125	
	24-hr	50	
Lead	1-month	N/A	
	3-month	2	
Manganese	Annual	119	
Mercury	1-hr	5	
	24-hr	2	
Nickel	1-hr	5	
	24-hr	2	
Selenium	24-hr	25	
	Annual	10	
Zinc	24-hr	12	

National standards for $PM_{2.5}$ do not exist; the U.S. Environmental Protection Agency standards are used for $PM_{2.5}$ and are as follows:

- 24-hour $PM_{2.5}$ = 35 µg/m³
- Annual $PM_{2.5}$ = 12 µg/m³

Further information regarding air quality compliance may be found in sections 4.1.5 (Existing Environment), 6.0 and 7.0 (Impacts and Mitigation).

2.2.3.2 The Clean Air Act 1964

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

2.2.3.3 Noise Abatement Act 1997

The Noise Abatement Act of 1997 was created in order to regulate noise caused by amplified sound and other specified equipment. This act has been said to address “some concerns but is too narrow in scope and relies on a subjective criterion” (McTavish). Given this, McTavish conducted a study to recommend wider and more objective criteria in accordance with international trends and standards, but tailored to Jamaica’s conditions and culture.

National guidelines (NEPA) used for noise levels are shown in Table 2-5; values for commercial, industrial and residential areas are specified.

Table 2-5 NEPA guidelines for daytime and night time noise in various zones

ZONE	NEPA Daytime Guideline (dBA)	NEPA Night Time Guideline (dBA)
Commercial	65	60
Industrial	75	70
Residential	55	50

Noise surveys and modelling undertaken for this project are presented in sections 4.1.7, 6.1.1.3 and 6.2.1.2. Mitigation measures recommended to comply with the existing standards are found in section7.1.1.1 and 7.1.2.1.

2.2.3.4 Water Quality Standards

The NRCA has primary responsibility for control of water pollution in Jamaica. National Standards for industrial and sewage discharge into rivers and streams, in addition to standards for ambient freshwater exist. For drinking water, World Health Organisation (WHO) Standards are utilized and these are regulated by the National Water Commission (NWC). Since 1996, Jamaica has had draft regulations governing the quality of the effluent discharged from facilities to public sewers and surface water systems. The now gazetted Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013 guidelines require various facilities to meet certain basic water quality standards for sewage effluent and trade effluent discharge (Table 2-6 and Table 2-7).

Due to the fact that the proposed project environs is composed of the marine environment and riverine systems (Rio Bueno River), the Draft National Ambient Marine Water Quality Standards, 2009 and Draft National Ambient Freshwater Quality Standards, 2009 are also referenced (Table 2-8 and Table 2-9 respectively).

Further information regarding water quality may be found in section 4.1.6. Section 6.0 and 7.0 also describes potential impacts and recommended mitigation measures to ensure compliance with respective legislation.

Table 2-6 Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013, Various Sewage Effluent Standards

Source: National Environment and Planning Agency (NEPA)

THE NATURAL RESOURCES CONSERVATION AUTHORITY ACT

THE NATURAL RESOURCES CONSERVATION AUTHORITY (WASTEWATER AND SLUDGE) REGULATIONS, 2013

Sewage and Trade Effluent Standards

Effluent Standards

Table 1—*Sewage Effluent Standards for Existing Plants*

PARAMETER	EFFLUENT LIMIT
BOD_5	20 mg/L
TSS	30 mg/L
Nitrates (as Nitrogen)	30 mg/L
Phospates	10 mg/L
COD	100 mg/L
pH	6-9 pH units
Faecal Coliform	1000 MPN/100 ml.
Residual Chlorine	1.5 mg/L

Table 2—*Sewage Effluent Standards for Plants other than Existing Plants*

PARAMETER	EFFLUENT LIMIT
BOD_5	20 mg/L
TSS	30 mg/L
Total Nitrogen	10 mg/L
Phosphates (PO_4-P)	4 mg/L
COD	100 mg/L
pH	6-9 pH
Faecal Coliform	1000 MPN/100 ml.
Residual Chlorine	1.5 mg/L
Floatables	not visible

Table 4—*Standards for Sewage Effluent to be used for Irrigation*

PARAMETER	STANDARD LIMIT
Oil and Grease	10 mg/L
Total Suspended Solids (TSS)	1.5 mg/L
Residual Chlorine	0.5 mg/L
Biochemical Oxygen Demand (BOD_5)	15 mg/L
Chemical Oxygen Demand (COD)	<100 mg/L
Faecal Coliform	12 MPN/100ml.

Table 2-7 Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013, Trade Effluent Standards

Source: National Environment and Planning Agency (NEPA)

Table 3—*Trade Effluent Standards*

PARAMETER	TRADE EFFLUENT LIMIT
Ammonia/ammonium measured as NH_4	1.0 mg/L
Barium	5.0 mg/L
Beryllium	0.5 mg/L
Biological oxygen demand (BOD)	<30 mg/L
Boron	5.0 mg/L
Calcium	No standard
Chemical Oxygen Demand (COD)	<100mg/L or <0.01 kg/1000 kg product
Chloride	300 mg/L
Colour	100 TCU
Cyanide (free)	0.1 mg/L
Cyanide (Total as CN)	0.2 mg/L
Detergent	15 mg/L
Dissolved oxygen (DO)	>4mg/L
Faecal Coliform	<100 MPN/100 ml
Fluoride	3.0 mg/L
Iron	3.0 mg/L
Magnesium	No standard
Manganese	1.0 mg/L
Nitrate as NO_3	10 mg/L
Oil and Grease	10 mg/L or < 0.01 kg/1000 kg product
PH	6.5 - 8.5
Phenols	0.1 mg/L
Phosphate as PO_4	5 mg/L
Sodium	100 mg/L
Sulphate	250 mg/L
Sulphide	0.2 mg/L
Temperature	±2° of ambient
Total Coliform	<500 MPN/100 ml
Total Dissolved Solids (TDS)	1000 mg/L
Total Organic Carbon (TOC)	100 mg/L
Total Suspended Solids (TSS) (maximum monthly average)	50 mg/L
Total Suspended Solids (TSS) maximum daily average	<150mg/L

PARAMETER	TRADE EFFLUENT LIMIT
Trace Metals:	
Zinc	1.5 mg/L
Lead	0.1 mg/L
Cadmium	0.1 mg/L
Arsenic	0.5 mg/L
Chromium	1.0 mg/L
Copper	0.1 mg/L
Mercury	0.02 mg/L
Nickel	1.0 mg/L
Selenium	0.5 mg/L
Silver	0.1 mg/L
Tin	No standard
Total Heavy Metals	2.0 mg/L

Table 2-8 Draft national ambient marine water quality standards for Jamaica, 2009

Source: National Environment and Planning Agency (NEPA)

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

*Reactive phosphorus as P
**Nitrates as Nitrogen

Table 2-9 Draft national ambient freshwater water quality standards for Jamaica, 2009

Source: National Environment and Planning Agency (NEPA)

Parameter	Measured as	Standard Range	Unit
Calcium	**(Ca)**	**40.0-101.0**	**mg/L**
Chloride	**(Cl^-)**	**5.0- 20.0**	**mg/L**
Magnesium	**(Mg^{2+})**	**3.6- 27.0**	**mg/L**
Nitrate	**(NO_3^-)**	**0.1- 7.5**	**mg/L**
Phosphate	**(PO_4^{3-})**	**0.01 - 0.8**	**mg/L**
Potassium	**(K^+)**	**0.74- 5.0**	**mg/L**
Silica	**(SiO_2)**	**5.0- 39.0**	**mg/L**
Sodium	**(Na^+)**	**4.5- 12.0**	**mg/L**
Sulfate	**(SO_4^{2-})**	**3.0- 10.0**	**mg/L**
Hardness	**($CaCO_3$)**	**127.0-381.0**	**mg/L (as $CaCO_3$**
Biochemical Oxygen Demand	**(O)**	**0.8- 1.7**	**mg/L**
Total Dissolved Solids		**120.0-300**	**mg/L**
pH		**7.00- 8.40**	
Conductivity		**150.0-600**	**µS/cm**

2.2.3.5 Public Health Act 1985

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

- No individual or organisation 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 organisation 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.

2.2.3.6 The National Solid Waste Management Authority Act 2001

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

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

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

2.2.3.8 Country Fires Act 1942

Under the Country Fires Act of 1942, the setting of fire to trash without prior notice being given to the nearest police station and the occupiers of all adjoining lands is prohibited. In addition, a space of at least fifteen feet in width must be cleared around all trash to be burnt and all inflammable material removed from the area. Section 6 of the Act empowers the Minister to prohibit, as may be necessary, the setting of fire to trash without a permit.

2.2.3.9 Factories Act 1961

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

2.3 REGIONAL AND INTERNATIONAL LEGISLATIVE AND REGULATORY CONSIDERATIONS

2.3.1 United Nations Convention on Biological Diversity

Signed by 150 government leaders at the 1992 Rio Earth Summit, the Convention on Biological Diversity (CBD) is committed to promoting sustainable development. The CBD is regarded as a means of translating the principles of Agenda 21 into reality and recognizes that "biological diversity is about more than plants, animals and microorganisms and their ecosystems – it is about people and our need for food security, medicines, fresh air and water, shelter, and a clean and healthy environment in which to live".

Jamaica became a party to the CBD on April 6, 1995. Jamaica's Green Paper Number 3/01, 'Towards a National Strategy and Action Plan on Biological Diversity in Jamaica', is evidence of Jamaica's continuing commitment to its obligations as a signatory to the Convention.

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

CITES generally seeks to protect endangered plants and animals and owing to the cross boundary nature of animals and plants. This protection requires international cooperation. It aims to ensure that international trade of wild animal and plant species does not threaten the survival of the species in the wild, and it accords varying degrees of protection to over 35,000 species.

This convention was drafted in 1963 at a meeting of members of the International Union for Conservation of Nature (IUCN) and finalised in 1973. After being opened for signatures in 1973, CITES entered into force on 1 July 1975. Jamaica became a Party to CITES on June 22, 1997. In 2000, Jamaica enacted domestic legislation, the Endangered Species (Protection, Conservation and Regulation of Trade) Act, 2000 and Regulations to fulfil its obligations to CITES. The Management Authority for CITES in Jamaica is the Natural Resources Conservation Authority (NRCA). The Authority receives applications for permits and certificates to trade internationally in endangered species. The processing of applications is coordinated with the local Scientific Authority.

3.0 DESCRIPTION OF THE PROPOSED PROJECT

3.1 BACKGROUND

3.1.1 Project History

Previous mining operations conducted on the project property by Jose Cartellone Civiles S.A. yielded material that was used for the construction of The Queens Highway leg of the North Coast Highway from Montego Bay to St. Ann's Bay. Though not suitable for wearing course applications, the road base and fill applications requires strong, resistant material for the road type that was constructed. With its use in construction already illustrated, the proponent seeks to further extract material from this area for applications within this area and other value-added applications. Due to its high calcium carbonate composition, this deposit has far greater value than mere aggregate usage. This realization has stimulated the proponents, Jamaica World Mining, to further pursue a quarry licenses for its extraction.

Continental Placer Inc. was engaged to prepare a Geology and Site Evaluation report for the property. In 2009 a drilling programme was completed by them which qualified and quantified the limestone deposit on the entire property. Subsequently, in April of 2015 a project summary was submitted. From their evaluation the total volume of limestone reserves (proven, probable and possible) on the 2,303,740 m^2 (569.2 acres) property was 335,300,000 tons. A further possible reserve of 126,000,000 tons was also projected. These figures were obtained from seven (7) boreholes that were done on the property. Physical and chemical analysis was conducted on samples taken from the area by Atlantic Testing Laboratories found the material favorable for aggregate applications as well as a 96.1% $CaCO_3$ content. The latter places the material in suitable category for pharmaceutical applications in all the South East United States. Further work being conducted on the resource will confirm the material's suitability for the above applications and a more detailed tonnage estimate for a 500,000 m^2 area located in the south western corner of the property.

The area proposed for a limestone quarry is based on the extent of limestone deposits, land ownership and the operational feasibility for the area of interest. With the chemical and physical quality of material here found to be amongst the highest for limestone on island, its extraction and utilization for aggregates and value-added applications would be significantly profitable.

3.1.2 Study Area

This site is in the area of Jamaica known as Rio Bueno and the proposed project is located at Bengal, St. Ann, off the north coast Queen's Highway east of Rio Bueno and to the west of Discovery Bay (Figure 1-1, Figure 1-2 and Figure 3-1). The proposed site is situated 4 kilometres from the Trelawny Parish border. The proponent Jamaica World Mining has put forward a quarry application on 50 hectares of land within this area. Table 3-1 delineates the area of interest.

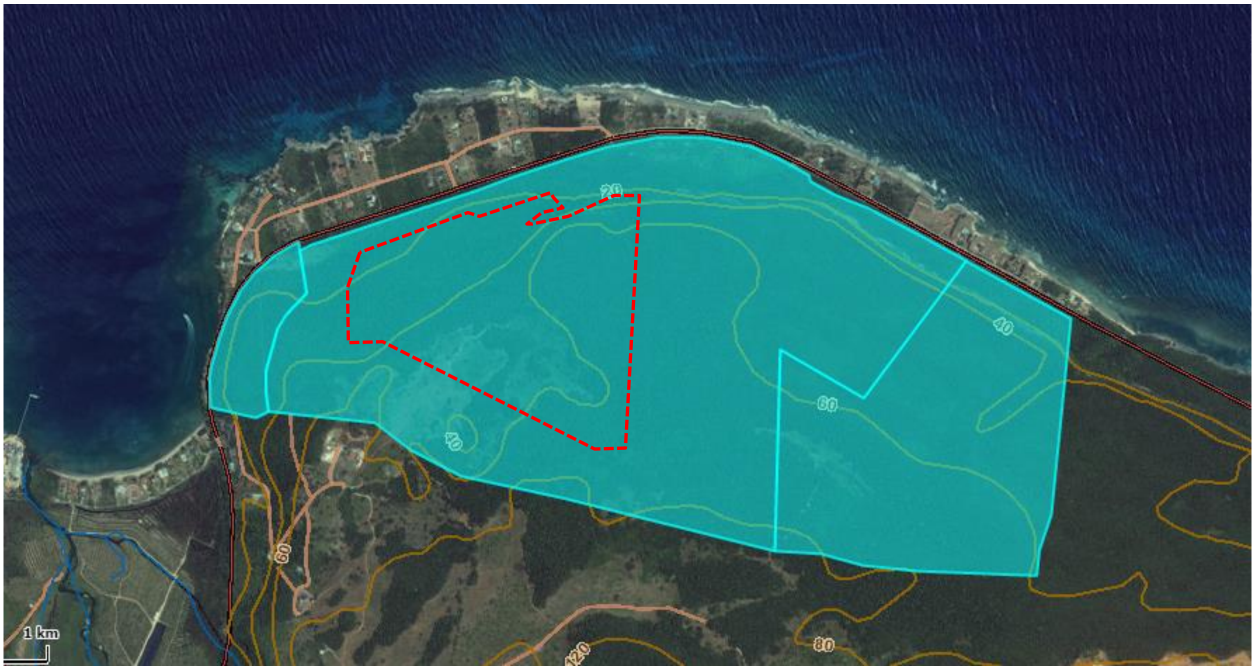


Figure 3-1 Map showing property location and proposed quarry site. Red polygon identifies the proposed quarry area (Source: NLA, iMap Jamaica)

Table 3-1 GPS Coordinates for the field area

BOUNDARY	COORDINATES
North	18°28'33.08"N 77°26'38.57"W
South	18°28'09.86"N 77°26'37.91"W
East	18°28'15.88"N 77°26'26.41"W
West	18°28'23.06"N 77°27'53.10"W

Table 3-2 Proprietor land reference information

Valuation Number:	01406016002
Volume & Folio:	1431/627
Address:	Bengal & Red Valley, Discovery Bay, St. Ann, Jamaica
Approximate Area (m^2):	2303740

Aerial photos (Plate 3-1 - Plate 3-6) as well as a composite orthorectified drone image of the project area (Figure 3-2) show the project site from various angles.

Plate 3-1 Drone picture looking from the east showing Disturbed Northern boundary sub-area (taken February 21, 2017)

Plate 3-2 Drone picture looking from the east showing Disturbed Northern boundary sub-area (taken February 21, 2017)

Plate 3-3 Drone picture looking from the east showing Disturbed Northern boundary sub-area (taken February 21, 2017)

Plate 3-4 Drone picture looking from the west showing Disturbed Northern boundary sub-area (taken February 21, 2017)

Plate 3-5 Drone picture looking from the west showing Disturbed Northern boundary sub-area (taken February 21, 2017)

Plate 3-6 Drone picture looking from the west, looking at the main entrance showing Disturbed Northern boundary sub-area (taken February 21, 2017)

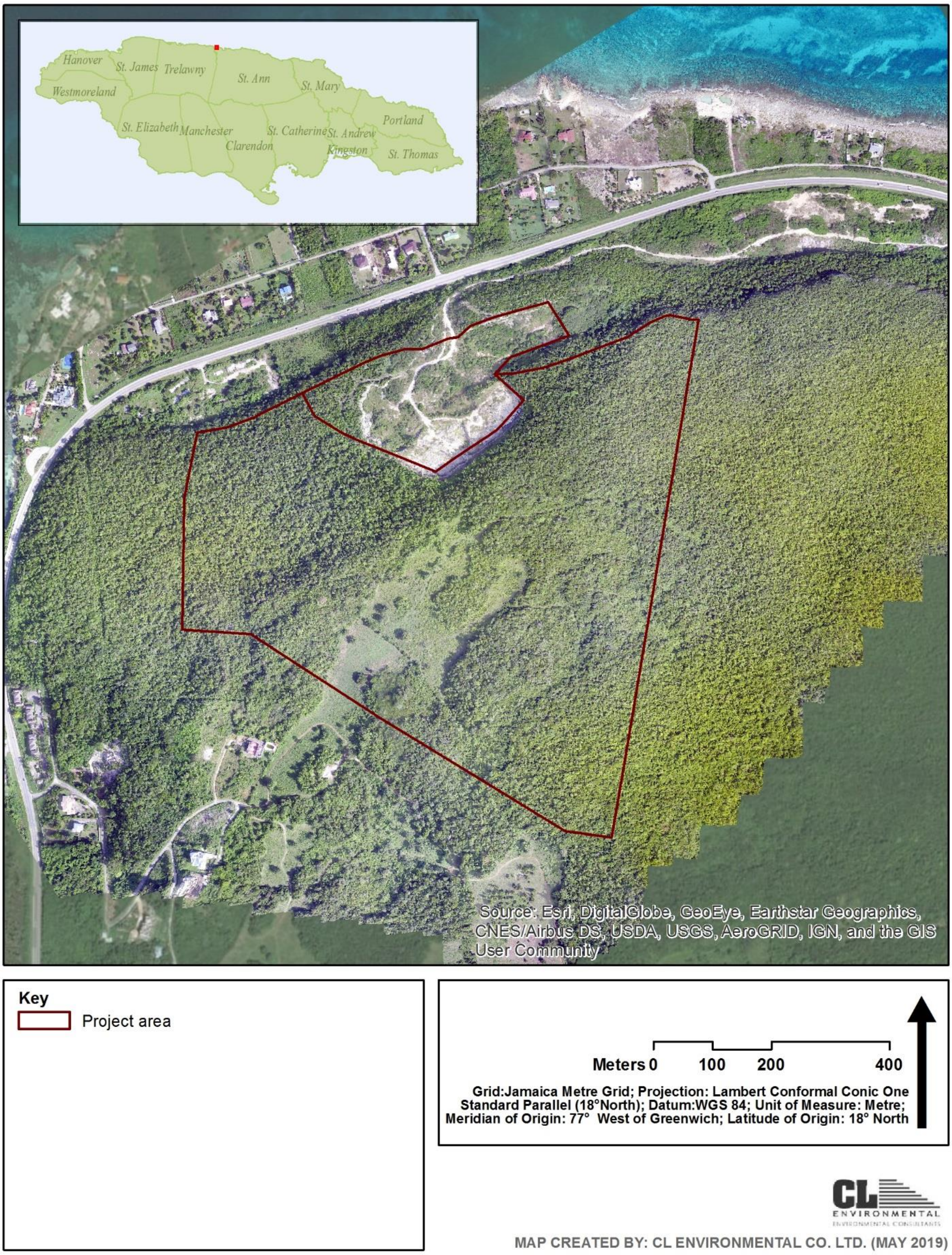


Figure 3-2 Orthorectified drone image of study area (taken October 13, 2016)

3.1.3 Summary of Proposed Operations

Rio Bueno will be an open-pit quarry with trucks and loading equipment. The proposed production fleet consists of two pieces of quarry loading equipment and three trucks and two yard loaders. This equipment will feed a fixed plant, producing crushed stone, sand, and fines products. Material will be washed using fresh water from a pump established on site, with process water ponds established to minimize runoff, water will be re-used in the plant.

Site access from the North Coast Highway is proposed to be placed east of the previous site access used by the previous quarry operators. This was arrived at following discussions with the National Works Agency (NWA). With the development of the new site access, noise exposure to the public will be minimized with plant operations being screened naturally by the regrowth of shrubs and trees. Truck traffic exposure will also be minimized by the new site access. The location of the entrance along the section of the roadway allows for improved sight distance.

A 50-hectare block was the area applied for the establishment of a quarry operation. The area is further divided into three blocks, allowing for extraction moving south east extracting 2 million tonnes per annum. Extraction will occur with the objective's rehabilitation goals as one of the primary objectives. The slope angles to be achieved will ensure for future development plans for the proponent, Jamaica World Mining. Upon phased completion, reclamation for that phase will be completed, in conjunction with starting a new phase.

The initial phase (Phase I) is the pit development of the quarry based on expected zoning, property limits, buffers, and reclamation areas and the subsequent mining. During this phase the old plant site area on the north side of the property (along Queens Highway) will be rehabilitated. The new entrance will be in use, and the plant will be set up in the designated area. Mining will begin in the already exposed pit moving south ward. The already exposed pit will provide a suitable area for storage of the overburden removed, which will be used during the reclamation of the mined area.

The first and final phases covers a 15-hectare block and will extract approximately 11.295 million tonnes (yield tons are 7.9M with the 30% loss), which results in a duration of approximately 6 years for each Phase at an average output of 2M tonnes of per year. The second phase will produce a higher yield as it is a larger area for extraction. Located on 20 hectares the mined tonnage is calculated to be approximately 15M tonnes that should last for approximately 8 years. The quarry life is calculated to be 20 years but suspected to be more should the property be mined to sea level.

Potable and process water will be trucked to the site, with electricity to be taken from the Jamaica Public Service Company grid serving the area. Solid waste generated from the quarry operators will be collected and taken by a private solid waste contractor when required and taken to the approved municipal dump site located at Tobalski or Hadden sites. No solid waste will be generated from quarrying, as all materials displaced during quarrying will either be sold or stored for reuse during rehabilitation of mined areas.

3.2 PROJECT COMPONENTS

3.2.1 Project Layout and Facilities

Figure 3-3 illustrates the general layout of the facilities on site. Figure 3-4 illustrates the engineered drainage layout plan for the quarry programme with sedimentation ponds and drainage canals for surface water runoff, facilities and crushing areas depicted. The sediment ponds used for storm water will be constructed in areas where the topography is conducive to water collection. The fixed assets and facilities shall be located on the base of each completed quarry phase. As this surface would have been already rehabilitated this is the best proposed location for equipment.

3.2.1.1 Drainage System

The drainage system includes:

- **West Canal & East Canal**
  Surface drainage system for areas outside the quarry area. The system prevents water coming from outside to enter the interior of the quarry.
- **West Pond & East Pond**
  These are for water storage system for water coming from West Canal and East Canal. The system restores water to its natural course downstream.
- **West Drainage Canal & East Drainage Canal**
  Surface drainage system for area inside the quarry.
- **West Sedimentation Pond & East Sedimentation Pond**
  These are designed for water storage system for water coming from West Drainage Canal and East Drainage Canal. The system takes control of the sediments and water flow keeping out from working areas.
- **East Sedimentation Pond N45**
  The Auxiliary Pond in the drainage system, not for storage but for energy dissipation of the water coming from N55 quarry area.
- **East Sedimentation Pond N35**
  The Auxiliary Pond in the drainage system not for storage but also for energy dissipation of the water coming from N45 quarry area.
- **East Sedimentation Pond N45 and East Sedimentation Pond N35**

The Auxiliary Ponds in the drainage system are for storage but also for energy dissipation of the water coming from N45 and N55 quarry areas (Figure 3-5 and Figure 3-6).

There are no apparent river or gullies or surface drainage on the proposed project site. Karst systems in the surrounding area however, are very vulnerable to ground water pollution due to the relatively rapid rate of water flow and the lack of a natural filtration system. Water quality monitoring in the form of sediment traps and coastal water quality/sediment plumes monitoring should be done during the mining activities. This is discussed in further detail in 4.1.3.

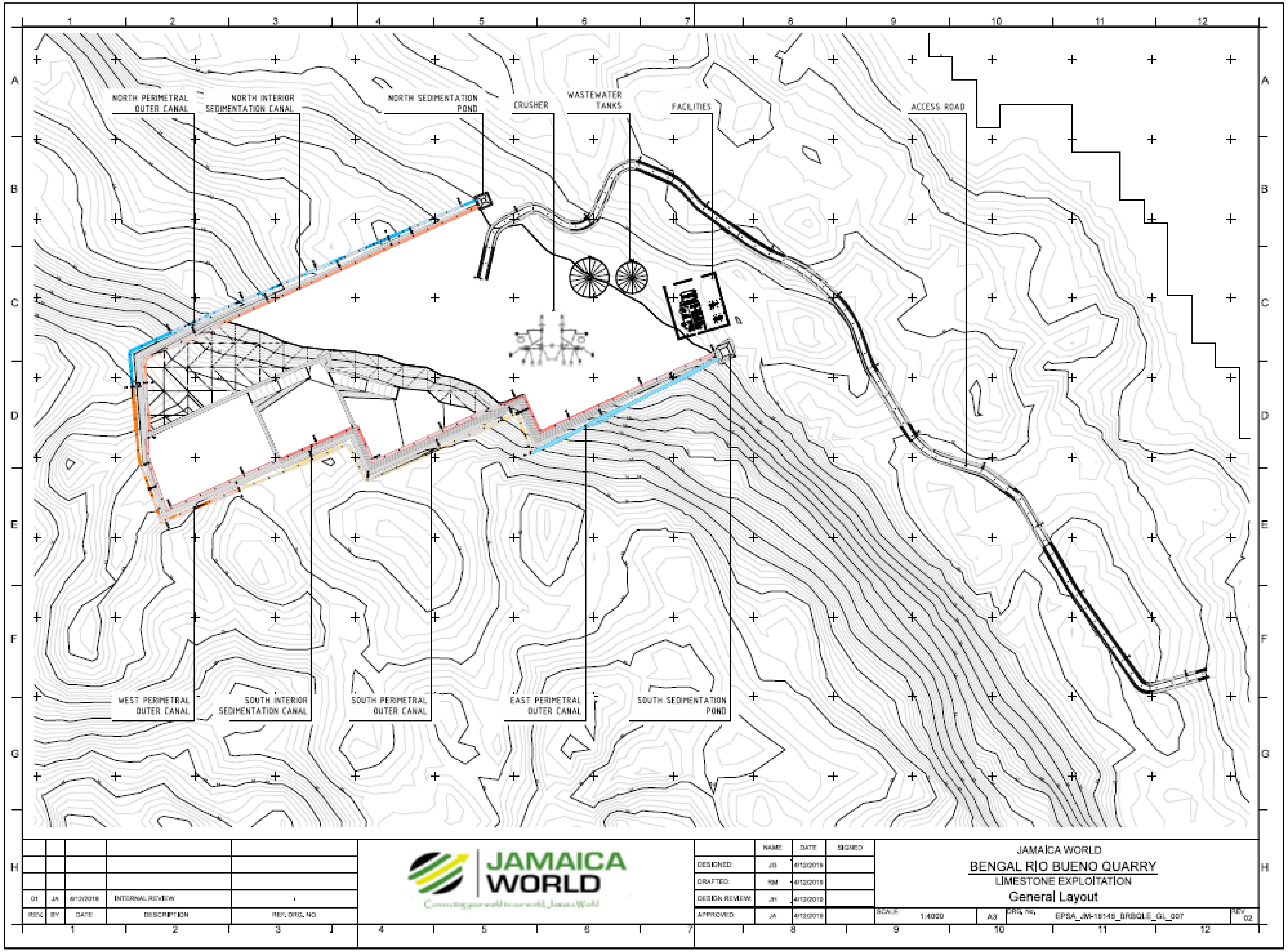


Figure 3-3 General Layout of quarrying facilities on site

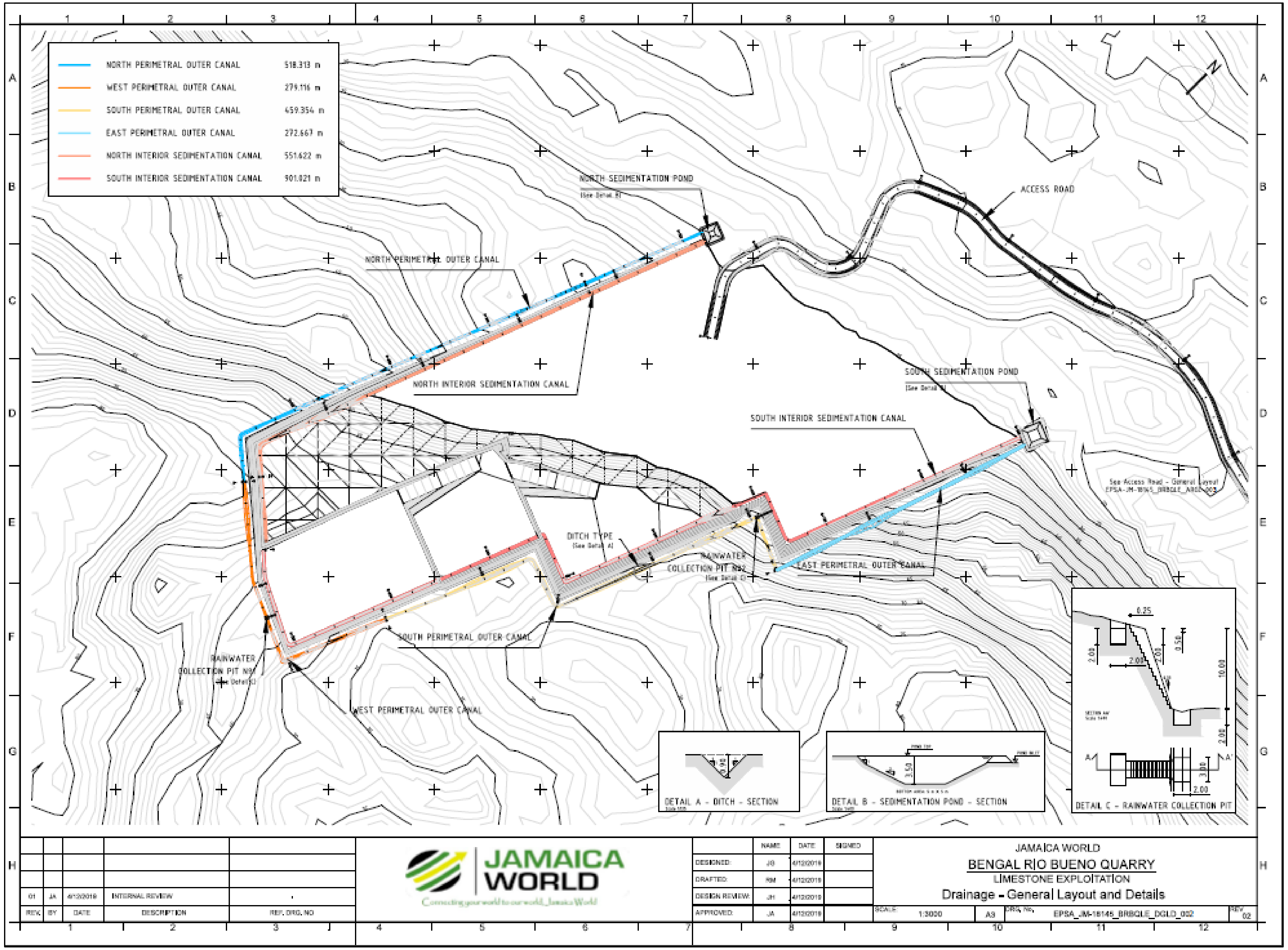


Figure 3-4 Drainage Layout for quarrying facility

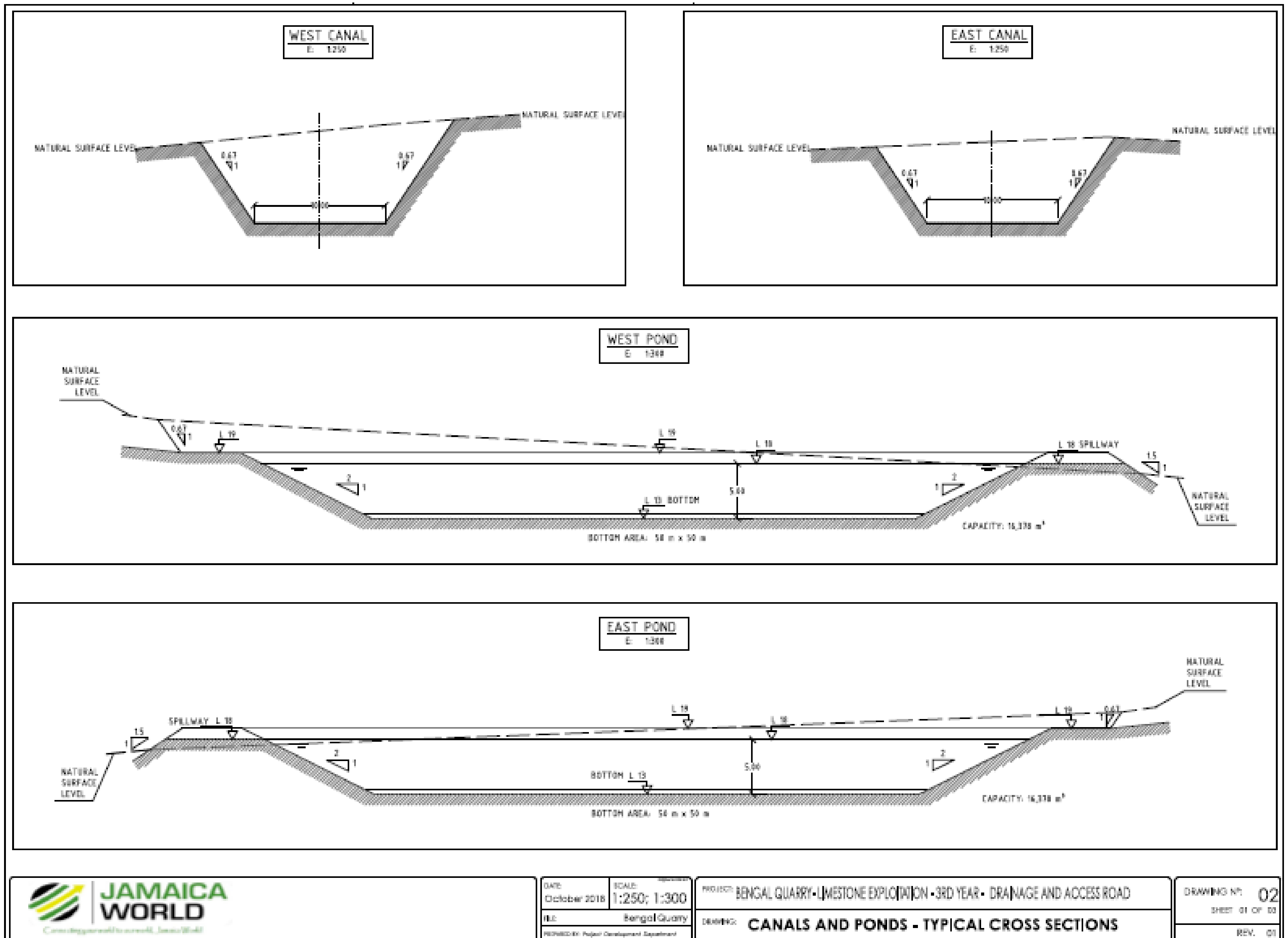


Figure 3-5 Sizes and dimensions of the sedimentation ponds and the drainage canals

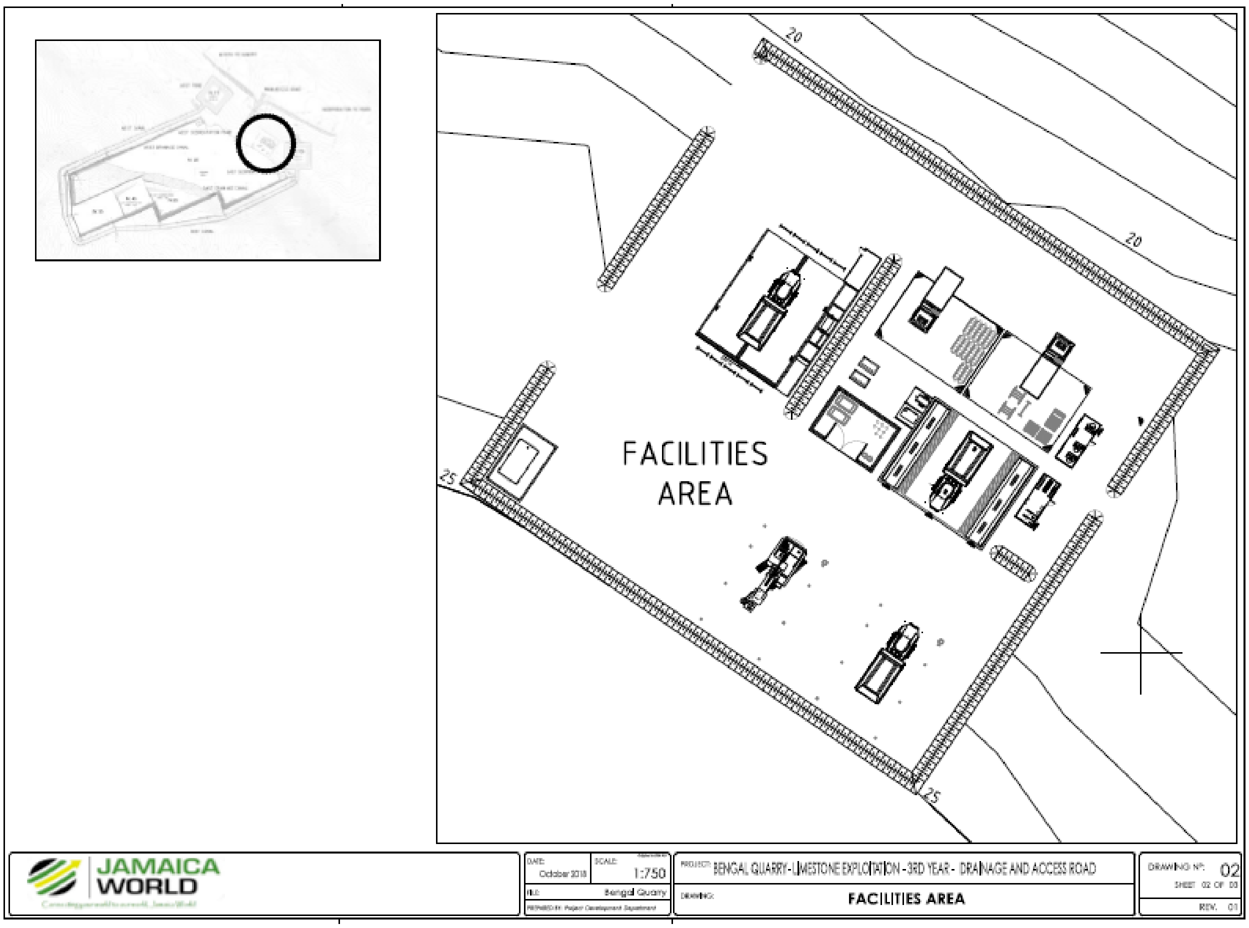


Figure 3-6 Facilities area intended for Contractor's facilities (workshop, offices and parking area).

3.2.1.2 Processing Plant

The plant is a nominal 250 tph unit consisting of the following units:

- Hopper and vibrating grizzle
- Primary impactor
- Secondary impactor
- Primary vibrating screen
- Secondary vibrating screen
- Reclaiming screen
- Conveyors

3.2.1.3 Water Supply

Water supply for the quarrying operations will be done by trucking water to storage tanks onsite. A large capacity water tank or multiple smaller tanks will be set up at each crusher and secured in proximity to the operating site. Water will be purchased and trucked to the proposed quarry location at regular intervals. A 150,000-gallon (567,811.768 litres) water storage tank would be installed on property within each crushing area (Figure 3-10). Additionally, a water truck, with a tank of an approximate capacity of 20,000 litres will be used to wet the area to control the dust in the working areas and haulage roads. This will be a scheduled part of the daily operations. The water tank truck will load water directly from the runoff ponds or from the large storage water tank.

3.2.1.4 Wastewater Treatment

Wastewater Generation and Characteristics

The daily wastewater volumes expected from the quarry was estimated using the typical wastewater flow rates from commercial sources as outlined in Table 3-2 of the Metcalf & Eddy 4th edition. The daily wastewater was estimated to be between 5,700 and 13,000 litres per day. The average value of 7,500 litres/day will be utilized for the design (Table 3-3).

Table 3-3 Estimated wastewater generation rate

Parameters	Value			Units
	Low	Average	High	
Employee population	100	100	100	persons
Per Capita flow rate	57	75	130	L/person/day
Total Flow	5,700	7,500	13,000	L/day

It anticipated the wastewater quality will be that of a domestic influent given the activities that will take place on the site. The developer manual's suggested influent profile for use is outlined Table 3-4.

Table 3-4 Developer manual's suggested influent wastewater profile

Parameter	Raw sewage	NEPA Std. (water direct discharge)
Total Suspended Solids (TSS) [mg/l]	220	20
Chemical Oxygen Demand (COD) [mg/l]	500	100
Biochemical Oxygen Demand (BOD5) [mg/l]	250	20
Total Nitrogen [mg/l]	40	10
Total Phosphorus [mg/l]	8	4
Total Coliform Bacteria [MPN/100ml]	10^7 – 10^8	200

Process Modelling and Treatment

The proposed processes for the wastewater effluent from the Quarry are as follows:

1. Grease trap (if kitchen facilities are contemplated)
2. Septic Tank
3. Evapotranspiration Bed

GREASE TRAP

Grease Traps are an essential component in the treatment process of wastewater. The purpose of the grease trap is to prevent the oil and grease conveyed from the kitchen facilities from getting into the wastewater treatment system, where it will limit the effectiveness of the system. In essence, the grease trap is a pre-treatment component that allows for the initial separation of solids, fats and grease; it then contains them in a small holding area and thus prevents these types of wastes from entering the main treatment system.

The main design considerations in modelling the grease trap is the flow rate coming into the system and the retention time of the effluent within the grease trap. The minimum retention time of 45 minutes (.75 hours) was utilized in design (Table 3-5). A fairly long retention time is needed in grease traps for the obvious reason that fats and oils take time to cool down and separate; the longer the time provided the more effective this process becomes.

Table 3-5 Grease trap calculation summary

Parameter	Value	Unit
Daily Flow	7500.0	L/day
Peaking factor	1.5	
Peak Flow	0.5	m^3/hr
Retention time	45	Minutes
FOGinf *	50	mg/l
Output, Size of Grease Trap:		
Minimum required Wet Well Volume	0.4	m3
Effluent (to wastewater system)		
FOGeff	25	mg/l
Removal efficiency	50%	

** Typical grease concentration for domestic kitchens*

SEPTIC TANK

The septic tank was designed with a three-day retention time to ensure that it can sufficiently treat the influent on high flow days (Table 3-6) (Figure 3-7). The removal efficiencies at the higher end of the septic tank range were utilized given the extended period of three days. The NEPA discharge standards cannot however be met at the end of septic tank treatment process as it only effects secondary treatment.

Table 3-6 Septic tank sizing

Parameter	Value	Unit
Septic Tank Design Parameters:		
Flow	7500	L/day
	1974	USGPD
Retention time	3	D
Per Capita sludge production	10.5	GPY
Cleaning Interval	1	Yrs
Required Tank Geometry:		
Sludge holding capacity	1052.6	USG
Treatment Capacity	5921	USG
Tank Volume Required	6974	USG
Effluent Predictions:		
COD	350	mg/l
BOD	138	mg/l

Parameter	Value	Unit
TSS	88	mg/l
Total Nitrogen	40	mg/l
Phosphates-P	8	mg/l
Faecal Coliform	1916268	per 100ml

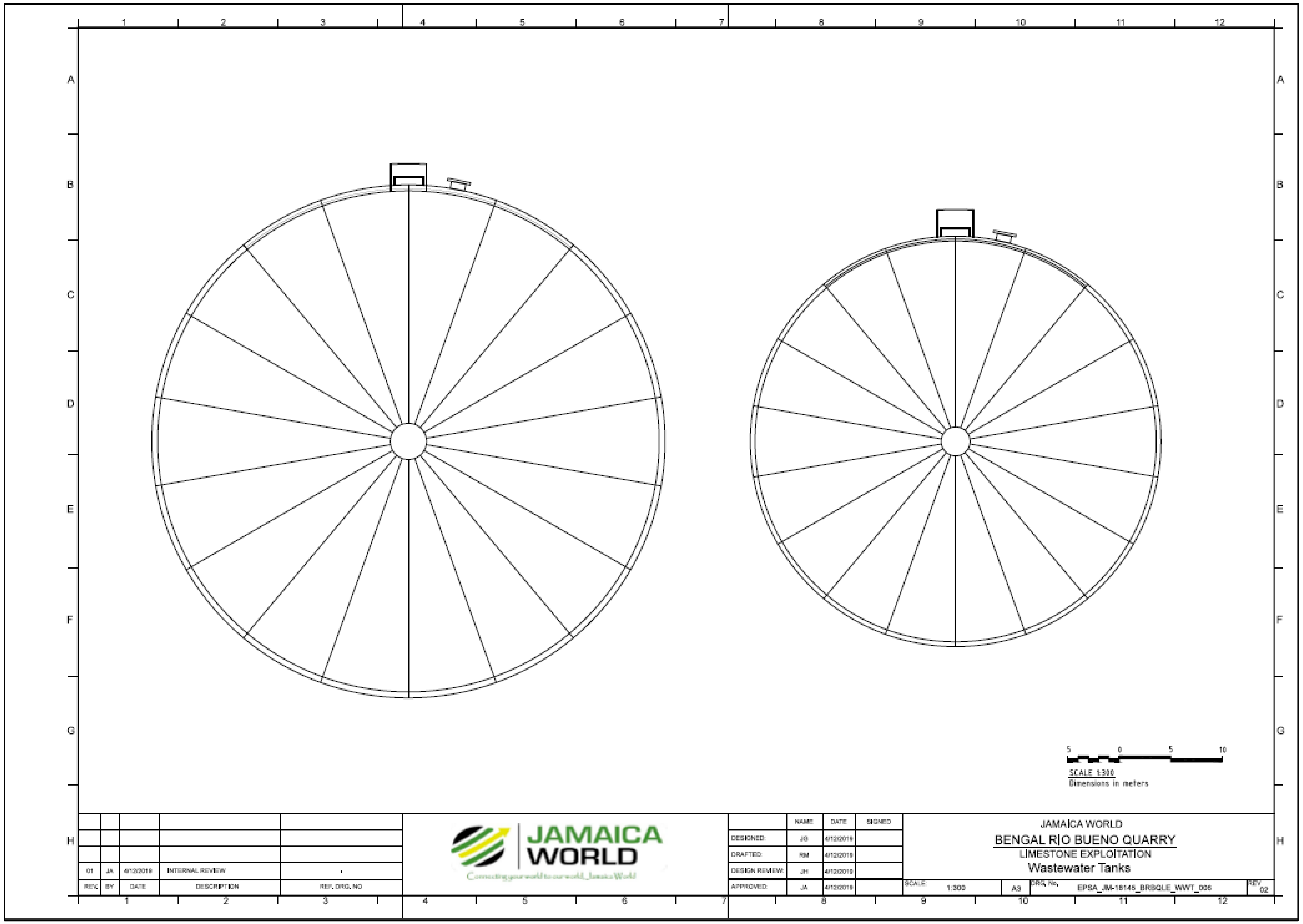


Figure 3-7 Septic Tanks for wastewater treatment

EVAPOTRANSPIRATION BED

The final step in the treatment process is the evapotranspiration bed where the liquid waste is utilized by plants and the excess given off to the atmosphere as vapour. The evapotranspiration system is designed to have no effluent. Influent wastewater is disposed via transpiration through vegetation or evaporation from bed surface (Figure 3-8). The recommended approach to sizing this system is the use of hydraulic balance method which ensures the bed does not overtop in prolonged wet periods when evapotranspiration losses may be lower than inputs from rainfall and effluent load. The minimum area required for the evapotranspiration bed is 2,250 square meters (Table 3-7).

The evapotranspiration bed will have a monitoring well in a corner (Figure 3-8). Sand wicks will be incorporated in the gravel to provide continuous capillary rise in sand. Vegetation will have a deep root zone and leaves will support proper transpiration.

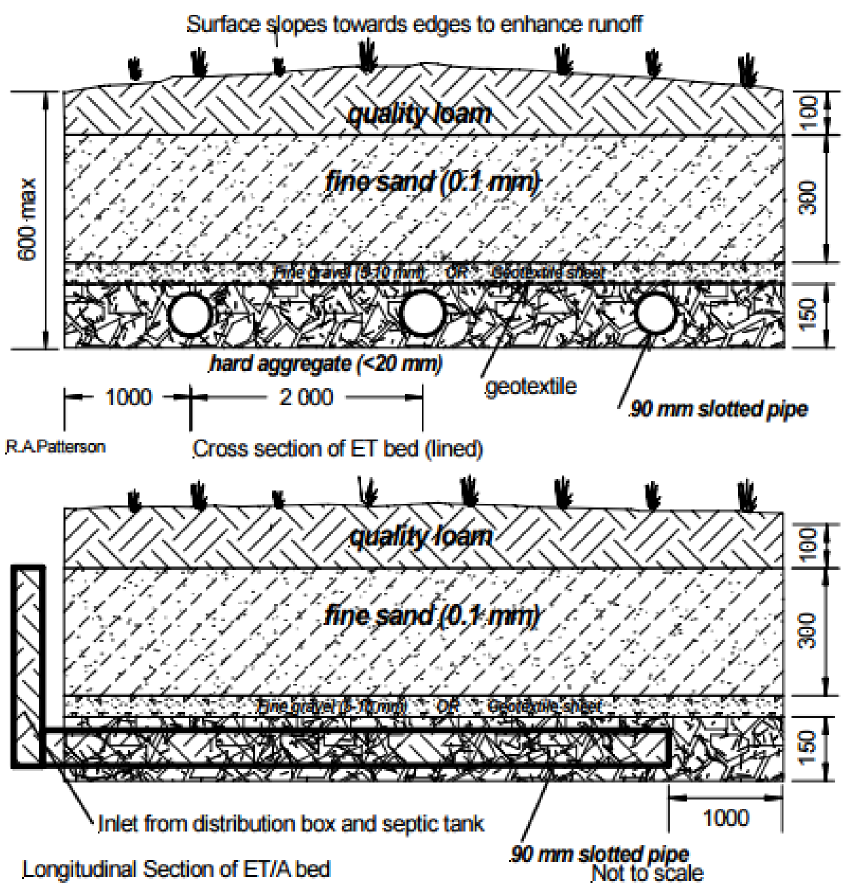


Figure 3-8 Cross and longitudinal section of evapotranspiration bed

Table 3-7 Summary calculations for hydraulic balance and sizing of the evapotranspiration bed

Month:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Inflow	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	L/d
Bed Parameters													
Void Ratio	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
Pan Evaporation - E_0	126	124	152	158	171	184	188	182	154	143	125	122	mm/month
Precipitation - P	132	86	40	87	99	67	58	65	111	118	199	189	mm/month
Crop Evapotranspiration - ET_0	107.1	105.4	129.2	134.3	145.35	156.4	159.8	154.7	130.9	121.55	106.25	103.7	
Cr	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	
Cf	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
Bed Dimensions													
Length	45	45	45	45	45	45	45	45	45	45	45	45	m
Width	50	50	50	50	50	50	50	50	50	50	50	50	m
Area	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	m2
Water balance													
Total Input	233	210	233	225	233	225	233	233	225	233	225	233	m3
Total Output	241	237	291	302	327	352	360	348	295	273	239	233	m3
FOS	4%	13%	25%	34%	41%	56%	55%	50%	31%	18%	6%	0%	

3.2.1.5 Aggregate Storage

Stockpiling will be performed using loaders and trucks. After the stacking conveyors on the crushing plant stockpiles the aggregate, loaders are then used to load trucks which will transport the material to the stockpile area. The loads shall be spot dumped and placed in the stockpile by the loader. There is to be 5 stockpiles for each aggregate type present. These are 1”, ¾”, ½”, 5/8” stones and manufactured sand. The stockpiles for fine aggregates will be covered with tarpaulin along with being sufficiently wetted to reduce material loss to wind.

3.2.1.6 Liquids / Solvents Storage

The storage of liquids/solvent will be done following best practice methods, thereby, eliminating or reducing the adverse environmental impacts between storm water and any liquid / solvent storage tanks (including 55 -gallon drums and any miscellaneous containers). All containers will be stored indoors on elevated areas designed to contain any spills. Additionally, the potential for spills or leaks from any liquid / solvent containers or tanks stored at this facility (solvents will not be regularly used on site), large containers will be placed away from high traffic areas to reduce accidental punctures.

Implementation, inspection and good housekeeping practices in all areas of liquid and solvent storage will be enforced. Indoor storage and coverage of all liquid storage containers will prevent contact with storm water. Drip pans will be provided for all liquid/solvent filling areas or areas where spills or leaks may occur. Pans will be immediately cleaned after use and all containers will be labelled clearly as to their contents. Spill prevention techniques will be employed and used to respond promptly to spillage, thereby minimizing the potential adverse impact. Spill prevention techniques also refer to locating spills, immediately responding by cleaning the area.

3.2.1.7 Fuel Storage

All fuelling on site will be done in areas that are not heavily trafficked. Fuel storage will be done in tanks on the premises on structurally sound platforms away from busy operations. Fuelling operations, maintenance activities and other fuel transfers will occur in this area.

3.2.1.8 Other Facilities Storage Area

Heavy equipment maintenance, damaged equipment storage, parts storage, waste storage and fuel storage along with office facilities, restrooms and washrooms will all be in a common facilities area illustrated in Figure 3-9.

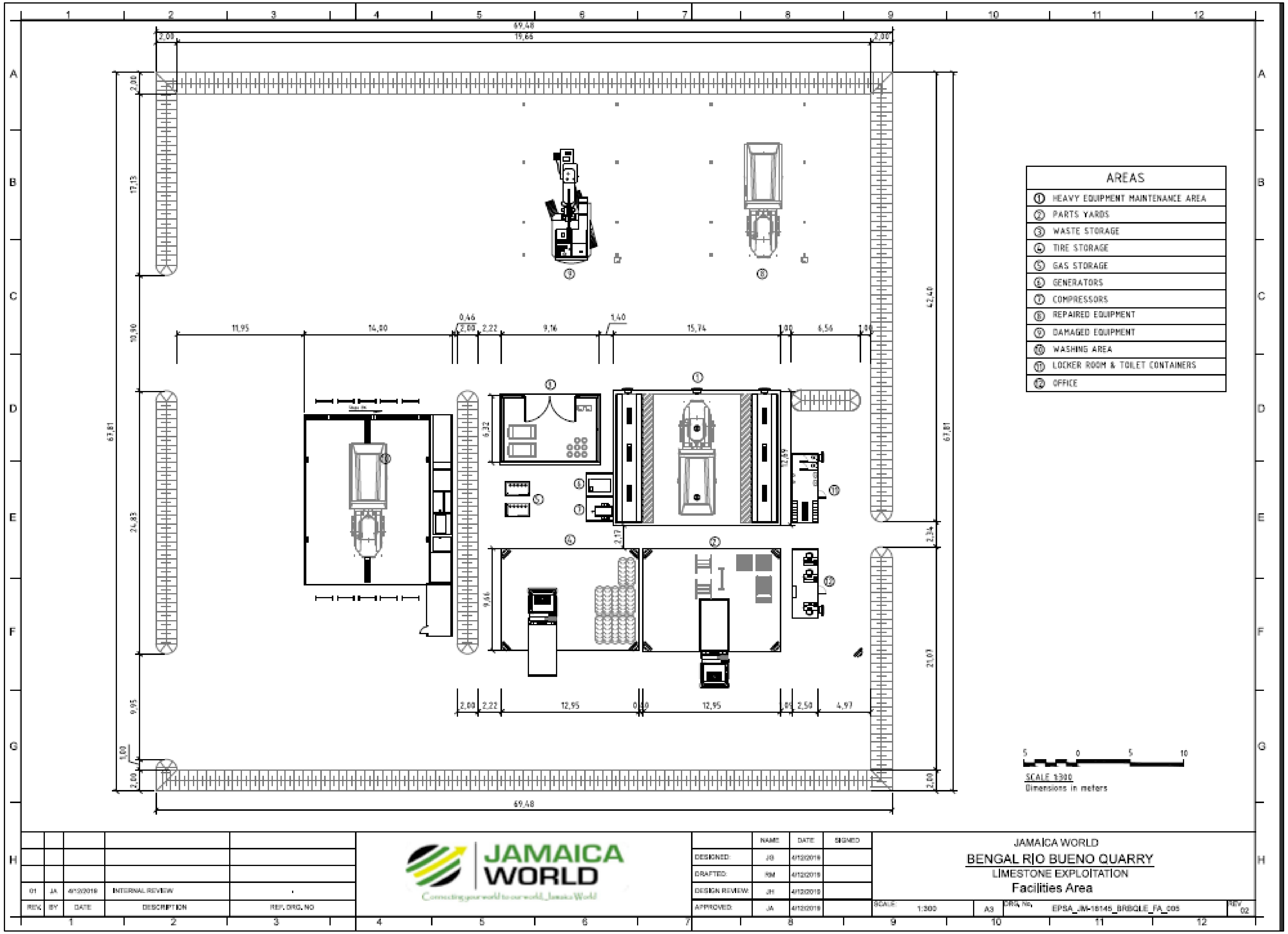


Figure 3-9 Facilities Area

3.2.2 Equipment

The use of a 2 large fixed plant setup capable of crushing 2 million tonnes per annum is the ideal primary operation (Figure 3-11). A mining fleet of Cat 980 Front End Loaders combined with over the road 25t haul trucks will feed this facility. This option requires more initial capital but would have lower operating costs. The crushed rock will then be transported to the port via covered trucks.

Quarrying consists of bench drilling and blasting (by a contractor) and mining the limestone rock. The blasted rock will be mined using front-end loaders (FELs) loading into haulage trucks for removal from the pit. The haul trucks dump into the primary crushers within the crushing area. Using two HST 315 Cone Crushers for primary crushing, the loaded material is processed to produce the required specifications of aggregate at a rate of 350-500 tonnes per hour (tph). Due to the high decibel levels that these machines will produce (95-105 dB), their location inside the designated crushing area away from the main road and surrounding residential areas is necessary. After passing through the primary crusher, the rock is transported by belt to the crushing and screening facilities, resulting in the desired product sizes. The daily mining and processing operations average is approximately 8000 tonnes.

The fixed crushers will be placed in the crushing area illustrated in Figure 3-10 and Figure 3-11.

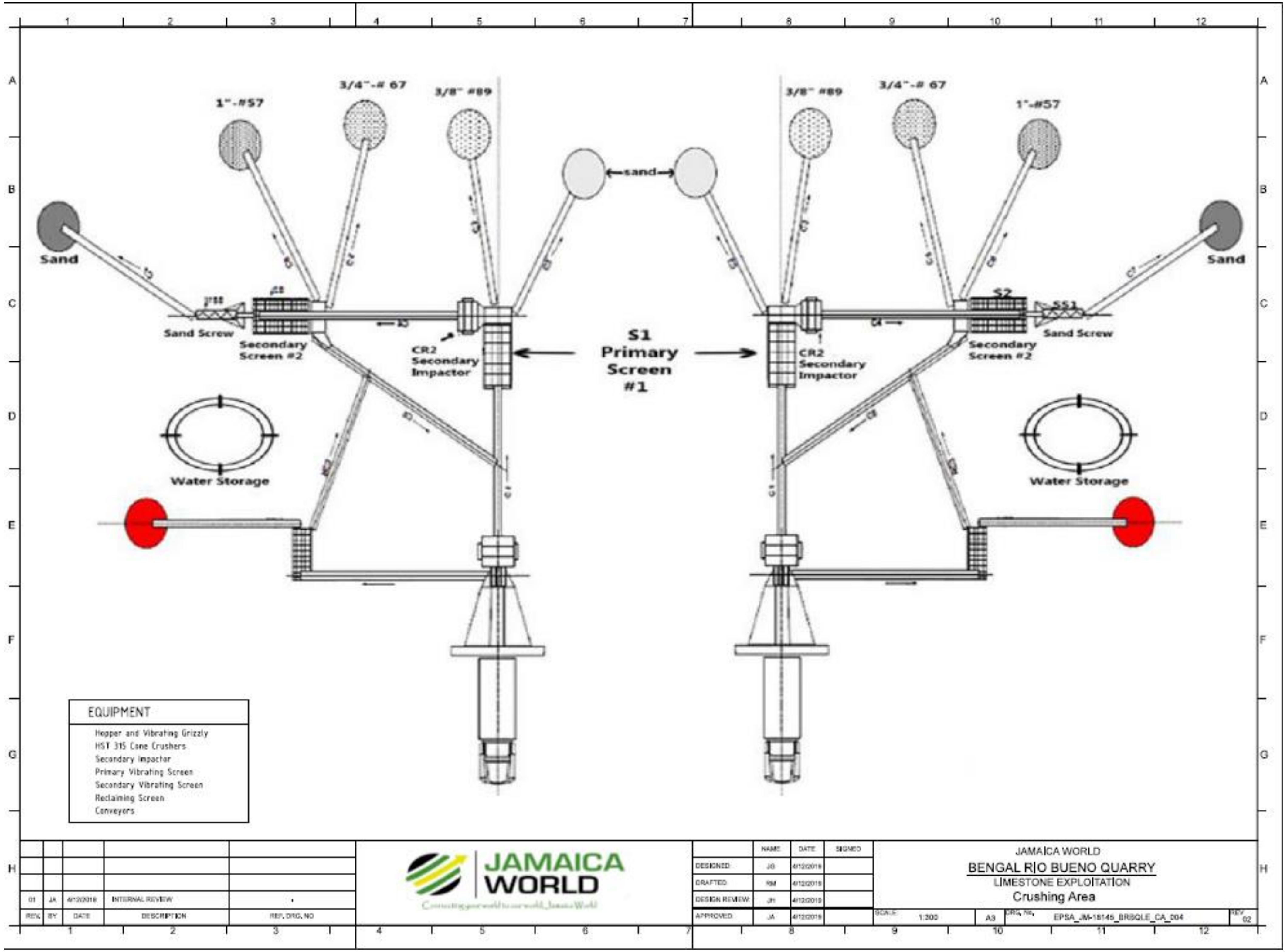


Figure 3-10 Crushing area equipment each with a water storage tank

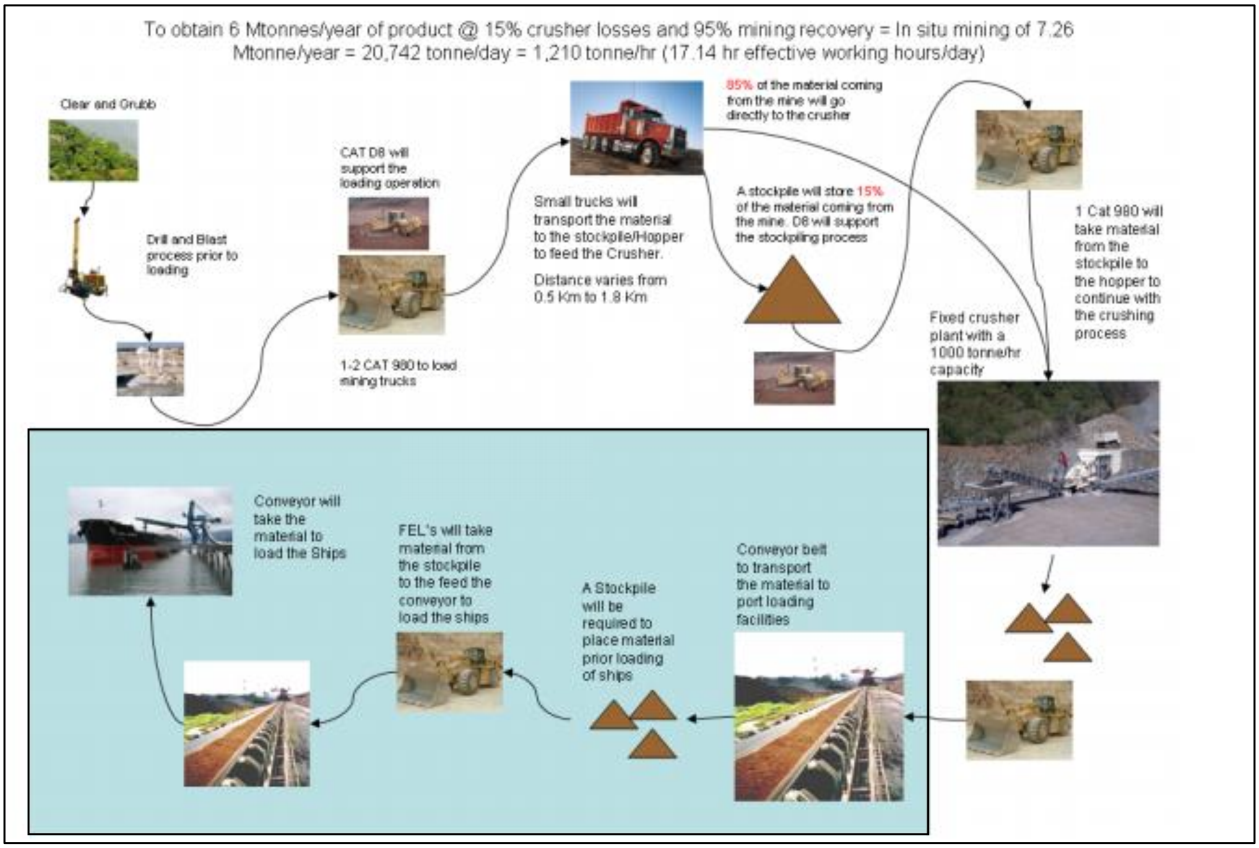


Figure 3-11 Fixed Crushers Scenario

This study is based on a crushing reject level of 15%. In general, mobile crushing equipment working on a road construction job will see this level of reject, as almost the entire product can be used as road base. However, for an export market, it expected that the percentage of rejects could be higher due to the product requirements. A fixed plant option was the basis used for this preliminary proposal cost estimate. It was assumed that the crushing facilities would be in place by the end of the first quarter within the first year of operation.

Equipment selections were based on equipment currently available on the island and equipment utilized in the last quarry application. The main mining fleet included the following:

- Caterpillar D10 track dozer
- Subcontract drill & blast operation
- Caterpillar 980 front end loaders
- Rear dump 25t over the road trucks
- Caterpillar D8 track dozer
- Caterpillar 14 grader

- Caterpillar 988 Wheel Loader
- Fixed crushing plant
- Fixed weigh station

3.2.3 Access to Site

The site is more easily accessed at the north-western section of the property. The site access from the North Coast Highway is proposed to be placed east of the previous site access (Figure 3-12). With the development of the new site access, noise exposure to the public will be minimized as the plant operations will be screened naturally by the re-growth of foliage (trees and shrubs) that will limit the visibility of the quarry operations from the road.

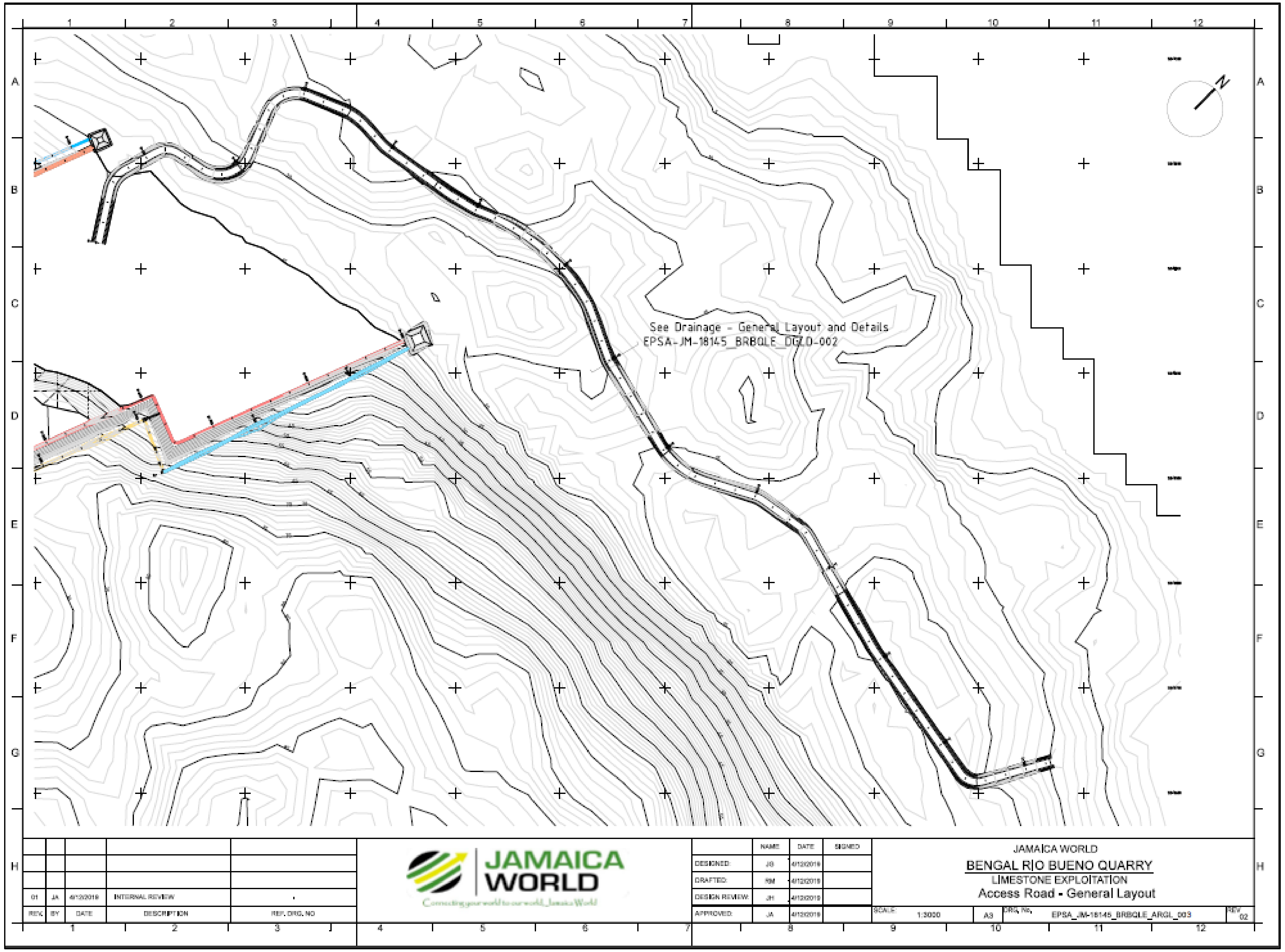


Figure 3-12 Quarry Access road

Truck traffic exposure will also be minimized by the access. The site access is proposed to be located on the end of the gradual curve in the road, allowing for motorists moving in either direction to be able to sight the quarry entrance from distance. East of the proposed quarry access there is approximately 2 km of straight roadway before approaching a right curve (traversing the Queens Highway from east to west). Approaching from the west of the proposed quarry access, there is approximately a 400m gradual, right bend in the roadway before approaching the proposed entrance on the right.

This is a safer ingress and egress point as oncoming traffic will be in clear site of the quarry entrance. Additionally, the proposed entrance is located in an area with less residential development.

Stones extracted from a quarry will be transported to the nearby towns, construction sites and ports. Figure 3-13 shows the haul route from the quarry to the Rio Bueno Port, where potential export will take place from. Naturally, the quarry must be located near to the main network of roads leading to these locations. The proposed site is therefore at an advantageous location when considering transportation and haulage costs. However, ingression and egression from the main thoroughfare has to be considered. This will guide the development of the haulage/haul road.

Figure 3-13 Transportation route from quarry to port (Google Maps, 2018)

With the majority of dust from quarry operation being identified as coming from the road surface the haulage roads maintenance and development need to be addressed when lowering the dust nuisance. The materials used to build the proposed 1 km of haulage road will be river asphalt and river aggregate. This will be amply wetted when haulage of material commences utilizing water trucks.

The main haul road is proposed here to be connected to the northern segment of the project area where the old quarry is situated. This road has already been cut and may be widened to 10 m to facilitate access for high capacity haul trucks from the operating area to the public road network. Additional secondary haulage roads may be developed after blasting to connect the benches to the main haul road. This established route has direct access to the main road to the north and is approximately 450 m in length to the proposed operating area. An additional haulage road may be developed if the operator decides to extract the limestone deposits from the southern section of the area of interest.

With the speed limit of the main thoroughfare (North coast Highway) at 80 km per hour, signs will be needed along with staffing and the installation of traffic control lights (stop lights) for the egress and ingression of vehicular traffic to and from the quarry.

3.2.4 Distribution and Sales

3.2.4.1 Estimate of Potentially Mineable Tonnes

The area proposed for material extraction encompasses 500,000 m^2 to the south west of a 2,303,740 m^2 property. The terrain is hilly, as the entire property is composed of raised reef limestones which support plant species that are indigenous to the dry white-limestone forest. The demarcated area is approximately 70 metres above sea level on average. Its highest point is 85 metres above sea level (recorded in the field at the south-eastern delineated section) and the base of the old quarry face averages at 30 metres above sea level. This results in the thickness of the deposit to be an average of 40 metres.

From borehole data from previous research on the property by Continental Placer Inc. (2009) went to depths of 90 ft. (27 m) for one hole and 120 ft. (36 m) for the other four. From this data the average thickness of hard limestone was 47 ft (12 metres). Extrapolating the borehole data and corroborating these results with the findings from the recently concluded field survey, the thickness of the hard limestone was assumed to be greater than 27 metres. Since the bore holes did not retrieve samples to depths below 36 metres and the old quarry's floor is on average 30 metres above-sea-level (40 metres lower than the average site elevation), the conservative thickness of the deposit was estimated to be 30 metres, with 10 metres of missing material assumed to be rubble limestone of variable hardness with clays and material lost with the overburden removal. This thickness is used when calculating the proven resources for the site.

The estimated total tonnage of limestone raw material is further reduced by 5 % so as to account for losses experienced with cavities that are naturally associated with a limestone deposit and other losses that may be encountered within the bedrock. Using a density value of 2.51 (the lowest value obtained from samples submitted to the Mines and Geology Laboratory in 2018), the tonnage estimate was calculated using the formula;

T=A (avTh x avSg)

Where:
pT= Proven reserve (5% less than the reserve estimate in metric tons)
T= Reserve estimate (metric tons)
A=Area of the Deposit **(500,000 m^2 or 50 hectares)**
avTh= Average Thickness **(30 m)**
avSg=Average Specific gravity of sample **(2.51)**

T= 500,000 x30 x 2.51

T= 37,650,000 metric tons

pT= 35,767,500 metric tons

This is the lowest tonnage value that can be extracted from the deposit using the conservative estimates for thickness and specific gravity. From the resource assessment conducted on the property it was concluded that due to the height difference observed at the base of the quarry a further 20 metres thickness could be easily extracted. This will increase the total mineable tonnage.

3.2.4.2 Planned production rate

The deposit life is projected to be at least 20 years using the conservative estimates. If executed properly, the total life of the deposit can be lengthened to 30 years, should extraction be done to sea level. The 20 year quarry life was calculated based on a production rate of 2 million metric tons per annum. Table 3-8 illustrates the planned production rate based on four different weekly extraction rates. The total reserves would last for approximately 20 years of quarrying and production (with ongoing rehabilitation as the quarry progresses) based on 2 million metric tonnes (796,812.75 m^3) extraction per annum.

With the assumption that the annual quarry production was to be kept at 2 million metric tonnes of limestone for the entire duration of the mining operations, then the reserves would last for the proposed preliminary quarry plan. Provided that a quarry licenses is granted by the Mines and Geology Division, should the extracted tonnage be increased to twice the projected output the expected life would be reduced to approximately 10 years.

Table 3-8 Estimated disposal rate or volume of extracted material for different time scenarios

		Disposal Rates (*weekly amount for 50 weeks)*			
Volumetric Estimates		**For 285 years**	**For 29 years**	**For 19 years**	**For 10 years**
Area (m^2)	500,000				
Tonnage (t)	35,767,500	1,000 m^3	10,000 m^3	15,000 m^3	30,000 m^3
Volume(m^3)	14,250,000				

3.2.4.3 Port Information

The Rio Bueno Harbour and Port is located approximately 1.5 km from the proposed operating site and details are included in Table 3-9. The Rio Bueno Port is the proposed port to be used for export of quarry material. The port facility at Discovery Bay is not mentioned because it is a bauxite export point. Alumina and other contaminants will render the $CaCO_3$ useless for value added applications.

Table 3-9 Port details for the Port of Rio Bueno

PORT ATTRIBUTES	PORT DETAILS
Port Name	Port of Rio Bueno
Maximum size & Anchorage Depth	Up to 152 m; 23.2m and over
Cargo Pier Depth	7.1m - 9.1m
Harbour size, type, shelter	Very Small, Coastal, Natural, Poor
Lift & Cranes	100+ ton lift, fixed cranes
Pilotage	Yes, available
Loading & Unloading	Wharves, Med. Moor, anchor

3.2.5 Workforce

3.2.5.1 The Quarry Operator

It is the duty of the proponent that all extraction is conducted in conjunction with the stipulated government requirements. Therefore, to ensure this operation proceed within these guidelines, the proponent has engaged in dialogue with different companies employ the services of one that has the competencies, track record and expertise in reclamation of quarries after the mining operation is completed. Most recently, the proponent has been in dialogue with ESPA, a company with over 50 years of experience in the mining industry. They operate primarily in the following sectors:

Mining:

- Metal
- Coal
- Quarries

Civil Works:

- Mining civil works
- Linear works (Motorways and Railways),
- Hydraulic Works
- Other Infrastructures projects

"In EPSA we recognize that our activities cause impact so a priority issue for us is to carefully manage the processes before, during and after our involvement in a project. Our efforts are geared towards careful protection of the environment and responsible use of resources".

3.2.5.2 Employees

The proposed workforce for the quarry operation is between 50-100 personnel. This includes, quarry managers, truck drivers, machinery operators, maintenance workers, office attendants, secretaries, accountants, procurement officers and security guards.

3.3 PHASED ACTIVITIES

3.3.1 Conceptual Mining Plan and Process

When in operation, Rio Bueno Quarry will mine and produce aggregates from deposits located on-site. The deposit contains a relatively homogeneous limestone quality. It is dense and possesses a high $CaCO_3$ (85.5-99.1%) and low $MgCO_3$ content, ranks as favourable for Flue-gas desulfurization (FGD) regarding the composition of raw materials from the surface samples collected. The loosening of the dense limestones is expected to be done by bench blasting.

The proposed method of mining will be mechanized open cast mining. The basic mining techniques adopted will be use of machines and blasting. For the systematic working of open cast mines, the main development work will be the forming of systematic benching. The height of bench will not be kept more than 10 m at a time and the width of the benches will be always kept safe according to provisions. The material is then loaded from the blast site onto haul trucks by a front-end loader and is transported to the processing plant. The extracted material is dumped into a feed-hopper where it is then crushed, conveyed, screened, and stockpiled.

Aggregate materials will be transported off-site via trucks belonging to independent carriers, contractors, and others for a variety of construction-oriented uses off-site. Products made for export are then transported by haul trucks to a second stockpile where it will be transported to the port. The products to be transported off-site in trucks are typically loaded into trucks by a front-end loader or from a loading bin.

Based on the proposed strategy of operation outlined above, the following mining blocks were developed:

- Using two 150,000 m^2 boundary for phase 1 and 3 of extraction and a 200,000 m^2 for phase 2, the quarry blocks for material extraction was developed. The tonnage for each block was generated based on an assumed 30 m thickness which is the lowest extractable thickness calculated from field surveys.
- An assumed density of 2.51 was used in the tonnage calculations.
- The blocks would then be scheduled, starting in the north-western area, directly south of the previous quarry. Mining will be scheduled to progress to the south.

- Mining operations will start with clearing the vegetation from the mining block and then drilling and blasting a portion of the limestone. Over burden clearance will be done with Caterpillar D10 track dozer.
- From field surveys, the site has little to almost no topsoil so there was no cost included for topsoil removal. Extraction for the deposit was assumed to require drilling and blasting.

The plant is scheduled to operate between 8 and 12 hrs per day generating an initial 250,000 tpy and graduating to approximately 1.1mt within 6 years.

3.3.2 Pre-operation

Removal of overburden includes clearing of all trees and vegetation along with loose material. Vegetation endemic to the site will be relocated to other areas on the property. Unusable overburden material may include limestones exposed to surface weathering containing cavities and in-filled soil sediment. Overburden is estimated here to be less than 5% of the calculated volume of deposits and range from 0.3 m up to 1 m in some sections where dissolution features are less prominent.

Considering the characteristics of the surface, it is expected that only the vegetation cover will have to be removed. Limestone sections, which are contaminated with clay or other terrigenous material, will be discarded. The 5% reduction in the total mineable tonnage as stated before identifies the strong possibilities for loss due to karst hollows and hollows filled with clay material.

3.3.3 Operation

3.3.3.1 Extraction Technique

The proposed quarrying technique is modified open pit mining which will be aided by regulated blasting initiatives to loosen deposits. This initial quarry plan is designed around a 30-year production period with target projections for the 5, 10, 20- and 30-year phases. The proposed quarry operations will continue with the pre-existing quarry scarp situated approximately 450 m from Queen's Highway which runs east to west in proximity to the northern coastline. Benches would be developed at 10 m intervals and extend the across the pre-existing quarry face from the old quarry. This is a suitable option as the major haul road and operational areas are already defined/cut and only require minor work and rehabilitation before commencing any production. This will follow the sequence of creating benches at 10 m heights with cut back at a slope angle of 65 - 75°; this will allow for extraction starting at the north-western sections moving towards the south-east over 30 years.

The presence of a closed depression as well as the extensive flat areas in the southern portions of the property makes it a suitable option for locating equipment, crushing plants and office. Access roads will however be connected through the small community which extends from the quarry site to the Queen's Highway in Rio Bueno. Figure 3-14 highlights a preliminary procedure for extracting the deposits continuing from the 'Old Quarry'. The operational approach proposed will cut back terraces with 10 m benches using a bench ratio of 1:2.

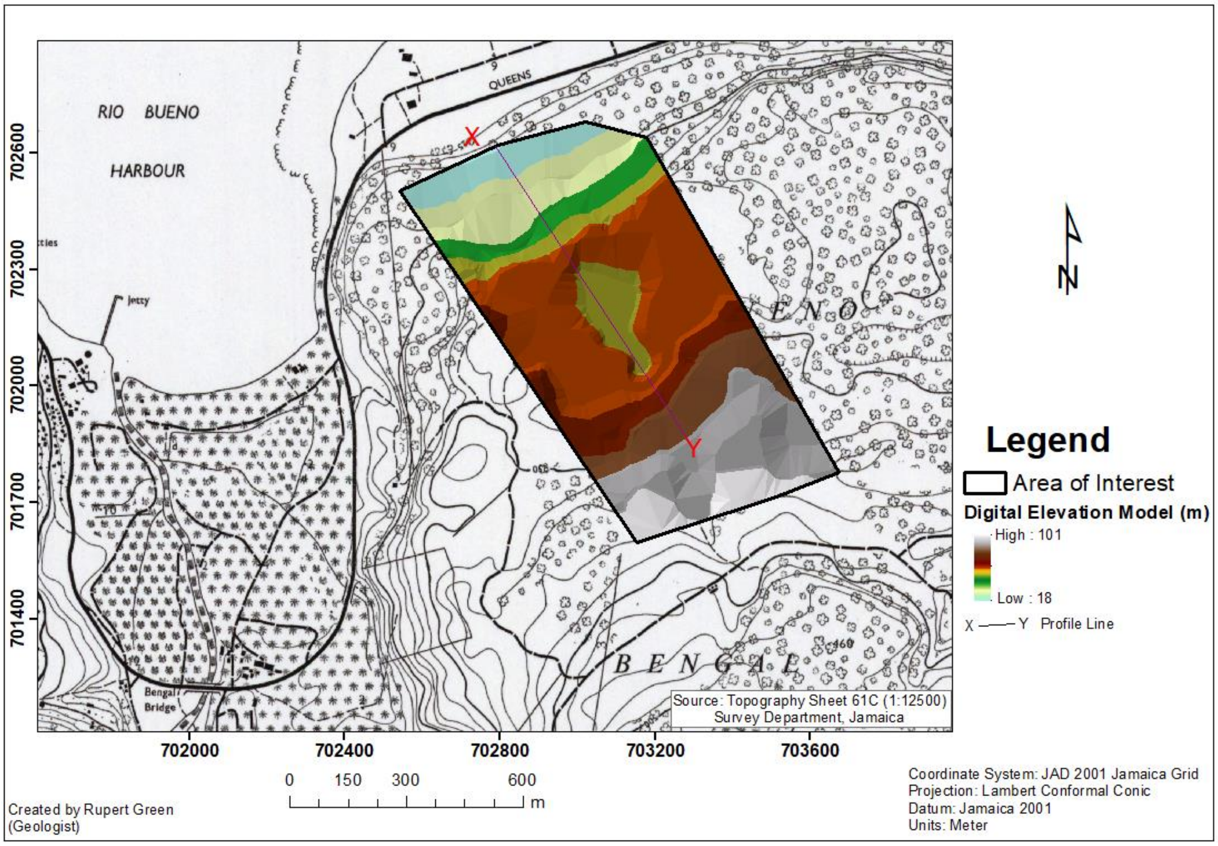


Figure 3-14 Digital Elevation Model showing cross section for bench design

3.3.3.2 Proposed Bench Design

The cross section below (Figure 3-15) defines the proposed design for initial quarrying operations and shows the bench heights and slope angle for the cutbacks. The section also interpolates the current topography after developing benches and the final target slope angle and design post-operations.

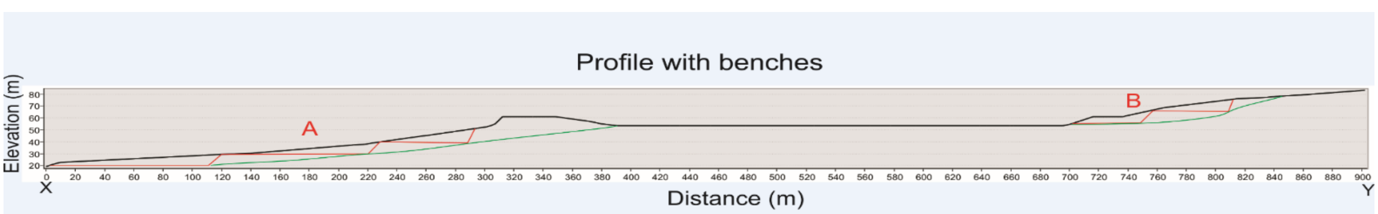


Figure 3-15 Cross section of quarry showing the present topography (black line), bench heights and slope angle (red line) and the target slope angle post-quarrying (green line)

The bench design will be dependent on blasting techniques but should conform to the projected slope angles and cut back distance. The 3D model (Figure 3-16) shows how benches designed as proposed above can be utilized to extract the limestone deposit. Additionally, the bench design will allow for best practices to be employed during the extraction process. This will lead to more economical and environmental quarry programme, hereby decreasing the adverse environmental impact on the surrounding environs.

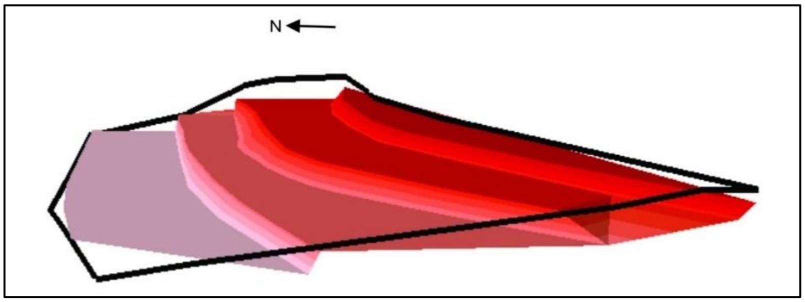


Figure 3-16 Digital Elevation Model showing hypsography

The slopes developed will also be done with restoration and reclamation in mind that will align with the future property development plans by the proponent. The overall topography of the landscape will therefore change and is projected in Figure 3-17. The DEM in Figure 3-16 shows the hypsography after quarrying. If the target slope can be achieved from benches and slope stability operations the proposed area for quarrying will be fit for further development.

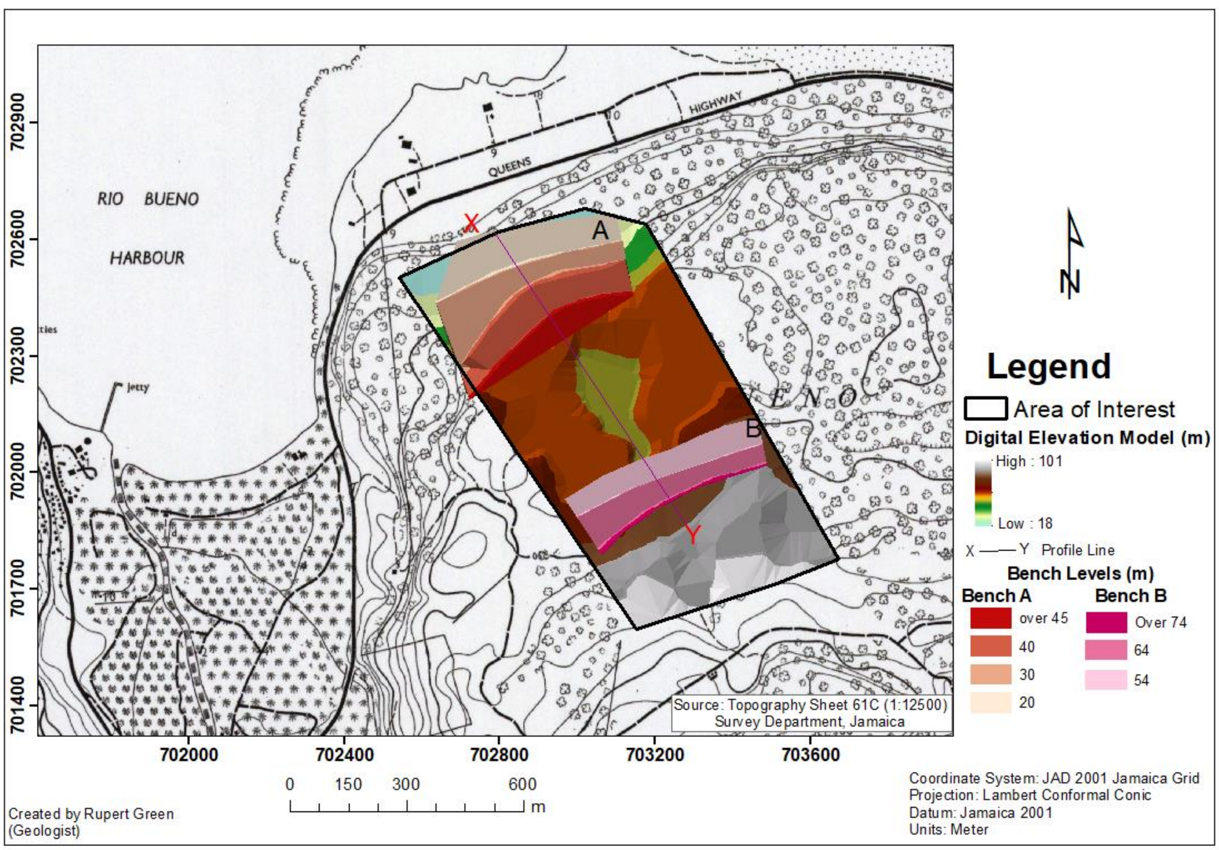


Figure 3-17 Digital Elevation Model (DEM) overlain on topographic map for the area of interest showing terracing configuration after preliminary operations

3.3.3.3 Blasting and Ripping

The hard limestones will be loosened by blasting in the form of several standard bench blasts. Blasting shall be used as the basic approach whereby ripping may be applied if necessary. With the quarry face developed, it is now possible for single row blasts to be used. This consumes fewer explosives and will be sustainable for the operation.

The removal of this material, due to its density, will require blasting. The controlled blasting is proposed by adopting all the safety measures as guided by the Mines and Geology Division and under their supervision. Multiple blast holes of 1.0 to 1.5 m depth will be drilled with the help of Sandvik Dx800 Drill Rig, Jack Hammer and Air Compressor of 100 cfm capacity. It is estimated about 54.56 kg of explosives per hole is required. About 150 - 200 holes per blast are proposed.

Limestone operations may come with additional challenges because of geology, as caves and clay veins severely affect blast performance. Therefore, optimizing blasting operations at limestone quarries can be defined as a challenge that should be approached step by step on a rational basis.

Each individual bench blasting will amount to 15-30 thousand metric tonnes. A twice per month blasting regime is recommended to obtain the target tonnage for extraction per annum if full annual production capacity of 2 million metric tonnes is to be actualized.

The quarry proposes to mine and process limestone in one 20 hectare and two 15 hectare pits, approximately 30m deep (from surface elevation) and 305m wide. There is no plan for extraction below sea level. The quarry operation should extract material from the deposit to the old quarry floor which is 30 metres above sea level.

The quarry's bench heights will average 10m. The processes of drilling and blasting will be subcontracted to licensed local professionals. The blast patterns will vary from a 3.5m x 3.5m to 4m x 4.5m, with 150mm holes or smaller. The quarry operation will utilize two pit loading equipment. Two Caterpillar® 349 for loading and a Caterpillar® 349 hydraulic hammer for particle resizing. Each blast is to produce 15-30 thousand tonnes of 800 mm boulders with three (3) trucks will be used in mining and stockpiling, two Moxy A30s (28 tonne) and one CAT® A25 (23 tonne) haul truck. Two yard loaders (CAT® 966s) will also be on site along with auxiliary equipment.

3.3.3.4 Processing

Primary classification will be done using a Vibrating Grizzly Feeder and an Impact Crusher, which will be constructed with a retaining wall in the floor of the crushing area with a dumping point from an existing pit wall to minimize neighbour impact and the need to drill and blast closer to the Queen's Highway. This will produce at a rate of 500 tonnes per hour (TPH) average. The oversize from the primary feeder is fed into the primary impactor. Once crushed the material then feeds the Primary Screen. The reclaim comes from under the Primary Grizzly Feeder and produces a crusher run/fill estimated at 30% of production. This is done over a Reclaim Screen from the smaller sized material scalped from the Primary Feeder. This fill/dirt material will be used to reclaim benches in the quarry.

Specifically, raw material with size ranging from 50.8 cm (20 inches) to 100 microns diameter or less (dust) is recovered from blasting at the mining area. The blasted material is pushed unto a loading shelf from which it is loaded into trucks, carried and dumped in the hopper. The vibrating grizzle takes the material into the primary impactor while separating all the material below 4" from the -20" feed. Feed above 4"is crushed by the primary impactor to form a- 4" product. The material that is separated by the vibrating grizzly is taken to a reclaiming screen where the particles below 1/2"(typically dirt) is screened and taken to a dump pile for use as material in the reclamation process. Particles above 1/2'" are returned to the process via a return conveyor. Both the products from the primary impactor and the reclaiming screen are taken to the primary screen where the product of sand and 3/8 stone is removed from the feed stock and separated into piles of 3/8" and sand.

The bigger particles from the primary screen are then taken to the secondary crusher where it is reduced to final product sizes of sand ,3/4" and 3/8". This product from the secondary crusher is sent to the secondary screen where the products are separated and placed in piles while oversized material is returned to the secondary screen via conveyor belt. This forms a recirculating circuit in which the products are systematically reduced to the required product sizes.

The secondary and tertiary plants consist of 2 Screens and 1 Secondary Impactor with the option of putting in a tertiary crusher for expanded re-crushing. The secondary screen (first or primary screen in the circuit) will produce at most, two products: a minute amount of Dry Sand (ASTM M10 or 5mm) and a 10mm (ASTM #89) to a 25mm (ASTM #57s) material. This screen has the ability to re-crush all material. The oversize material from this screen is then fed into the secondary impactor. The tertiary circuit consists of a second screen where final concrete stone and sand are made.

The secondary and tertiary screen will produce products ranging from an ASTM #3 (50mm material), and consistently a #57 (25mm") or #67 (20mm) or #7 (16mm), and a #89 (10mm), and a Washed Concrete Sand (5mm) and/or an M10s (Unwashed 5mm- Asphalt Sand). Wash water will be used on the secondary screen and feed the wash screw.

3.3.3.5 Washing of Products

Washing of products will take place on both the primary and secondary screens and the required rate of flow is 3GPM water per tonne per hour (TPH) of material. Approximately 90% of water used will be recycled.

Waste water from the primary screen will flow towards the secondary screen and combine with the water from the secondary screen. The combined flow will be directed towards the open drain system which will lead to the settling ponds. Water is settled overnight and reused in washing operations.

3.3.3.6 Extraction Progression

Due to the extent of the area proposed for mining, the recommended bench heights and slope angle suggested in the proposed bench design will be incorporated for the three mining sequences illustrated in Figure 3-18, Figure 3-19 and Figure 3-20. The area for each phase is given along with the expected tonnage of material that is expected to be extracted.

Phase 1

Phase one will commence at the old quarry face with the fixed quarry assets located on the floor of the old quarry operation.

Figure 3-18 Phase 1 of quarry programme

Table 3-10 Quarry life estimates at different production rates for phase 1

Extraction Amounts		Quarry life at:		
Area m^2	Tonnage	2 mil ton per yr.	3 mil ton per yr.	4 mil ton per yr.
150,000	11,295,000	5.6 years	3.8 years	2.8 years

Phase 2

Phase two will commence in the south of the proposed mining area, with the progression of mining taking place in a south easterly direction. This model assumes that the fixed mining equipment and facilities will be relocated to the mined-out section of the first phase.

Figure 3-19 Phase 2 of quarry programme

Table 3-11 Quarry life estimates at different production rates for phase 2

Extraction Amounts		Quarry life at:		
Area m²	Tonnage	2 mil ton per yr.	3 mil ton per yr.	4 mil ton per yr.
200,000	15,060,000	7.53 years	5.02 years	3.77 years

Phase 3

Phase three may require a new haulage route, to reduce the use of the main thoroughfare by haulage trucks as extraction progresses.

Figure 3-20 Phase 3 of quarry programme

Table 3-12 Quarry life estimates at different production rates for phase 3

Extraction Amounts		Quarry life at:		
Area m²	Tonnage	2 mil ton per yr.	3 mil ton per yr.	4 mil ton per yr.
150,000	11,295,000	5.65 years	5.02 years	3.765 years

3.3.3.7 Hours of Operation

The proposed quarry operation is slated to operate within the hours of 8:00 am to 6:00 pm six days a week, Monday to Saturday. Blasting and crushing will commence at 9:00 am to 3:00 pm during weekdays with no blasting to be conducted on a Saturday. This is to permit residents within the area to commute to work and school without being impacted by dust and vibrations or over the weekend periods. Operations should be concluded during the evening hours as stipulated by the Mines and Geology Division.

3.3.4 Quarry Closure (Decommissioning) and Rehabilitation Plan

Upon closure or completion of the quarrying phase, all equipment involved in the quarry operations will be removed from the site. Rehabilitation of the land, post-production, will be determined by the land owners. Vegetation can be re-planted in areas adjacent to the quarrying operations and utilized to rehabilitate the land post- operations.

Favourable factors for development can be based solely on the location of the property and include access to the Queen's Highway and northern coastline as well as the proximity to neighbouring towns, ports and river system. It is also projected that quarrying operations will expose an extensive area of bedrock on the property suitable for constructing residential building plots or industrial facilities. The creation of benches followed by the levelling of the terrace post-operations will reduce the amount of slope stability operations typically required.

A detailed Rehabilitation Plan is provided herein.

3.3.4.1 Reclamation

The open-pit or open cast mining of natural aggregates, regardless of its extent, interferes with the natural environment. Relief is transformed, soil profile is disturbed, water relations may change and flora is badly affected. It is for these reasons that post-industrial area reclamation is necessary. Figure 3-21 illustrates the reclamation of a bench with back fill after mining. Using the removed overburden, the quarry face would be back filled creating a slope with a repose angle that will foster replanted flora as the quarry advances to the next phase.

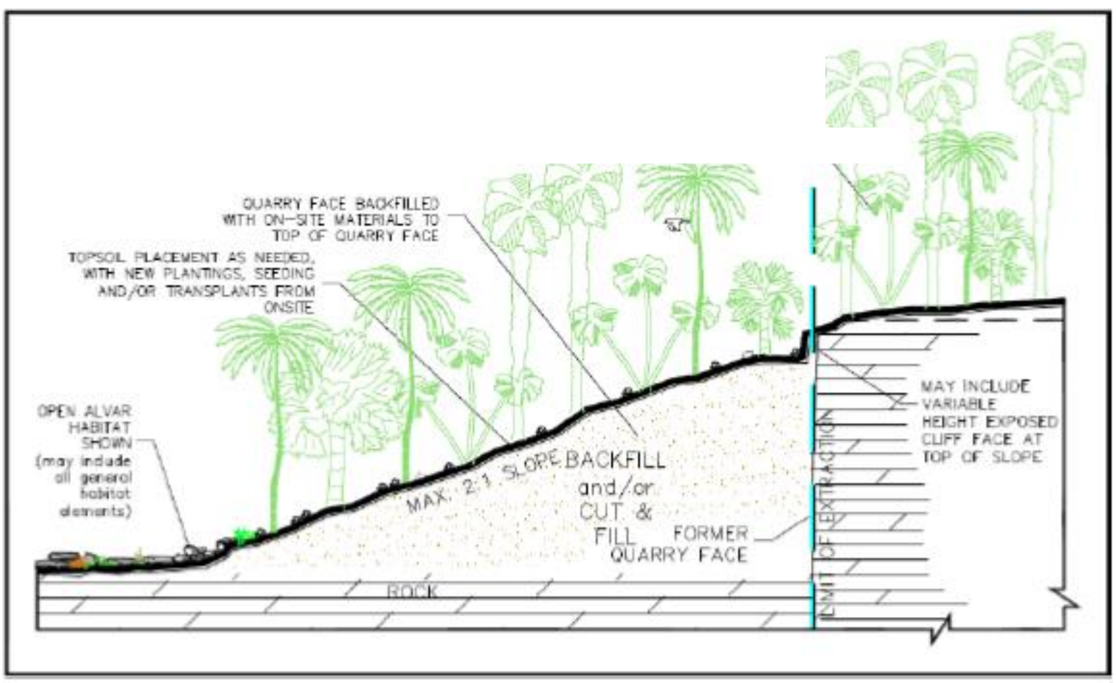


Figure 3-21 Sideslope Detail (backfilled slope)

Rational planning and ongoing reclamation at each phase of mining will occur. With the small volumes of overburden observed in field surveys, the levelling and stabilizing of the rock faces will be the main focus due to the environment in which the deposit exists.

For steep slopes, Figure 3-22 illustrates the methods for reclamation that will be employed. Rock debris from previous blasting operations will be placed at the base of a cliff (talus). This pile will also consist of organic debris (bush, fallen trees etc.) and become shelter for rodents, insects or small birds. The steeper cliff face will provide a habitat for nesting birds and cliff vegetation.

The top soil that exist within the designated mining areas is not sufficient to be utilised as reclamation material. The geomorphology consists of mainly rock with very little top soil. Material for reclamation will be sourced from private suppliers.

It's worth noting, however, after mining operations have ceased, the proponent aims to further develop the property. The demand of the local populace may influence changes in the level of investment provided. Therefore, it is integral for the mining programme to be undertaken to ensure further investments can be made for the rehabilitation and development of the property.

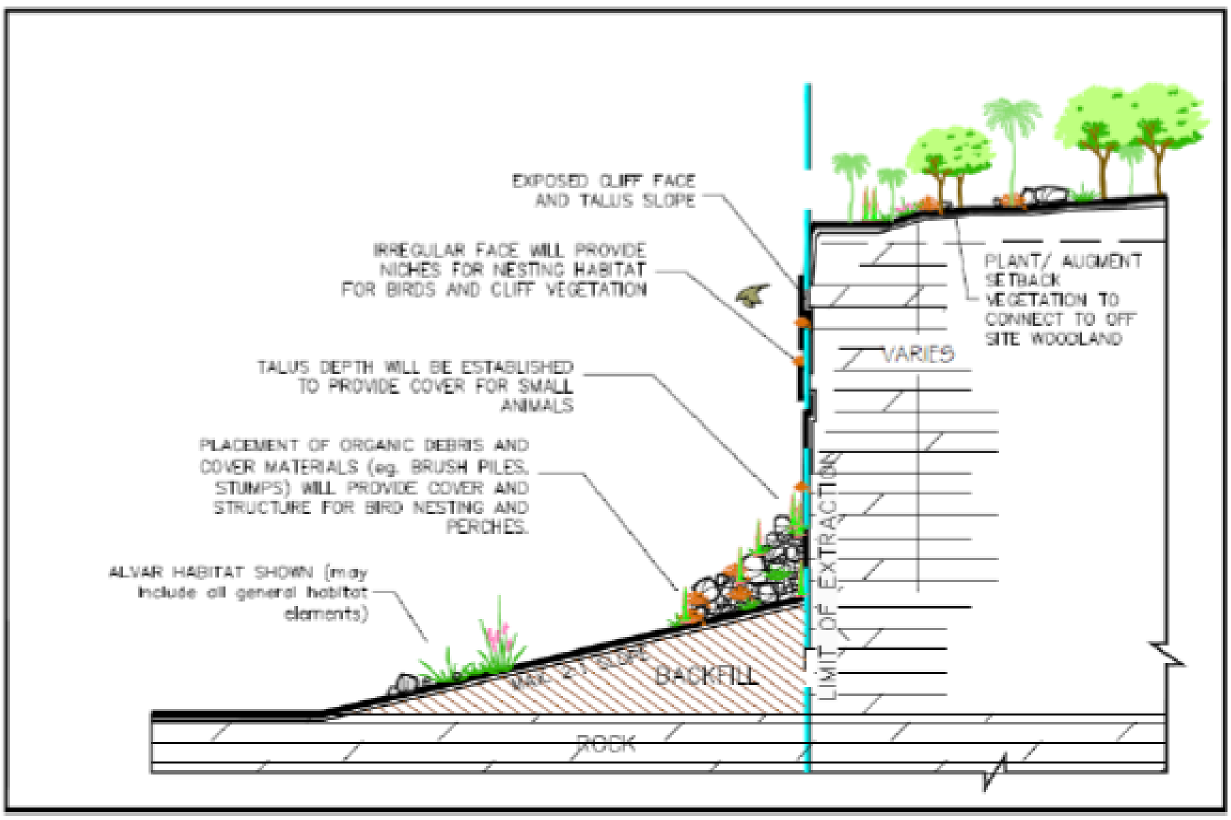


Figure 3-22 Sideslope Detail (talus slope and exposed cliff face)

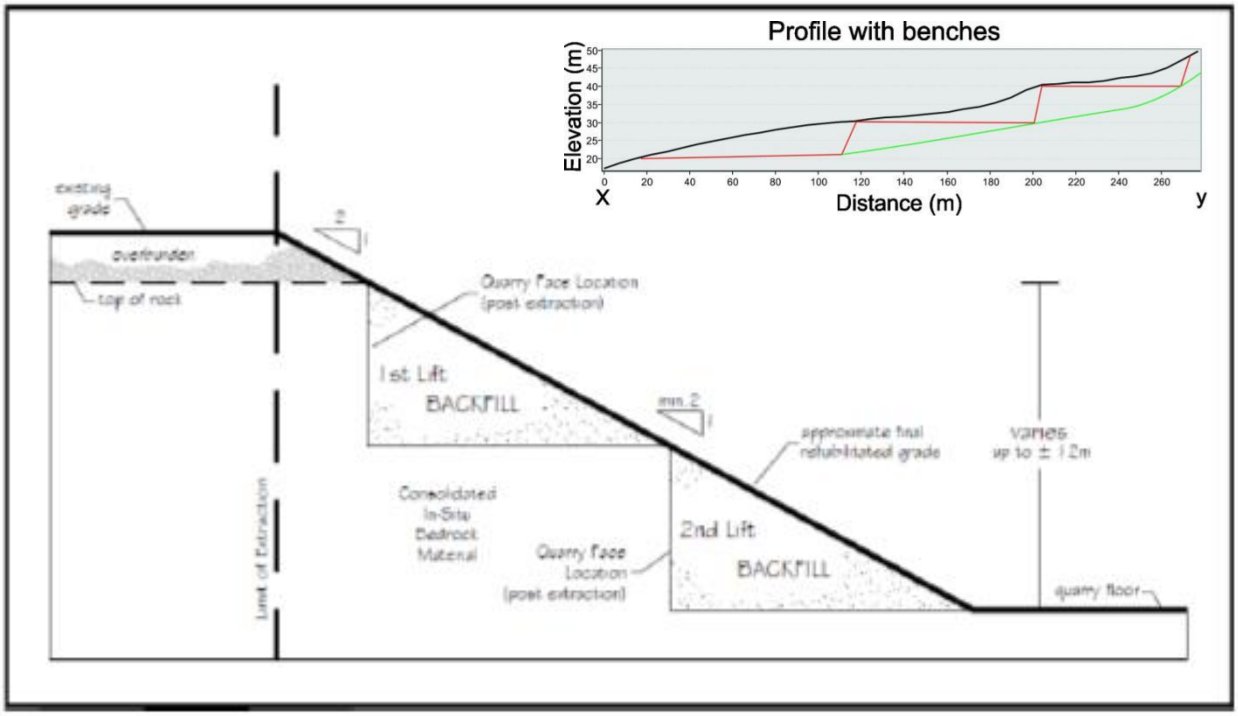


Figure 3-23 Quarry Profile vs Reclaim Slope with Backfill

3.3.4.2 Rehabilitation

As stated before, all extraction will occur on the premise of land preparation for further development purposes identified by the proponent. The presentations illustrated here are the post closure characteristics that will be obtained after all quarry operations have ceased. It should be noted that reclamation will be occurring concurrently with the extraction activity.

The Progressive Rehabilitation Plan requires the pit to be converted into a space having 2:1 interior slope from the top of dirt to the top of rock. The quarry property surrounding and on these filled in benches is to be planted with local flora to become shrub lands, as close to original plants as possible. Table 3-13 shows the recommended vegetation to be used to re-vegetate the decommissioned quarry. The species listed are predominantly native trees and shrubs. However, it is estimated that only two of these species are presently available in the local horticulture industry.

Table 3-13 Species recommended for re-vegetation of decommissioned quarry

Species Name	Common Name	Habit
Portlandia grandiflora	Bell Flower	Tree
*Euphorbia punicea***	Jamaican Poinsettia	Tree
Hohenbergia penduliflora	Tank Bromeliad	Herbaceous

Species Name	Common Name	Habit
Thrinax parviflora	Thatch Pole	Tree
Bursera simaruba	Red Birch	Tree
Tabebuia heterophylla	White Cedar	Tree
Plumeria obtusa	Wild Frangipani	Tree
Tabernaemontana laurifolia	Milkwood	Shrub
Anthurium grandifolium	Wild Coco	Herbaceous

** - Endemic

All final slopes will be 2:1 as shown in Figure 3-21. All rehabilitation will be developed as the pit final walls are established. The start date for rehabilitation of newly mined areas will be at the beginning of the second phase of extraction (phase II). By this phase at least one final wall should be established on the west/southwest side of the quarry.

Quarry rehabilitation will take into account the following:

- biodiversity
- water
- soils
- landscape
- all local regulations
- the input of all stakeholders (landlords, neighbours, local authorities, associations and The St. Ann Municipal Corporation)

The quarry will be rehabilitated according to the best practices for mine development. This will be guided by the recommendations (if required) and the supervision of the Mines and Geology Division (MGD). The plan will induce constructive dialogue between the MGD and Contractor/Client during its initial development, then in the course of its implementation and finally whenever updated. Regular communication will be maintained with the relevant authorities regarding this matter.

At each mining phase, it is important to consult local authorities, neighbours, nature conservation organizations and the mining personnel and the quarry manager. The rehabilitation plan will be held at the disposal of the public and communicated under the appropriate form, especially in the form of a displayed document with drawings and plans accessible to all persons arriving on the quarry.

The rehabilitation plan will be updated periodically (regulation permitting) to make way for possible changes of conditions: new regulations, new techniques, and new opportunities for final use. The on-site rehabilitation plan will include:

1. **An illustration of the final stage of the quarry site.**
   This document (a map and digital rendering) will illustrate the final shape and approximate topography of the quarry once rehabilitated. The main habitats created during this process will be visibly indicated on the map legend. Also, the remaining infrastructure and phase 2 of the development plans by the proponent will be shown.
2. **A series of detailed descriptions covering each area of the restored site will reflect the proposed specific after use.**
   The descriptions will be an enlarged view of the main map showing and explaining the details of the habitat type. It will usually include insight on the reasons these particular restoration choices were made.
3. **A list of works to be completed in order to achieve the rehabilitation status.**
   This is a broad schedule illustrating the progression of the rehabilitation works. This section is designed to help field managers or contractors to understand the main earth moving operations, fitting-out options and key elements for the success of the rehabilitation
4. **A schedule showing the sequencing of the rehabilitation works.**
   A graphic depiction, showing a series of intermediate steps with the main volumes calculated, with one intermediate position presented.

3.3.4.3 Maintenance and Visual Inspection

All existing waste debris and trash present on the site will be collected and dispose of. A daily site inspection is proposed, followed up by a more thorough monthly inspection for the presence of debris and/or trash to be then disposed of promptly and in a proper manner. Dust control on this site, particularly during prolonged dry weather periods is suggested, using a water truck, dust screens and dust cannons.

In following best management practises, all recycling procedures must be adhered to in the highest degree possible, in order to recycle as many waste materials on the site. All staff will be trained for site maintenance and follow a schedule routine operation for housecleaning and the maintenance of a well-organized aggregate storage and work areas surrounding plant operations.

All plant equipment, support equipment, site conditions are to be maintained using all best management practices. Thus, maintaining a visual perspective that is not considered an eyesore to the surrounding community. Regular inspections will be conducted and frequent maintenance to ensure that all equipment and site conditions operate in the manner designed.

The implementation of the rehabilitation plan must be monitored on an annual basis by the operation to ensure accruals are updated regularly. A set of indicators specific to the quarry will be developed locally in order to be able to monitor and evaluate progress towards the rehabilitation goals.

3.3.4.4 Decommissioning

At the time of decommissioning the following activities will aim to satisfy the health, safety and environmental issues associated with closing operations of the facility in a manner which mitigates any adverse environmental impact.

1. Notification to relevant local authorities of change in status of the facility.
   Security personnel will be present at all times, as it would be during normal operations until the plan has been completed. Signage will be clearly posted at the entrance of the facility alerting the public that the facility is "Closed" and the area is "Restricted."
2. Vehicular and pedestrian access will be restricted to only personnel necessary to carry out the activities associated with the closure plan.
3. All access will be via the posted security personnel and recorded in the security log.
4. All equipment used during operation will be removed
5. Administrative office structures will be transported off the property (no permanent structures would be constructed)
6. Portable toilets and hand wash facility leased would expire and returned to the operator
7. All product stockpiles will be removed
8. It is anticipated that solid waste will be generated during the project. At all times waste minimization will be encouraged. Waste produced can be classified as follows:
   a. Scrap iron
   b. rubble
9. Materials will be disposed of by the usual means (i.e. collection by municipal waste operators).
10. With regard to long-term water pollution potential upon closure of the quarry, this is expected to be minimal. Heavy suspended sediments and siltation is only expected during construction and operations, via heavy rainfall events resulting in run-off of suspended sediments, debris flow and land erosion. Soil erosion and siltation of watercourses could have a negative impact on the flow regime and water quality within the study area. Residual sediments and material in the decommissioned quarry may result in short term, minor siltation of water quality in the study area, but will cease after a while.

3.3.4.5 The Quarry Decommissioning Contractor

It is the duty of the proponent that all extraction is conducted in conjunction with the stipulated government requirements. Therefore, to ensure this operation proceeds within these guidelines, the proponent has engaged in dialogue with different companies to employ the services of one that has the competency, track record and expertise in reclamation of quarries after mining operations have been completed.

Most recently, the proponent has been in dialogue with ESPA, a company with over 50 years of experience in the mining industry.

They operate primarily in the following sectors:

- Mining

  - Metal
  - Coal
  - Quarries
- Civil Works
  - Mining civil works
  - Linear Works (motorways and railways)
  - Hydraulic Works
  - Other Infrastructure projects

3.4 PROJECT TIMELINE

Phase 1 is estimated to be a five-year extraction programme.

- 2 months for preparation and equipment arrangement for the quarry operation.
- 56-month extraction programme (at 2 million tonnes every 12 months)
- 2-month timeline for decommission and commencement of phase 2.

Phase 2 would be a renewal of the quarry license. This would have been submitted 4 months before the license expiration date.

- 2 months for preparation and equipment set up for extraction
- 120-month operation. This is the largest area therefore the renewed license should expire before phase 2 is completely extracted. Phase 2 should be completed 24 months into the renewed license.

Phase 3 should take three years (36 months) for extraction to be completed.

4.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 PHYSICAL

4.1.1 Geology

4.1.1.1 Regional Geology

The proposed development is part of the North Coast Belt, one of the morphotectonic structures that make up Jamaica. The North Coast Belt is separated from the Clarendon block and its Cretaceous core of the Central Inlier by the E-W oriented Duanvale fault system. The Duanvale fault system is a series of left-lateral strike slip faults that connects the Enriquillo-Plantain Garden fault zone East of Jamaica with the Walton fault zone West of Jamaica. Together these faults form the boundary between the Caribbean plate and the Gonave microplate and are generally considered to have started to develop in early to middle Miocene.

The Geology map in Figure 4-1 displays the geology for the region north of the Duanvale Fault. The map is an adaptation of the 1: 50,000 Geological Map Series (metric edition) Falmouth Browns Town Sheet 3, Land, 1991 & 1973, and Donovan, 1993. The map shows the distribution of following 5 formations: the Walderston–Browns Town Formation and the Montpellier Formation, both of the White Limestone Group, the Hope Gate Formation, the Falmouth Formation and the Quaternary Alluvium. The map symbols and the formation names used in the in 1:50,000 Geology Map published by Mines and Geology Division were maintained except for the Coastal Group which was substituted with the Hope Gate Formation.

Walderston-Browns Town Formation consist of two litho/biofacies constituting a lateral variation of the same stratifigraphic unit (Mitchell, 2004). The Brown Town Formation in the north is considered a shallow-water unit deposited near the platform margin of the Clarendon Block. It is in essence a structureless deposits of very white and occasional light pink packstones, wackestones and carbonate mudstones. It contains prominent coral faunas and an assemblage of foraminifers dominated by the large lenticular foraminifer Lepidocyclina. Its estimated age is Upper Oligocene to Middle Miocene. The Walderston Formation to the south is regarded to be a shallow-water unit formed in the interior of the Clarendon Block platform. The Walderston Limestone consists largely of off-white massive to well-bedded grainstones and packstones dominated by miliolids. The Brown Town and Walderston facies are not differentiated and are displayed as one in 1:50,000 Geology Map published by Mines and Geology Division. The Walderston-Brown Town Formation in Figure 4-1 is expected to represent the facies of the Brown Town Formation only.

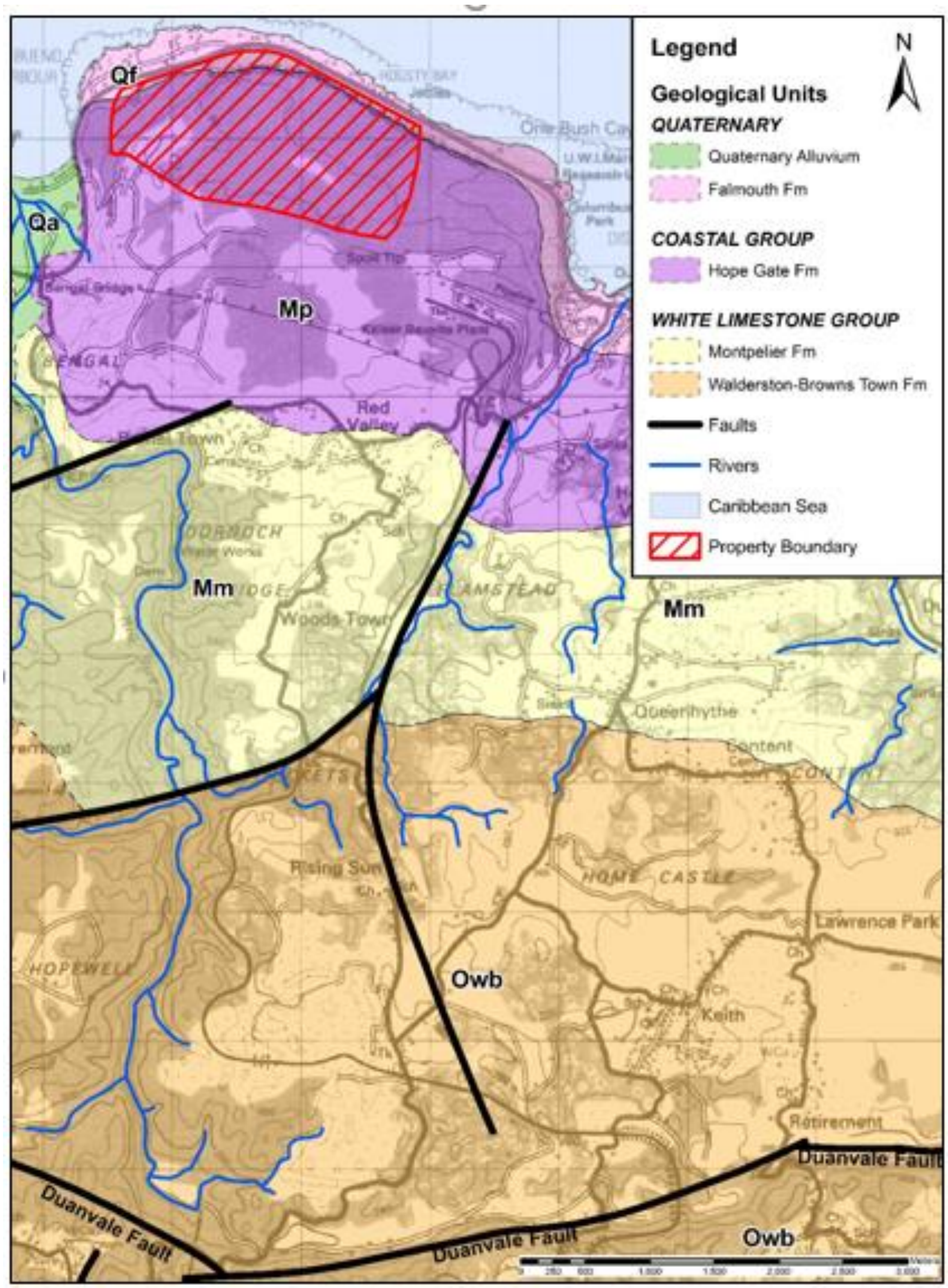


Figure 4-1 Geological map

The North Coast Belt is characterised by the deposition of the deep-water limestones of the Montpelier Formation which ranges in age from late Middle Eocene to Early Miocene and has an estimated thickness of more than 300m. The Montpelier Formation consist predominantly of evenly bedded chalks or micrites interbedded with nodular chert layers and bioclastic rich layers. The micro-fauna of the Montpelier formation is dominated by large lens shaped planktonic foraminifers. The depositional environment is defined as the bathyal zone along the margins of the shelf plateau with depths ranging from 200 m and 2,000m. This is further supported by the sedimentary structures which are often folded and deformed and include evidence of turbidites and debris flows.

4.1.1.2 The Geological Units of the Proposed Development

The Hope Gate Formation and Falmouth Formation are the only two geological units that are exposed within the boundaries of the proposed development. The Hope Gate Formation takes up the bulk of the property. The Hope Gate Formation is exposed in the towering cliff bordering the Queen's Highway and in the 50m terrace level to the south; the Falmouth Formation occupies the lower terraces along the northern edge of the property, near the coast to north of the said cliff. Although both Formations are in essence coralline biolithites, they are very distinct rocks. The Falmouth formation is relative soft, moderately lithified and contains primarily aragonite-Mg-calcite. Hope Gate Formation on the other hand is a dolomitized hard rock and consists mainly of calcite and dolomite.

The Falmouth Formation developed unconformably on top of the dolomitized reef deposits of the Hope Gate Formation and is of Upper Pleistocene age (0.13 Ma) (Land, 1991). Erosional terraces cut in the Hope Gate formation, served as the hard substratum on which the reef terraces of the Falmouth formation were formed. The Falmouth formation to the north of the property is a relative dense packstone. It consists of calcareous plates of Halimeda, shallow water corals and abundant molluscs set in a friable matrix of weekly-cemented carbonate sands and muds. The low diversity of the corals and the abundance of molluscs indicates that the Falmouth Formation represents a back-reef environment very similar to the modern Jamaican back-reef deposits. (Boss, 1987)

The Hope Gate Formation is a dense, coral-rich, massive, dolomitized limestone which consists of a coral framework encrusted and filled in with authigenic reef sediment. It has been dated based on strontium $^{87}Sr/^{86}Sr$ isotope data and coral biostratigraphy to be of Upper Pliocene to Lower Pleistocene age (Land, 1991). The aragonite coral framework has been dissolved and is partially or completely replaced by calcite and/or dolomite. The bulk composition of the dolomite in the Hope Gate formation is $Ca_{1.16}Mg_{0.84}(CO_3)_2$. One third of the dolomite is in the form of clear, sparry crystals which fill in the molds of molluscs and the voids left by dissolved corals, the rest of the dolomite is micrite mixed with variable amounts of calcite. The Dolomitic rocks of the Hope Gate formation have an average porosity of 5% and a bulk density of 2.57g/cm^3, as compared to recent lithified Jamaican reef deposits which have an average porosity of 19% and a bulk density of 2.21 g, (Land, 1973).

The aragonite rich Falmouth formation is separated from the overlying the dolomitized Hope Gate formation by a sharp erosional contact. All indications are that the diagenesis and dolomitization of the Hope Gate formation occurred concurrently or shortly after the deposition of the Hope Gate formation before the deposition of the Falmouth formation started. Because of the higher $^{87}Sr/^{86}Sr$

ratios and higher $\delta^{18}O$ of the Hope Gate dolomite, meteoric water (i.e. ground water that has recently originated from the atmosphere) is not considered to have been involved in the precipitation of most Hope Gate dolomite. The current accepted hypothesis surmises that the massive dolomitization of the Hope Gate Formation was the result of the circulation of near-normal seawater through the reef deposits. Interaction with the underlying Miocene Montpellier chalks is expected to have raised $^{87}Sr/^{86}Sr$ ratio $\delta^{18}O$ of the seawater to achieve the precipitation of dolomites with $^{87}Sr/^{86}Sr$ values close to those of the chalk and $\delta^{18}O$ values slightly higher than the normal seawater in which the reef system developed. The forces driving the seawater circulation may have included thermal buoyancy, dispersion due to meteoric discharge, tidally induced flow and other still to be identified processes (Land, 1991).

Hope Gate Formation is the geological unit that the proposed quarry development is targeting to extract and it is the only formation that outcrops within the boundaries of the proposed mining area. The overburden is minimal or non-existing, bedrock is often exposed even in the depressions. The distribution of dolomite within the Hope Gate formation, both laterally and vertically, is quite uniform.

In 1968, while searching for fossil sclerosponges (HARTMANand GOREAU,1970) the late T. F, Goreau chanced upon a small outcrop of "chalky" *Halimeda grainstone* (quarry B-1 of LAND, 1973), which contains deep water species including *Halimeda cryptica.* The grainstone appears to have been a local sand channel within the reef, which became so densely cemented by Mg-calcite marine cement as to almost entirely preclude subsequent diagenesis, (Land 1991)

A total of 7 boreholes were drilled, 6 of boreholes were terminated at a depth of 36.6 m (120ft) and one at a depth of 27.4m (90ft). Five (5) of the seven (7) hole are located in the western section of the property, where the quarry operation would start and two (2) in the western section of the property where extraction would only take place in the final phases of the quarry development (Table 4-1).

Table 4-1 Borehole information

Borehole #	Elevation AMSL		Depth Borehole		Thickness Hard Limestone	
	ft.	m	ft.	m	ft.	m
Western Section of Property						
DDH 1-09	194	59.1	120	36.6	45	13.7
DDH 2-09	150	45.7	120	36.6	48	14.6
DDH 3-09	170	51.8	90	27.4	55	16.8
DDH 6-09	217	66.1	120	36.6	55	16.8
DDH 7-09	200	61.0	120	36.6	53	16.2
Eastern Section of Property						
DDH 4-09	225	68.6	120	36.6	35	10.7
DDH 5-09	237	72.2	120	36.6	41	12.5

The bedrock encountered was assigned either a 'hard limestone' or a 'limestone' designation

The hard limestone is creamy white in colour with pinkish hues, medium to fine grained (usually fine), massive, vuggy and commonly horizontally fractured. It is the hard limestone encountered in the upper portions of the coreholes, and averages 14.5m (47 ft.) in thickness. Vug surfaces tend to be covered with fine calcite crystals, sometimes appearing as a 'fuzzy' surface. There is a dominant fracture at 40º from vertical, though fractures of 70º to vertical were noted. The vugs also tend to be weathered and discoloured reddish-brown.

The limestone is creamy white to pink, medium to fine grained (usually fine), massive, and commonly horizontally fractured. It is the limestone encountered in the lower portions of the coreholes. Total thickness is not known because this limestone was never fully penetrated.

The borehole logs recorded numerous 'crushed rubblized zones' were noted in. In the moderate to strongly lithified sections, these rubblized zones tended to have rubble of varying sizes (sand and silt sized to 2-3-inch core pieces). In the variably lithified sections, these zones tended to be sand and silt sized.

Fractures and the crushed rubblized zones would often be discoloured pink to red-brown. This discoloration indicates that water and air are able to seep through virtually the entire thickness of bedrock drilled, though the weathering effects are minimal down hole. Occasionally there would be black to brown staining in an open fracture; this staining is probably organic material that travelled with water down the fractures.

4.1.2 Geomorphology

4.1.2.1 Introduction

The region in which the development is located, is characterized by a succession of erosional terraces which have an overall dip of 2.5 degrees to the North. The elevation of the property varies from a low of 1.5 m near the coast to a high of 94m inland with a mean of 58m AMSL. The erosional terrace between 50 to 90m AMSL makes up 81% of property and will further in text be referred to as the main erosional terrace. Approximately 1km wide, this terrace is bordered to North by a prominent vertical escarpment and several erosional terrace levels some of which are below sea level. To the South the terrace is bordered just outside the property boundary by moderate slopes forming the irregular-shaped edge of an erosional plateau at about 165m AMSL.

The northern portion of the study area was demarcated by the 'old quarry' access road along the Queens's Highway. The area assessed forms part of a prominent reef terrace which terminated as northern facing scarps and cliffs. Traversing west from the old quarry cut, the topography gently increases up a small hill. This hill slopes towards the alluvial flat to the south east and towards the western portion of the study area. The property can be categorized as a dry limestone forest based on the distinct honey comb weathering patterns and fauna specific to these environments in Jamaica. The Rio Bueno Harbour is located approximately 3 km from the 'Old Quarry' entrance with the Rio Bueno River draining to the north (Figure 4-2).

Figure 4-2 Map showing proposed quarry location, geomorphology and land use for the area assessed (Base Map: 1:50000 Metric, Sheet 3)

4.1.2.2 Slope Analysis

Table 4-2 and Figure 4-3 present the slope analysis results for the proposed development. The slope analysis is based on 1m contour data provided by the developer and the slope classification of the Mines and Geology Division (MGD) enhanced with additional subclasses to bring out topographical variations in the lower range of the scale.

Table 4-2 Percentage Area of the Slope Classes

Slope Classification MGD				*Enhanced*	
CLASS	CATEGORY	SLOPE (°)	AREA (%)	SLOPE (°)	AREA (%)
-	Gently Sloping	0° - 10°	86.5%	0° - 5°	63.0%
				>5° - 10°	23.5%
1	Moderately Sloping	>10° - 18°	7.7%	>10° - 15°	6.1%
				>15° - 18°	1.7%
2	Steeply Sloping	>18° - 26°	3.0%	>18° - 21°	1.3%
				>21° - 26°	1.7%
3	Steep to Very Steeply Sloping	>26° - 30°	1.2%	>26° - 30°	1.2%
4	Very Steep to Near Vertical	>30°	1.5%	>30°	1.5%

Less than 3% of the property consists of steep to near vertical slopes (>26º) or escarpments. The slope analysis classified 86.5% of the property as gently sloping (0º - 10º) and 63% of the property as very gently sloping with slopes ranging from 0º to 5º. Apart from the escarpments separating the terraces, and some localized steeper sloping features, the topography of the property can overall be characterized as a gently rolling landscape.

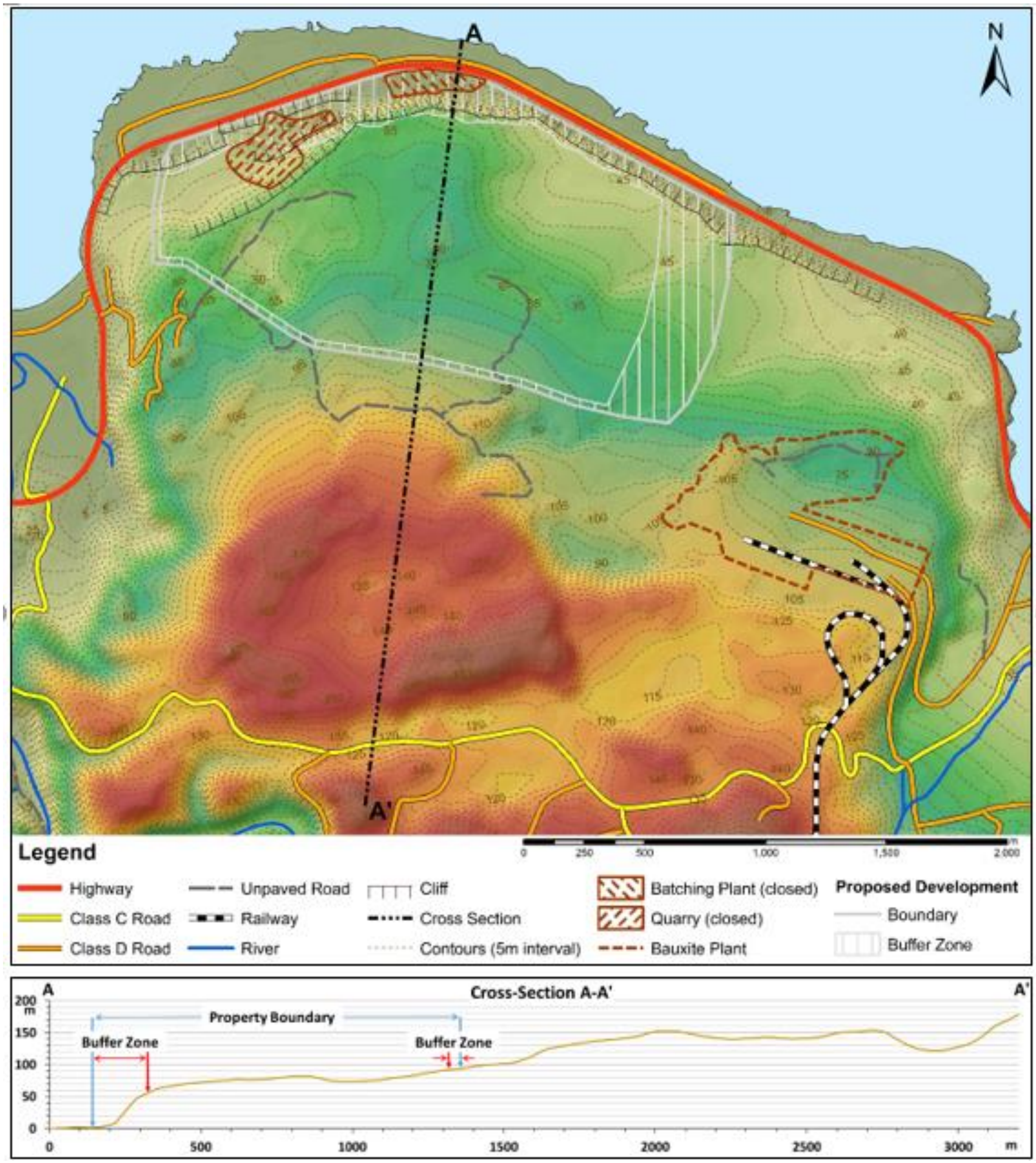


Figure 4-3 Topographic profile

The 3D model presented in Figure 4-4 also highlights the slope angles and topographic relief for the area of interest.

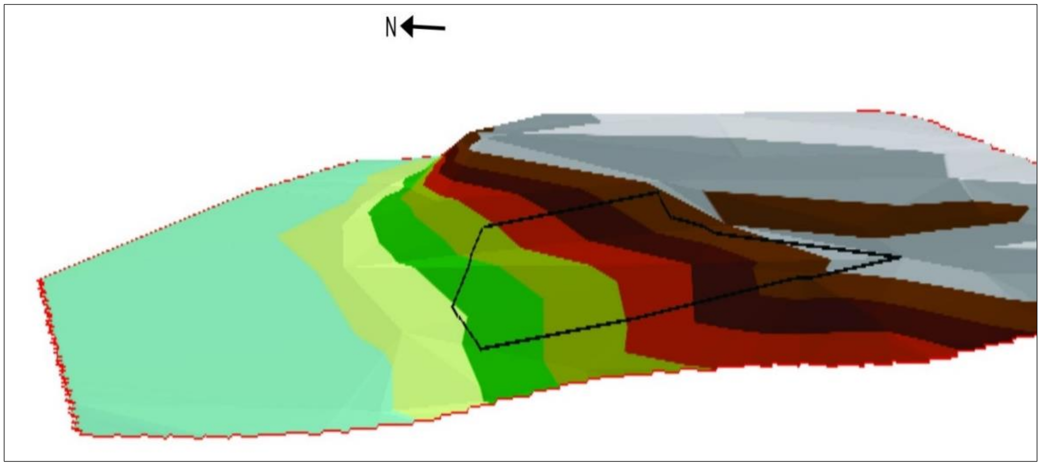


Figure 4-4 3D representation of the area of interest showing elevation changes and present slope

Slope Aspect (Direction)

The slope aspect or direction analysis in Figure 4-5 shows that the dominant slope aspect for this property has a general northerly orientation. In aggregate 71% of the property slopes to the N, NE or NW with a moderate skew to east of the north. The largest proportion of the property (30.6%) is sloping to the North; 25.3% of property slopes to the NE and 15.2% to the NW. Slopes trending to the south are the least common with just 3.8% of the property sloping to the south.

The spatial distribution of slope aspect in the east of the property is distinctly different from the west. In the east the slope aspect has a pattern of rectilinear elongated bands while in the west the slope aspect displays a patchwork of semi-circular, rounded cluster. Of note is also the narrow zone along the edge of the main terrace in which the slope aspect is S and SW or opposite to dominant aspect of the property. This indicates that the terrain along the edge of the main terrace slopes basically towards the interior of the terrace, away of the cliff edge and forms a small ridge or barrier which prevents the runoff from the main terrace to go over the cliff.

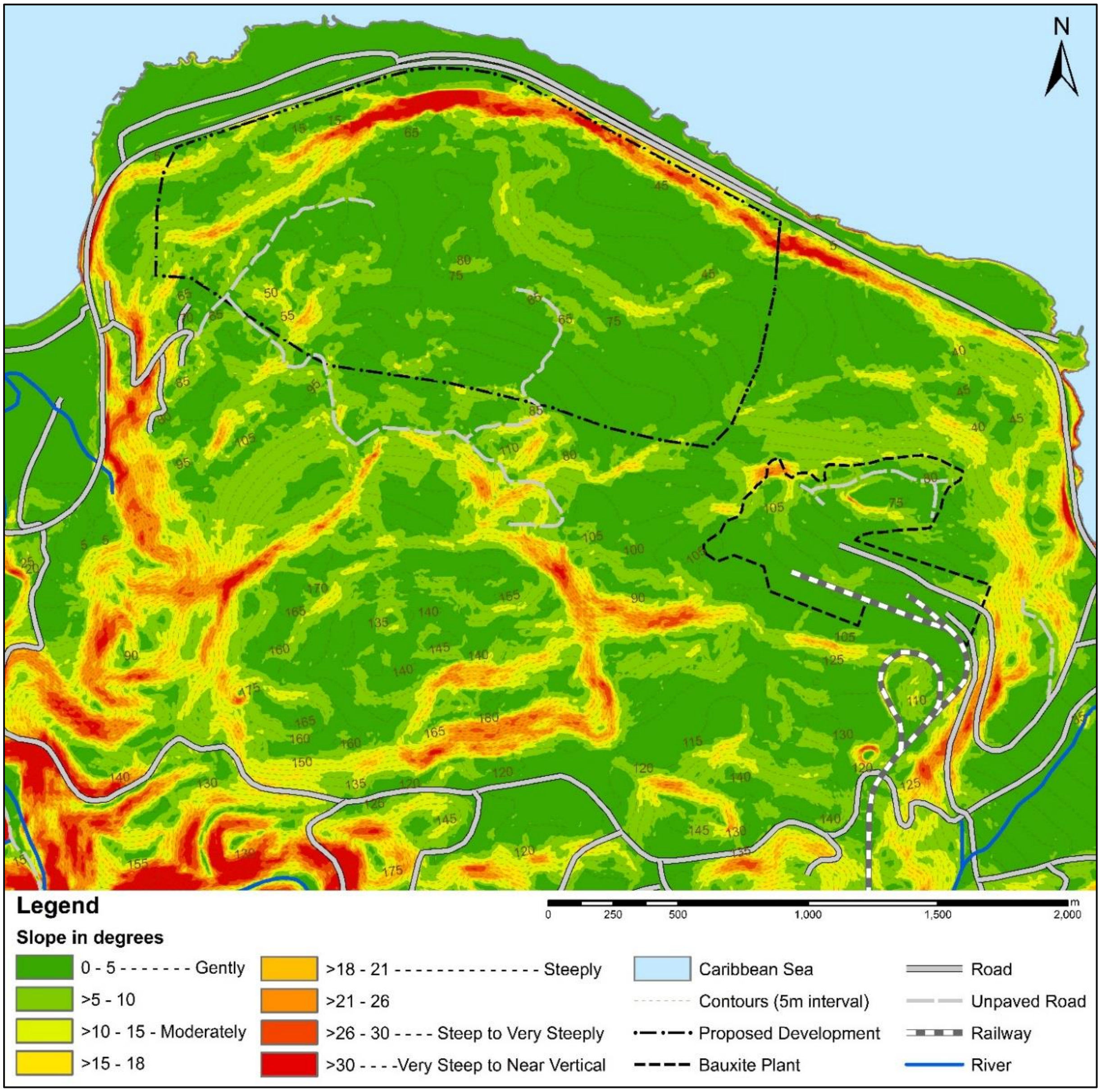


Figure 4-5 Slope map

The Main Erosional Terrace (50 and 90 m AMSL)

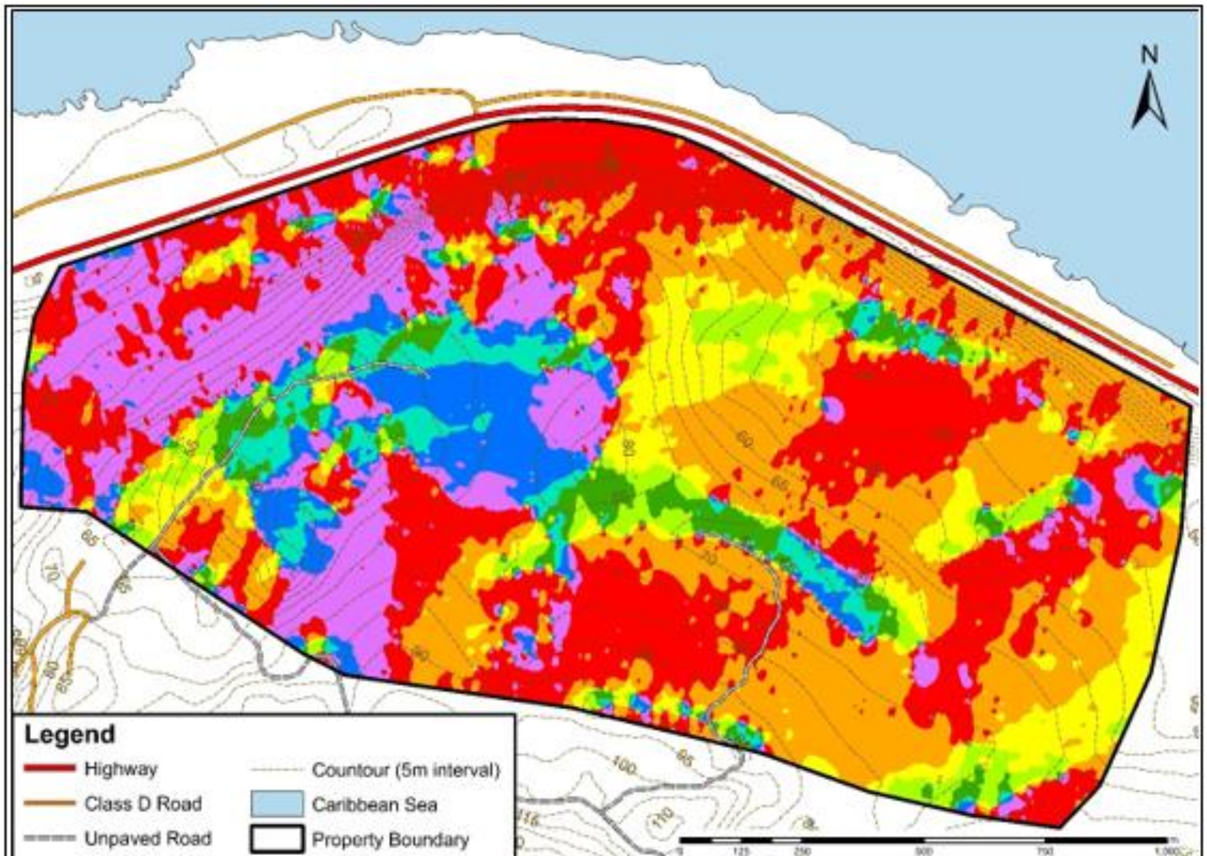
A broad, N-S trending ridge which raises about 15m above the surrounding terrace cuts the main erosional terrace in two. (Figure 4-6). The ridge meets the terrace escarpment almost at right angles behind the abandoned processing plant area and is noticeable in the escarpment as an increase in the height of the escarpment. Although both side of the ridge are part of the same topographic unit, there are conspicuous morphological differences, which are also evident in the slope aspect map (Figure 4-5). The depressions west of the ridge are sub-circular while east of the ridge the depressions are generally rectilinear, elongated and many times longer than they are wide.

The closed depression W1 in the western section of the property is a subcircular dish shaped structure with a flat bottom and gentle sloping edges or doline. This doline has a diameter of approximately 300m and coalesces in the SE with a smaller depression which gives the doline a more elongated appearance. A relatively large asymmetric collapse structure is located in that area hidden below the tree cover. The southwestern border of the collapse structure is a 15m high, partially overhanging cliff. The fairly straight cliff is approximately 30 m long and trends to the NW (315º). Parts of the cliff face, mainly overhanging sections, are covered with small dripstone and flowstone deposits. An open sinkhole is located at the foot of the cliff. It is an open vertical fissure or shaft of about 0.5m wide and a few meters long. The slope opposite to cliff is a moderate steep scree slope which consist of limestone block and rubble (Plate 4-1). Although the entire depression slopes toward the sinkhole in the collapse structure, no signs of channel formation caused by concentrated runoff could be identified. A similar asymmetrical collapse structure is located in the closed depression W4. Nearly identical in size, shape an orientation, this collapse structure has cliff segments with larger overhangs but lacks the open sinkholes structure present in W1.

The elongated closed depression E1 East of the ridge is at least 400 m long and 100m wide. Six (6) separate open sinkholes were identified in this depression. They are lined up and are located in the line of trees in the middle of the depression. This lineament of sinkholes has a trend 305º (between NW and WNW) which is roughly parallel with the escarpment in the eastern section of the property. The sinkholes are point features with an average diameter of 2m which are partially filled with vegetation, dirt and debris and appear to be formed at the intersection of fissures. This is evident in very middle of the depression where the largest sinkhole is located. This sinkhole structure is formed at the intersection of 4 fissures. The red lines in Plate 4-2 indicate the location of these fissures on the ground. The main sinkhole shaft is located at the upper right intersection of these fissures. The intersection of the 4 fissures resulted in the development of column or block with a cross section 2m by 3m. As the sinkhole develops this column is be expected to break eventually and collapse in the space created by the expansion of the sinkhole

Grikes or kluftkarren, were observed in the eastern section of the property on the edges of the closed depressions E1 and E2. These near vertical open fissures are widened by solution processes. The grikes vary in width from a few centimetres to 30 cm and can be traced over a distance of 10 to 15m. Grikes become less permeably with depth and have the potential to form perched water tables. The trend of these grikes is 60º or approximately ENE at both locations which is roughly parallel with the cliff or the edge of main terrace in the western section of the property.

The closed depression E3 and E4 near the edge of the main terrace are associated with 2 short valleys which terminate in these depressions. The valley ending in the depression E3 is about 150 long and runs approximately parallel to the edge of the main terrace; the valley terminating in depression E4 is 250 m long and has the same trend as the grikes near the depressions E1 and E2 (60º or approximately ENE). A third valley with the same orientation passes through the buffer zone in the SE corner of the property and terminate in a closed depression outside the property. These three valleys are blind valley. Any surface runoff that may pass through these valleys and reach the closed depression is, disappears underground through the sinkhole in these depressions.



Compass Point	Bearing	Aspect Classes			Area
N	0º	337.5º	-	22.5º	30.6%
NE	45º	22.5º	-	67.5º	25.2%
E	90º	67.5º	-	112.5º	9.7%
SE	135º	112.5º	-	157.5º	4.7%
S	180º	157.5º	-	202.5º	3.8%
SW	225º	202.5º	-	247.5º	4.3%
W	270º	247.5º	-	292.5º	6.5%
NW	315º	292.5º	-	337.5º	15.2%

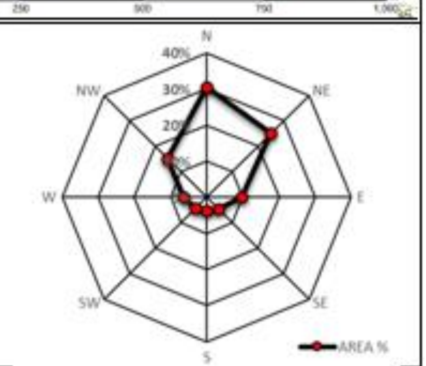


Figure 4-6 Aspect map

Plate 4-1 Collapse Structure in W1 (Screen on the left & Cliff on the right side of photo)

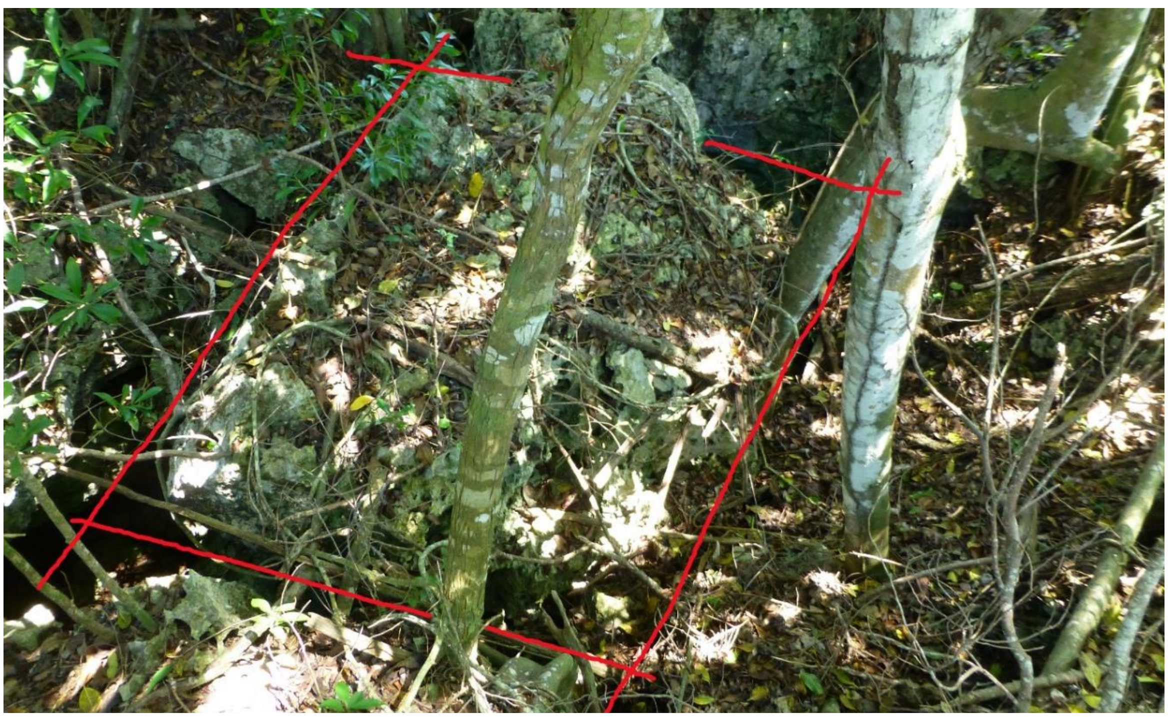


Plate 4-2 Sinkhole in the Elongated Closed Depression E1 (Red Line = location of gaping fissures)

Escarpments and Lower Terraces North of the Main Terrace

The abandoned processing plant, in the northern tip of the property, is located on the erosional terrace that forms the shoreline between Discovery Bay and the bay of Rio Bueno, the same terrace that carries the highway and the partially developed Bengal subdivision. This terrace has an elevation of 1 to 2 m AMSL high near the coast and reaches a maximum height of ±5m inland. The width of this terrace increases from 100 m to 120 m in the East (Discovery Bay) to 350m in the West (Rio Bueno). In vicinity of the closed processing plant the terrace is 220m wide.

The cliff which defines the scenic view along the Queen's Highway, coincides with the northern boundary of the property between Discovery Bay and the closed processing plant. The cliff is straight and has a constant alignment of 298^{o} (approximately WNW-ESE) over a distance of almost 2km. At the abandoned processing plant the orientation of the cliff changes to E-W or 90^{o}. The height of the cliff gradually increases from 40m in the east to 60 m AMSL behind the closed processing plant.

The cliff is dotted with shallow caves or niche-like features adorned with dripstones deposits such as flowstones, drapes and stalactites (Plate 4-3). These niches occur on average at an elevation of 35 m AMSL and appear to indicate the position of an ancient regional water table. Overall the cliff face has a smooth and rounded appearance, which is probably caused of dissolution processes.

Plate 4-3 Cliffs along the Queen's Highway and detail of niche with stalactites

The cliff continues to the west of the closed processing plant for at least 800m. The alignment of the cliff changes to 59^{o} (approximately ENE-WSW) and its elevation reduces to 55m AMSL. Two additional terrace levels appear in this area, one at 15m and one at 25m AMSL. The escarpment in this area including the one associated of 55m terrace level are less pronounced except for the quarry face in the back of old quarry. The escarpment associated with the 15m terraces forms the boundary between the property and the Queen's Highway. In its current configuration this escarpment and its vegetation are high enough to hide the view of the quarry along the Highway corridor.

4.1.2.3 Geomorphological Considerations

The area in which the property is located is classified based on its large scale morphological features as a marine terrace landscape. The marine terraces have also been altered by karst processes and a karst morphology has been superimposed over the marine terrace morphology. The property has in fact all the typical features of a karst landscape including closed depressions, collapse structures, sinkholes, underground conduits and a general absence of surface drainage. The karst features east and west of the ridge in the middle of the property, are different although both are part of the same geomorphic unit. The topography to west of the ridge seems to be more mature and more karstified than to East. This may be caused by differences in water regime, lithology and structural characteristic such as joint density or a combination of all three.

Most of the geotechnical and hydrological challenges posed by the karst morphology are related to the presence of underground conduits and cave systems. The conduit and caves systems provide fast discharge to the groundwater table with little or no capacity to filter out possible contaminants. Quarry activities may also induce the collapse of caves and intersecting conduits. Conduits and cave systems are irregular in shape and distribution and are subject to rapid change. The anisotropic and heterogeneous nature of these systems make it difficult to predict subsurface conditions and their potential impact of the environment. Specific mitigation will however be addressed by a quarry plan that will reflect in near real time the conditions of the quarry operations and provide mitigating solution as the need arises. The geotechnical and hydrological implications of these systems are discussed further in the sections on geology and hydrology.

4.1.3 Hydrology and Hydrogeology

4.1.3.1 Regional Hydrology

The communities of Bengal and Red Valley along with the proposed quarry site are located within the boundaries of the Dry Harbour Mountain Basin and managed by the Rio Bueno- White River Watershed Management Unit (Figure 4-7). The proposed quarry site is also located to the east of the Rio Bueno River.

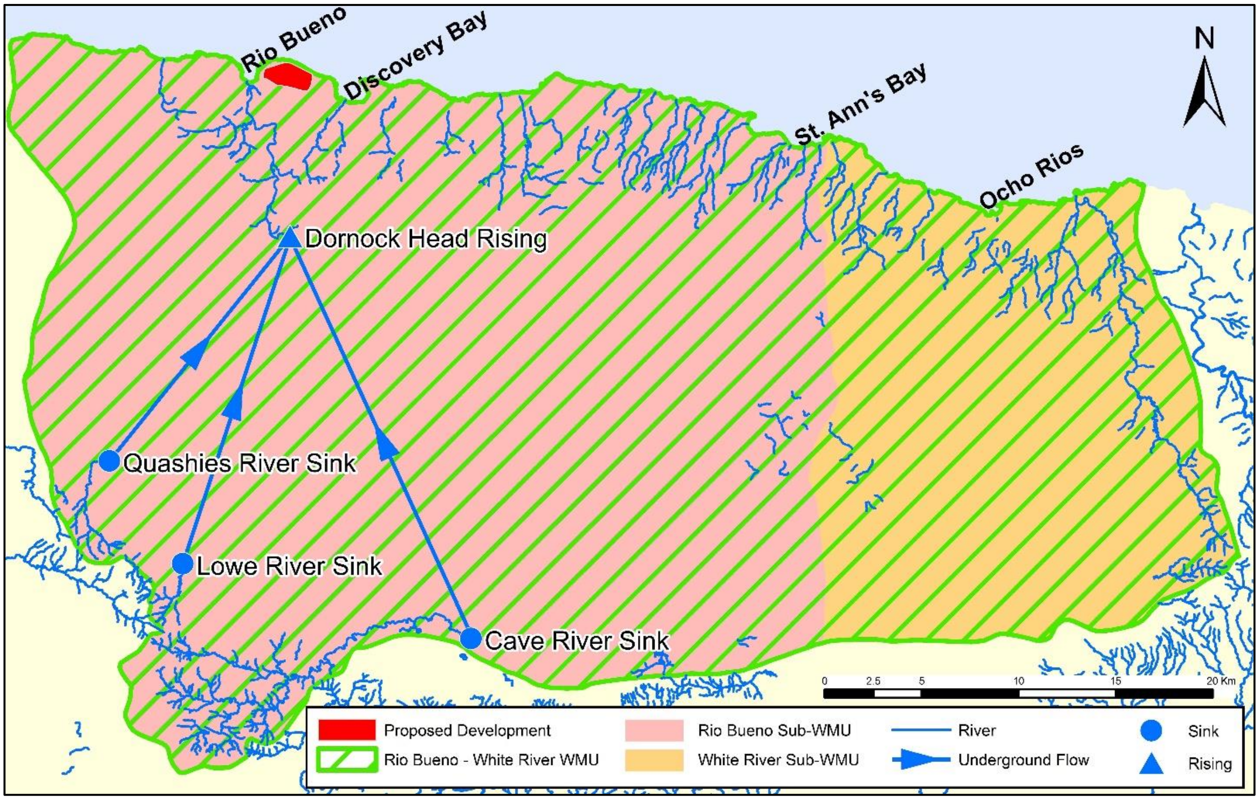


Figure 4-7 Regional Hydrology

The Watershed Management Units were defined based on the Hydrological and Demand Basins of the Water Resources Authority and the physical characteristics of the catchment basins including vegetation cover, land use, slopes, erodibility and erosion rates. With a total area of 1567.95 km^2, the Rio Bueno - White River Watershed Management Unit is the second largest Watershed Management Unit in Jamaica. The boundaries of this particular WMU are identical to the boundaries of the Dry Harbour Mountain Hydrological and Demand Basin of the Water Resources Authority. To facilitate the environmental management of the WMU, the unit was split up in to two (2) units with similar characteristics, the Rio Bueno Sub-Watershed Management Unit and White River Sub-Watershed Management Unit.

The hydrostratigraphic unit for the area can be classified as a coastal aquiclude. These units include low permeability rocks of the Coastal Group distributed along the northern coastline of the island. An assessment of aquifer vulnerability maps show that Bengal and its environs have a high to very high potential for salt water intrusion and wastewater contaminants in water wells.

The lack of springs and groundwater within this formation is typical for the predominant rock type. However, interpretations of the regional groundwater flow in the underlying more permeable limestone identifies a general flow direction from the south towards the northern coastline (Figure 4-8).

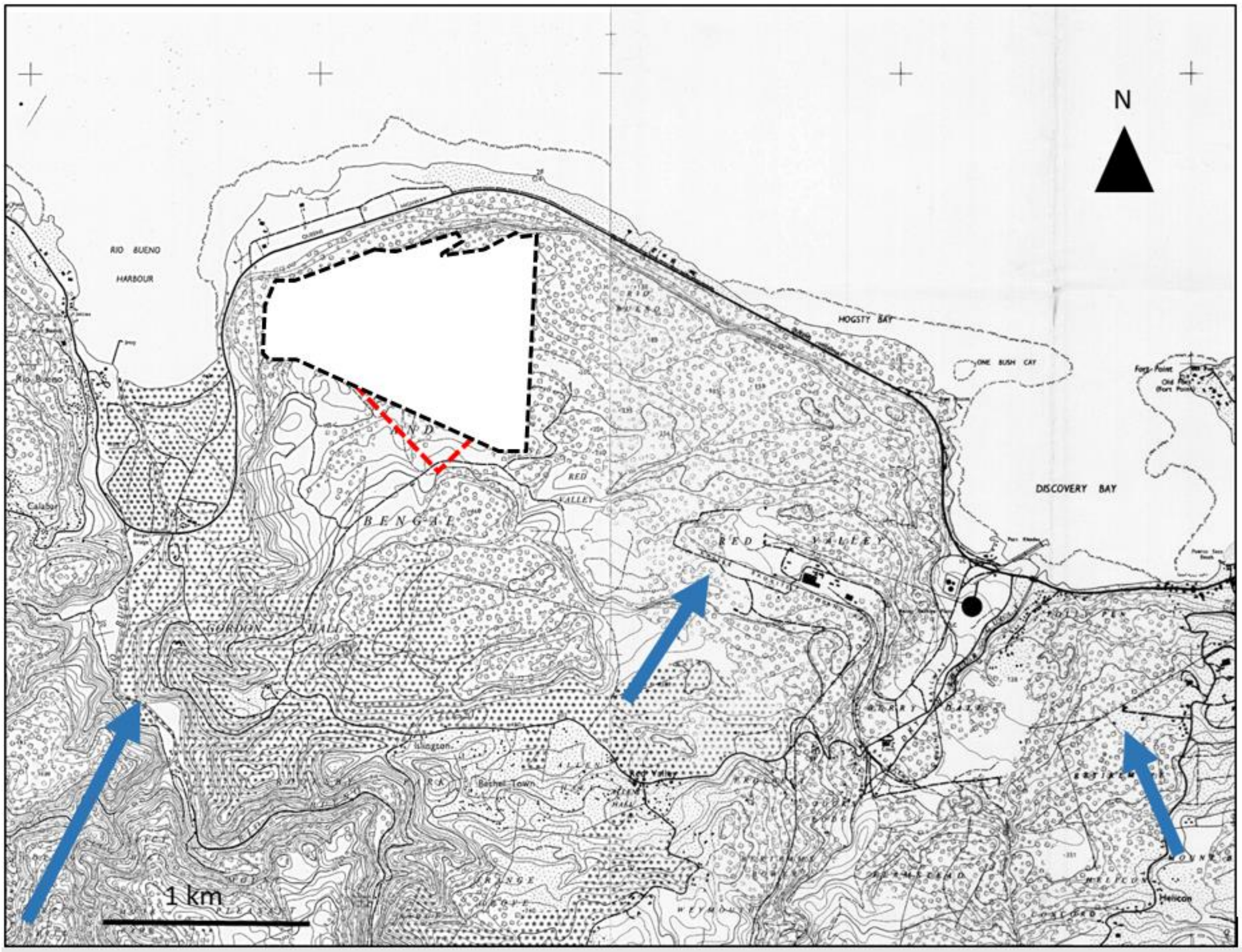


Figure 4-8 Topographic map showing regional groundwater flow directions for the area (blue arrows). White area outlines the proposed quarry site (Source: JAD 1:12,500, WRA)

Except for the narrow band of cretaceous volcanic rocks along its southern boundary, the Rio Bueno - White River WMU consist almost entirely of limestone deposits and is dominated by karst processes and karst topography. The dissolution of the limestone deposit by water created an interconnected subterranean drainage network which make it very difficult to identify the exact limits of the drainage area of rivers and effectively manage water resources in this WMU.

The rivers near the southern edge of the WMU end abruptly a short distance after they enter the limestone area. The rivers terminate in sinks and caves and completely disappear underground. The central area of the WMU has no rivers or streams because rain fall and surface runoff is almost immediately channelled or absorbed by the karstic limestone aquifer which carries the water underground towards the coast in the north. This underground drainage system consists of a complex interconnected system of conduit aquifers including caves, open joints and fractures and diffuse matrix aquifers including intergranular porosity, bedding planes, closed and clogged joints and fractures. Approximately 10 km from the coast rivers and stream reappear in the landscape. Many are intermittent seasonal streams which only carry water during wet seasons or during heavy rainfall.

The Rio Bueno river to the west of the proposed development is one of the few perennial stream in this WMU. The source of the Rio Bueno river is the Dornock Head Rising near Stewart Town. Although It has a length of only 11.7 km and a surface drainage area of 26.4 km^2, it is a fairly reliable and significant source of water for the region. Groundwater originating from several of the rivers in the upper reaches of the basin emerges at the Dornock Head Rising. The Quashies and Cave rivers disappearing in swallow holes near Albert Town and Cave Valley, have been proven to be connected to the Dornock Head Rising with groundwater tracing test. A connection is also surmised between the Lowe River Sink and the Dornoch Head Rising but this is still to be tested.

The inflow from these rivers into Dornoch Head Rising the ensures that the discharge of the Rio Bueno is consistent and large enough to operate two (2) small hydro plants with an aggregate capacity of 3.6 MW and to allow the Dornoch Treatment Plant extract 0.75 million gallons of water per day from the river. In “The draft St. Ann WS Parish Plan – October 12, 2011” it is reported that the NWC plans to construct a new treatment plant and increase the extraction from the Rio Bueno to 3 million gallons of water per day.

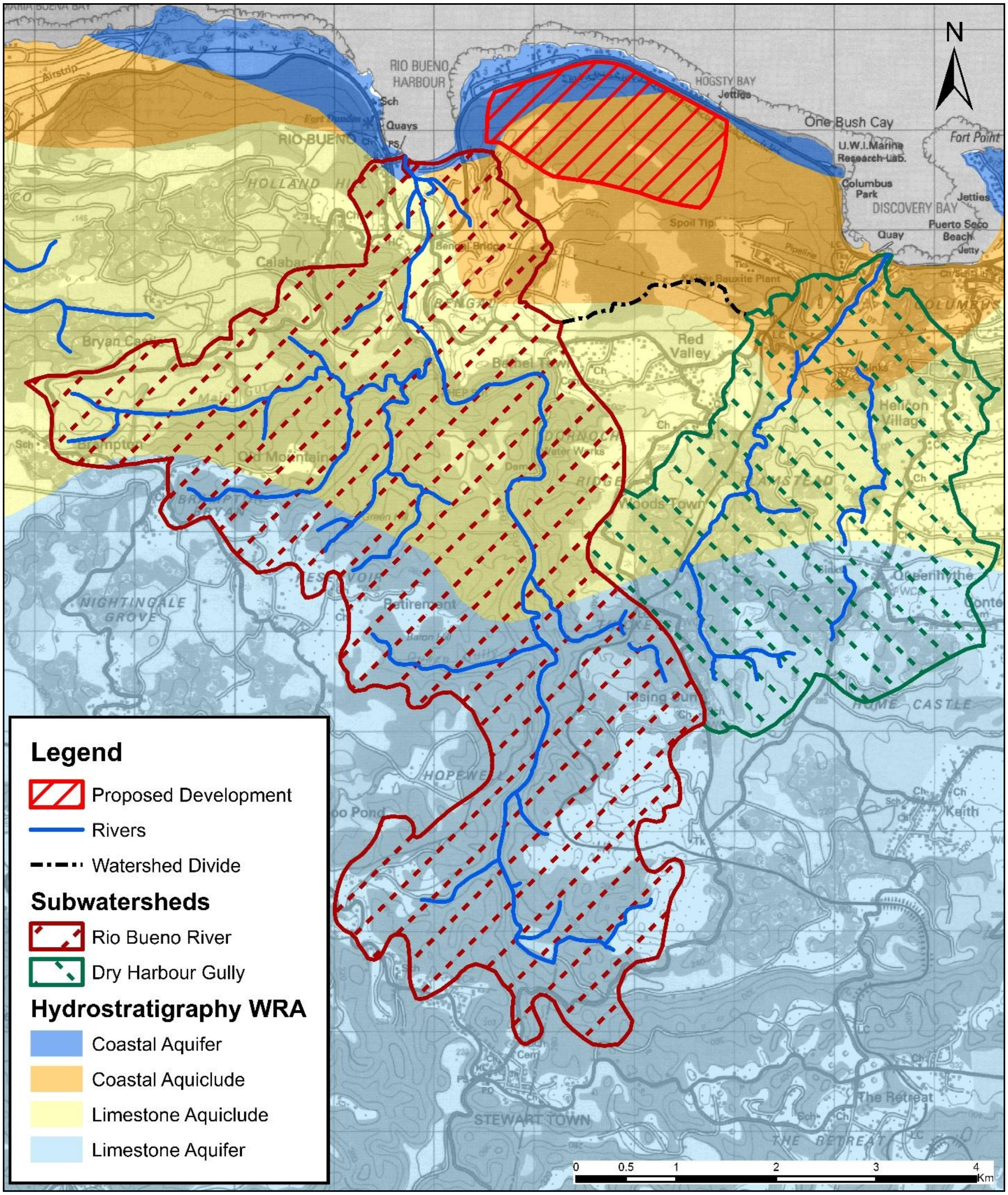
The Dry Harbour Gully to east of the proposed development 6 km long and has drainage area of 12km. It is a seasonally stream which exits in Discovery Bay east of the Bauxite Pier. The small estuary which is normally blocked by a sand bar is the It is the only stream that directly discharges into the harbour. Freshwater or mixed fresh and marine water is continually released in the Discovery through submarine vents and fractures (Anthony M. Greenaway, 2006). Overall more fresh water is believed to be discharged into the sea at Discovery Bay by these submarines’ vents then by surface drainage.

4.1.3.2 Hydrology of the Proposed Development

The proposed development is located in a small watershed which wedged between the Rio Bueno watershed to West and by the Dry Harbour Gully Watershed to the east, in a sub watershed of about 9.6 Km^2 with no apparent river or gullies or surface drainage (Figure 4-9).

Karst systems are very vulnerable to ground water pollution due to the relatively rapid rate of water flow and the lack of a natural filtration system. Sediment trap, environmental monitoring should include monitoring of sediment plumes in the coastal areas during the mining phase.

A standalone Drainage Estimation Report is attached in Appendix 4.



Source Jamaica Water Resources Authority Water Information System

Figure 4-9 Hydrostratigraphy of the Rio Bueno River & Dry Harbour Gully

4.1.4 Climate

Climate data (temperature, relative humidity, rainfall, wind speed, wind direction and barometric pressure) for January to November 2016 was obtained for Bengal Farm (located south of the proposed project site), from the National Meteorological Service of Jamaica (Table 4-3).

Lowest average temperatures were recorded in February (24.35°C) while the highest were in July (27.96°C). Average relative humidity ranged from a low of 84.49% in August to a high of 87.8% in October. Average wind speeds between January and July were somewhat similar, the highest being 3.77 m/s in March and the lowest being 1.9 m/s recorded in October. The dominant wind direction for each month was southwest, however, in November, both south-westerly and north-easterly wind directions were dominant. Average barometric pressure ranged from a low of 1010.20 millibar in October to a high of 1015.35 millibar in March. Highest average rainfall recorded was in September (18.04 mm), with the second highest being in May (4.0 mm), while the least rainfall was observed in March (0.51 mm).

Table 4-3 Climate data for Bengal Farm (January to November 2016)

Month	Temperature (°C)	Relative Humidity (%)	Wind Speed (m/s)	Dominant Wind Direction	Barometric Pressure (mb)	Rainfall (mm)
January	24.66	84.92	3.16	SW	1014.70	2.90
February	24.35	86.33	3.28	SW	1015.30	2.46
March	25.07	84.98	3.77	SW	1015.35	0.51
April	26.02	84.59	3.68	SW	1013.08	1.14
May	26.37	86.68	3.70	SW	1013.47	4.00
June	27.29	85.15	3.74	SW	1014.66	1.32
July	27.96	82.05	3.57	SW	1015.00	0.86
August	27.58	84.49	2.80	SW	1013.23	2.18
September	27.23	85.80	2.52	SW	1013.61	18.04
October	26.67	87.81	1.90	SW	1010.20	1.80
November	25.80	86.65	2.04	NE / SW	1012.05	3.26

4.1.5 Air Quality

Coarse particles are airborne pollutants that fall between 2.5 and 10 micrometres in diameter. Fine particle are airborne pollutants that fall below 2.5 micrometres in diameter. Sources of coarse particles include crushing or grinding operations, and dust stirred up by vehicles traveling on roads. Sources of fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

4.1.5.1 Historical Particulate Ambient Air Quality

Historical particulate ambient air quality monitoring data in the vicinity of the proposed quarry location was available from 2010 to 2018 from Annual Ambient Air Quality Report (2010-2012 data) compiled by the National Environment & Planning Agency as well as through the Access to Information Act (2013-2018 data). The data in Table 4-4 and Table 4-5 revealed compliance with the respective standards for each year at all monitoring sites (Figure 4-10, Table 4-6), which are in the vicinity of the Noranda Jamaica Bauxite Partners facility location.

Table 4-4 Noranda Bauxite Partners Historical TSP Ambient Air Quality Data

Location	Year	Highest 24h mean, µg/m³	Annual Mean, µg/m³
Farm Town	2010	90	17
	2011	70	28
	2012	100	34
	2013	53.21	28.38
	2014	86.41	30.15
	2015	81.56	32.18
	2016	72.43	27.20
	2017	74.25	27.10
	2018	82.97	30.45
Old Folly	2010	74	16
	2011	43	15
	2012	85	31
	2013	49.04	27.02
	2014	88.18	31.30
	2015	84.69	33.01
	2016	66.11	26.44
	2017	68.81	27.91
	2018	87.88	32.10
Bengal	2010	120	23
	2011	61	29
	2012	124	40
	2013	55.86	29.64
	2014	80.18	31.31
	2015	88.52	31.67
	2016	83.17	25.72
	2017	65.57	24.08
	2018	88.26	30.30
Clinic	2010	70	14
	2011	50	18
	2012	77	30
	2013	56.30	25.71
	2014	103.87	29.12
	2015	88.72	30.21
	2016	64.10	21.33
	2017	86.56	23.14
	2018	90.15	26.76
Rousseau	2010	132	29
	2011	88	42
	2012	124	59
	2013	58.41	48.38
Calderwood	2010	140	27
	2011	48	33
	2012	na	na
Clydesdale	2010	102	19
	2011	86	20
	2012	na	na
Green Hill	2010	68	16

Location	Year	Highest 24h mean, µg/m³	Annual Mean, µg/m³
	2011	66	18
	2012	na	na
NEPA	*Standard*	*150*	*60*

na= Not Available

N.B. Rousseau station went out of operation hence no data after 2013. No data available after 2011 for Calderwood, Clydesdale or Green Hill.

Table 4-5 Noranda Bauxite Partners Historical PM10 Ambient Air Quality Data

Location	Year	Highest 24h mean, µg/m³	Annual Mean, µg/m³
Queens Road	2010	110	13
	2011	59	27
	2012	103	33
	2013	51.49	25.39
	2014	104.89	30.54
	2015	105.26	38.11
	2016	92.14	32.27
	2017	97.10	26.51
	2018	79.21	27.99
NEPA	*Standard*	*150*	*50*

Table 4-6 Noranda Bauxite Partners Ambient air quality monitoring data station coordinates

NAME	NORTHINGS	EASTINGS
Old Folly	706099.0084	700499.0458
Clinic	705971.9009	700344.366
Queens Road	702481.2356	702743.4217
Rosseau	704688.5766	702682.845
Bengal	702542.1402	701724.9271
Farm Town	703815.6214	699773.7474

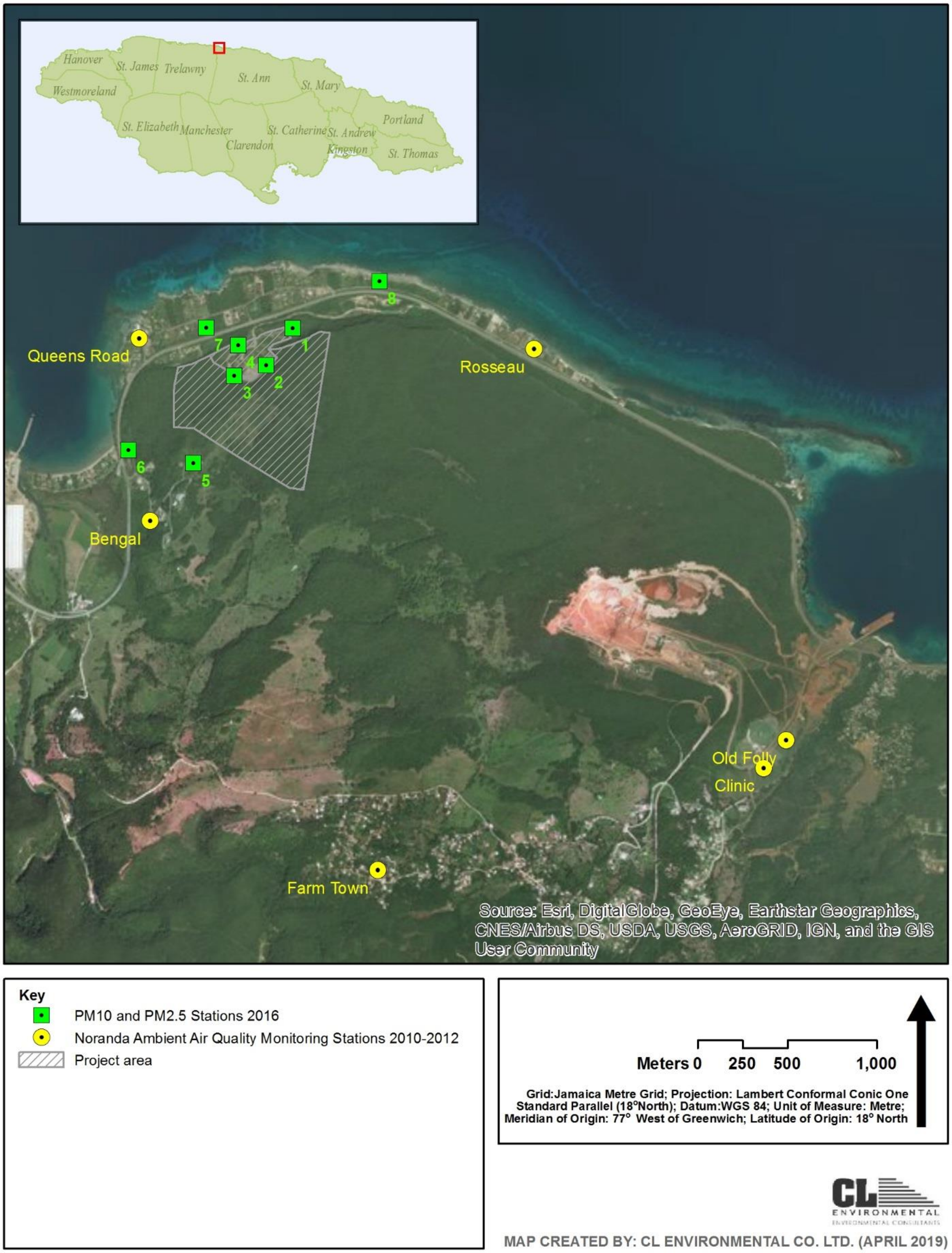


Figure 4-10 Map showing air quality and particulate monitoring stations

4.1.5.2 2016 Sampling

Methodology

PM10 and PM2.5 particulate sampling exercises were conducted at eight (8) locations (listed in Table 4-7 and illustrated in Figure 4-10) for 24 hours each on three separate occasions, using Airmetrics Minivol Tactical Air Samplers. The PM10 sampling exercises were conducted from 12:00am – 12:00am on January 23rd – 24th, February 10th – 11th and March 4th – 5th, 2016. The PM2.5 sampling exercises were conducted from 12:00am – 12:00am on January 21st – 22nd, January 29th – 30th and March 2nd – 3rd, 2016.

Table 4-7 Particulate monitoring station coordinates

STATION #	LOCATION (JAD2001)	
	NORTHINGS	EASTINGS
STN 1	702790.67	703344.67
STN 2	702590.92	703200.20
STN 3	702531.87	703016.78
STN 4	702707.75	703038.14
STN 5	702041.20	702793.30
STN 6	702115.07	702430.82
STN 7	702797.62	702861.70
STN 8	702967.24	703261.11

4.1.5.3 Results

PM10

All locations had averaged particulate PM10 values compliant with the 24-hour NRCA standard of 150μg/m³. Average values ranged from 18.19 μg/m³ at Station 2 to 81.06 μg/m³ at Station 8. The average PM10 values at the boundaries of the proposed quarry site were low, ranging from 18.19 – 29.77 μg/m³, while the offsite residential locations were slightly higher. This is perhaps due to the proximity to the North Coast Highway, and dust stirred up from vehicular traffic and residential construction activities nearby. One PM10 reading at Station 8 (175.28 μg/m³) was non-compliant with the 150 μg/m³ standard. The summarized results of the PM10 sampling runs are shown in Table 4-8 below. Detailed run results are shown in Table 4-9.

Table 4-8 Summarized PM 10 Results

STATION	AVERAGE RESULT (μg/m³)	RANGE (μg/m³)	NRCA STD. (μg/m³)
STN 1	**21.16**	5.0 – 44.17	150
STN 2	**18.19**	12.36 – 28.89	150
STN 3	**29.77**	13.19 – 59.03	150
STN 4	**27.13**	11.25 – 53.61	150
STN 5	**29.86**	13.19 – 39.58	150
STN 6	**45.00**	15.83 – 67.64	150
STN 7	**30.42**	10.14 – 59.31	150
STN 8	**81.06**	16.53 – 175.28	150

NB. Numbers in red are non-compliant with the standard/guideline

Table 4-9 Detailed PM10 Results

Sampling Date	STATION	Result $[PM_{10}]/ugm^{-3}$	NRCA PM10 Std [PM10]/ugm-3
January 23-24, 2016	STN 1	5.00	150
	STN 2	13.33	
	STN 3	13.19	
	STN 4	11.25	
	STN 5	13.19	
	STN 6	67.64	
	STN 7	10.14	
	STN 8	51.39	
February 10-11, 2016	STN 1	44.17	150
	STN 2	28.89	
	STN 3	59.03	
	STN 4	53.61	
	STN 5	39.58	
	STN 6	51.53	
	STN 7	59.31	
	STN 8	175.28	
March 4-5, 2016	STN 1	14.31	150
	STN 2	12.36	
	STN 3	17.08	
	STN 4	16.53	
	STN 5	36.81	
	STN 6	15.83	
	STN 7	21.81	
	STN 8	16.53	

NB. Numbers in red are non-compliant with the standard/guideline

PM2.5

All locations except for Station 5 (54.21 µg/m³) had averaged particulate PM2.5 values compliant with the 24-hour US EPA standard of 35µg/m³. Average values ranged from 8.62 µg/m³ at Station 1 to 54.21 µg/m³ at Station 5. The average PM2.5 values at the boundaries of the proposed quarry site were low, ranging from 8.62 – 12.13 µg/m³, and so were the offsite residential locations except for a one-off reading of 143.19 µg/m³ at Station 5, which is also non-compliant with the 35 µg/m³ standard. It is possible that there was burning occurring nearby that resulted in this extremely high PM2.5 reading. Station 6 also had a reading of 37.22 µg/m³ which was non-compliant with the 35 µg/m³ standard.

The summarized results of the PM2.5 sampling runs are shown in Table 4-10. Detailed run results are shown in Table 4-11.

Table 4-10 Summarized PM 2.5 Results

STATION	AVERAGE RESULT (µg/m³)	RANGE (µg/m³)	US EPA STD. (µg/m³)
STN 1	**8.62**	1.81 – 15.42	35
STN 2	**9.49**	0.42 – 19.86	35
STN 3	**12.13**	1.25 – 22.64	35

STATION	AVERAGE RESULT (µg/m³)	RANGE (µg/m³)	US EPA STD. (µg/m³)
STN 4	**11.30**	1.53 – 21.25	35
STN 5	**54.21**	0.56 – 143.19	35
STN 6	**15.93**	1.25 – 37.22	35
STN 7	**11.44**	6.39 – 15.28	35
STN 8	**10.00**	6.53 – 16.53	35

NB. Numbers in red are non-compliant with the standard/guideline

Table 4-11 Detailed PM2.5 Results

Sampling Date	STATION	Result [$PM_{2.5}$]/ugm^{-3}	US EPA PM2.5 Std [PM2.5]/ugm-3
January 21-22, 2016	STN 1	N/A	35
	STN 2	**8.19**	
	STN 3	**12.50**	
	STN 4	**11.11**	
	STN 5	**18.89**	
	STN 6	**9.31**	
	STN 7	**15.28**	
	STN 8	**16.53**	
January 29-30, 2016	STN 1	**15.42**	35
	STN 2	**19.86**	
	STN 3	**22.64**	
	STN 4	**21.25**	
	STN 5	**143.19**	
	STN 6	**37.22**	
	STN 7	**6.39**	
	STN 8	**6.53**	
March 2-3, 2016	STN 1	**1.81**	35
	STN 2	**0.42**	
	STN 3	**1.25**	
	STN 4	**1.53**	
	STN 5	**0.56**	
	STN 6	**1.25**	
	STN 7	**12.64**	
	STN 8	**6.94**	

NB. Numbers in red are non-compliant with the standard/guideline

4.1.6 Water Quality

4.1.6.1 Methodology

Three water quality sampling exercises were conducted at six (6) stations on December 2nd, December 12th, 2015 and January 21st, 2016. Stations 1-5 are located within the marine environment, while Station 7 is located within the Rio Bueno freshwater environment.

Weather conditions were fair and sunny on the first two sampling days and overcast on the final day. Their locations are listed in Table 4-12 and depicted in Figure 4-11. There is no Station 6 as this station was omitted due to inability to locate a waterway on land close to Station 7.

Temperature, conductivity, salinity, dissolved oxygen, turbidity, total dissolved solids, pH and Photosynthetically Active Radiation (PAR) were collected in situ using a Hydrolab DS-5 water quality multi probe meter. Whole water samples were collected in pre-sterilized bottles, stored on ice and taken to Caribbean Environmental Testing and Monitoring Services Limited (CETMS Ltd.) for analysis of Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), phosphates, nitrates, fats oil and grease (FOG) and faecal coliform. Each of the water quality samples was collected at a depth of approximately 0.5 m; this was facilitated with the use of a boat where necessary.

The Hydrolab calibration certificate can be seen in Appendix 5.

Table 4-12 Coordinates of water sampling stations

STATION #	LOCATION (JAD2001)	
	NORTHINGS (m)	EASTINGS (m)
BWQ1	703056.6818	703819.7265
BWQ2	704181.2691	703121.8601
BWQ3	702304.2053	702740.2243
BWQ4	703179.2371	703234.2553
BWQ5	701833.5577	702019.4416
BWQ7	702059.6182	701224.801

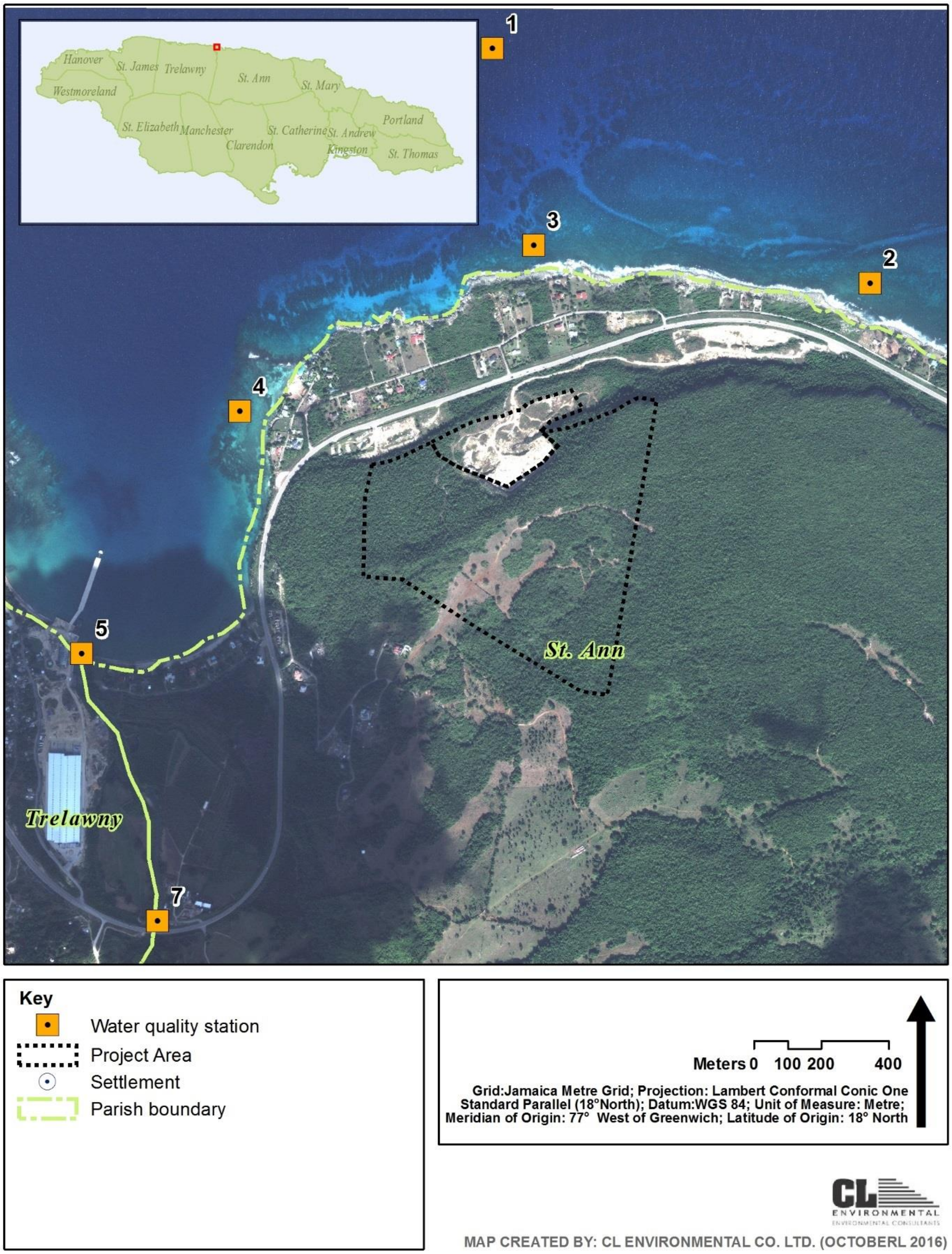


Figure 4-11 Map showing water quality sampling stations

Results

Table 4-13 shows the average physical data while Table 4-14 shows the average biological and chemical data for the stations sampled.

Table 4-13 Average physical water quality data

Stn	TEMP. °C	COND (mS/cm)	SAL (ppt)	pH	PAR (uE/cm/s)	D.O. (mg/l)	Turb (NTU)	TDS (g/l)
BWQ1	28.53	54.87	36.42	8.24	225.69	6.33	0.92	35.21
BWQ2	28.25	54.80	36.41	8.20	478.73	5.53	1.13	35.10
BWQ3	28.35	54.80	36.38	8.24	456.78	5.80	3.06	35.07
BWQ4	28.27	55.02	35.85	8.24	327.93	5.38	2.29	34.88
BWQ5	27.09	47.64	27.56	8.22	365.00	6.49	2.63	27.35
NEPA Marine Standard	-	-	-	*8 – 8.4*	-	-	-	-
BWQ7	23.44	0.42	0.21	8.34		9.04	2.90	0.29
NEPA Freshwater Standard	-	*0.15 – 0.6*	-	*7 – 8.4*	-	-	-	*0.12 – 0.3*

Table 4-14 Average biological and chemical water quality data

Station	BOD (mg/l)	TSS (mg/l)	NITRATE (mg/l)	PHOSPHATE (mg/l)	F.COLI (mpn/100ml)	FOG (mg/l)
BWQ1	11.04	5	1.27	0.03	84	3.70
BWQ2	3.82	5	1.27	0.09	38	3
BWQ3	2.96	5	1.30	0.04	61	3
BWQ4	6.47	5	1.07	0.05	180	2.63
BWQ5	5.93	5	0.93	0.09	180	3
NEPA Marine Standard	*1.16*	-	*0.007 – 0.014*	*0.001 – 0.003*	*13*	-
BWQ7	3.20	5	0.90	0.10	180	3
NEPA Freshwater Standard	0.8 - 1.7	-	0.1 – 7.5	0.01 – 0.8	-	-

TEMPERATURE

Temperature values varied across the stations ranging from 23.44 – 28.53 °C. Highest temperatures were obtained at station 1 whereas the lowest was obtained at station 7 (Rio Bueno). The water temperatures recorded for Stations 1 - 6 were expected in a tropical marine area influenced by the Trade Winds (≈27 –30 °C). Temperature at Station 5 was also lower than Stations 1-4 due to this station being at the Rio Bueno discharge point.

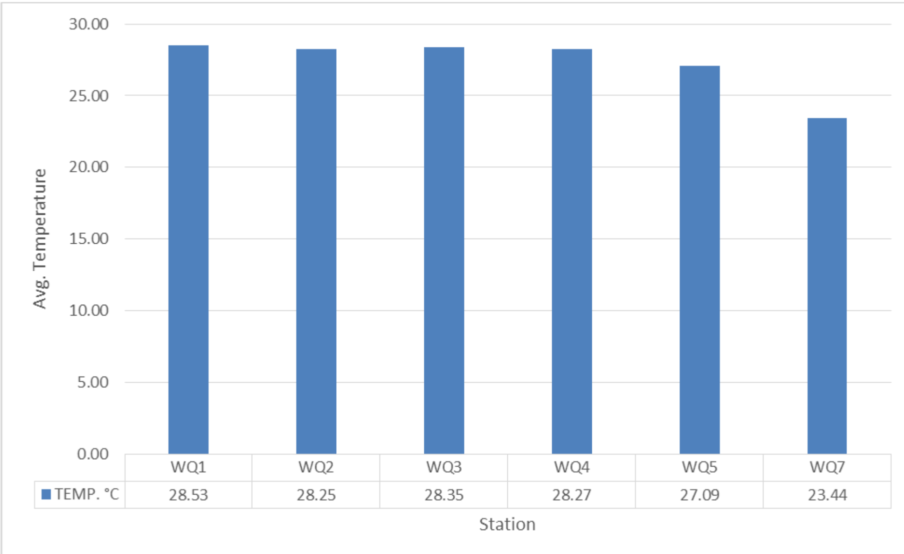


Figure 4-12 Temperature values at the various stations

SPECIFIC CONDUCTIVITY (SPC)

Specific conductivity varied across the stations ranging from 0.42 – 55.02 mS/cm. Highest specific conductivity was obtained at station 4, whereas the lowest specific conductivity was obtained at station 7 (Rio Bueno). Conductivity at Station 5 was also low due to this station being at the Rio Bueno discharge point. Station 7 was complaint with the NEPA freshwater standard of 0.15 – 0.6 mS/cm.

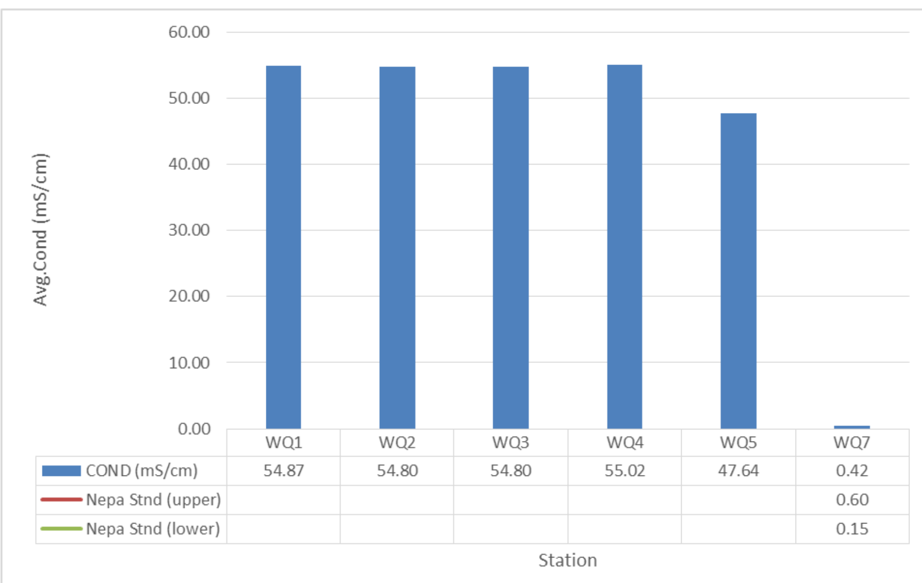


Figure 4-13 Conductivity values at the various stations

SALINITY

Salinity varied across the stations ranging from 0.21 – 36.42 ppt. Station 1 had the highest salinity values whereas station 7 (Rio Bueno) had the lowest value. Salinity at Station 5 was also low due to this station being at the Rio Bueno discharge point.

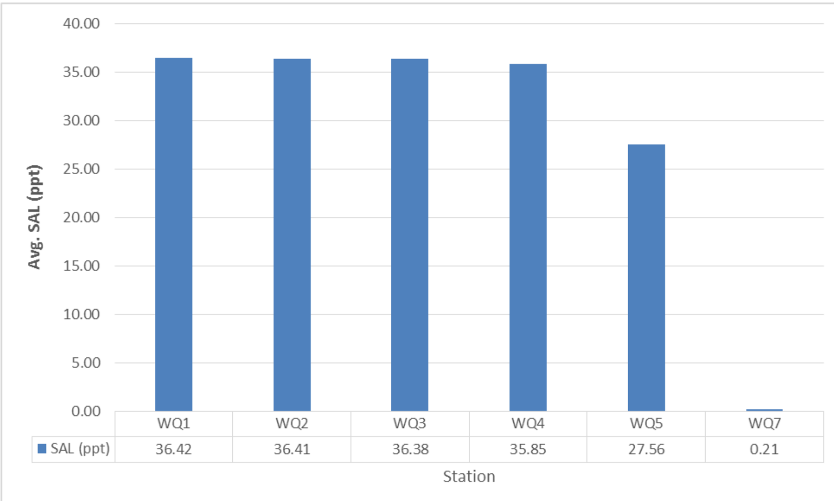


Figure 4-14 Salinity values at the various stations

PH

The pH values showed little variation across the stations ranging from 8.20 - 8.34. The highest pH values were obtained at station 7 (Rio Bueno) whereas the lowest pH obtained at station 2. In marine waters, pH levels tend to range between 8-9 pH units. Higher pH indicates the possibility of photosynthesis changing the pH within the zone. All pH values obtained were compliant with their respective NEPA marine (8 – 8.4) and freshwater (7 – 8.4) standards.

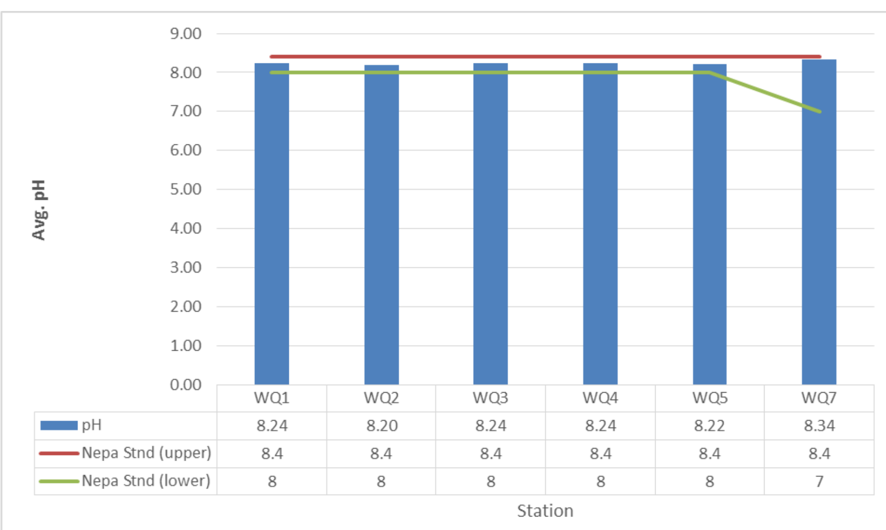


Figure 4-15 pH values at the various stations

DISSOLVED OXYGEN (DO)

Dissolved oxygen values varied across the stations ranging from 5.38 – 9.04 mg/l. Station 7 (Rio Bueno) had the highest dissolved oxygen value whereas the lowest was obtained at station 4. Dissolved oxygen levels were all within acceptable levels (>4 mg/l) and above the level that would be considered detrimental to aquatic life (≤ 3 mg/l).

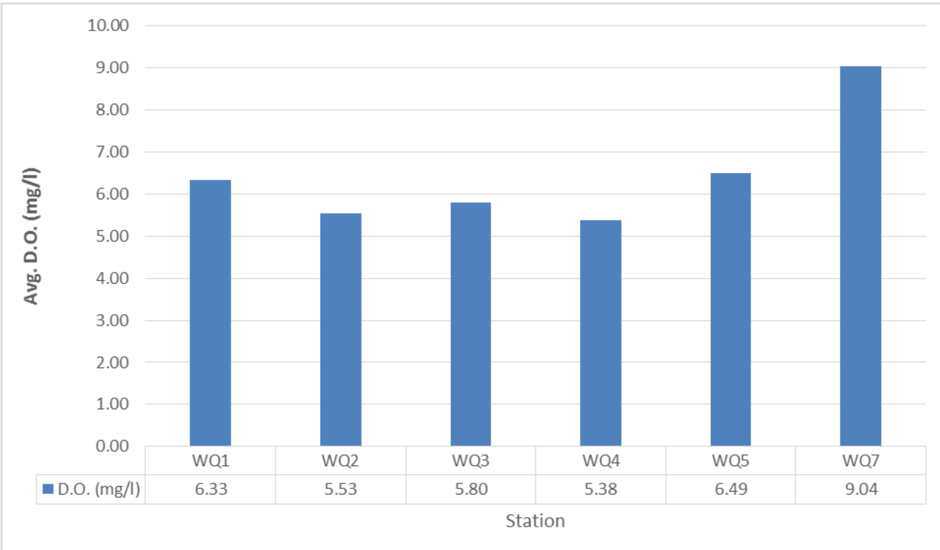


Figure 4-16 Dissolved oxygen values at the various stations

TURBIDITY

Turbidity varied across the stations ranging from 0.92 NTU at Station 1 to 3.06 NTU at Station 3.

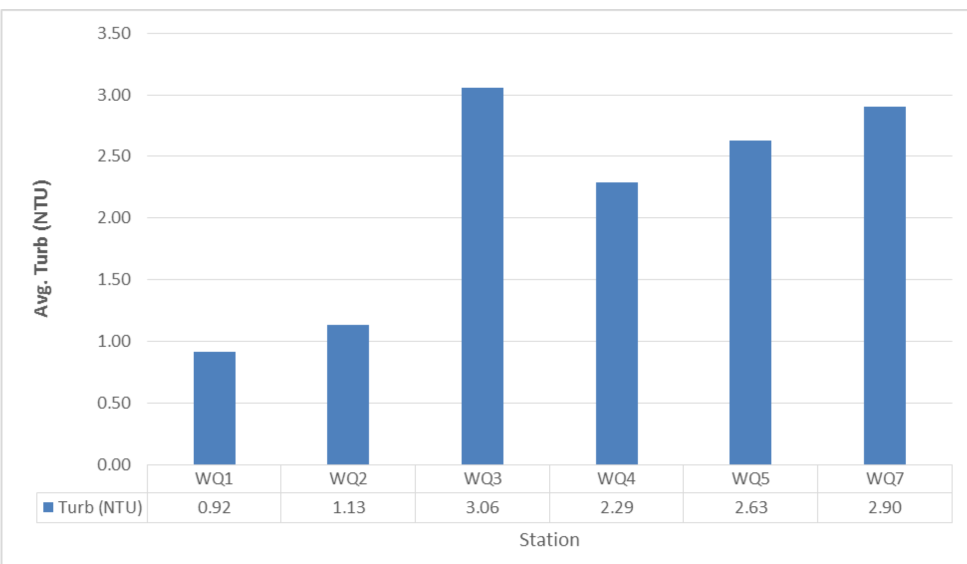
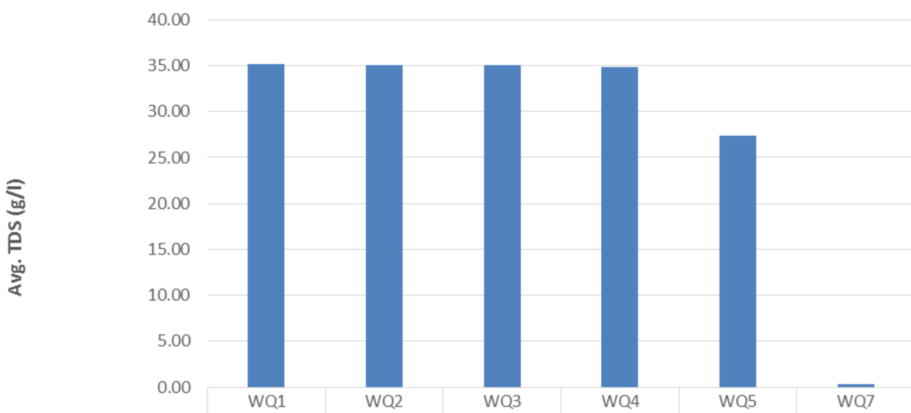


Figure 4-17 Turbidity values at the various stations

TOTAL DISSOLVED SOLIDS (TDS)

The TDS values varied across the stations ranging from 0.29 – 35.21 g/l. Highest values were obtained from station 1 whereas the lowest value was obtained at station 7 (Rio Bueno). Station 7 (0.29 g/l) was compliant with the NEPA freshwater standard of 0.12 - 0.3 mg/l.



	WQ1	WQ2	WQ3	WQ4	WQ5	WQ7
TDS (g/l)	35.21	35.10	35.07	34.88	27.35	0.29
Nepa Stnd (upper)						0.30
Nepa Stnd (lower)						0.12

Figure 4-18 TDS values at the various stations

PHOTOSYNTHETICALLY ACTIVE RADIATION (PAR)

PAR varied across stations ranging from 225.69 – 478.73 uE/cm^2/s. Highest PAR values were observed at station 2, whereas the lowest value was reported at station 1. The decrease in PAR with depth is expected as less light is able to penetrate with increasing depth. Cloud cover, time of day and the presence of organic and inorganic material also affect the amount of PAR available. No PAR value was available for Station 7 due to the shallow nature of the river where the sample was taken, thus the water quality probe was unable to submerge entirely.

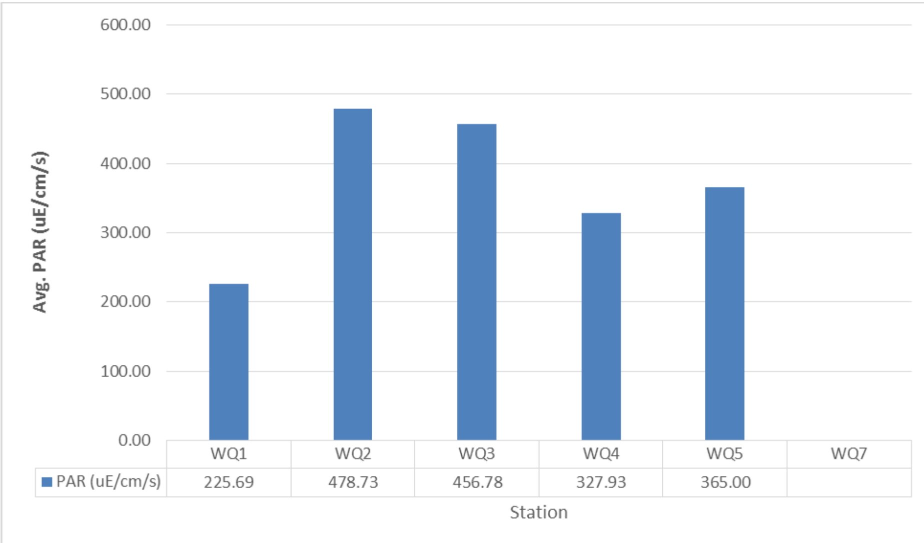


Figure 4-19 PAR values at the various stations

BIOCHEMICAL OXYGEN DEMAND

BOD values varied across the stations ranging from 2.96 – 11.04 mg/l. Station 1 reported the highest value (11.04 mg/l) and the lowest value was reported at station 3 (2.96 mg/l). All stations had BOD values above the respective NEPA marine and freshwater standards.

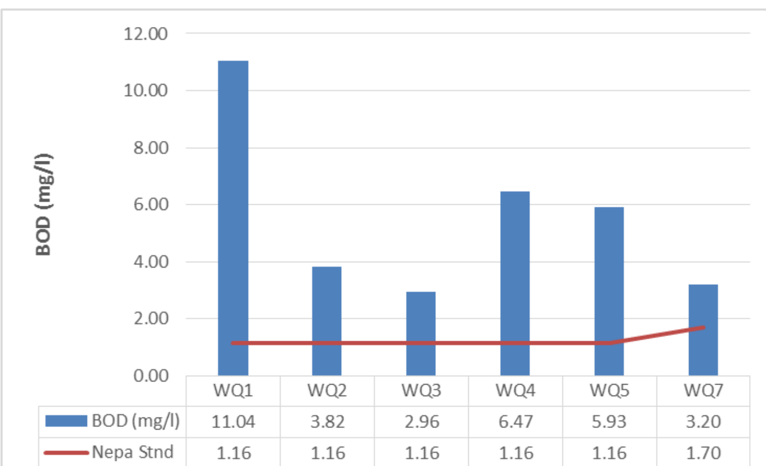


Figure 4-20 BOD values at the various stations

TOTAL SUSPENDED SOLIDS

TSS concentrations were all 5 mg/l. These concentrations indicated clear water as they were below 20mg/l.

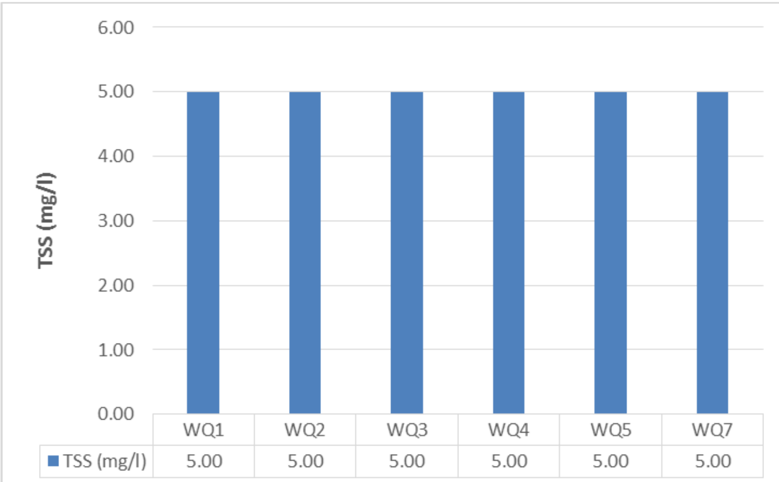


Figure 4-21 TSS values at the various stations

NITRATE

Nitrate values varied across the stations ranging from 0.9 – 1.3 mg/l. The lowest nitrate values were reported at station 7 whereas the highest value was observed at station 3. All marine stations were above the NEPA marine standard for Seawater for nitrates, while station 7 was compliant with the NEPA freshwater nitrate standard. These nitrate values are typical for Jamaican coastal waters.

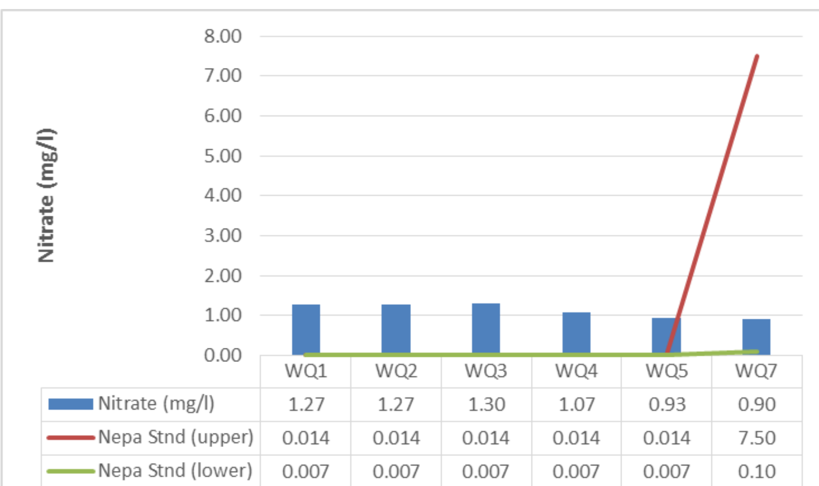


Figure 4-22 Nitrate values at the various stations

PHOSPHATE

Phosphate values varied across the stations ranging from 0.03 – 0.1 mg/l. The lowest phosphate values were reported at station 1 whereas the highest value was observed at station 7. All marine stations were above the NEPA marine standard for Seawater for phosphates, while station 7 was compliant with the NEPA freshwater phosphate standard. These phosphate values obtained are typical for Jamaican coastal waters.

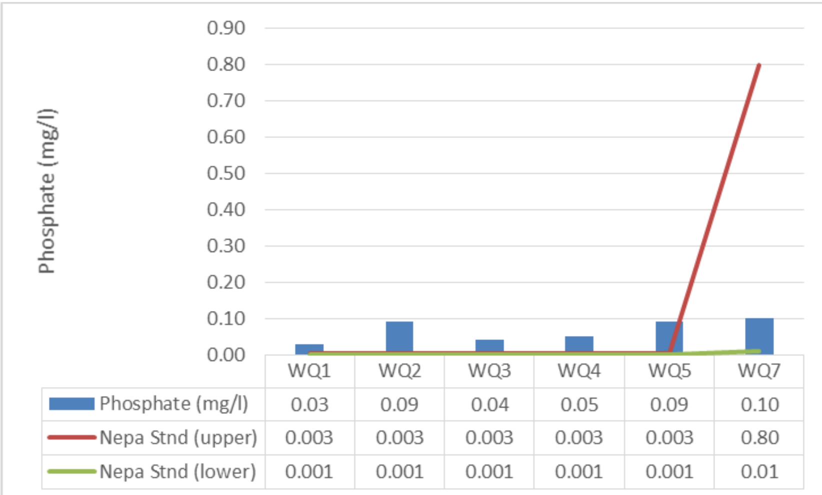


Figure 4-23 Phosphate values at the various stations

FOG

FOG ranged from 2.63 – 3.7 mg/L. The highest FOG was found at station 1, while the lowest FOG was at station 4.

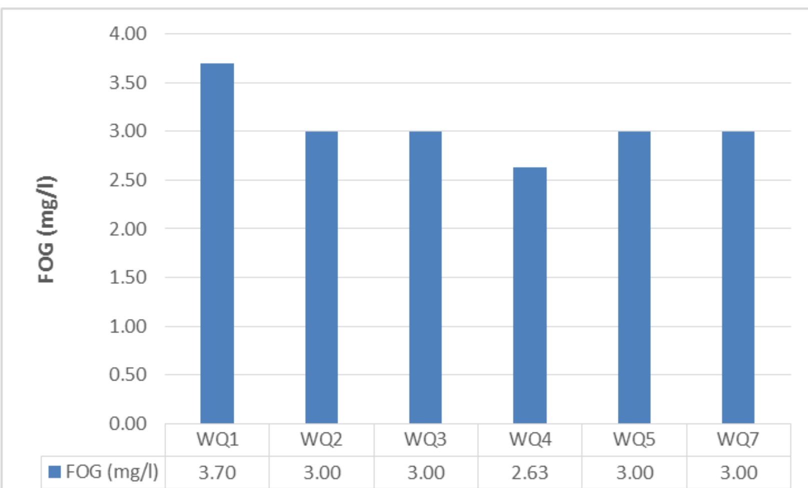


Figure 4-24 FOG values at the various stations

FAECAL COLIFORM

Faecal coliform (F. Coli) values varied across the stations ranging from 38 – 180 MPN/100ml. Stations 4, 5 and 7 had the highest values of 180 MPN/100ml, while Station 2 had the lowest coliform value of 38 MPN/100ml. None of the marine stations sampled were complaint with the NEPA faecal coliform standard for seawater of 13MPN/100ml.

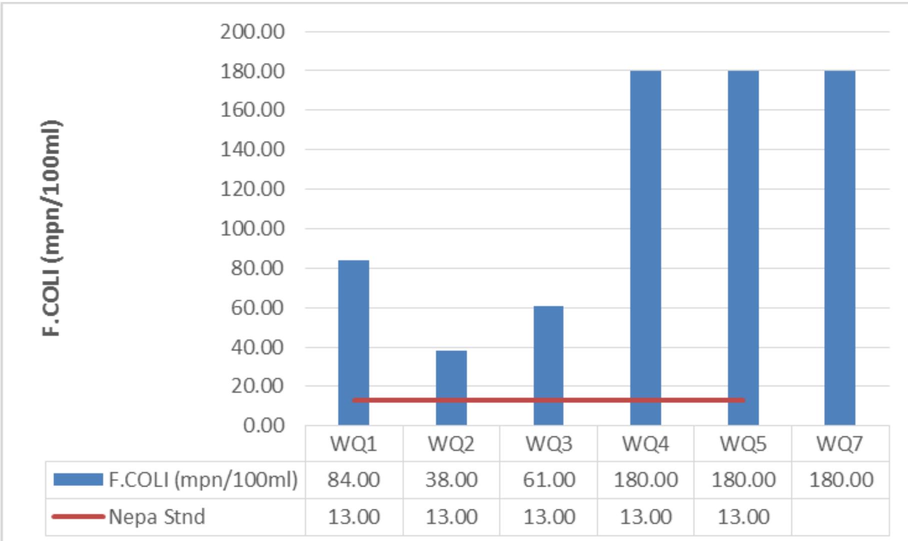


Figure 4-25 Faecal coliform values at the various stations

4.1.7 Noise

4.1.7.1 Methodology

Noise level readings were taken from 7:00am Thursday January 21st, 2016 to 7:00am Sunday January 24th, 2016, by using Quest Technologies SoundPro DL Type 1 hand held sound level meters with real time frequency analyser 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 6). The meters were programmed using the Quest Suite Professional II (QSP II) software to collect third octave, average sound level (Leq) over the period, Lmin (The lowest level measured during the assessment) and Lmax (The highest level measured during the assessment) every ten seconds.

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

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

where N = number of measurements, L_j = the jth sound level and j = 1, 2, 3 .... N.

Nine (9) noise meters with outdoor monitoring kits were set up (Plate 4-4). These meters were left for the entire seventy-two (72) hour assessment period in an outdoor measuring system and programmed to collect data every 10 seconds. Table 4-15 and Figure 4-26 lists and shows the locations of the noise monitoring stations. A windscreen (sponge) was placed over the microphone to prevent measurement errors due to noise caused by wind blowing across the microphone. The microphone of the meters was at a height of approximately 1.5m above ground and had an unobstructed view of the roadway (>135°). There were no vertical reflecting surfaces within 3 m (10 feet) of the microphone.

Noise statistics (L_{10} and L_{90}) were also be calculated at each location.

Plate 4-4 Noise (right) and particulate (left) meter

Table 4-15 Noise monitoring location coordinates

STATION #	LOCATION (JAD2001)	
	NORTHINGS (m)	EASTINGS (m)
STN 1	702790.67	703344.67
STN 2	702590.92	703200.20
STN 3	702531.87	703016.78
STN 4	702707.75	703038.14
STN 5	702041.20	702793.30
STN 6	702115.07	702430.82
STN 7	702617.07	702434.93
STN 8	702797.62	702861.70
STN 9	702967.24	703261.11

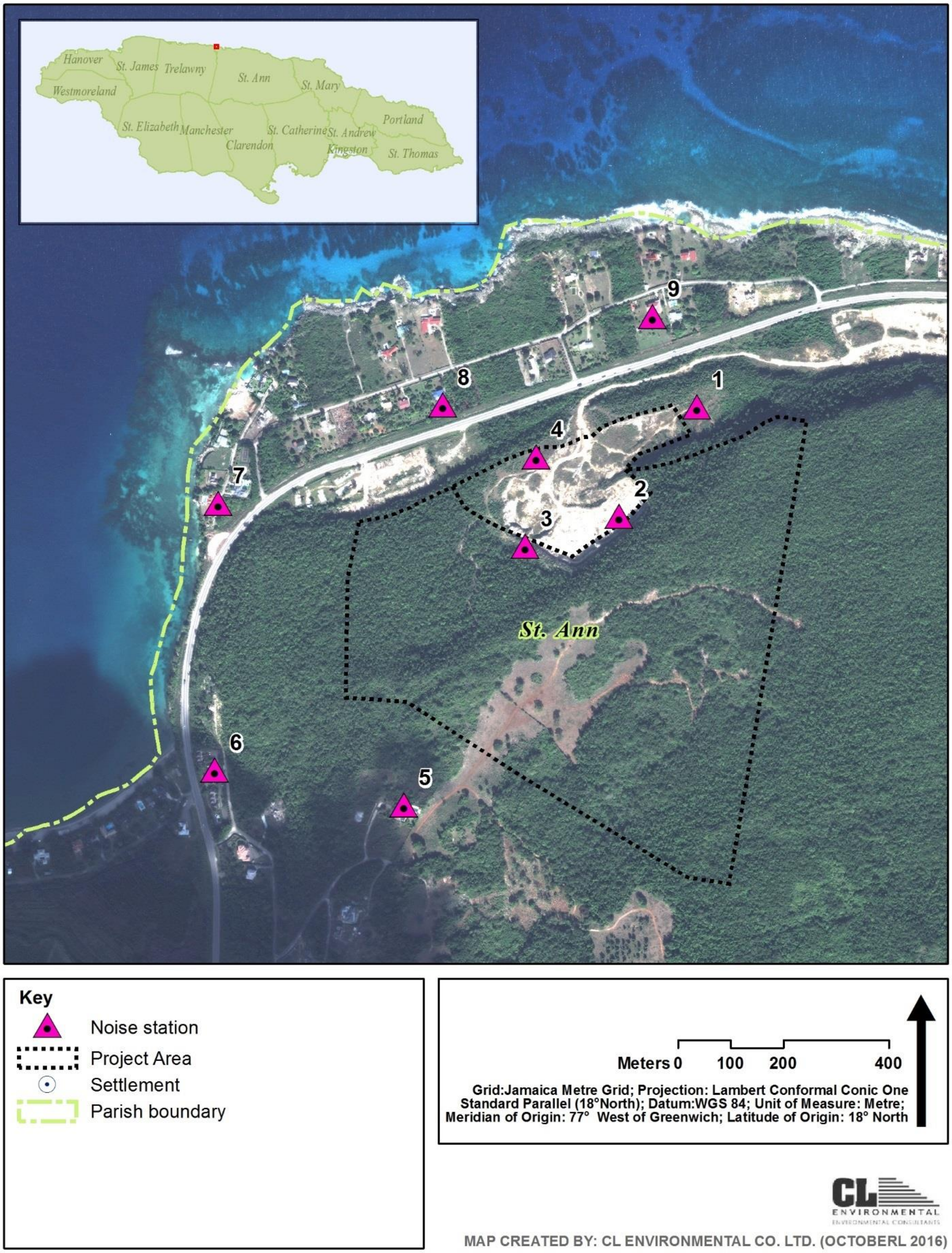


Figure 4-26 Location of noise monitoring stations

4.1.7.2 Results

Table 2 shows the minimum, maximum and average noise levels over the 72 hour assessment period, as well as the geometric mean centre frequencies obtained at each station.

Noise data was unavailable for Station 2 due to equipment malfunction during the noise assessment.

Table 4-16 Ambient Noise data at all stations

Stn.#	Average Leq (72 hr)	Min (dBA)	Max (dBA)	Geometric Centre Frequency (Hz)	Octave Band Range (Hz)
1	45.5	30.3	72.1	12.5	11-14
2	N/A	N/A	N/A	N/A	N/A
3	44.1	28.3	77.8	12.5	11-14
4	44.1	28.8	76.8	12.5	11-14
5	42.4	27.7	81.6	12.5	11-14
6	55.7	29.6	89.4	630	561-707
7	50.2	34.1	86.5	63	56-71
8	56.0	31.9	93.3	63	56-71
9	58.1	31.4	89.7	63	56-71

STATION 1

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.3 dBA to a high (Lmax) of 72.1 dBA. Average noise level for this period was 45.5 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-27.

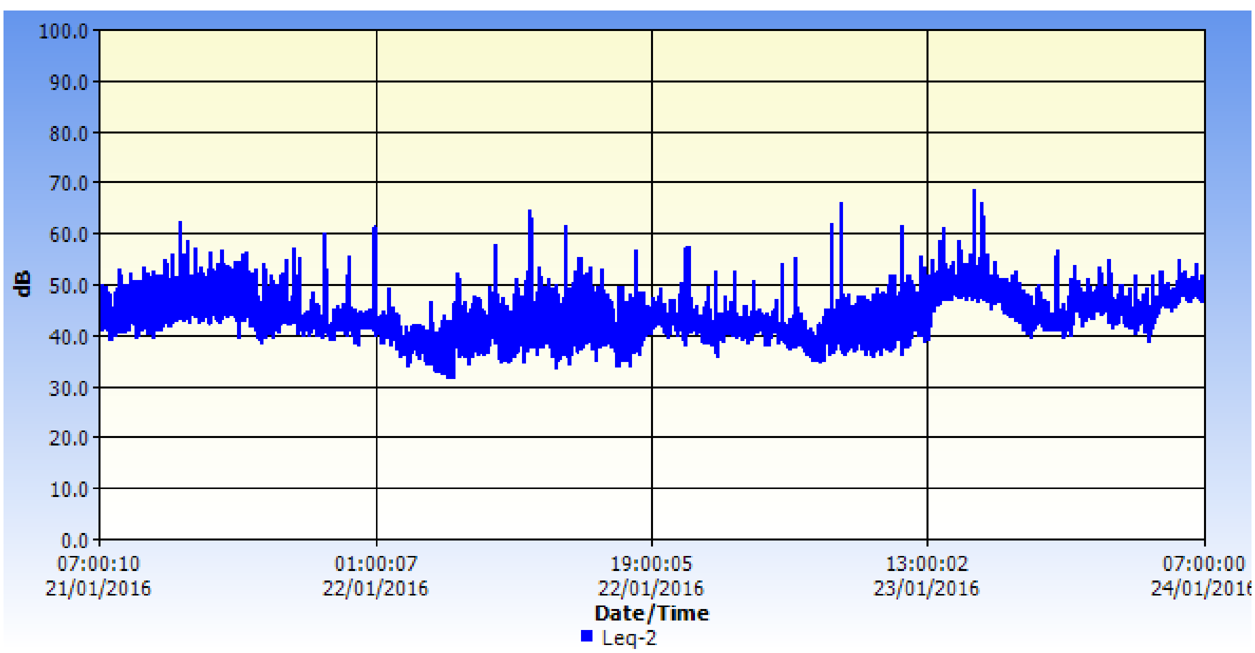


Figure 4-27 Noise fluctuation (Leq) over 72 hours at Station 1

OCTAVE BAND ANALYSIS AT STATION 1

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 4-28).

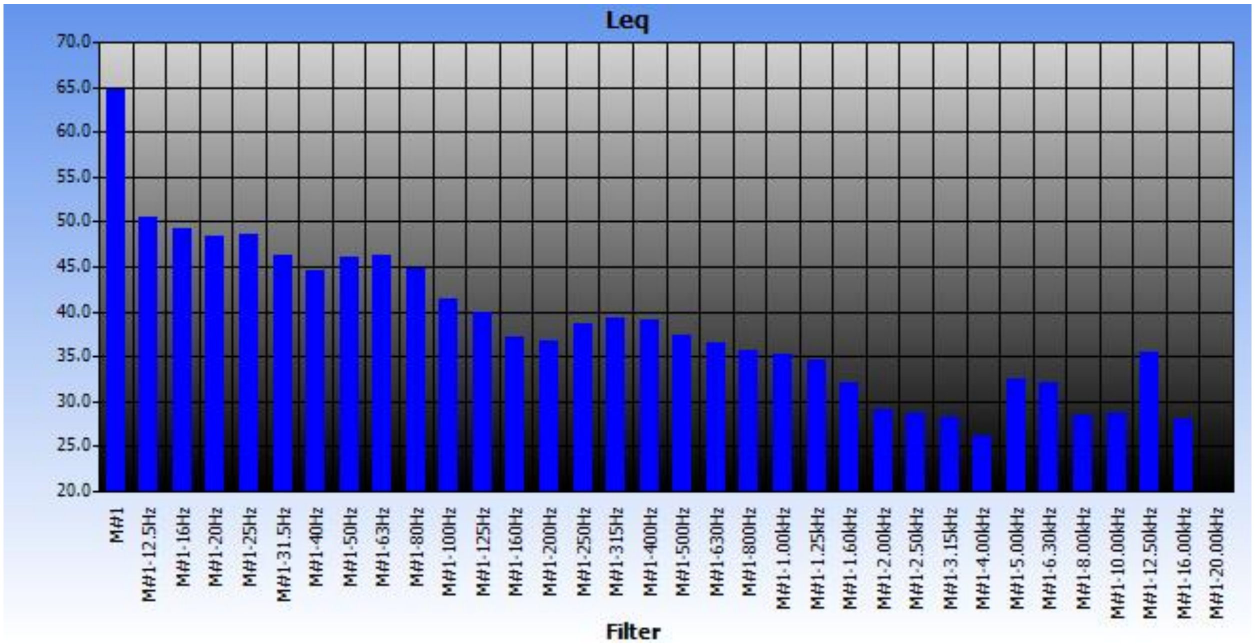


Figure 4-28 Octave band spectrum of noise at Station 1

L10 AND L90

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

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

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

Figure 4-29 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈55.5% of the time), no significant fluctuations (L10 – L90) (≈43.1% of the time) and large fluctuations (L10 – L90) (≈1.4% of the time) in the noise climate at this station. The overall L10 and L 90 at this station for the time assessed were 48.4 dBA and 38.6 dBA respectively.

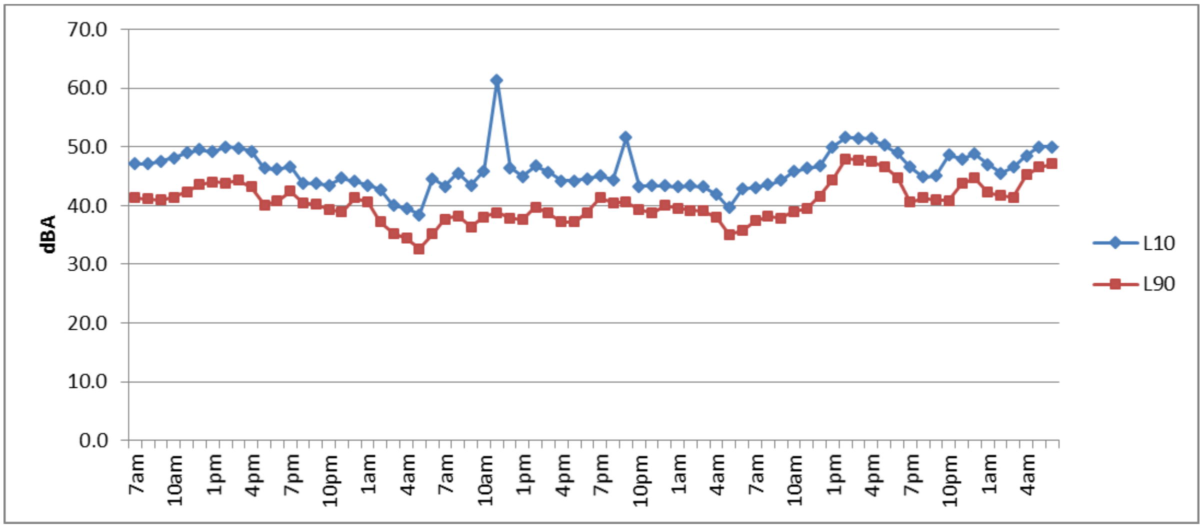


Figure 4-29 L10 and L90 for Station 1

STATION 3

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 28.3 dBA to a high (Lmax) of 77.8 dBA. Average noise level for this period was 44.1 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-30.

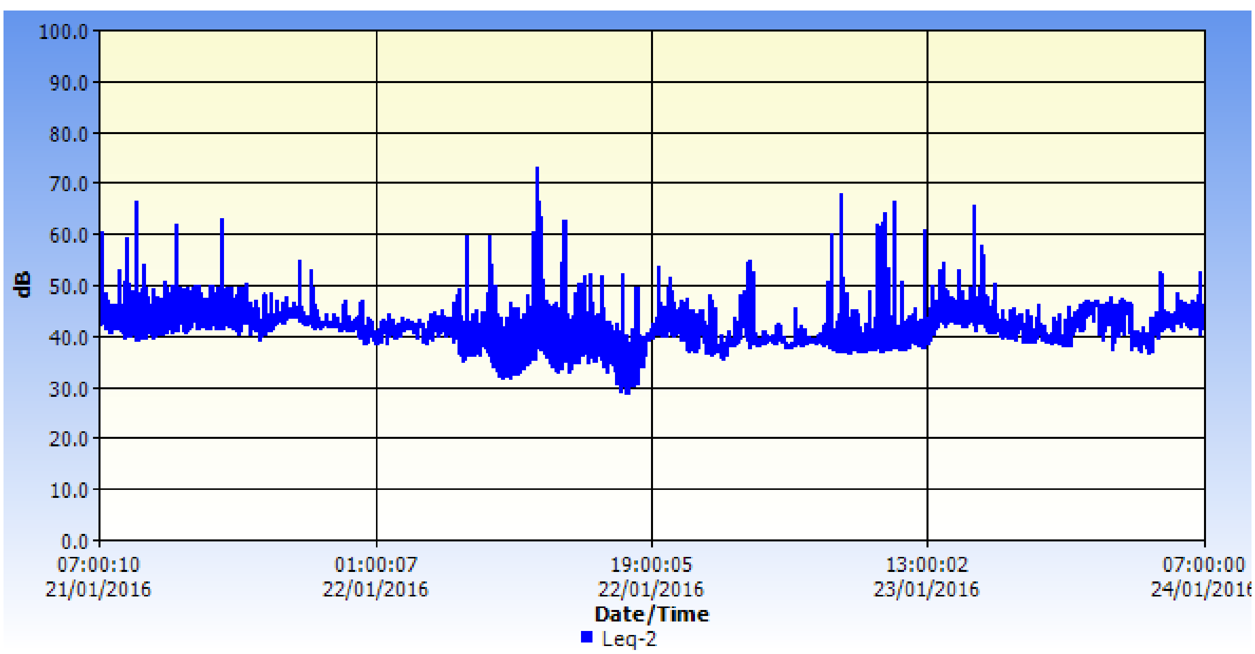


Figure 4-30 Noise fluctuation (Leq) over 72 hours at Station 3

OCTAVE BAND ANALYSIS AT STATION 3

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 4-31).

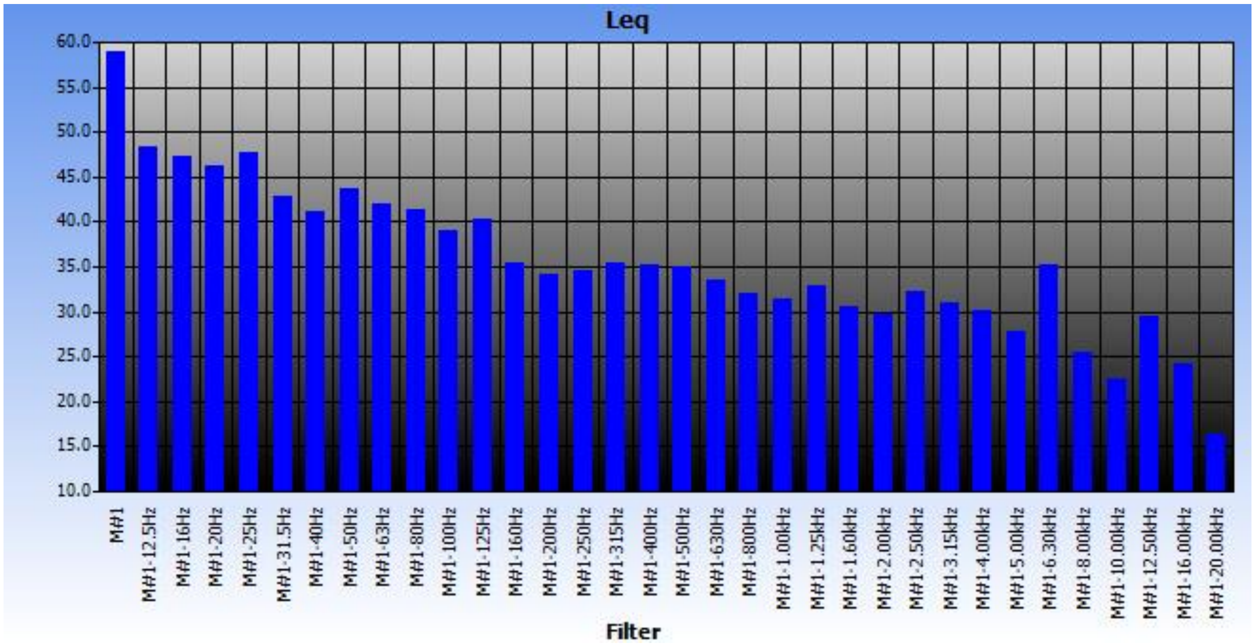


Figure 4-31 Octave band spectrum of noise at Station 3

L10 AND L90

Figure 4-32 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈29.2% of the time), no significant fluctuations (L10 – L90) (≈68.1% of the time) and large fluctuations (L10 – L90) (≈2.7% of the time) in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 44.9 dBA and 37.2 dBA respectively.

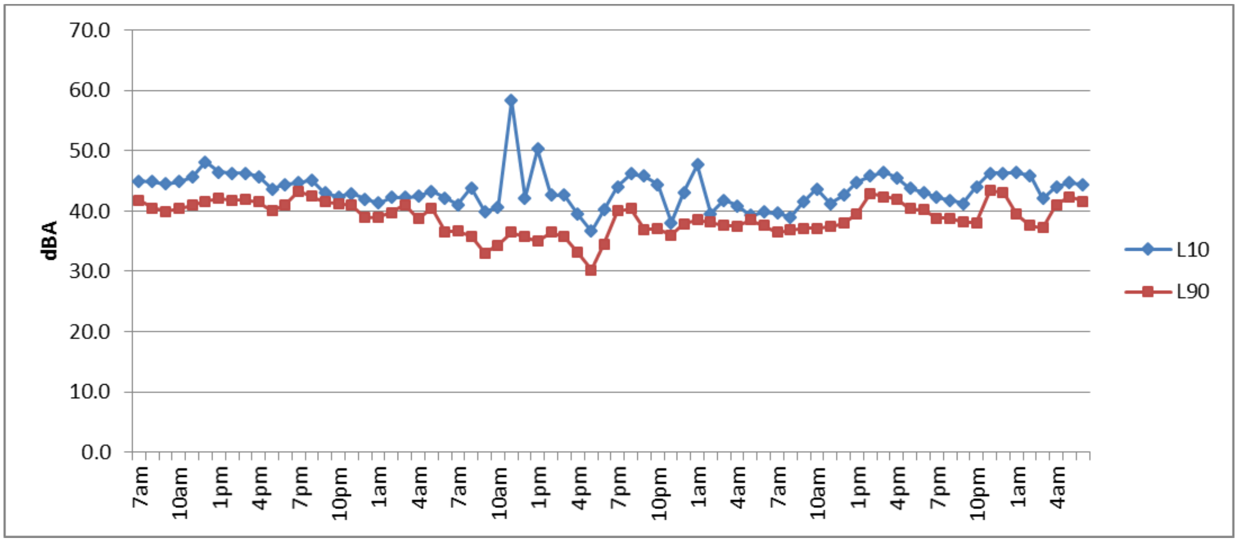


Figure 4-32 L10 and L90 for Station 3

STATION 4

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 28.8 dBA to a high (Lmax) of 76.8 dBA. Average noise level for this period was 44.1 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-33.

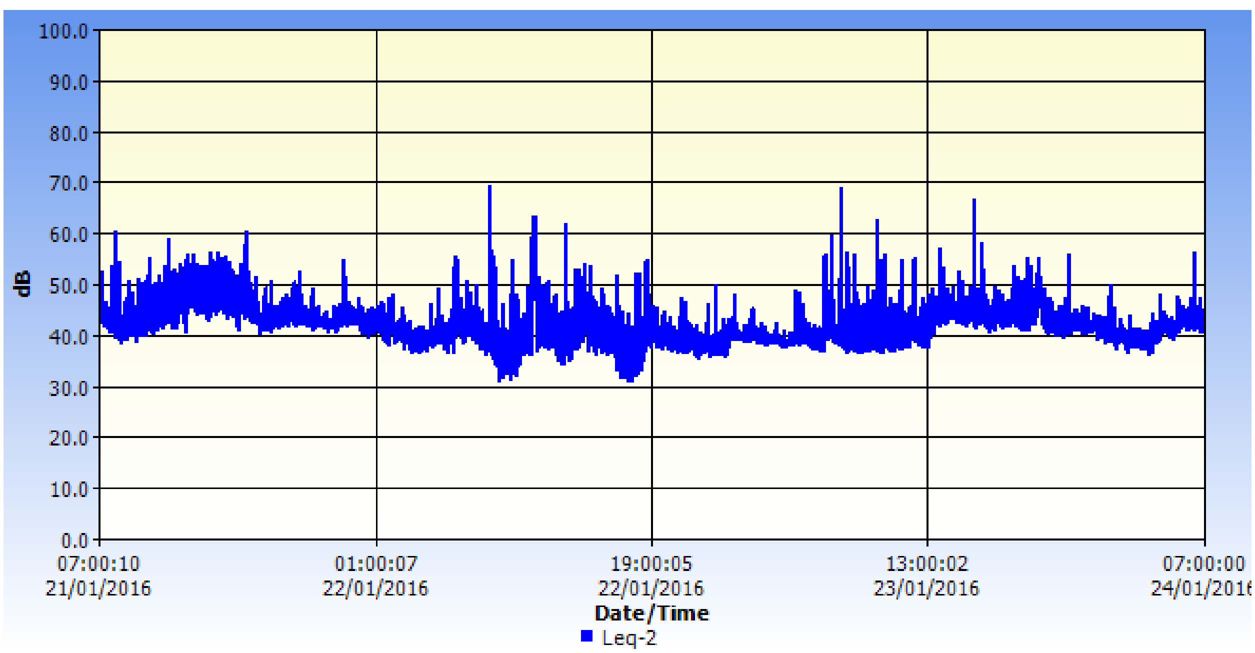


Figure 4-33 Noise fluctuation (Leq) over 72 hours at Station 4

OCTAVE BAND ANALYSIS AT STATION 4

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 4-34).

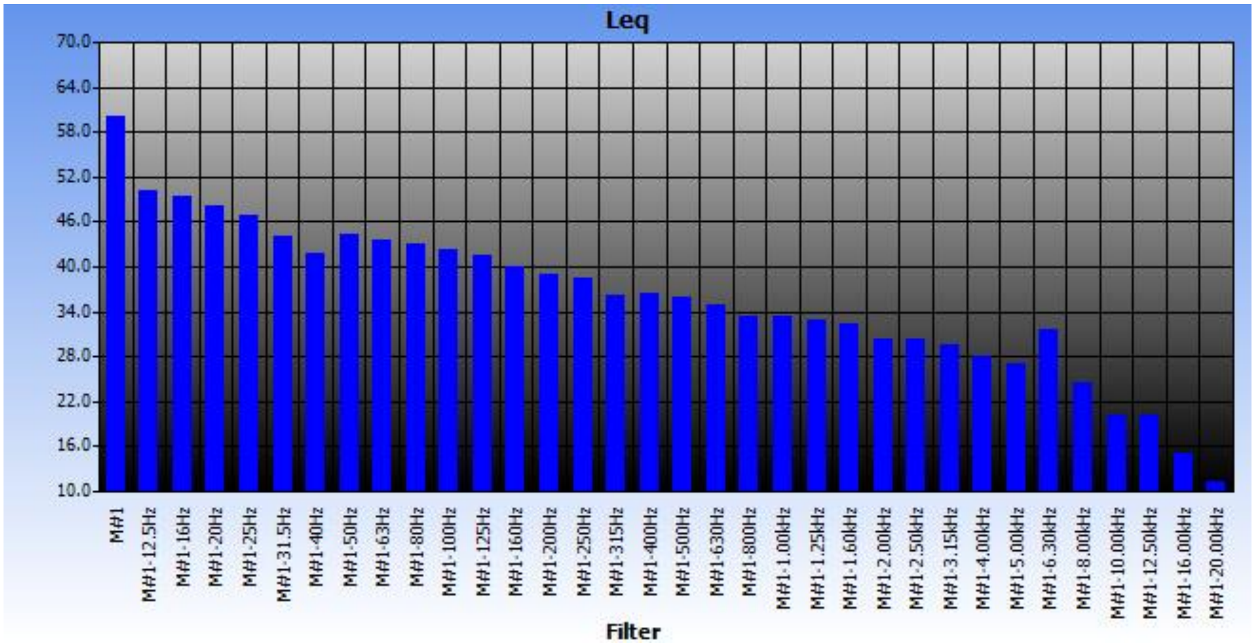


Figure 4-34 Octave band spectrum of noise at Station 4

L10 AND L90

Figure 4-35 depicts the hourly L10 and L90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈41.6% of the time), no significant fluctuations (L10 – L90) (≈56.9% of the time) and large fluctuations (L10 – L90) (≈1.5% of the time) in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 46.3 dBA and 37.8 dBA respectively.

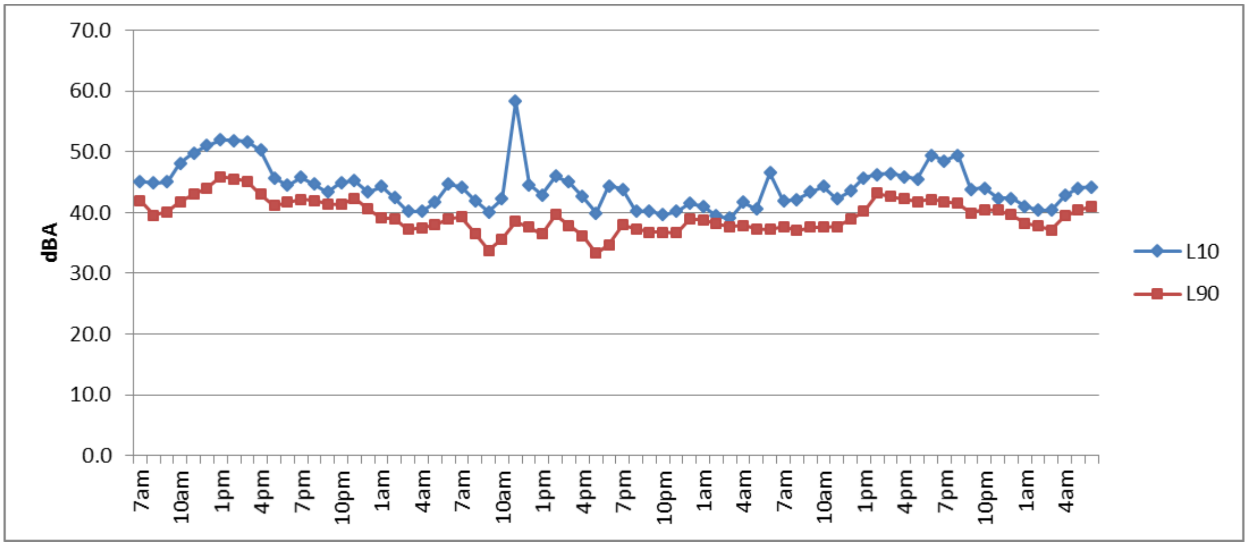


Figure 4-35 L10 and L90 for Station 4

STATION 5

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 27.7 dBA to a high (Lmax) of 81.6 dBA. Average noise level for this period was 42.4 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-36.

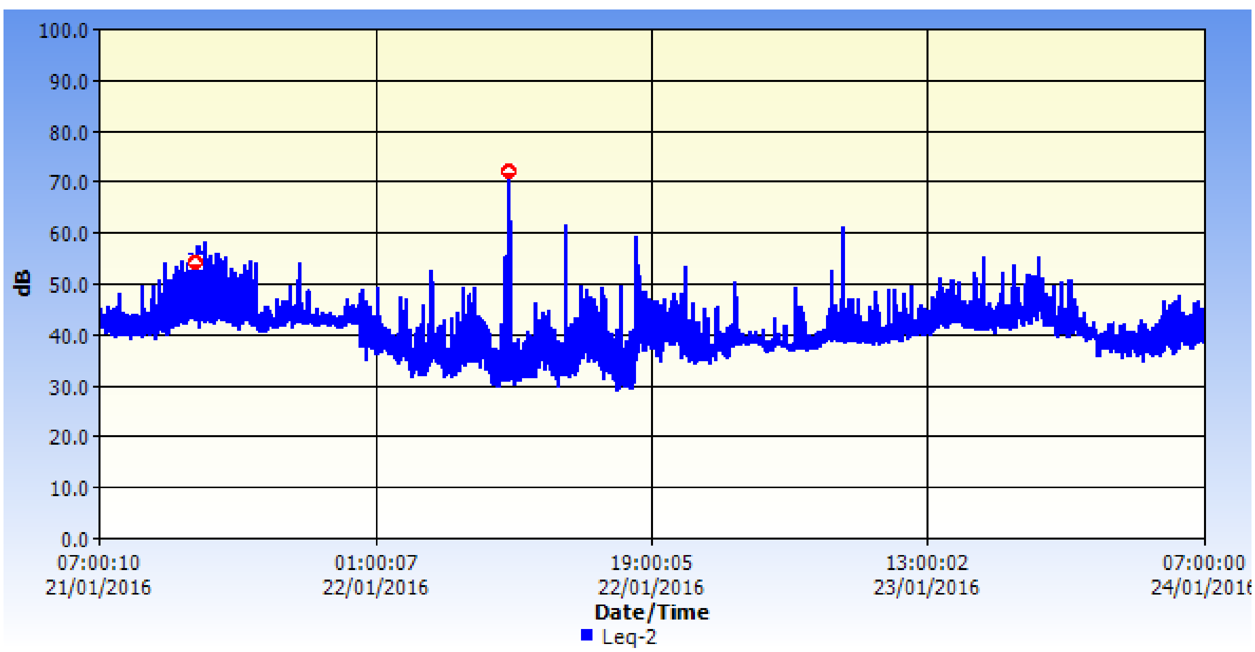


Figure 4-36 Noise fluctuation (Leq) over 72 hours at Station 5

OCTAVE BAND ANALYSIS AT STATION 5

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz. (octave frequency range is 11 - 14 Hz) (Figure 4-37).

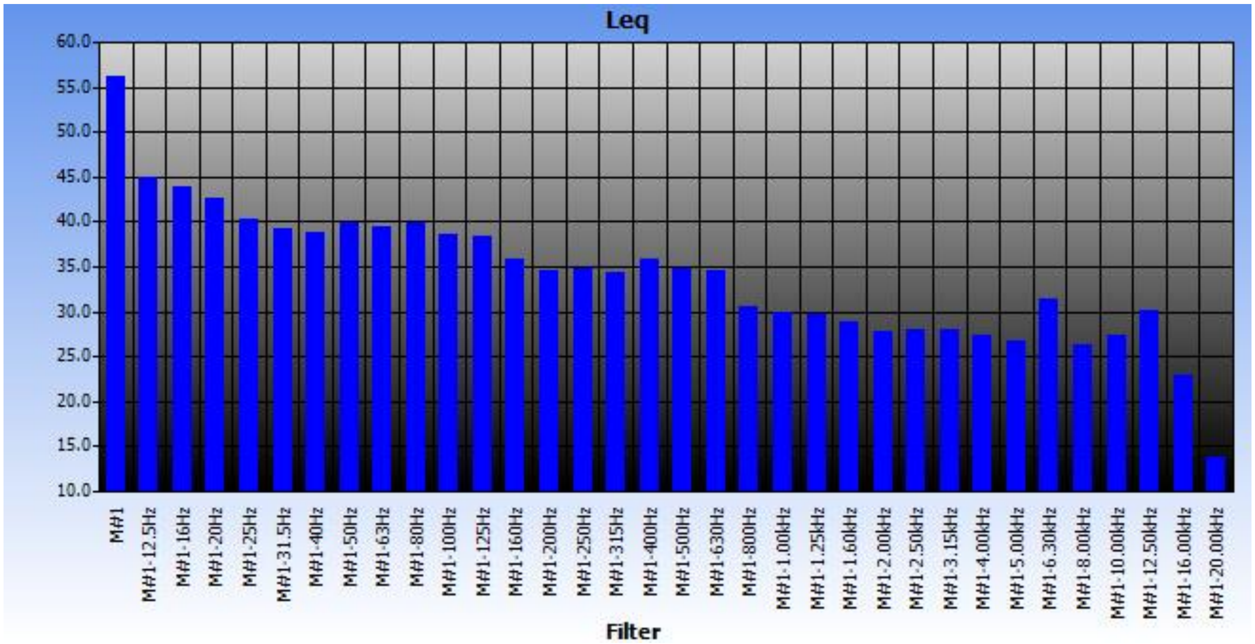


Figure 4-37 Octave band spectrum of noise at Station 5

L10 AND L90

Figure 4-38 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈40.3% of the time), no significant fluctuations (L10 – L90) (≈58.3% of the time) and large fluctuations (L10 – L90) (≈1.4% of the time), in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 44.8 dBA and 35.1 dBA respectively.

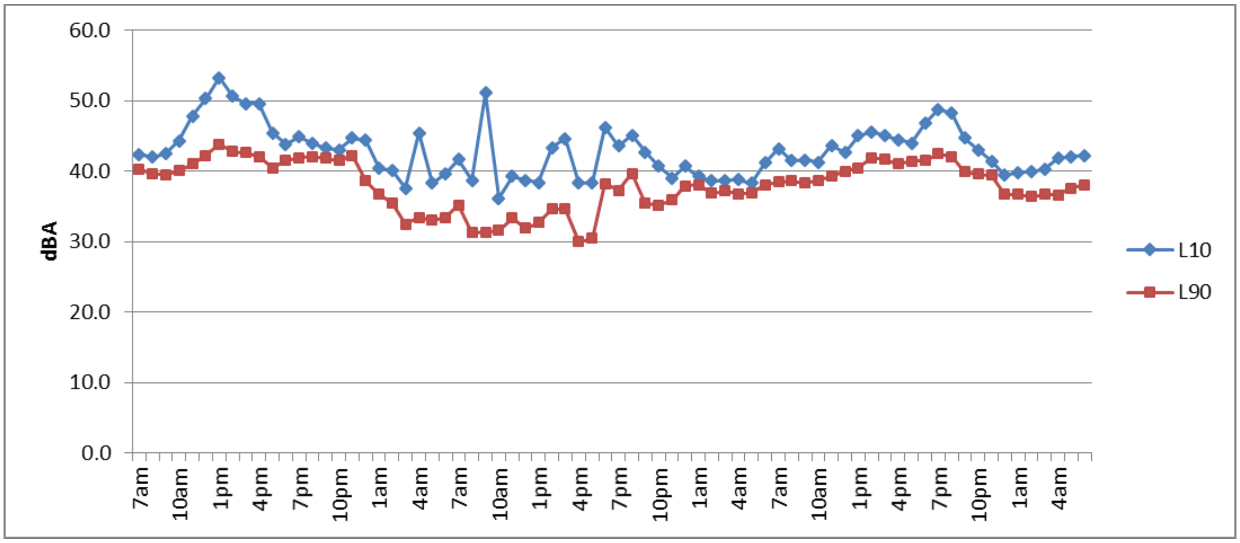


Figure 4-38 L10 and L90 for Station 5

STATION 6

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 29.6 dBA to a high (Lmax) of 89.4 dBA. Average noise level for this period was 55.7 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-39.

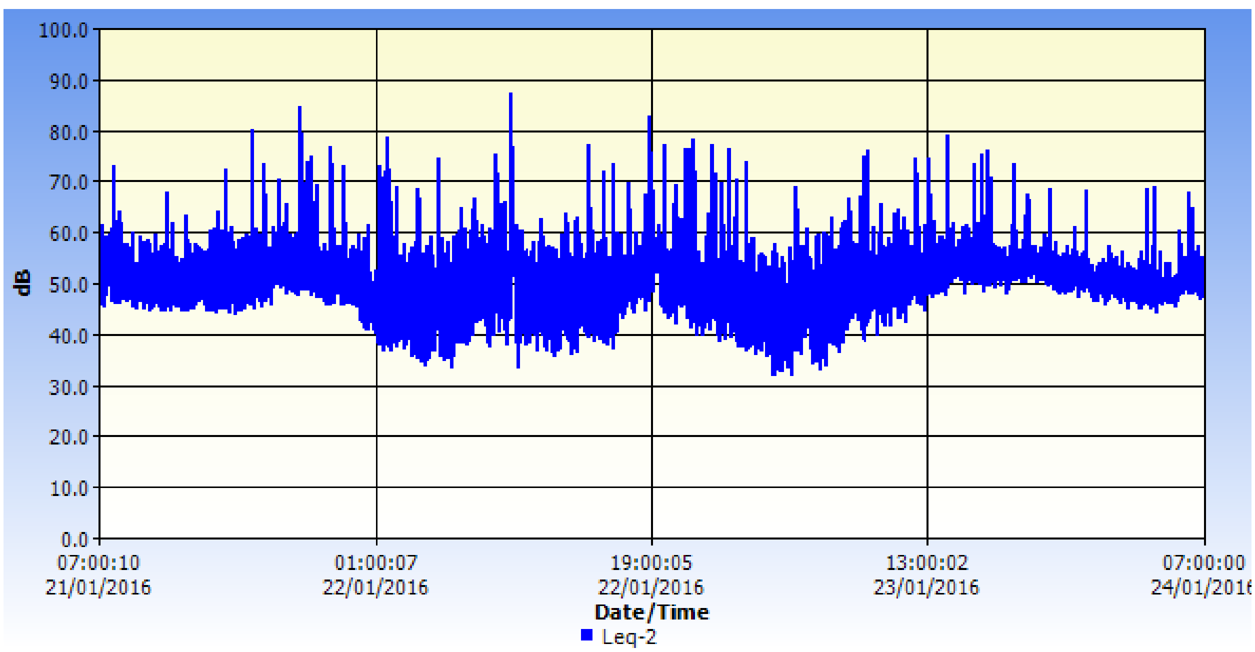


Figure 4-39 Noise fluctuation (Leq) over 72 hours at Station 6

OCTAVE BAND ANALYSIS AT STATION 6

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 630 Hz. (octave frequency range is 561 - 707 Hz) (Figure 4-40). Although the noise was centred around the 630 Hz frequency, there was also dominant noise emitted in the 25 Hz frequency (22 – 28 Hz).

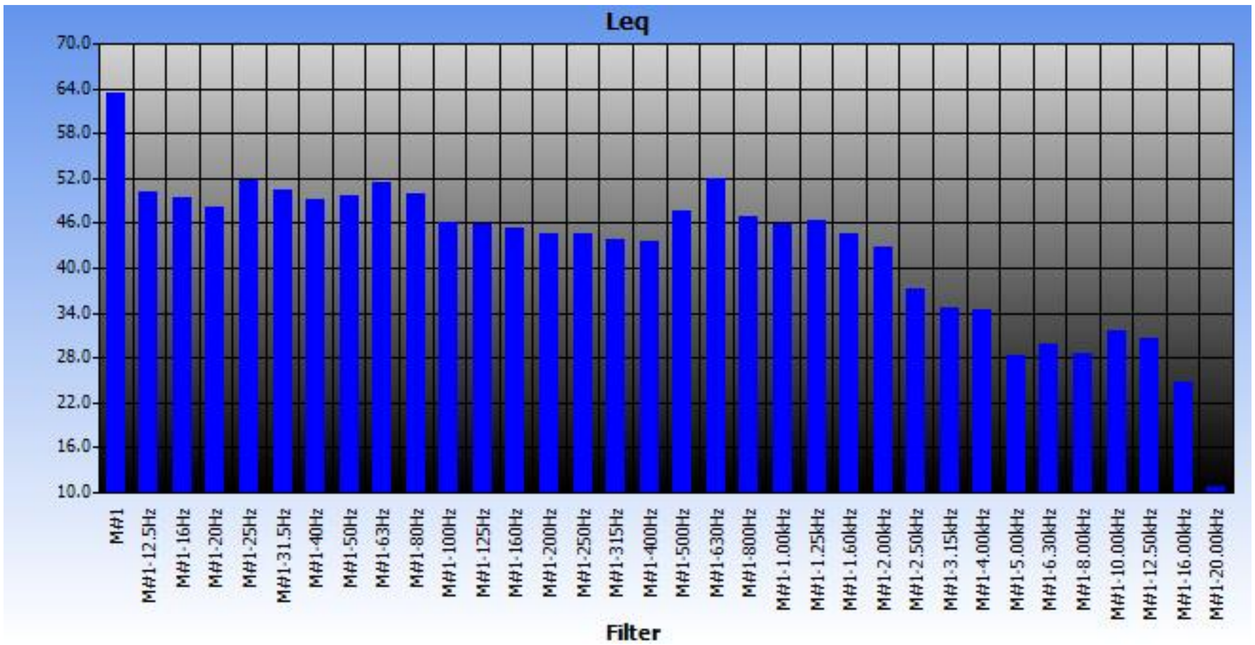


Figure 4-40 Octave band spectrum of noise at Station 6

L10 AND L90

Figure 4-41 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations (L10 – L90) (≈15.3% of the time), moderate fluctuations (L10 – L90) (≈73.6% of the time) and large fluctuations (L10 – L90) (≈11.1% of the time) in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 54.6 dBA and 43.7 dBA respectively.

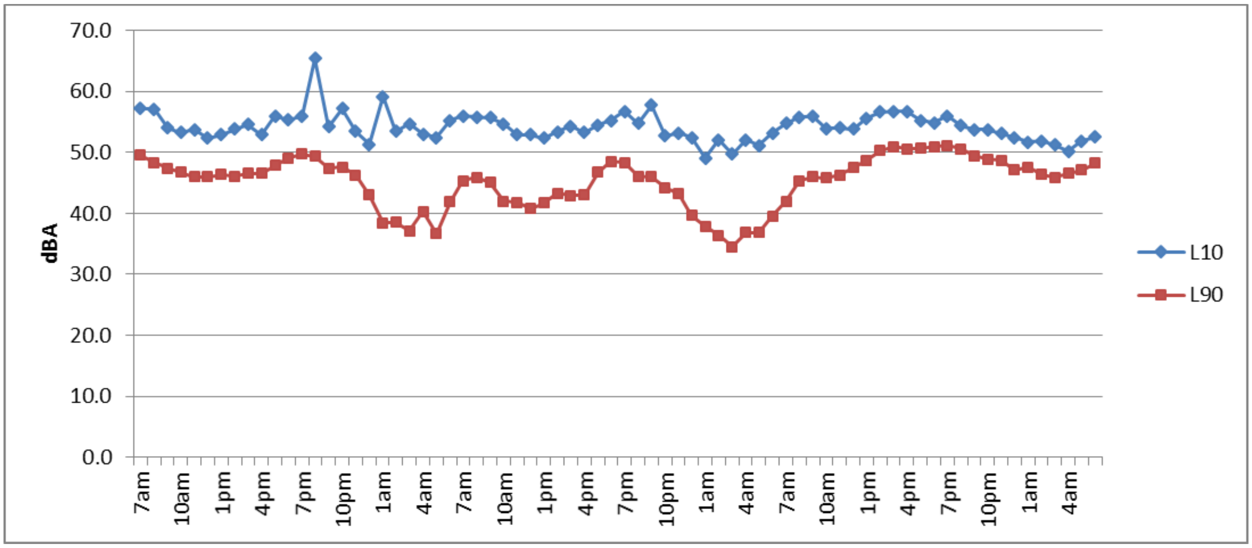


Figure 4-41 L10 and L90 for Station 6

STATION 7

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 34.1 dBA to a high (Lmax) of 86.5 dBA. Average noise level for this period was 50.2 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-42.

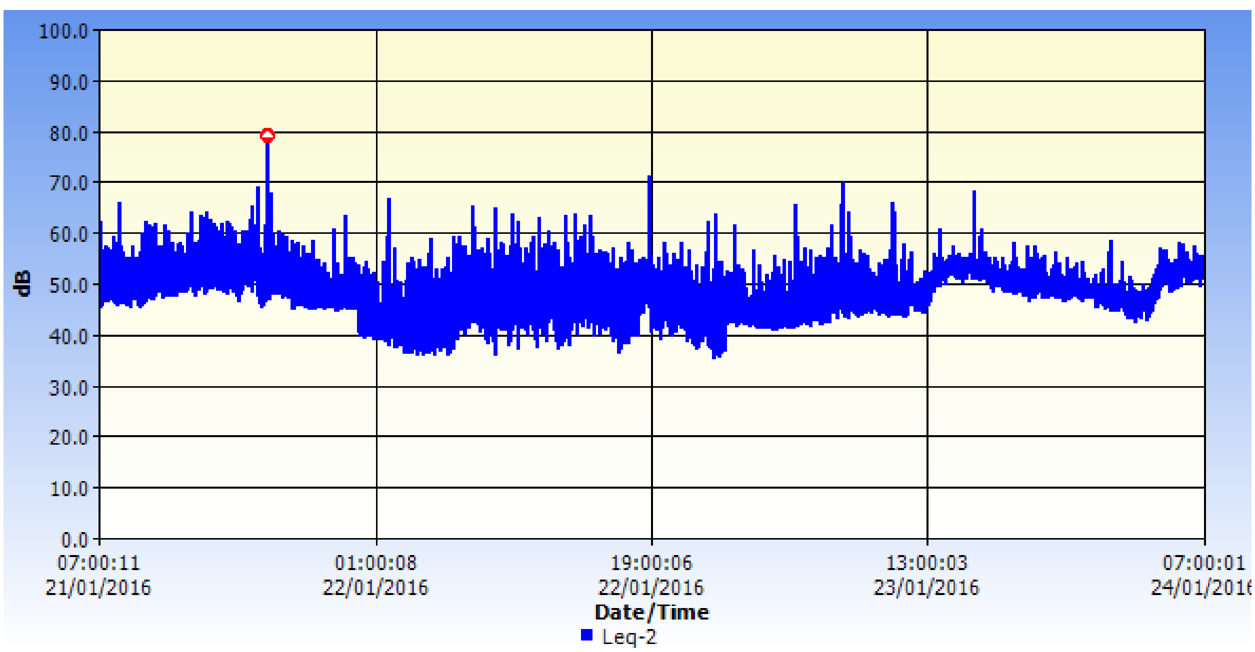


Figure 4-42 Noise fluctuation (Leq) over 72 hours at Station 7

OCTAVE BAND ANALYSIS AT STATION 7

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56 - 71 Hz) (Figure 4-43).

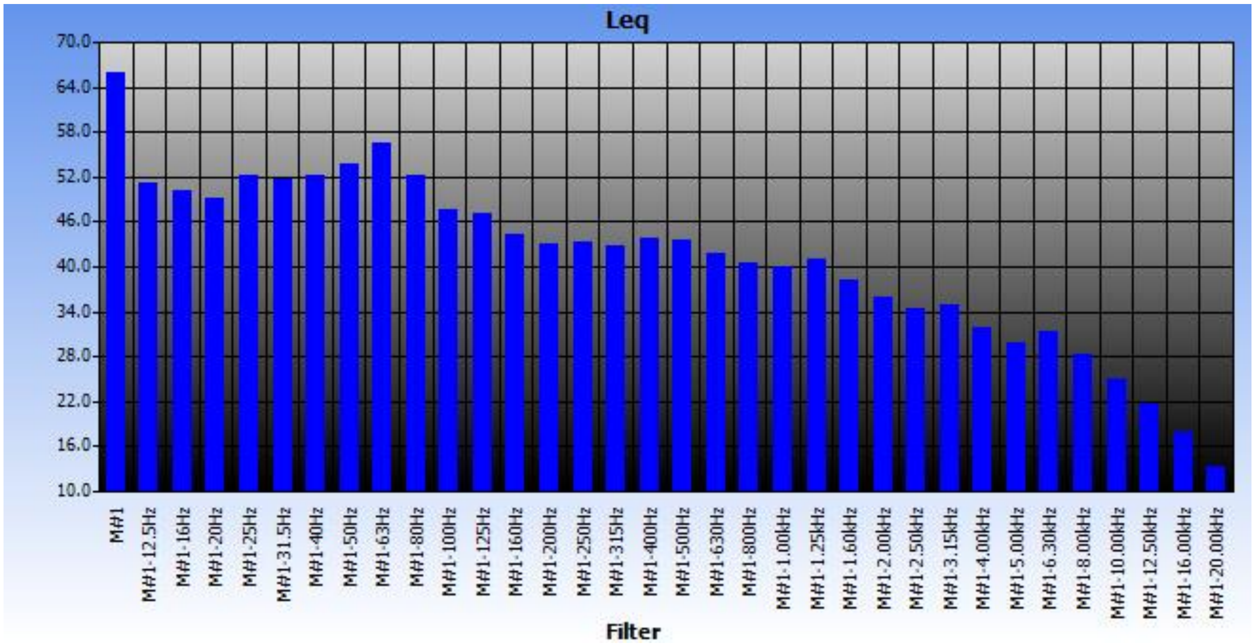


Figure 4-43 Octave band spectrum of noise at Station 7

L10 AND L90

Figure 4-44 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations (L10 – L90) (≈34.7% of the time) and moderate fluctuations (L10 – L90) (≈65.3% of the time) in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 52.8 dBA and 41.7 dBA respectively.

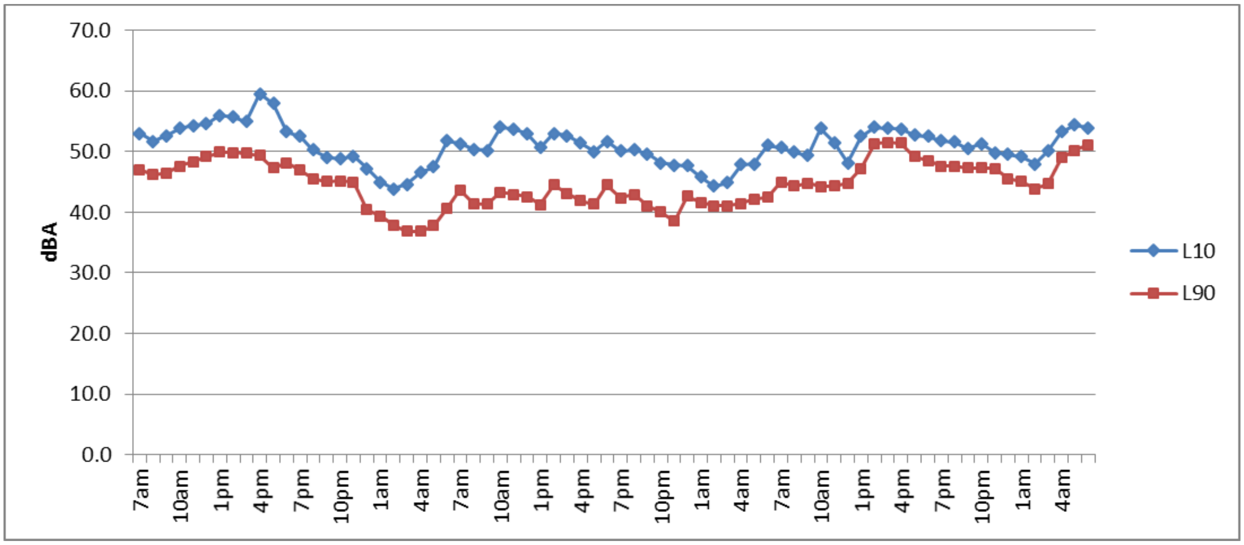


Figure 4-44 L10 and L90 for Station 7

STATION 8

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 31.9 dBA to a high (Lmax) of 93.3 dBA. Average noise level for this period was 56 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-45.

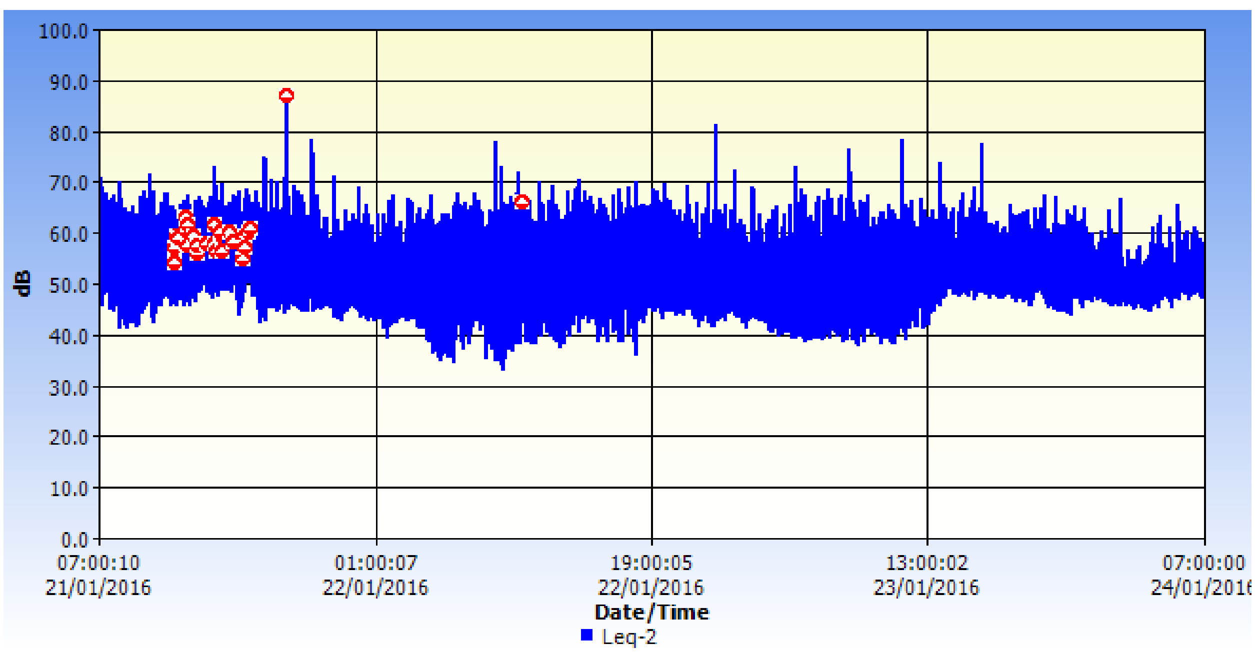


Figure 4-45 Noise fluctuation (Leq) over 72 hours at Station 8

OCTAVE BAND ANALYSIS AT STATION 8

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 4-46).

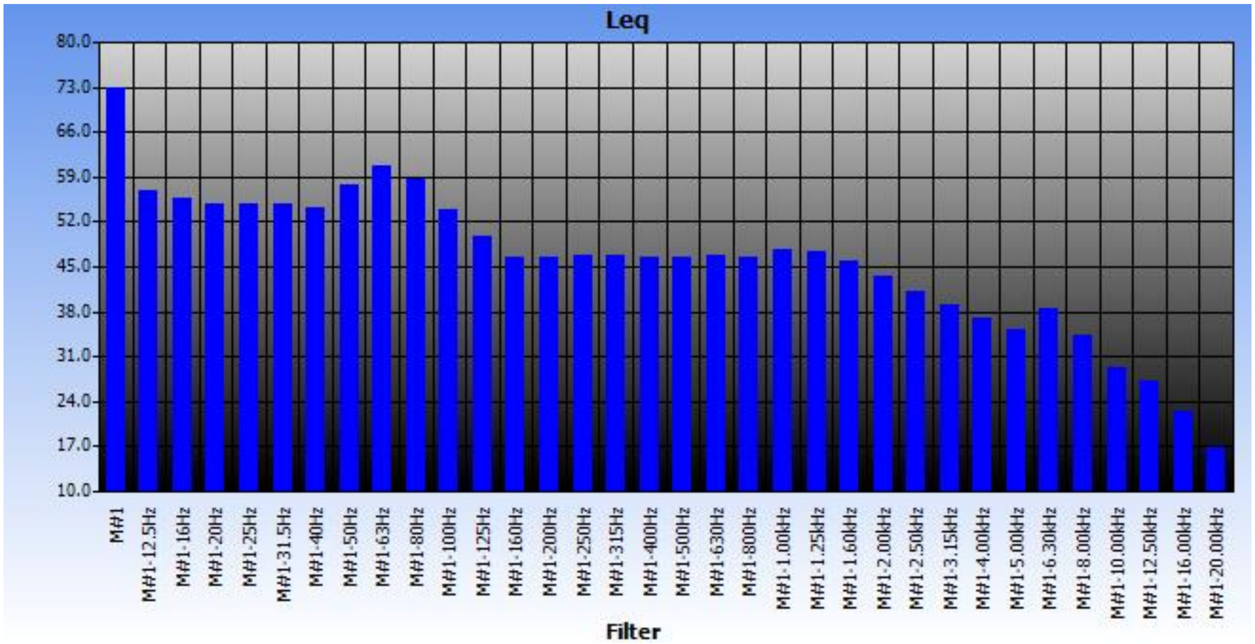


Figure 4-46 Octave band spectrum of noise at Station 8

L10 AND L90

Figure 4-47 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈73.6% of the time), large fluctuations (L10 – L90) (≈23.7% of the time) and no significant fluctuations (L10 – L90) (≈2.7% of the time) in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 59.1 dBA and 43.5 dBA respectively.

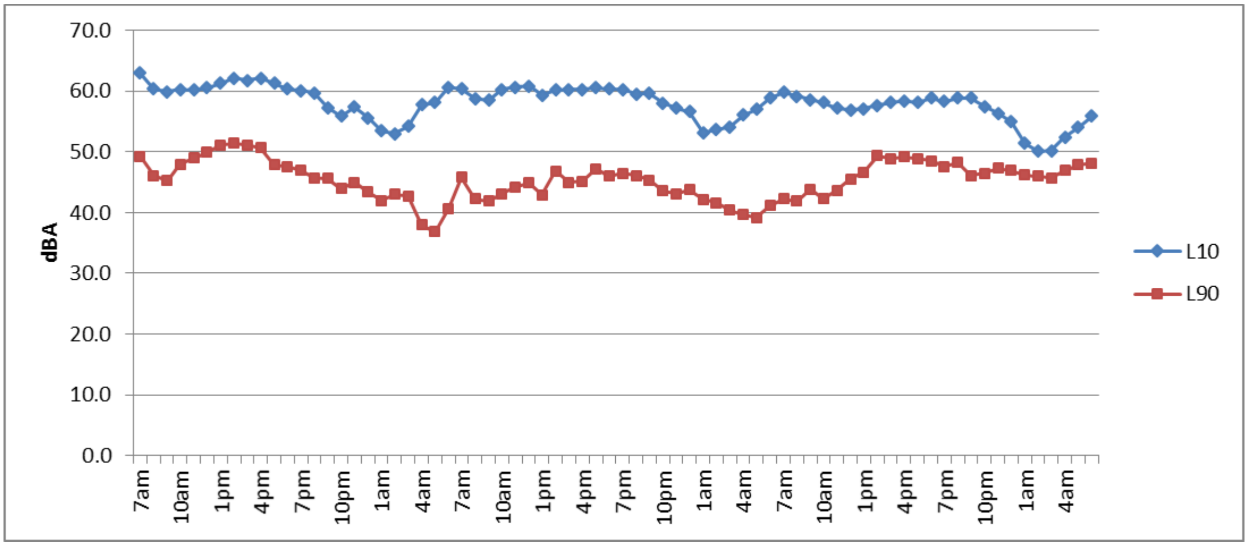


Figure 4-47 L10 and L90 for Station 8

STATION 9

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 31.4 dBA to a high (Lmax) of 89.7 dBA. Average noise level for this period was 58.1 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4-48.

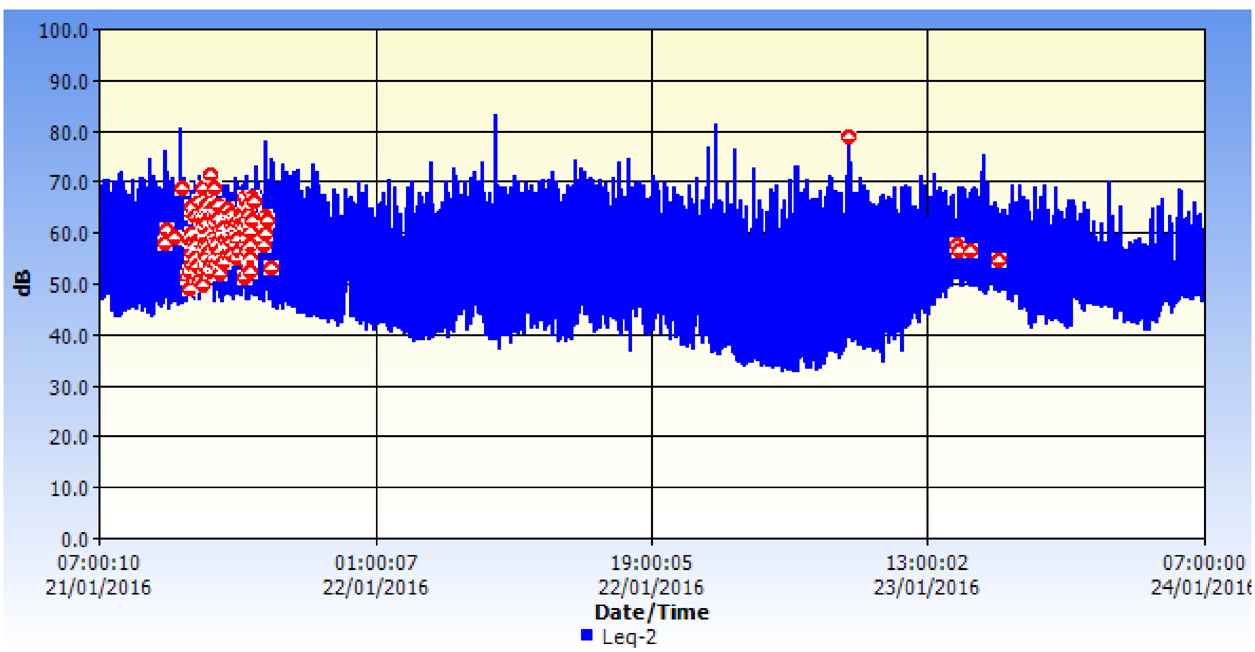


Figure 4-48 Noise fluctuation (Leq) over 72 hours at Station 9

OCTAVE BAND ANALYSIS AT STATION 9

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56 - 71 Hz) (Figure 4-49).

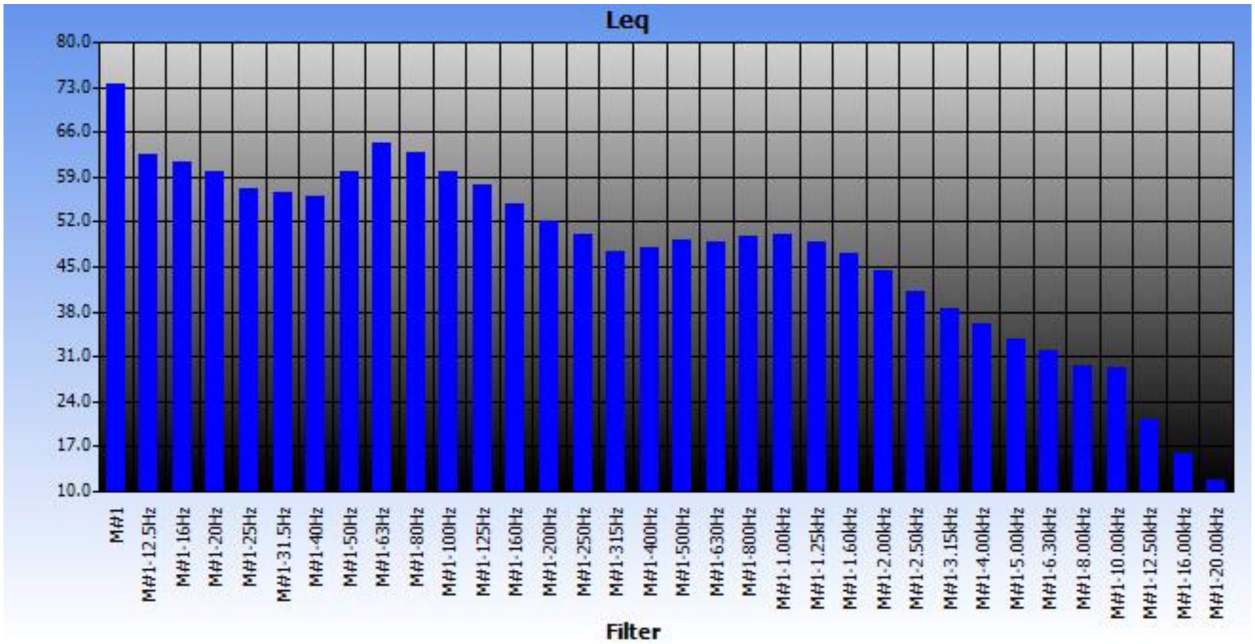


Figure 4-49 Octave band spectrum of noise at Station 9

L10 AND L90

Figure 4-50 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈41.7% of the time) and large fluctuations (L10 – L90) (≈58.3% of the time) in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 61.6 dBA and 42.4 dBA respectively.

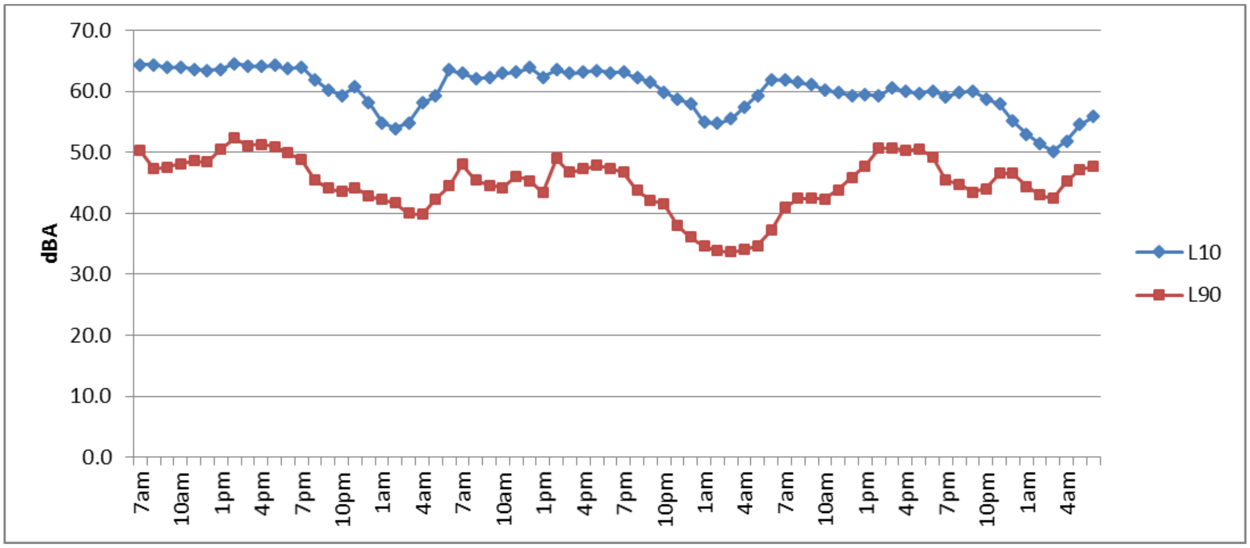


Figure 4-50 L10 and L90 for Station 9

Comparisons of Ambient Noise Levels with NEPA Daytime and Night Time Guidelines

Comparison of the ambient noise levels in the study area with the National Environmental and Planning Agency (NEPA) guidelines are shown in Table 4-17. The noise levels at the stations on the proposed quarry site boundaries were all compliant with the NEPA industrial daytime and night time guidelines. The residential stations 6, 8 and 9 had daytime and night time noise levels which were non-compliant with both the NEPA day and night time standards. Stations 6, 8 and 9 are located closest to the North Coast Highway and may be prone to vehicular noise as a result, hence the elevated noise levels.

Table 4-17 Comparison of daytime and night time noise levels at the stations with the NEPA guidelines

Stn.#	Zone	7 am. - 10 pm (dBA)	NEPA Guideline (dBA)	10 pm. - 7 am (dBA)	NEPA Guideline (dBA)
1	Industrial	46.2	*75*	44.1	*70*
2	Industrial	N/A	*75*	N/A	*70*
3	Industrial	45.1	*75*	42.0	*70*
4	Industrial	45.3	*75*	41.3	*70*
5	Residential	43.6	*55*	39.6	*50*
6	Residential	56.8	*55*	53.1	*50*
7	Residential	51.4	*55*	47.7	*50*
8	Residential	57.2	*55*	53	*50*
9	Residential	59.3	*55*	54.9	*50*

NB. Numbers in red are non-compliant with the standard/guideline

4.1.8 Pollution Sources

4.1.8.1 Solid Waste Dumping

Illegal solid waste dumping is a major problem at the northern-most part of the property by the North Coast Highway. Solid waste such as tyres, plastic bottles, food containers, paint cans, old boxes and other commercial-type refuse were seen along the access road leading off the North Coast Highway toward the proposed site. The main entrance to the site was blocked off to prevent unauthorized access, however, persons still use the area as an illegal dumpsite.

Table 4-18 shows the illegal dumping photos and Figure 4-51 shows corresponding map where these dump sites were observed. Skeletal remains of what appears to be large mammals were also observed in piles dumped onto the property close to the main road (Plate 4-5).

Table 4-18 Location and pictures depicting the illegal solid waste dumpsite seen February 2017

ILLEGAL SOLID WASTE DUMPSITE	PICTURE
1	
2	

ILLEGAL SOLID WASTE DUMPSITE	PICTURE
3	
4	
5	

ILLEGAL SOLID WASTE DUMPSITE	PICTURE
6	
7	
8	

Plate 4-5 Skeletal remains of what appears to be large mammals on property

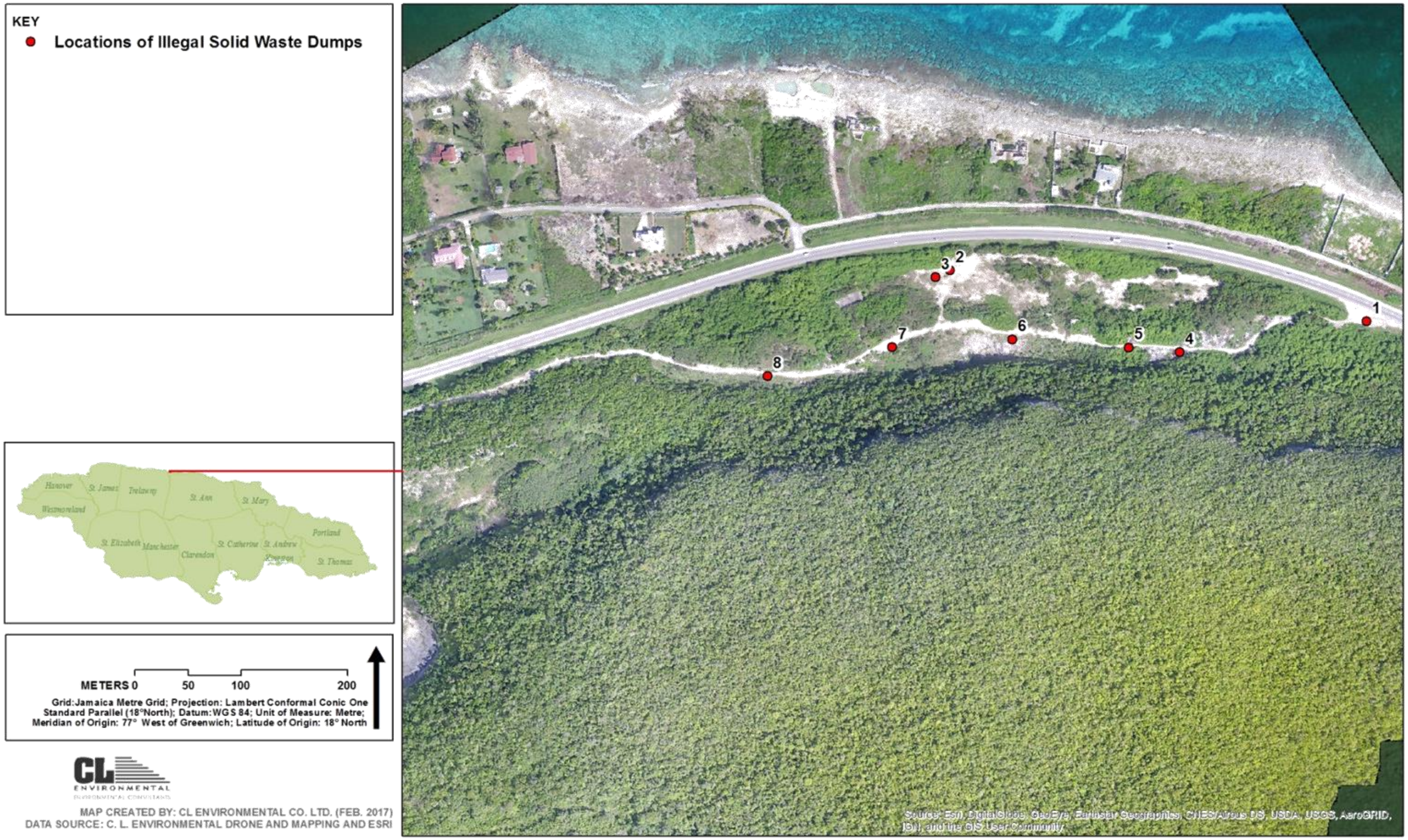


Figure 4-51 Locations of illegal solid waste dump sites on property (February 2017)

The following month (March 13, 2017), bulldozers and garbage trucks were observed removing the solid waste from site (Plate 4-6 and Plate 4-7). The waste was disposed of at an approved facility.

Plate 4-6 Garbage being removed from the site (March 13, 2017)

Plate 4-7 Garbage being removed from the site (March 13, 2017)

4.1.9 Natural Hazards

4.1.9.1 Earthquakes and Seismicity

Jamaica is characterized by medium-high seismic hazards due to the location of the Island on the Gonavave microplate bounded by the Oriente Fracture Zone to the North, the Cayman Spreading Center to the west, the Enriquillo Plantain Garden and the Walton Fault zones to the south (Salazar, et al 2013). All along the north coast the rocks forming the limestone terrace in the coastal plain are faulted to varying degrees, indicative of seismic activity continuing to the present day (Horsfield, 1972). This terrace was formed only about 120,000 years ago, so that the region, as a whole must be considered as still seismically active. Faulting affecting more recent unconsolidated or semi-consolidated sediments is difficult to identify, but the continued occurrence of earthquakes is well documented (Shepherd & Aspinall, 1980).

Earthquake hazard zoning for Jamaica over the period from 1692 to the present shows that the proposed project lies within a zone of low probability of high intensity earthquakes in Jamaica (5-9 per century) (Figure 4-52). Figure 4-53 shows the location of the epicentres and the magnitude of recent earthquake events in and around Jamaica for the period of 1977 to 2014; it illustrates that earthquake activity is negligible in the vicinity of the proposed project.

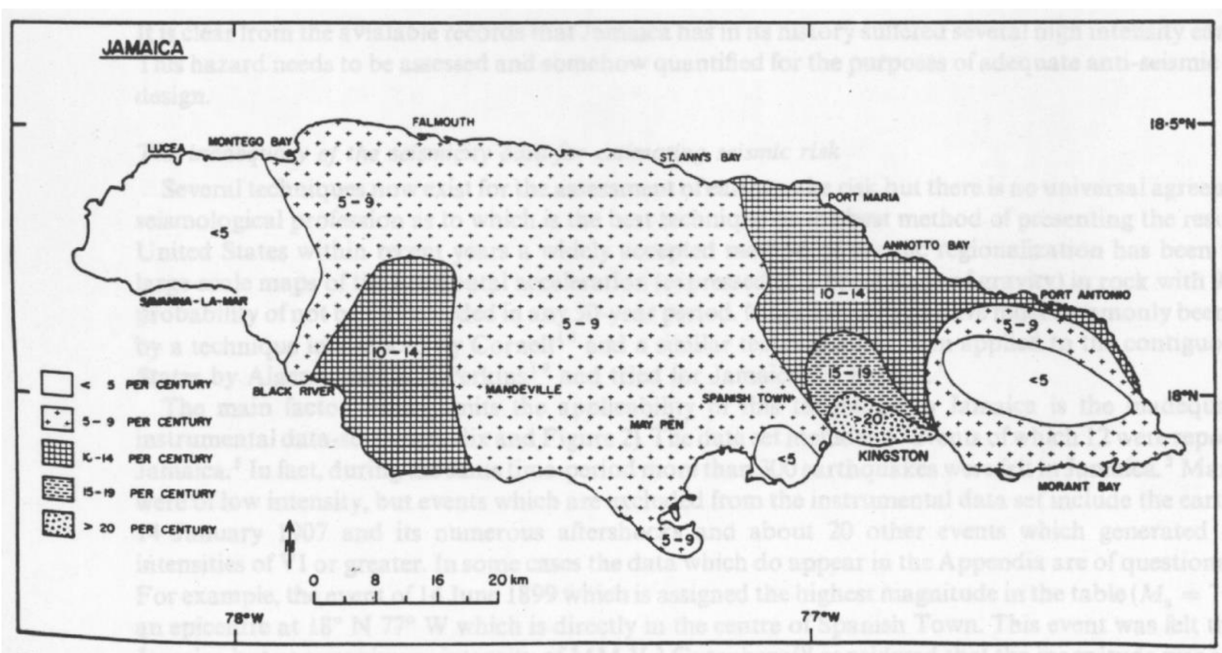
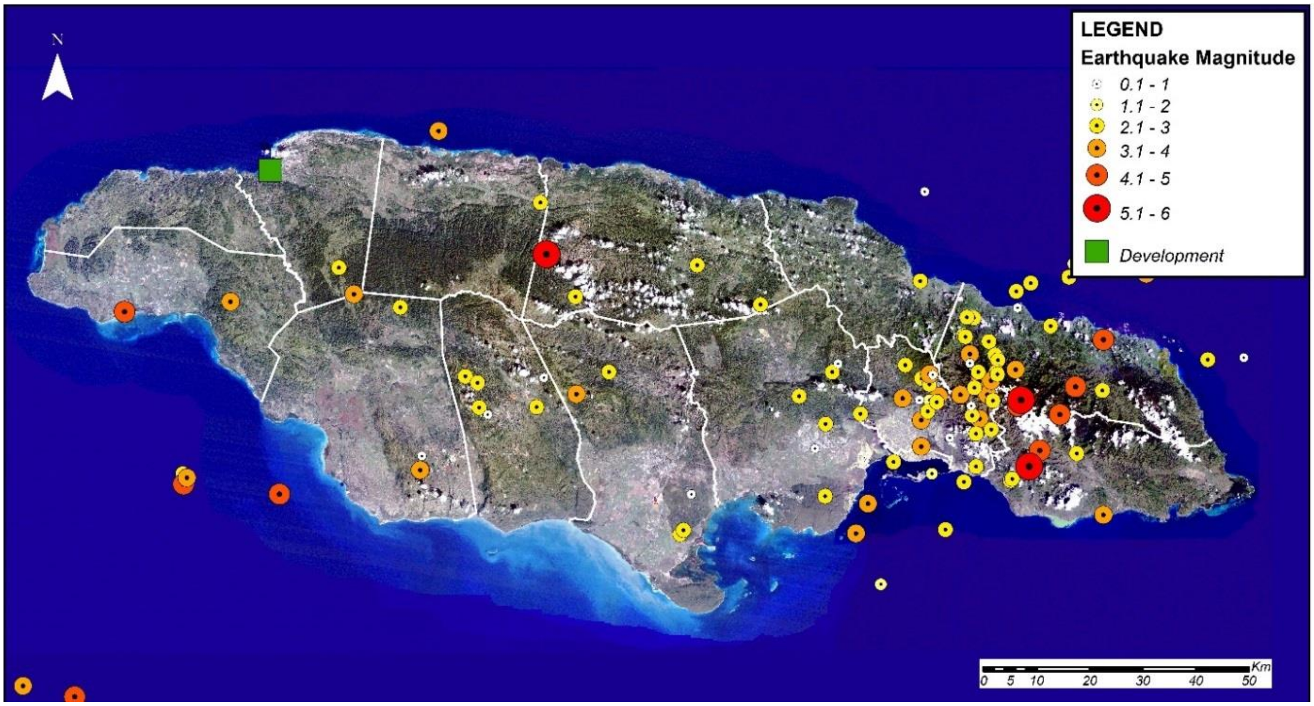


Figure 4-52 Map showing number of times per century that intensities of MM VI or greater have been reported, 1880-1960 (from Shepherd & Aspinall, 1980)



Source: earthquake.usgs.gov Earthquake Archive

Figure 4-53 Earthquakes in Jamaica 1977-2014

4.1.9.2 Hurricanes, Storm Surge and Climate Change

Extreme rainfalls and sea levels are typically associated with hurricanes and tropical storms and depressions. Hurricanes can form almost anywhere in the Tropical Atlantic Basin from the West Coast of Africa near the Cape Verde Islands, to the Gulf of Mexico and the Caribbean Sea which are the main development areas. Jamaica lies in the Atlantic hurricane belt west of one of the Main Development Area, Cape Verde Islands. Over the past twenty years, at least five major hurricanes have impacted the Caribbean region (Figure 4-54).

In recent times, global and regional climate change models have been predicting changes in the climate conditions that may increase the impacts of the coastal hazards. Jamaica's Second National Communication (SNC) on Climate Change (Government of Jamaica, 2011) lists the main climate change hazards as follows:

- Sea level rise
- Increase in extreme events – precipitation and drought
- More intense storms and increased storm surge levels
- Increased temperature

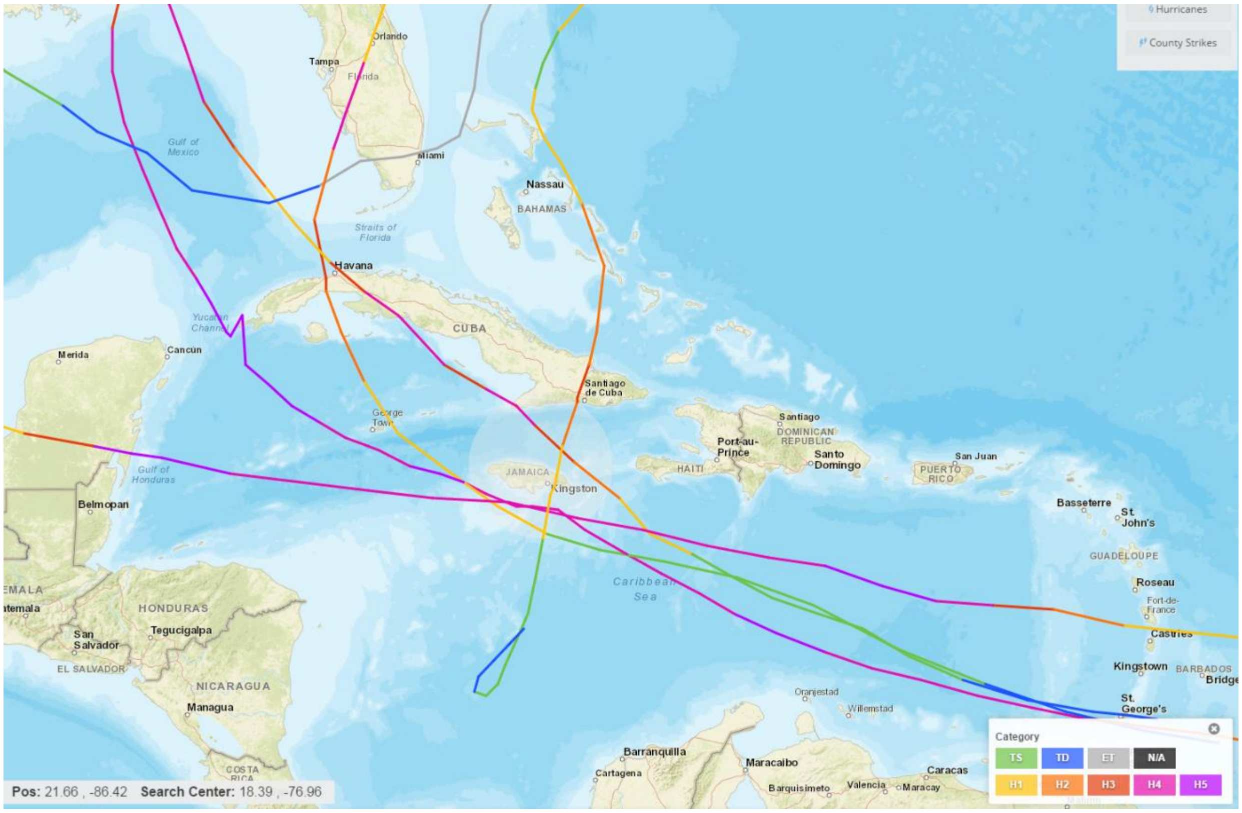


Figure 4-54 Tropical storms/Hurricanes passing through the Caribbean and within 500km of Jamaica over the past fifteen (15) years.

The Intergovernmental panel on Climate Change (IPCC) have made projections based on numerical models which indicate tropical storms are far more intense storms than in previous years. The (2007) IPCC report (Solomon, 2007) stated the following:

> *"There is evidence from modelling studies that future tropical cyclones could become more severe, with greater wind speeds and more intense precipitation. Studies suggest that such changes may already be underway; there are indications that the average number of Category 4 and 5 hurricanes per year has increased over the past 30 years."*

Others have isolated the influence of increasing temperatures on the frequency of hurricanes and have suggested that a 0.5°C increase will result in a 40% increase in hurricane activities (Saunders & Lea, 2008). The predictions of the IPCC are consistent with the number of category 4 and 5 storms that have tracked within 400 kilometres Jamaica in the past 130 years (Figure 4-55); the number of category 4 and 5 storms has increased from 10 to 15 storms per twenty year intervals up to 1950 to 30 to 35 storms per twenty years after 1950. This doubling of storm occurrences coupled with increased sea level rise can result in shoreline retreat as beach profiles adjust to a more intense wave climate.

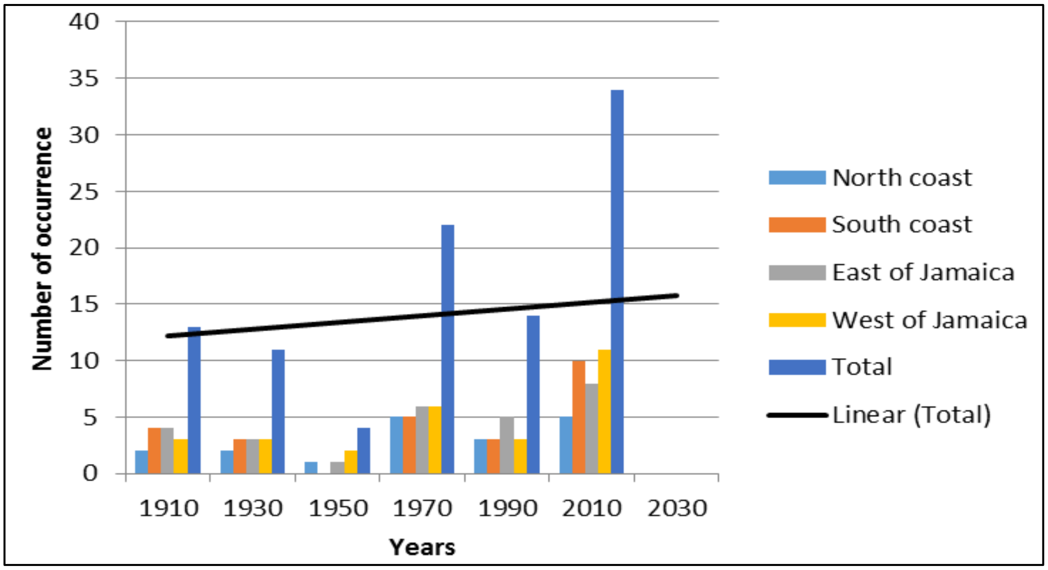


Figure 4-55 Occurrences of Category 4 and 5 hurricanes that have passed within 300 kilometres of Jamaica's shoreline since 1890 to 2014, in twenty years intervals.

4.1.9.3 Flooding

Historical flood zones and points database from Mona GeoInformatics Institute and the Office of Disaster Preparedness and Emergency Management were searched with the results showing that the Property does not fall in a flood prone area (Figure 4-56). The areas identified on the map were influenced by storm surges.

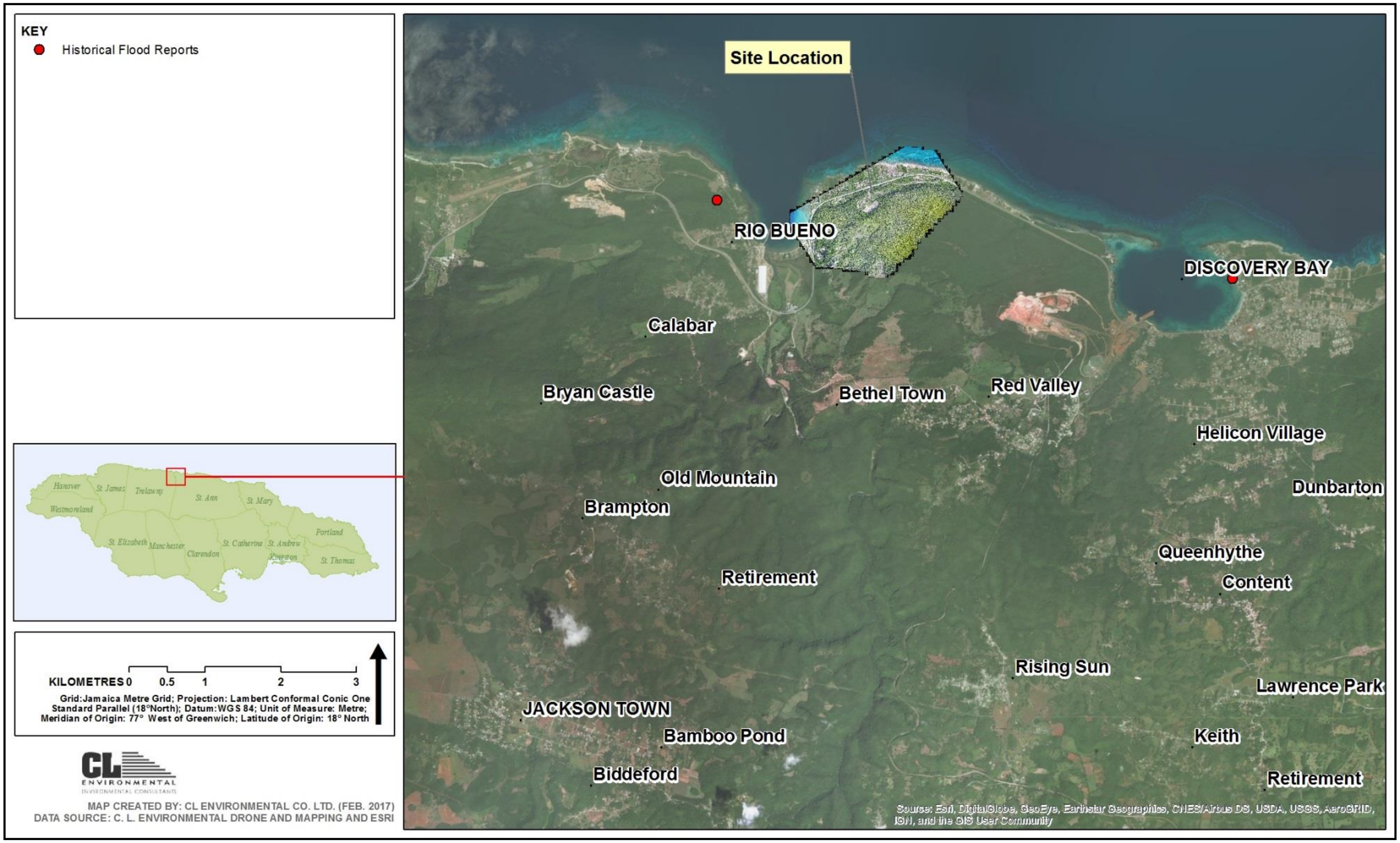


Figure 4-56 Historical flood prone areas

4.2 BIOLOGICAL

4.2.1 Ecological Services

Ecosystem services have been thought of as all-natural processes or services on which humans depend. However, the concept of ecosystems services has become an important model for linking the functioning of ecosystems to human welfare. Understanding this link is critical for a wide-range of decision-making contexts. While there have been several attempts to come up with a classification scheme for ecosystem services, there has not been an agreed upon, meaningful and consistent definition for ecosystem services (Brendan Fisher, 2009).

Natural processes tend to vary over time and space, as well as between species. The ecosystem services these natural processes provide are therefore also highly variable. It is often assumed that ecosystem services are provided linearly (unvaryingly, at a steady rate), but natural processes are characterized by thresholds and limiting functions (Koch, 2007).

The effects of climate change have become increasingly obvious and the need for increased climate mitigation and perhaps more importantly, resilience, is well documented. Therefore, recognizing the multiple functions provided by ecosystems at different scales is imperative. Ecosystems provide critical services that enable communities to cope with and recover from disasters (Richard Munang, 2013). Ecosystem services are essential in the adaptation and response to climate change impacts and associated disaster risks. The specific details of links between climate change impacts, ecosystem degradation of the project area and increased risk of climate-related disasters are not known. However, decades of global research have shown the devastating impacts of deforestation, decreases in biodiversity and the general loss of ecosystem services

The complexity of and range of the ecosystem services provided by the flora and fauna of the project area is not uniformed. That is, the existing natural environment ranges from a mined area to a secondary forest used for varying farming and agricultural activities to a dry limestone forest, less used by locals. Some flora and fauna are common to multiple areas as they are able to utilize less suitable habitat nearby. During this, study several key species were identified for either their endemism, conservation status or the unique habitat they provide. Biodiversity maintains ecosystem functions, loss of habitat, species and fragmentation by natural or anthropogenic sources, impacts the natural process. Endemism can be seen as a reflection of biodiversity, that is high levels of endemism in a given area indicates a high level of biodiversity. The exact degree to which each individual or habitat affects the balance within a system is unknown. For example, insects were estimated to provide services valued at least $57 billion to the United States (Vaughn, 2006).

The woodland/dry limestone forest area contained the highest levels of endemism and thus biodiversity with bromeliads identified as an essential habitat for multiple species. Endemic flora also included orchids, which have a higher conservation status than some other endemic flora. Endemic faunal species include the macrofauna found in the bromeliads, seven (7) species of amphibians (some with an extremely limited distribution range) and eighteen (18) species of reptiles. Forty-eight (48) of the fifty-eight (58) bird species were found in woodland areas, several of which were both endemic and forest-dependent. The most unique feature of the proposed project area however was seen in the classification Order: Lepidoptera; nine (9) families and thirty-two (32) genera. Four (4) of these were endemic and five (5) were endemic subspecies. Both *Marpesia chiron* and *Eurytides marcellinus* are given conservation value however, this represents a new record of *Marpesia chiron* in Jamaica.

Insects and in particular, the pollinators, provide an obvious link to essential human services such as pollination of crops and decomposition of material and soil health. The forested area is also essential for several birds seen outside this area, thus emphasising the importance of this area in supporting the modified/impacted areas.

One way of looking at the economic implications of the removal of a service is given by (Vaughn, 2006). The study estimated that the annual value of four (4) ecological services provided by primarily native insects in the United States was more than $57 billion ($0.38 billion for dung burial, $3.07 billion for pollination, $4.49 billion for pest control of native herbivores, and $49.96 billion for recreation) and this was considered to be a conservative estimate.

The ecosystem services of the woodland provide direct services to humans and also helps the surrounded degraded systems. Loss of this area is likely to result in the long-term loss of a wide range of ecosystem services of both the immediate and surrounding areas. Most notably, this may also result in a decrease in climate resilience and adaptation and increase the risk of climate-related disasters.

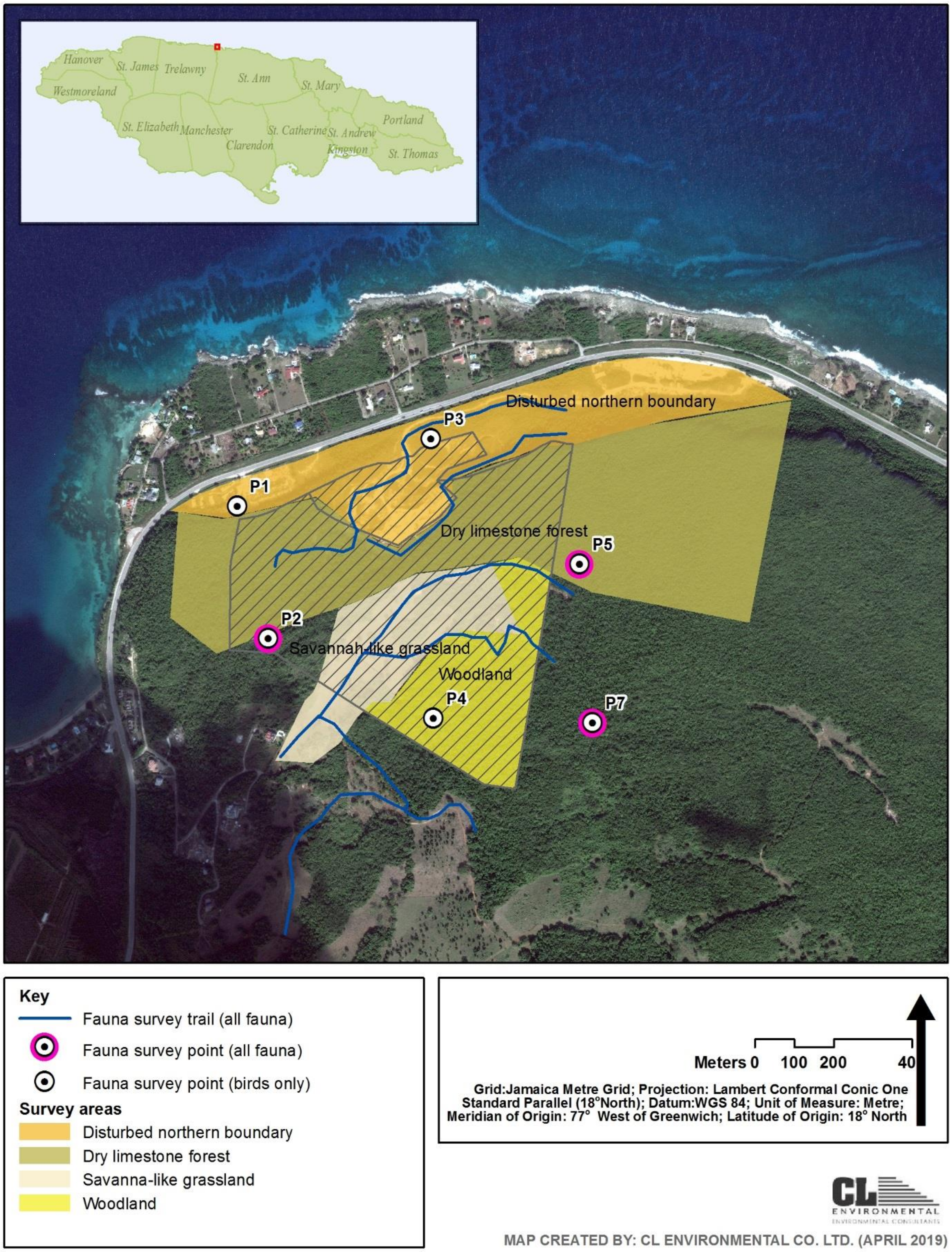
4.2.2 Flora

4.2.2.1 Introduction

The survey of the area was conducted over a two-day period in April 2016 and this resulted in the observation of three distinct sub-areas (or plant communities). In the northern side of the proposed site there is a very disturbed area to the north bordering the Queens highway. This is delineated for the inner core by a steep ridge and isolating a fairly intact dry limestone forest and southwest of this is another disturbed savanna type area. The three distinct sub-areas are as follows (Figure 4-57):

1. Disturbed Northern Boundary
2. Dry Limestone Forest
3. Savanna-like Grassland

All three areas were surveyed, and the results documented and presented below. The Disturbed Northern Boundary sub-area was surveyed on day 1 along with the northern half of the Dry Limestone Forest sub-area. The Savanna-like Grassland sub-area was surveyed on day 2 along with the southern half of the Dry Limestone Forest sub-area.



**Flora survey was not undertaken in the woodland area*

Figure 4-57 Flora and fauna survey areas

Methodology

A walk-through method was used to assess the species composition due to the structure of the three sub-areas. A walk through consists of identifying and documenting each new species encountered until there were no new species being observed. This gives a more accurate view of the diversity within each sub-area once done thoroughly. The relative abundance was also observed, and this was documented and ranked using a DAFOR scale. The majority of the plants observed were identified during the walk-through exercises and the remaining unidentified plants were verified subsequent to the survey from samples collected or digital images captured during the survey process. The average vegetation height of the sub-areas was also documented during the walk-through exercises on both days.

Results and Discussion

DISTURBED NORTHERN BOUNDARY

In this area the vegetation is predominantly invasive and introduced species with a few species representative of a coastal strand community as well as residual species from the typical dry limestone scrub forest. The close proximity to the roadway that allows easy access to the area (Plate 4-8). This is evidenced by its use as a dumping site for industrial, domestic and agricultural waste. Several mounds of waste were observed within this strip between the ridge and the main roadway. There is also an old abandoned roadway that is used as the access points to the area that housed a quarry at the western section in the past and this facilitates the dumping in several areas along this old roadway. The overgrowth of vegetation just along the Queens Highway acts as concealment for person involved in these illegal dumping activities. This general area is the proposed site of the processing plant. The sub-area is dominated by *Leucaena leucocephala*, *Tecoma stans* and *Nerium oleander*.

This area depicts in general a tropical dry forest based on Holdridge's Life Zones or more accurately a classical dry limestone scrub forest ecosystem based on Asprey and Robbins. Approximately two-thirds of the surface rock in Jamaica is limestone (Asprey and Robbins 1953), so the plant communities occurring on limestone are an important part of Jamaica's vegetation. This sub-area extends from the ridge beyond the disturbed northern boundary towards the Savanna-like south-western boundary. There is a gradual transition on the south-western boundary with increasing soil presence and decrease in the average vegetation height and species richness. According to Asprey and Robbins, a dry limestone scrub forest is a sparse, vegetation cover of low forest and tall shrubs growing on bare limestone rock. They further point out that there is practically no soil except for that deposited in small crevices or washed down to level areas. Leaf litter is also almost absent, and the forest floor is a mosaic of jagged honeycomb rock. The little litter present is lodged in crags and crevices of the limestone substrate. The species found here are adapted to the heat as well as the lack of soil and water. This xerophytic vegetation is also tolerant of salt spray and sweeping winds. The canopy is about 8 to 10 m high on average and it's fully intact, which means sunlight is able to penetrate through to the under-canopy and ground level. There is also evidence of tree extraction in this sub-area with an increasing occurrence towards the transitional area.

Plate 4-8 Disturbed Northern Boundary

DRY LIMESTONE FOREST

This area is dominated by *Euphorbia punicea*, *Zamia erosa*, *Comocladia* spp., *Bursera simaruba*, *Metopium brownii*, *Broughtonia sanguinea* and in some areas *Agave morrisii*. Twelve (12) endemic species were observed within this sub-area, these are: *Thrinax parviflora*, *Zemisia discolor*, *Hylocereus triangularis*, *Euphorbia punicea*, *Brassavola subulifolia*, *Broughtonia sanguinea*, *Phyllanthus arbuscula*, *Peperomia clusiifolia*, *Passiflora perfoliata var. perfoliata*, *Portlandia grandiflora*, *Zanthoxylum spinosum* and *Schlegelia parasitica*. It should be noted that Orchidaceae species, Cactaceae species, Euphorbia species and Zamia species are listed on the fourth schedule of the Endangered Species (Protection, Conservation and Regulation) Act. The orchids are also listed under CITES which regulates international trade of all orchid species. *Phyllanthus arbuscula* and *Portlandia grandiflora* are considered near threatened by the IUCN Redlist of Threatened Species. Additionally, *Zamia erosa* though not endemic to Jamaica is endemic to the Greater Antilles and is considered vulnerable by the IUCN Redlist of Threatened Species. Tank bromeliads (in this case Hohenbergia penduliflora) are important species in this dry limestone forest because their ability to store water in the bases of their leaves. The pools of water can also act as a micro-habitat that support some species (micro-fauna) entire life cycle and this has resulted in them being ecosystems themselves. The water stored is also important for other animals such as birds, frogs, crabs and lizards. The importance of these plants within the context of a dry limestone forest is even more significant because of the scarcity of water which when available quickly evaporates due to the heat or drains away through the limestone substrate.

The forest is also a potential source of commodities such as oxygen, medicine, oils and resins among other things. It represents a genetic resource for rare and endemic species that are necessary for facilitating the adaptation of our coastal environment to effects of climate change. General pictures of this area are shown in Plate 4-9 - Plate 4-11

Plate 4-9 Section on the lime stone sub-area

Plate 4-10 Typical flora including bromeliads

Plate 4-11 Section of the lime stone sub-area

SAVANNA-LIKE GRASSLAND

This area is predominantly grassy with interspersed shrubs and trees (Plate 4-12 and Plate 4-13). This continues into a transitional area with a mix of dry limestone vegetation (Plate 4-14). The presence of soil gradually declines until it merges with the core dry limestone forest. The average height of the vegetation within this area is about 1 m and the transitional vegetation increases to about 3 to 4 m in height. As mentioned above there is evidence of extraction of trees within the transitional area. The sub-area is dominated by grasses, *Pisonia aculeata*, *Cucumis anguria* and other species commonly found in pastures and disturbed areas. The transitional area is dominated by *Croton cascarilla* and *Helicteres jamaicensis*.

Plate 4-12 Boundary Area

Plate 4-13 Savanah Area

Plate 4-14 Transitional Area

Summary

The vegetation present within the proposed site is different for the three distinct sub-areas. Two of the sub-areas show a high degree of anthropogenic activity and impacts and the third shows significantly less of these activities and impacts. In total there are one hundred and thirty-seven (137) plant species that were identified and documented (Appendix 7). These 137 plants are spread across fifty-four (54) plant families and one hundred and twenty-seven (27) genera with the highest representation occurring in the families Leguminosae, Euphorbiaceae and Asteraceae with 10, 8 and 7 species respectively. The endemism percentage for the proposed site is approximately ten percent (10%). This is less than the approximately thirty percent (30%) national endemism percentage. This is a diverse assemblage of species with the core species from the dry limestone forest and additional species from the two boundary areas.

The Dry Limestone Forest sub-area had the most observed species of the three sub-areas with a total of 74 species while the Disturbed Northern Boundary sub-area and the Savanna-like South-western Boundary sub-area had a total of 26 and 52 species respectively (Figure 4-58).

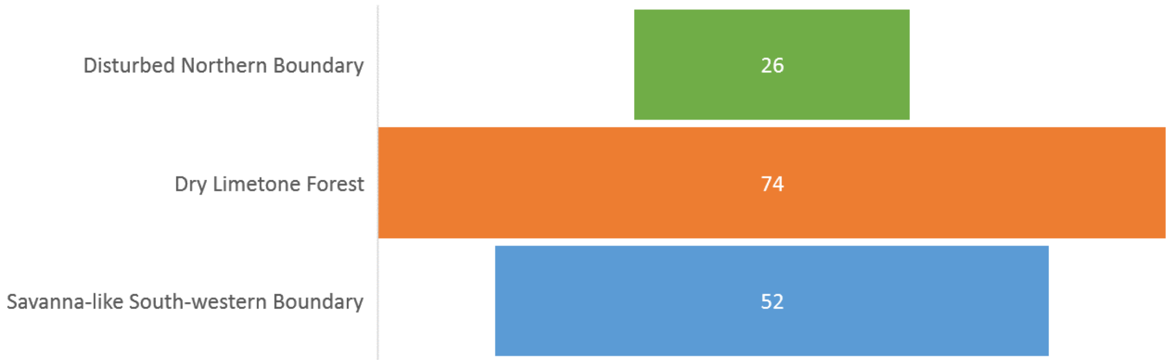


Figure 4-58 Number of species (flora) within each survey area

4.2.3 Fauna

4.2.3.1 Approach

The faunal study (including macro-fauna) was conducted between January 29 and February 8, 2016.

Habitat Types and Sampling Zones

Fauna composition is strongly dependent on habitat types, which in turn are mainly determined by physical factors such as rainfall, elevation, type of substrate, proximity to sea as well as human land use. For ease of sampling the proposed project area was divided into four (4) sampling zones, 3 of which are in common with the vegetation survey, and furthest south the fourth zone, a woodland area assessed for fauna only (Figure 4-57):

1) Disturbed Northern Boundary
2) Dry Limestone Forest
3) Savanna-like Grassland
4) Woodland

Methodology

INVERTEBRATE ASSESSMENT

Larger specimens such as butterflies and spiders were recorded directly. Flight nets, sweep nets, beating tray, and direct search of quadrats were used to sample other groups. Specimens collected were taken back to the laboratory for identification. Soil/litter samples were collected and examined in the laboratory. Material was identified using appropriate literature or the collections at the University of the West Indies. A DAFOR rating was established for all recorded species.

BROMELIAD FAUNA

Bromeliad fauna were studied in the field as well as in the laboratory. In the field over 30 bromeliads were examined using long forceps (30-40 cm). The litter was carefully removed, and any animals observed were recorded. The plants were not damaged, and the material removed was replaced. Additionally, six bromeliads were examined in detail; the plants were carefully removed, enclosed in plastic bags and transported to the laboratory. In the laboratory the plants dissected, leaf by leaf, each leaf axil being carefully examined.

AMPHIBIANS AND REPTILES

Search points were selected throughout the area to cover all the vegetation and substrate types. The micro-habitats identified were actively searched. All specimens seen were identified or pictures were taken for further study if necessary. It was necessary to capture some specimens for closer examination; these were placed in glass bottles or catchment containers; but were subsequently returned to the habitat. Tree lizards of the genus *Anolis* were assessed during slow walks through the area. On nightly visits nocturnal species were spotted using a high beam torch; additionally, frogs were identified from their calls.

AVIFAUNA ASSESSMENT

Point counts and line transects were used for the assessment of the avifaunal community (Figure 4-57). Bird species were either identified with the aid of binoculars, or by their calls. The point count method is based on the principle of counting birds seen and heard at a defined point or spot. This was carried out for 8 minutes, before moving to another point a specified distance away >150 m.

Table 4-19 DAFOR scale used to rank the bird densities in the study

	Total number of birds observed during the survey
Dominant	≥ 20
Abundant	15 – 19
Frequent	10 – 14
Occasional	5- 9
Rare	< 4

The line survey was conducted from sunrise until approximately 10:30 am in the morning and late afternoon from 4 pm to 6 pm. Night surveys were carried out for the nocturnal bird species. This entailed visiting several of the trails and noting the bird activity. The assessments were between 7pm to 12 pm.

BATS

Attempts will be made to locate any caves, rock faces and sinkholes which are being used by bats as rousting areas within each zone. If a bat roost/cave is found, the area will be marked for further studies. In addition, the vegetation will also be assessed for the presence of endemic Jamaica tree bat *(Artibeus jamaicensis)* that usually roost in trees in the day.

HUTIA

These animals are very secretive, and their presence is often most easily be detected from their fecal droppings and by survey of users of the area. The survey will be carried out within each zone in both day and night. A presence/ absence scale will be used in this assessment.

4.2.3.2 Results

Invertebrate Fauna

The invertebrate fauna was rich and included several endemic species and endemic subspecies; this was due partly to several habitat types occurring here. Most species have wide distributions across Jamaica, including sites within the System of Protected Areas. However, all species whose distribution is limited to a single island are generally considered to be somewhat vulnerable.

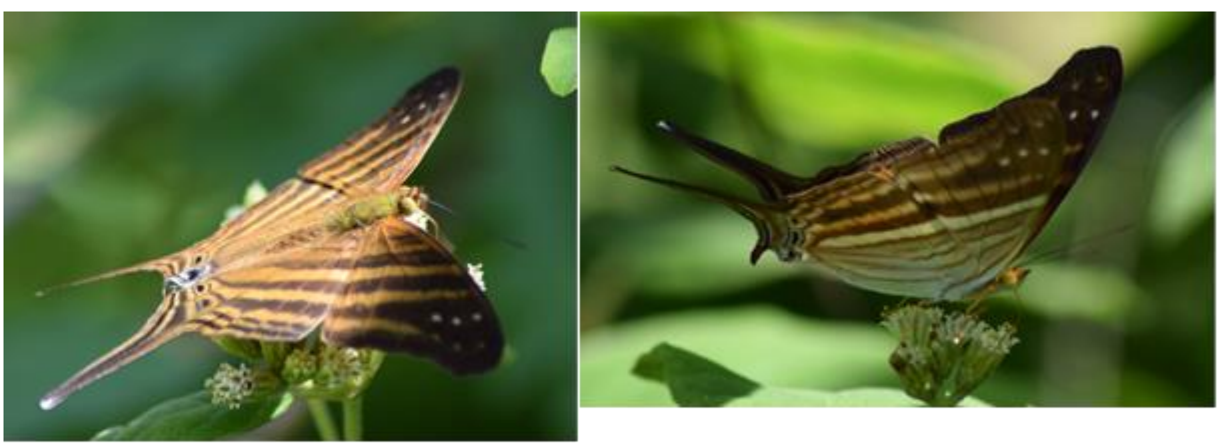
The Lepidoptera fauna of all the sample sites were combined. The species are highly mobile and there was tremendous overlap across sample zones; moreover, species were often observed migrating from zone to zone. The remaining invertebrate fauna were kept separate according to the sample sites.

LEPIDOPTERA (BUTTERFLIES AND MOTHS)

The butterfly fauna was diverse and included four endemic species and five endemic subspecies (Table 4-20). Most of the butterflies are widespread across Jamaica and have not been assigned special conservation status. Two species of butterflies require special conservation consideration, *Eurytides marcellinus* and *Marpesia chiron*.

Marpesia chiron

This represents a new record of *Marpesia chiron* in Jamaica. *Marpesia chiron* has a wide distribution stretching from Southern Texas to Brazil and Argentina, Cuba and the Isles of Pines, Hispaniola, Puerto Rico and Jamaica (Smith *et al.* 1994). The species is common on the Central American mainland and is sometimes referred to as the Common Dagger Tail (Riley 1975). Breeding populations have been recorded on three of the island of the Greater Antilles, Cuba and the Isles of Pine where it is fairly common, Hispaniola where populations are localized, and Puerto Rico where sightings are rare and breeding populations if they exist, are highly localized (Smith *et al*. 1994). However, no breeding population has been reported from Jamaica so far.



Note that the wings are undamaged, suggesting freshly emerged specimens rather than migrants.

Plate 4-15 *Marpesia chiron*

Records from Jamaica are rare and include sightings and or collections in1929, 1931 and 1951 (Brown and Heineman (1972); all except one are from the north western region of the island and it is generally believed that the species might be a migrant to the island (Brown and Heineman 1972, Smith *et al*. 1994). The Jamaican population, however, is of tremendous interest since the specimen from this this species was first described and named by Fabricus in 1775 (the type specimen), was from this island.

On January 31, 2016, a single specimen of *M. chiron* was observed at the quarry site at Rio Bueno. This specimen was in excellent condition and appeared to be fresh. One week later, February 7, the species was again observed. As many as three individuals were observed at any one time, but a study of wing marks (from numerous photographs) suggests that the number of individuals at the site was higher.

Interestingly, Rio Bueno was the site of the 1951 record. The repeated records from Rio Bueno, and the fresh specimen on January 31 suggests the possibility of a breeding population. The suggestion by Brown and Heineman (1972) that “a breeding colony should be sought by resident collectors” seems even more applicable at this time to this location. A rapid survey of the area revealed the presence of species of *Ficus*, one of the larval food plants, but no larvae were found. Given that Jamaica is surrounded by breeding populations it is highly plausible that such a population could be established on the island. Srygley *et al*. (2014) noted that this species feed on several members of the family Moraceae, including some species non-native to the Neotropics. Adams (1970) recorded 17 species in 9 genera in that family of plants occurring in Jamaica, including some known species of food plants such as *Artocarpus heterophyllus* and. *Brosimum alicastrum.* There is clearly a need for careful study of the Rio Bueno site in an attempt to establish if a breeding population exists. The search should be extended beyond Rio Bueno given that two of the previous sightings (1929 and 1931) were from Baron Hill (Brown and Heineman 1972) approximately 4.5 km to the south of this site.

One other member of the genus occurs in Jamaica, this is *Marpesia eleuchea pelleni,* an endemic subspecies. *M. e. pellenis* is widespread throughout Jamaica, but never occurs in high numbers. A special report on the investigation of the presence of *Marpesia chiron* in Eastern Jamaica can be found in Appendix 8.

Plate 4-16 Marpesia eleuchea pellenis, the widespread endemic subspecies of dagger tail in Jamaica

Table 4-20 LEPIDOPTERA (Moths and Butterflies) recorded from the study area

FAMILY	SPECIES	COMMON NAMES	DAFOR RATING	DISTRIBUTION and COMMENTS
HELICONIIDAE	*Heliconius charitonius simulator*	The Jamaican Zebra	F	Widespread occurring in all parishes
	Dione vanillae insularis	The Tropical Silverspot	O	The subspecies *insularis* occurs in the Greater Antilles and Virgin Islands; occurs in all parishes sometimes in relatively large numbers
	Dryas iulia delila	Julia	F	**Endemic subspecies.** Common in grasslands and one of the few butterflies found in forests; found in all parishes in good numbers
PAPILIONIDAE	*Papilio thersites*	The Thersites Swallowtail	F	Seen in few sites in most parishes, in limited numbers
	Papilio andraemon	The Andraemon Swallowtail	O	In parishes, sometimes pest of citrus
	Papilio demoleus	Lime Swallowtail	O	All parishes, introduced, pest of citrus.
	Papilio thoas melonius	Thoas Swallowtail	R	**Endemic subspecies**. All parishes. Once the most common swallowtail in Jamaica; now among the rarest butterfly on Jamaica.
PIERIDAE	*Phoebis sennae sennae*	The Cloudless Sulphur	F	Widespread; present in all parishes
	Eurema nicippe	The Sleepy Orange	O/R	Not very common; prefers dry conditions; in NW parts of island
	Eurema nise nise	Cramer's Little Sulphur	O	Occurs in all parishes, sometimes in large numbers
	Ascia monuste eubotea	The Antillean Great White	O	Occurs all across the island sometimes in very large numbers; pest of Brassicae.
	Kricogonia lyside	Lyside	F	A pest of *Lignum vitae*; occurs in very large numbers at certain time of the year
	Appias drusilla jacksoni	The Jamaican albatross	O	Believed to be migratory; loves open ground and sunlight and dry areas; reported from 13/14 parishes
NYMPHALIDAE	*Precis evarete zonalis*	The West Indian Buckeye	F	Widespread but not abundant as it once was
	Euptoieta hegesia hegesia	The Tropical Fritillary	F	All parishes, more common in northern parishes
	Anartia jatrophae jamaicensis	The Jamaican White Peacock	O	Common in all parishes; generally low numbers
	Phyciodes frisia frisia	The Cuban Crescent Spot	F	Present in every parish
	Phyciodes pelops aegon	The Antillean Crescent Spot	O	Not common, found in several parishes at edge of forests
	Mestra dorcas	Dorcas	D	All across island in all parishes
	Historis acheronta	Cadmus	R	Found in all parishes, low numbers.
	Dynamine egaea egaea	The Jamaican Dynamine	R	Occurs in small numbers in most parishes
	Siproeta stelenes stelenes	The Antillean Malachite	F	Most often In moist forest in all parishes, often found around fallen fruits
	Phyciodes (Antillea) proclea	The Jamaican Crescent-Spot	A	**Endemic.** Occur in foothills as low as sea level; occurs at edge of forests.
	Marpesia eleucha pellenis	The Antillean Dagger Tail; Caribbean Daggerwing	O	**Endemic subspecies**. *M. e. pellenis* is widespread in Jamaica but not very common.
	Marpesia chiron	**The Many Banded Dagger-Tail**	**O**	**Jamaica is listed as the type locality for this butterfly although it was/is believed to be a migrant. See details below.**

FAMILY	SPECIES	COMMON NAMES	DAFOR RATING	DISTRIBUTION and COMMENTS
LYCAENIDAE	***Cyclargus dominica***	The Jamaican Blue	R/O	**Endemic**. Not very common but more widespread than suggested in collections
	Leptotes perkinsae	Miss Perkin's Blue	R	**Endemic.** Mainly north-western parishes.
	Leptotes cassius	The Cassius Blue	O	Widespread
APATURIDAE	*Anaea troglodyta portia*	The Jamaican Goatweed Butterfly	D/A	Occurs in many parishes; common where forests comes down to sea
HESPERIIDAE	*Wallengrenia otho vesuria*	Vesuria	O	Fairly widespread across parishes; not very abundant
	Pyrgus oileus	Syrichtus	O	Present in all parishes
	Urbanus proteus	The Common Tailed Skipper	A	Widespread; occurs all over the island
	Chioides catillus churchi	Church's Jamaican Skipper	O	Not as common as *U. proteus*; widespread but not very common
	Proteides mercurius jamaicensis	Skinner's Jamaican Skipper	O	**Endemic subspecies.** Fairly widespread but not common in Jamaica; does not occur in large numbers
	Achylodes mithridates mithridates	Fabricius's dusky wing	R	**Endemic subspecies**. Widespread in Jamaica, the type locality; not common
	Ephyriades brunnea jamaicensis	The Jamaican Hairy Dusky Wing	R	**Endemic subspecies.** Widespread, occurring in all parishes, numbers generally low but may be locally common. .
ARCTIIDAE	*Utetheisa bella*	Pink Handkerchief	R	Day flying moth, larva feeding on *Crotalaria retusa;* often common where the plant occurs; found in most parishes
NOCTUIDAE	*Cydosia nobilitella*		R	Widespread, occurring in several parishes but not common/abundant
	2 spp. unidentified		R	

End.: Endemic. Endemic species and subspecies are in bold.

Eurytides marcellinus, (Blue Swallowtail Butterfly)

This species is protected by Jamaican law and listed as "Vulnerable" by the IUCN. This species therefore requires special consideration. While there have been records of swarms of adults in the area, there is no information concerning the existence of a breeding population.

This species is endemic to Jamaica (Brown and Heineman 1972, Smith et al 1994). It is considered a vulnerable (V) species (Collins and Morris 1985), based on reduction in number of adult sightings which appears to be linked to habitat changes.

The adults feed on a wide variety of flowers while the only known larval food plant is *Oxandra lanceolata* (Black Lancewood). *O. lanceolata* occurs in woodlands on limestone, mostly in central and western parishes (Adams 1972). *O. lanceolata* was observed in the study site, moreover, the larval food plant has been recorded from the dry limestone forests extending approximately 3 km both east and west of Rio Bueno (specimens in the Herbarium of the Institute of Jamaica).

This butterfly is famous for its seasonal flight periods during which swarms might be observed; much of the remainder the year is spent hibernating in the soil as pupae (Garraway and Bailey 2005).

The area around Rozelle, in the parish of St. Thomas, is widely regarded as the centre of this butterfly's populations, with migrations across the island (Garraway et al 1993). However, J. Woodley (working from UWI Discovery Bay Marine Laboratory) kept careful records of E. *marcellinus* flights for the years 1982 to 1992, for the area extending from Discovery Bay (in St Ann) to Duncans (in Trelawny). He recorded several periods of swarming, and these were occurred at different times from the swarms in St Thomas (Garraway et al. 1993).

Major swarms were recorded further west in the Parish of St. James several decades ago (Lewis 1954) and in this decade (Brandon Hay, pers. comm). All indications therefore are that Woodley was observing swarms from an active north-coast breeding population (Garraway et al. 1993).

While the north coast area is clearly an important population centre for *E. marcellinus*, the actual geographic distribution of the breeding area has never been investigated. As a result of these findings an additional survey was conducted. This objective of the study was to determine the occurrence of *Marpesia chiron* in eastern Jamaica. The work was centred around Bath, parish of St. Thomas since it had previously been reported there (Brown and Heineman 1972).


Plate 4-17 *Eurytides marcellinus*

INVERTEBRATES (EXCLUDING LEPIDOPTERA) OF THE SAVANNA-LIKE AREA AND FOREST

Seventy-eight species of insects, belonging to 41 families were recorded. These were mainly generalists. The savanna-like sub area provided numerous herbs and shrubs which serve as larval food plants, while the flowers provided adult food.

Table 4-21 Arthropod fauna (excluding Lepidoptera) of the Grassland and Forest

FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR
ORDER: COLEOPTERA			
Scarabaeidae	*Oniticellus cubiensis*		R
	Cerea tetrica (Rutelinae)		F
	1 sp. Melolonthinae		R
	Strategus simson		R
	1 sp. uk. (Scarabaeinae)	Black Dung Beetle	R
	Strategus simson		O
	Macraspis tertadaactyla		O
Lycidae	*Thonalmus bicolor*		R

FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR
Carabidae	*Elaphropus yunax*		O
	Tachys sp.		O
Carabidae	*Platynus sp.*		O
Nitidulidae	1 sp. uk. (False Tortoise beetle)	Sap Beetle	R
Chrysomelidae	*Altica occidentalis*		R
	Typophorus nigritus viridIcyaneus	Sweet Potato Beetle	R
	4 spp. uk. Alticinae	Flea beetle	O
	Diabrotica bivittata		R
	Chalpeus sanquinicollis		O
	Cerotoma ruficornis		O
	Metriona propinqua		O
Cerambycidae	*Oxymerus*		R
Coccinellidae	*Hyperaspis connectens*		R
	Brachyacantha bistripustulata		R
	Scymnus roseicollis		R
	Coleomegilla cubensis		
HYMENOPTERA			
Apidae	*Apis mellifera*	Honeybee	A
Formicidae	*Camponotus* sp.	Carpenter Ants	O
Eumenidae	*Trypoxylon* sp	Mud Wasp	O/A
Sphecidae	*Prionys thomae*		O
HEMIPTERA			
Cydnidae	*Tominotus communis*		F
Rhopalidae	*Jadera aeola*		R
Pyrrhocoridae	*Dysdercus jamaicensis*		R
	Dysdercus andreae		R
Pentatomidae	*Thyanta perditor*		R
	Euschistus bifibulus		R
	Nezara viridula		O
	Oebalus pugnax		R
Coreidae	*Niesthrea pictipes*		R
HOMOPTERA			
Cicadellidae	*Hortensia similis*		O
Cicadellidae	1 sp. uk.		F
	Tylozygus fasciatus		R
	Poeciloscarte laticeps		O
	4 spp. uk.		O/R
Cixiidae	1 sp. uk		O
Dictyopharidae	1 sp. uk		O
Membracidae	*Quadrinaria* sp.		R
	Callicentrus aurifascia		F
DIPTERA			
Muscidae	*Musca domestica*	Housefly	O
Sarcophagidae	1 sp. uk.	Flesh fly	O
Tephritidae	1 sp. uk.		R
Syrphidae	*Onnida obesa*	Flower fly	R
Stratiomyidae	*Hermatia illuscens*	Soldier fly	R
Bombyliidae	*Poecilanthrax lucifer*	Bee fly	F
ODONATA			
Anisoptera:Libellulidae	*Tramea binotata*		O
	Erythemis plebeja		F
	Erythrodiplax umbrata		O
Zygoptera: Coenagrionidae	*Telebasis dominicanum*		O
ORTHOPTERA			
Acrididae	*Orphulella punctata*		R

FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR
Tettigoniidae	1 sp. uk. Conocephalinae	Meadow Grasshopper	R
	1 sp. uk. Decticinae	Shield-Backed Grasshopper	R
Gryllidae	*Halpithus* sp.		R
NEUROPTERA			
Chrysopidae	*Chrysopa* sp.	Green lacewing	F
Myrmeleontidae	1 sp. uk.	Antlion	R
Class: ARACHNIDA			
Thomisidae	1 sp. uk	Crab spider	F
Oxyopidae	1 sp. uk	Lynx spider	O
Salticidae	4 spp. uk.	Jumping spiders	F
Tetragnathidae	1 sp. uk.		R
Miturgidae	*Terminus insularis*		R

uk: unknown, identified

INVERTEBRATE FAUNA (EXCLUDING THE LEPIDOPTERA) OF MINED OUT DISTURBED NORTHERN BOUNDARY AREA

This site was highly disturbed and plant cover was sparse in most places. The variety of plants was also limited to colonizers. The invertebrate fauna was therefore limited.

The Arthropod fauna consisted of generalists, which occur in such sites across the island. Fourteen species from 8 families were recorded. There were no endemic species (Table 4-22).

Table 4-22 Arthropod fauna of the old Quarry Site (Lepidoptera excluded)

ORDER	FAMILY	GENUS & SPECIES	COMMON NAME	DAFOR
HYMENOPTERA	Sphecidae	*Prionyx thomae*		O
	Vespidae	*Sphex jamaicensis*		O
		Polistes crinitus	Paper wasp	O
	Apidae	*Apis mellifera*	Honeybee	F
	Scoliidae	*Campsomeris atrata*		R
NEUROPTERA	Chrysopidae	*Chrysops sp.*	Green Lacewing	O
	Myrmeliontidae	Larval pits of 1 sp. seen	Ant-Lion; Nanny-Goat	O
DIPTERA	Tachinidae	1 sp. uk.		R
ODONATA (Anisoptera)	Libellulidae	*Orthemis ferruginea*	Roseate skimmer	R
		Tramea insularis	Antillean glider	O
		Coryphaeschna sp.	Pilot darners	R
		Erythrodiplax umbrata	Band-winged dragon	O

uk. = unknown

The lands snails were very obvious in the open landscape and these are listed in Table 4-23 There were 11 species of land snails, from 7 families. All species were endemic to Jamaica; this was not surprising as 90% of Jamaica's 562 land snails are endemic (Rosenberg and Muratov 2006). No species have been assigned special conservation status.

Table 4-23 MOLLUSCA recorded in the Quarry site

FAMILY	SPECIES	DAFOR RATING	DISTRIBUTION/ COMMENTS
ANNULARIIDAE	*Colobostylus albus*	D	Occurring along rock face (live specimens) and at the bottom of hillside
BULIMULIDAE	*Bulimus diaphanus*	R	

FAMILY	SPECIES	DAFOR RATING	DISTRIBUTION/ COMMENTS
CAMAENIDAE	*Eurycratera jamaicensis*	O	3 broken pieces found on bare rock in quarry; could have been washed in or carried to site with other debris
	Zachrysia provisoria	F	Introduced snail; species tend to be present in very large numbers (dominant); but rather sparse in quarry
	Pleurodonte (Dentellaria) invalida	O	
HELICINIDAE	*Lucidella aureola*	R	
NEOCYCLOTIDAE	*Cyclochittya chittyi*	R	
SAGDIDAE	*Stauroglypta peraffinis*	R	
UROCOPTIDAE	*Urocoptis sp.*	R	
	Urocoptis brevis	R	
	Geoscala sevrilis	O	

BROMELIAD MACRO-FAUNA

Bromeliads create a rather special habitat in forests due to their ability to retain water in their leaf axils, consequently they are sometimes referred to as” tank epiphytes.” This is often the only freshwater habitat in many forests, especially in dry forest such as the sample sites. Because of the architecture of the plants there is very little evaporation and so the habitats remain stable, allowing the development of entire ecosystems within these plants. Many species of animals have become adapted to life in bromeliads and may be bromeliad dependents. These plant-held water ecosystems, referred to as phytotelemata, are now considered important features of tropical forests (Kitching. 2001, Frank and Lounibos 2009). Given this background, it was decided to pay special attention to the maco-fauna of the bromeliads in the area.

Two genera of bromeliads occurred in the site, *Hohenbergia* and *Tillandsia.* Members of the latter genus were small plants and generally did not retain water. *Hoenbergia* developed into large plants, and some retained over 1 litre of water and significant amount of detritus.

Twelve species of insects from 10 families were recorded from the bromeliads. Additionally, one spider (Aranea), one earth worm (Annelida) and one land snail (Pulmonata) was also recorded. Only one vertebrate, the endemic frog, *Osteopilus ocellatus* (the Jamaican Laughing Frog) was present. *O. ocellatus* is widespread across Jamaica, although numbers may be sparse in some south coast areas. The IUCN lists the conservation status of this species as ‘Least Concern”.

Plate 4-18 Bromeliads, most occurring directly on the rocky substraturm, often in clusters. The small bromeliads are Tillandsia sp. and the larger plants are Hohenbergia sp. Photo at lower right shows the large central water tank and the accumulation of debris.

Table 4-24 Macro-fauna from Bromeliad of the dry limestone forest

ORDER	FAMILY	GENUS & SPECIES	COMMON NAME	COMMENTS
PHYLUM ARTHROPODA				
CLASS INSECTA				
Diptera (Flies)	Tendipedidae (midges)	*Chironomus* sp.	Blood worms.	Larva. Common in anaerobic pools
	Chironimiidae	*Metriocnemus* sp.	Pale dipteran larvae	Larva. Common in anaerobic pools
		Monopelopia sp.		Larva. Common in anaerobic pools
	Stratiomyidae	Uk.	Soldier fly larvae	Common in anaerobic pools
	Ceratopogonidae	*Bezzia* sp.	Midge	Larva. Common in anaerobic pools

ORDER	FAMILY	GENUS & SPECIES	COMMON NAME	COMMENTS
	Syrphidae	*Eristalis* sp.	Rat-tailed maggots	Larva. Common in anaerobic water bodies
	Psychodidae	*Telmatoscopus albapunctatus*	Moth fly	Larva. Common in anaerobic pools and slow running water
Coleoptera (Beetles)	Carabidae	***Colpodes darlingtoni***	Beetle larvae	**Endemic**. Occurs in large wet bromeliads across Jamaica
Dictyoptera (Cockroaches)	Blattidae	Uk.	Cockroach	Common
Orthoptera (Grasshoppers and Crickets)	Gryllidae	Uk.	Tree cricket	Common
Odonata Zygoptera (Damsel flies)	Coenagrionidae	***Diceratobasis macrogaster***	Jamaican Bromeliad Damselfly	**Endemic**. Nymph. Widespread. Common in Bromeliads
Collembola		Uk.	Springtails	Widespread in detritus
		CLASS ARACHNIDA		
	Aranea	*Ctenus* sp.	Brown spider	Widespread
		PHYLUM: ANNELIDA; CLASS: OLIGOCHAETA		
	Megacsolecidae	*Dichogaster* sp.	Green earthworms	Common in large wet bromeliads
		PHYLUM: MOLLUSCA; CLASS: GASTROPODA		
Pulmonata	Veronicellidae	*Veronicella sloanei*	Slug	Common
		PHYLUM CHORDATA; CLASS: AMPHIBIA		
Anura	Hylidae	***Osteopilus ocellatus***	Jamaican laughing frog	**Endemic**. Wide spread, rare in some areas of south coast.

Endemic. Endemic species and subspecies are in bold

Chironomus sp. (Blood Worms)

Small worm-like insect larvae up to 13 mm long, bright red in colour. These are larvae of tiny flies sometimes called midges. The presence of haemoglobin in their tissues allows these larvae to obtain oxygen even in environments such as the bromeliad tanks where there is little oxygen. Blood worms feed on detritus (Johnson and Triplehorn 2005). Adults are tiny mosquito-like flies

Soldier Fly Larvae

They live and feed in the detritus. Larvae of this family can be found in a wide variety of habitats mostly in damp places in the soil, in animal excrement and other decaying organic matter (Johnson and Triplehorn 2005).

Telmatoscopus albapunctatus Larvae (Moth fly)

This larva is characterised by distinct gills on most segments of the body. It occurred in water among the detritus in the bottom of the tank. These are detritivores. Adults are tiny flies called moth flies as their wigs are covered with scales and hairs.

Colpodes darlingtoni obtusior. Endemic

This species is endemic to Jamaica; and has an obligate relationship with the bromeliad habitat. It has a wide distribution, occurring in large bromeliads at all altitudes. The larvae are flattened and up to 5 mm in length. The adults are remarkably flattened to allow movements between leaf axils.

Plate 4-19 Adult *Colpodes darlingtoni*, flattened to allow easy movement between the narrow axils of the Bromeliad leaves.

Dichogaster sp. (Green Earthworms)

These earthworms were green in colour; the green colour is due to the respiratory pigment haemocyanin which allows them to obtain oxygen even when oxygen concentration is very low. They were found in the detritus. The genus is widespread and little information is available of the Jamaican species, however it is believed to be endemic.

Diceratobasis macrogaster (Jamaican Bromeliad Damsel). Endemic.

This endemic species of damselfly is a bromeliad specialist in that their nymphs develop only in the axils of bromeliads. The nymphs generally occur where water accumulates for extended periods in these tank epiphytes, usually in forested areas. These nymphs are predators and are an important part of the phytotelmata. The IUCN has not assigned any special conservation status to *D. macrogaster*, largely because of limited data; however, because it needs bromeliads in forests, and because it occurs only on Jamaica, it is considered vulnerable.

Plate 4-20 Nymph of Diceratobasis macrogaster

Amphibians

Seven of the ten amphibian species recorded here are endemic to Jamaica (Table 4-25). Three species are considered endangered; *Eleutherodactylus grabha, Eleutherodactylus jamaicensis,* and *Osteopilus crucialis,* and special consideration should be given to these. All three endangered species are associated with bromeliads.

Many of the amphibians utilize bromeliads as habitats, even being obligate in some cases. The bromeliad population in this site is extensive; while an estimate of the density of plants was not conducted by this team, bromeliads form a significant part of the ground cover. This area is likely to be an important part of the geographic range of some amphibians.

ELEUTHERODACTYLUS GRABHAMI

Eleutherodactylus grabhami is listed as endangered because, despite its local abundance, its extent of occurrence is less than 5,000 km², and its distribution is severely fragmented. This species has a restricted range in western and central Jamaica. It is found in terrestrial and arboreal bromeliads or on rocks in wet limestone forests, and appears to be intolerant of any disturbance to its habitat. It is threatened by habitat degradation and deforestation.

ELEUTHERODACTYLUS JAMAICENSIS

Eleutherodactylus jamaicensis is listed as endangered because its extent of occurrence is less than 5,000 km², and its distribution is severely fragmented. This species is widely, but very patchily, distributed in the Jamaican interior, it is uncommon and almost always associated with arboreal or terrestrial bromeliads. Males call from, and eggs are laid in, bromeliads. Its dependence upon bromeliads in mostly undisturbed forest makes it especially susceptible to habitat loss.

Osteopilus wilderi (Green Tree Frog)

This is an endemic species. All stages of the lifecycle were found in the bromeliads.

Plate 4-21 Adult Osteopilus wilderi

The adults of *Osteopilus wilderi* are nocturnal, and hide in moist places (such as bromeliads) during the day. They lay their eggs in Bromeliads and the tadpoles develop in the water in the tank of the plant. The adults feed on insects; the young larvae feed on algae and detritus, while the mature larvae may tend towards a carnivorous diet.

OSTEOPILUS CRUCIALIS

Osteopilus crucialis, is listed as endangered (Table 4-25) because its extent of occurrence is less than 5,000 km², and its distribution is severely fragmented. This species is endemic to central Jamaica. There has been a decline in its abundance, and this species is now rarely encountered or heard calling, except in pockets of suitable habitat. This species is found in mesic broadleaf woods and forests on tree trunks and in bromeliads; it requires large dead trees. Males call from hollows in branches and bromeliads, and eggs are laid in bromeliads. It is not found in significantly altered habitats but can be found in regenerating forests. It is threatened by habitat degradation and deforestation.

Table 4-25 Amphibian Fauna of the study site

Species	Common name	Species Status	IUCN Status	DAFOR
AMPHIBINAS				
Rhinella marina	Cane Toad	Intro.	L. concern	O
Eleutherodactylus cundalli	Jamaican Rock Eleuth	End.	Near threa.	R
Eleutherodactylus gossei	Jamaican Forest Frog	End.	L. concern	O
Eleutherodactylus grabhami	Jamaican Pallid Frog	End.	Endangered	O
Eleutherodactylus jamaicensis	Jamaican Bromeliad Frog	End.	Endangered	O
Eleutherodactylus johnstonei	Lesser Antillean Frog	Intro.	L. concern	A
Eleutherodactylus pantoni	Jamaican Yellow-bellied Frog	End.	Near threa.	R
Eleutherodactylus planirostris	Cuban Flathead Frog	Intro.	L. concern	O
Osteopilus crucialis	Jamaican Snoring Treefrog	End.	Endangered	R
Osteopilus ocellatus	Jamaican Laughing Treefrog	End.	L. concern	F

Intro. = Introduced; End. = Endemic; L. concern = Least concern; Near threat. = Near threatened

Reptiles

Nineteen species of reptiles were recorded, 18 of which are endemic to Jamaica, the other being introduced (Table 4-26); One species has been considered for special conservation status, *Epicrates subflavus*, the Jamaican Boa. **This species is protected under Jamaican law and is also listed on CITES Appendix I.** While the species is fairy widely distributed the species is vulnerable and any loss of population is therefore important.

Table 4-26 Reptilian Fauna of the study site

Scientific name	Common name	IUCN Species Status	IUCN Status	DAFOR
Celestus barbouri	Limestone forest Galliwasp	End.	Endangered	R
Celestus crusculus	Jamaican Galliwasp	End.	Least Concern.	O
Celestus hewardii	Heward's Galliwasp	End.	Endangered	-
Anolis garmani	Jamaican Giant Anole	End.	Unknown	O
Anolis grahami	Jamaican Turquoise Anole	End.	Least Concern	O
Anolis lineatopus	Jamaican Gray Anole	End.	Unknown	D
Anolis opalinus	Bluefields Anole	End.	Unknown	O
Anolis sagrei	Brown Anole	End.	Unknown	O
Anolis valencienni	Jamaican Twig Anole	End.	Least Concern	R
Hemidactylus mabouia	Croaking lizard, Tropical House Gecko, Wood slave	Intro.	Unknown	F
Aristelliger praesignis	Croaking lizard, Cochran's croaking gecko	End.	Unknown	A
Sphaerodactylus argus	Ocellated geckos	End.	Least Concern	F
Sphaerodactylus goniorhynchus	Jamaican Forest Dwarf Gecko	End.	Near threatened	R
Sphaerodactylus richardsoni	Northern Jamaica Banded Dwarf Gecko	End.	Endangered	R
Epicrates subflavus	Jamaican Boa	End.	Vulnerable	R
Hypsirhynchus callilaemus	Jamaican Red Groundsnake	End.	Least Concern	R
Hypsirhynchus funereus	Jamaican Black Racerlet	End.	Least Concern	R
Tropidophis stejnegeri	Stejneger's Dwarf Boa	End.	Unknown	R
Typhlops jamaicensis	Jamaican Blindsnake	End.	Least Concern.	D

Intro. = Introduced; End. = Endemic; L. concern = Least concern; Near threat. = Near threatened

Avifauna

Sixteen (16) of the thirty (30) endemic birds of Jamaica were recorded in the area; 7 species are forest dependent and 10 were generalists (Table 4-27). None of the species of birds recorded have been listed as requiring special conservation status, however, the area is home to many forest dependent species. Many of the species recorded are likely to occur in sites adjacent to the proposed mining area. Removal of vegetation will negatively affect the bird populations as it will result in reduction in available habitat.

Bird species that are typical of a dry limestone forest (Downer and Sutton1990) were observed on the property. These birds include Caribbean Dove, Parakeets, Hummingbirds, Jamaican Woodpeckers, Orioles and Warblers.

Nine (9) migrant warblers were observed during the assessment, although the survey was carried in late January, a time when a larger number of migrant warblers were expected to be present. It should be note that the migrants are known to depart as early as late February.

Only one (1) nocturnal bird species, the Jamaican Patoo, was encountered during the survey. It should be noted that three (3) other nocturnal bird species such as the Barn Owl, Jamaican Owl and the Antillean Nighthawk have been reported in the area but were not encountered in the study.

A large number of Turkey Vultures were observed in the study area, including an albino (white) which local name is “Pastor John crow”. Many locals believe that the pastor john cow is the first vulture on site that blessed the food before the others eat. The vultures were observed going to and leaving a section of the cliff side, which is a possible nest. However, this area is not within the area zoned for development.

Plate 4-22 Jamaican patoo observed in the area zoned as dry limestone forest

Table 4-27 Species of bird observed during the assessment.

Scientific Name	Common Name	Status	Habitat Type observed	DAFOR
Falco sparverius	American Kestrel	Resident	S;DNB;W	*R*
Setophaga ruticilla	American Redstart	Migrant	DNB;DLF;W	*F*
Tachornis phoenicobia	Antillean Palm Swift	Resident	S	*O*
Coereba flaveola	Bananaquit	Resident	DNB; DLF;W	*A*
Mniotilta varia	Black and White Warbler	Migrant	DNB; DLF;W	*R*
Cypseloides niger	Black swift	Resident	S;W	*O*
Tiaris bicolor	Black-faced Grassquit	Resident	S; DNB;W	F
Dendroica striata	Blackpoll Warbler	Migrant	DNB;W	*R*
Dendroica caerulescens	Black-throated Blue Warbler	Migrant	DNB	*R*
Vireo altiloquus	Black-whiskered Vireo	Resident	DLF;W	*F*
Leptotila jamaicensis	Caribbean Dove	Resident	DLF;W	*R*
Bubulcus ibis	Cattle Egret	Resident	S; DNB	O
Pterochelidon fulva	Cave Swallow	Resident	S; DNB	*F*
Columbina passerina	Common Ground Dove	Resident	S; DNB;W	*F*
Geothypis trichas	Common Yellowthroat	Migrant	DNB;W	*R*
Sturnus vulgais	European Starling	Introduced	S	*O*
Tyrannus cubensis	Giant Kingbird	Resident	W	*R*
Ammodramus savannarum	Grasshopper Sparrow	Resident	S; DNB	*R*
Loxigilla violacea	Greater Antillean Bullfinch	Resident	DLF	*R*
Quiscalus niger	Greater Antillean Grackle	Resident	S; DNB	*O*
Forpus passerinus	Green-rumped Parrotlet	Resident	W	*O*
Todus todus	Jamaica Tody	**Endemic**	DLF;W	*R*
Corvus jamaicensis	Jamaican Crow	**Endemic**	DLF;W	*R*
Myiopagis cotta	Jamaican Elania	**Endemic**	W; DLF	*E*
Euphonia Jamaica	Jamaican Euphonia	**Endemic**	DNB;S; DLF	*A*
Saurothera vetula	Jamaican Lizard Cuckoo	**Endemic**	DNB;SW	*R*
Anthracothorax mango	Jamaican Mango Humming Bird	**Endemic**	SF;W	*R*
Icterus leucopteryx	Jamaican Oriole	**Endemic**	DNB; DLF;W	*F*
Contopus pallidus	Jamaican Pewee	**Endemic**	SF;W	*R*
Spindalis nigricephala	Jamaican Stripe-Headed Tanager	**Endemic**	DNB; DLF;W	*O*
Vireo modestus	Jamaican Vireo	**Endemic**	DNB;W	*R*
Melanerpes radiolatus	Jamaican Woodpecker	**Endemic**	DLF	*O*
Tyrannus caudifasciatus	Loggerhead Kingbird	Resident	S; DNB; DLF;W	*F*
Fregata magnificens	Magnificent Frigatebird	Resident	S; DNB	R
Mimus polyglottos	Nothern Mockingbird	Resident	S; DNB;F	*A*
Aratinga nana	Olive-throated Parakeet	Resident	DLF;W	*F*
Euneornis campestris	Orange Quit	**Endemic**	DNB; DLF;W	*R*
Seiurus aurocapillus	Ovenbird	Migrant	DLF;W	*R*
Dendroica palmarum	Palm Warbler	Migrant	W	*R*
Dendroica discolor	Praire Warbler	Migrant	DNB;W	*R*
Trochilus polytmus	Red-billed Streamertail	**Endemic**	DNB; DLF;W	*O*
Buteo jamaicensis	Red-tailed Hawk	Resident	DNB	*R*
Myadestes genibarbis	Rufous-throated Solitaire	Resident	DLF;W	*R*
Myiarchus barbirostris	Sad Flycatcher	**Endemic**	DNB; DLF;W	*O*
Molothrus bonariensis	Shiny Cowbird	Introduced	S	*R*
Crotophaga ani	Smooth-billed Ani	Resident	S; DNB;W	F
Myiarchus stolidus	Stolid Flycatcher	Resident	DLF;W	*O*
Carthartes aura	Turkey Vulture	Resident	S; DNB; DLF;W	*F*
Mellisuga minima	Vervain Hummingbird	Resident	DNB; DLF;W	*O*
Streptoprocne zonaris	White Collared Swift	Resident	W	*F*
Columba leucocephala	White Crowned Pigeon	Resident	DNB; DLF;W	O
Turdus aurantius	White-chinned Thrush	**Endemic**	W; DLF	*R*
Zenaida asiatica	White-Winged Dove	Resident	S; DNB; DLF;W	*D*
Dendroica petechia	Yellow Warbler	Resident	DNB; DLF;W	*O*
Tiaris olivacea	Yellow-faced Grassquit	Resident	S;W	*O*
Loxipasser anoxanthus	Yellow-Shouldered Grass quit	**Endemic**	S; DNB; DLF;W	*O*

Scientific Name	Common Name	Status	Habitat Type observed	DAFOR
Dendroica dominica	Yellow-throated Warbler	Migrant	S; DNB;W	*R*
Zenaida aurita	Zenaida Dove	Resident	S; DNB;W	*F*

S = Savanna-like Area; DNB = Disturbed Northern Boundary sub area; W = Woodland; DLF = Dry Limestone Forest

It should be noted that six (6) species of birds that were previously reported in the area were not observed in the study area (Table 4-28). This includes one migrant, one resident and four endemic species.

Table 4-28 Birds reported from the area not observed in this study

Scientific Name	Common Name	Status
Dendroica pharetra	**Arrow-Headed Warbler**	**Endemic**
Tyto alba	Barn Owl	Resident
Amazona collaria	**Yellow-billed Parrot**	**Endemic**
Hyetornis pluvialis	**Chestnut-Bellied Cuckoo**	**Endemic**
Pseudoscops grammicus	**Jamaican Owl**	**Endemic**
Chordeiles gundlachii	Antillean Nighthawk	Migrant

SAVANNA-LIKE SOUTH-WESTERN BOUNDARY SUB-AREA

Twenty-one species of birds were associated with this area during the study. The most dominant birds in the area were the Grassquits, particular the Yellow-face Grassquits. There were also other birds associated with the grassland such as, American Kestrel, Grasshopper Sparrow, Black Face Grassquit, Yellow Shouldered Grassquit.

Two (2) introduced species of birds that were encountered in the study were located in this area; European Starling and the Shiny Cowbird. Both species are known to be associated with savanna-like grasslands with emphasis on pastures.

DRY LIMESTONE FOREST SUB-AREA AND WOODLAND

There was no major difference in the birds located in the dry limestone forest and the woodland; hence the bird data for both areas was combined. Most of bird (n = 48) species identified in the study were recorded in this zone, including all the endemic birds, both forest and non-forest dependent.

DISTURBED NORTHERN BOUNDARY SUB AREA

Over 33 species of birds were observed in this area. The high number of birds recorded was a result of the mine located within a forested area. Several white Wing Doves, Common Ground Doves and Grassquits were present in the area. Several migrants were also observed foraging in the shrubs.

Bats

The general area is karstic, however no caves have been reported for the area in the Jamaica Underground: Caves, Sinkholes and Underground Rivers, 1998. During the walkthrough of property, only a few rock holes were observed and no large caves were observed. In addition, all the people who were encountered in the area and were later interviewed have reported that they have not encountered a cave or have seen a bat roost in the study area.

During the survey of the dry limestone forest in the night, a few bats were seen foraging in the vegetation. They were also observed foraging in the fig trees and Trumpet tree (*Cecropia peltata*). It is possible that these bats were the fruit eating. However, the bat species could not be identified to species due to the absence of bat detector.

Hutia

No signs of the hutia were observed during the survey of the property. It should be noted that although there were no signs of the hutia, the people who were encountered in the area also reported that they have not seen any Hutia in the area. It should be noted that the hutia is very secretive and could be present in the area. Further detailed studies would have to be carried out in the area to confirm their presence.

4.3 SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

4.3.1 Demography, Services and Infrastructure

4.3.1.1 Approach

Social Impact Area

In order to assess the various social elements of the proposed project, a Social Impact Area (SIA) is established. An SIA may be described as the estimated spatial extent of the proposed project's effect on the surrounding communities. Demographic analyses are carried out utilising this SIA demarcation, and social services, infrastructure and industrial facilities are described in relation to the SIA as well. For the purposes of this project, the SIA was demarcated as two (2) kilometres from the proposed development area, and specifically Phase I of the project, in addition to the proposed Operations Area (Figure 4-59). The SIA is located within two communities; primarily within the north-western section of Discovery Bay, and a smaller portion in the eastern section of Rio Bueno. The northern half of the SIA falls over the Caribbean Sea.

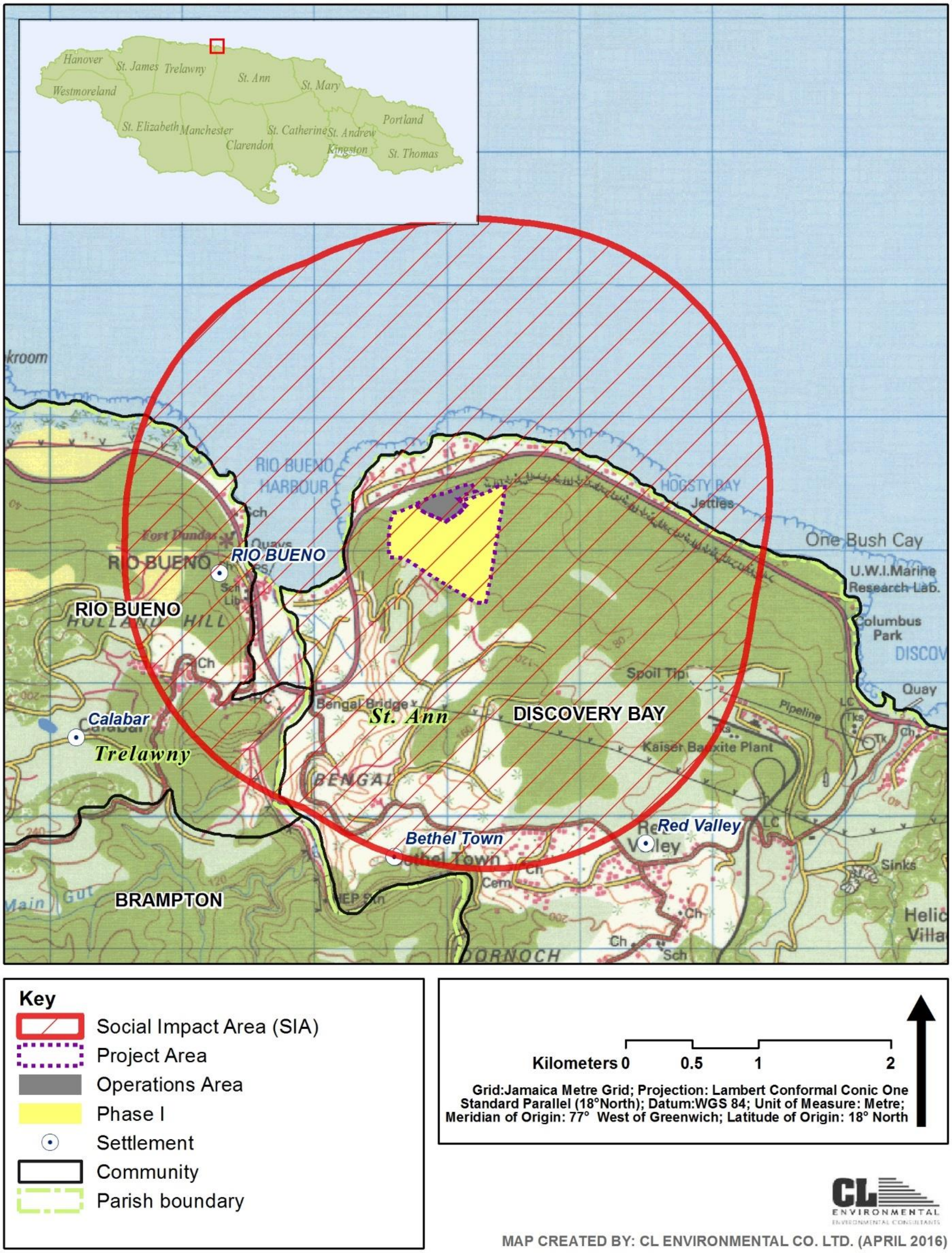


Figure 4-59 Map showing the Social Impact Area (SIA)

Demographic Analyses and Census Database

Population data were extracted from the Statistical Institute of Jamaica (STATIN) 2011 Population Census database for the SIA by enumeration district (ED). This was undertaken using Geographic Information Systems (GIS) methodologies, which were also used to derive visual representations of the data. In order to derive information from the census data the following computations were made:

- ***Population growth*** - was calculated using the formula [$i_2 = i_1 (1 + p)^x$]; where i_1 = initial population, i_2 = final population, *p* = actual growth rate and *x* = number of years.
- ***Population density*** – was derived by dividing the population by the land area. This is useful for determining the locations of greater concentrations of population.
- ***Dependency ratio*** – was calculated using the formula [child population + aged population /working population X 100], where the child population is between ages 0-14, the aged population is 65 & over and the working population is between ages 15-64 years. This ratio is useful for understanding the economic burden being borne by the working population.
- ***Male sex ratio*** – was calculated by using the formula [male population / female population X 100]. This in effect denotes the amount of males there are to every 100 females and is useful for determining the predominant gender in a particular area.
- ***Domestic water consumption*** - was calculated based on the assumption that water usage is 227.12 litres/capita/day and sewage generation at 80% of water consumption. Water consumption for workers in Jamaica is calculated at 19 litres/capita/day and sewage generation at 100% water consumption.
- ***Domestic garbage generation*** - was calculated at 4.11 kg/household/day (National Solid Waste Management Authority).

It should be noted that all Census data relates to the resident population and does not take into consideration persons working in or visiting the ED.

Other GIS Data

Geospatial data for various services and infrastructure, including schools, health centres, hospitals, police stations, fire stations and post offices were obtained from the Mona GeoInformatics Institute. Additional data were also gleaned from the 1984 national topographic maps (metric series) and satellite imagery available for the project. Other data sources are stated where applicable throughout.

4.3.1.2 Demography

Population Growth Rate

The total population within the SIA in 2011 was approximately 1,074 persons (STATIN 2011 Population Census). Examination of the 2001 population data showed that there were approximately 714 persons within the 2 km radius of the proposed development area in 2001. From this population, and that calculated for the year 2011 (1,074 persons), it was estimated that the actual growth within the SIA between 2001 and 2011 was approximately 4.16% per annum. Based on this growth rate, at the time of this study (2016), the population was approximately 1,317 persons and is expected to reach 3,652 persons over the next twenty-five years if the current population growth rate remains the same.

The annual growth rate for the SIA (4.16%) is greater than that for the parishes of Trelawny (0.30%) and St. Ann (0.35%), as well as the island (0.36%) between 2001 and 2011[3]. Using the regional rates for Trelawny and St. Ann respectively, the population in 2016 is estimated to be 1,090 and 1,093 persons, and in 2041, 1,175 and 1,192 persons.

Age & Sex Ratio

The segment of a population that is considered more vulnerable are the young (children less than five years old) and the elderly (65 years and over). In the SIA population, 10.2% comprised the vulnerable young category, whilst 8.5% comprised the elderly.

Table 4-29 shows the percentage composition of each age category of the population. This is compared on a national, regional and local (SIA) level. Percentage age distribution in the SIA for the 0-14 years age cohort (27.1%) is comparable to both parishes and island figures (27.7%, 27.2% and 26.1% respectively). As mentioned preciously, elderly persons aged 65 years and greater make up 8.5% of the SIA population; and this value is also comparable to other levels investigated. Within the SIA, the 15-64 years age category accounted for 64.4% and can therefore be considered a working age population, similar to that for the nation (65.9%) and the parishes of St. Ann (64.2%) and Trelawny (63.1%) (Table 4-29).

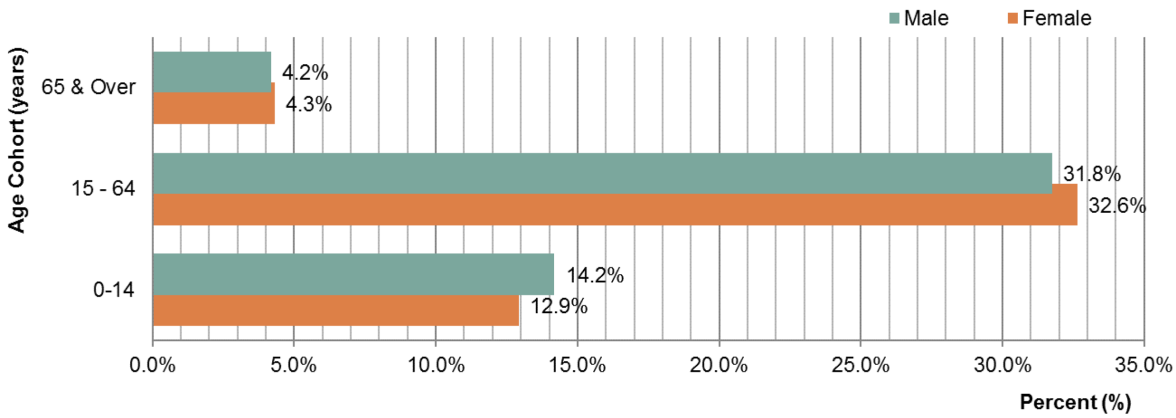
Table 4-29 Age categories as percentage of the population for the year 2011

Age Categories	Jamaica	Trelawny	St. Ann	SIA
0-14	26.1%	27.7%	27.2%	27.1%
15 - 64	65.9%	63.1%	64.2%	64.4%
65 & Over	8.1%	9.2%	8.6%	8.5%

Source: STATIN Population Census 2011

As seen in Figure 4-60, Census 2011 data indicated that there were 0.9% and 0.1% more females within the 15-64 years and 65 & over age cohorts respectively when compared to males; however, 1.3% more males than females in the 0-14 years cohort. Sex ratio for all age cohorts within the SIA was calculated to be 100.5 males per one hundred females.

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



Source data: STATIN Population Census 2011

Figure 4-60 Male and female percentage population by age category for the SIA in 2011

The population pyramid for the 2km SIA is shown in Figure 4-61; it reveals that within the SIA the 15-19 and 0-4 years age groupings make up higher proportions of the population structure. Additionally, there were considerably more females aged 25-29 years than males of the same grouping, whilst more males than females aged between 40 and 49 years of age.

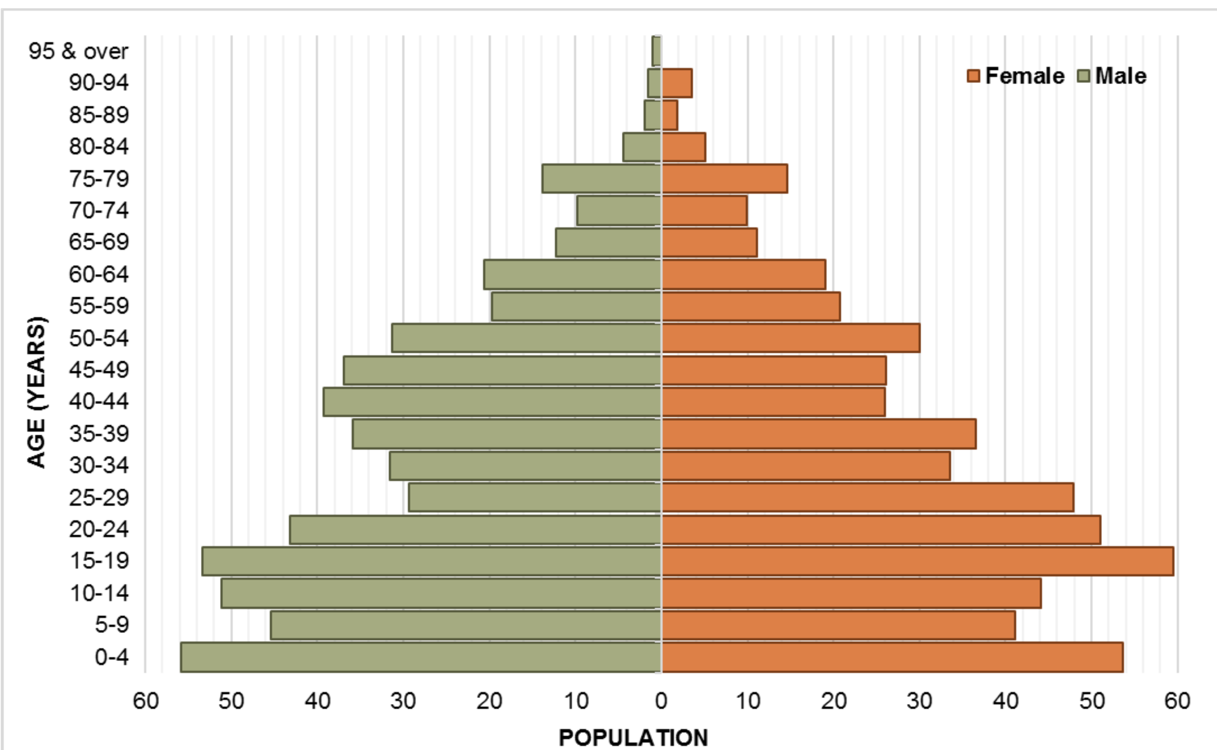
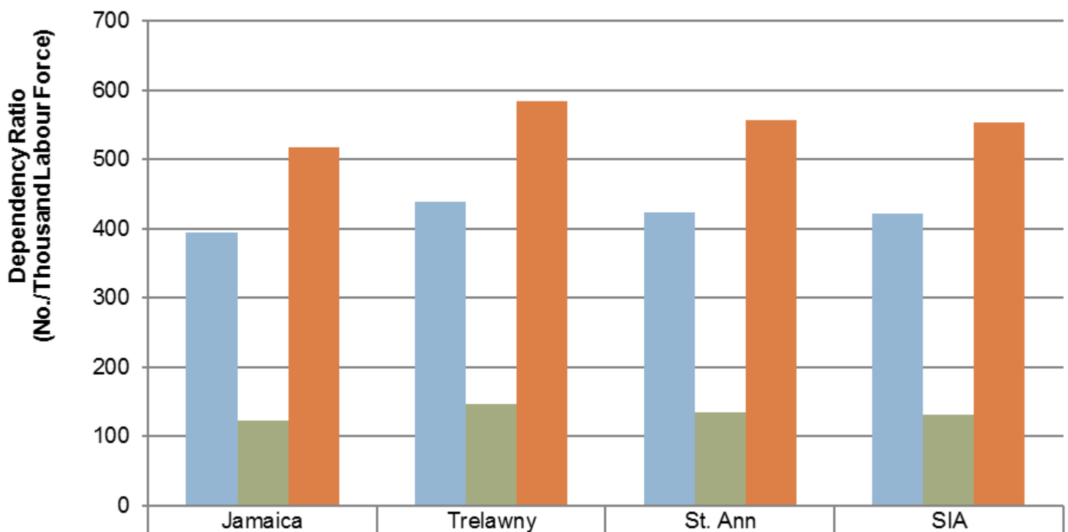


Figure 4-61 Population pyramid for the SIA in 2011

Dependency Ratios

The child dependency ratio for the SIA in 2011 was 421.2 per 1000 persons of labour force age; old age dependency ratio stood at 131.9 per 1000 persons of labour force age; and societal dependency ratio of 553.1 per 1000 persons of labour force. This indicates that the youth (child dependency) are far more dependent on the labour force for support when compared with the elderly in the SIA. These various ratios are comparable to the parish figures for St Ann, however differ with the national and Trelawny figures (Figure 4-62). Societal dependency is greater in the SIA when compared to the nation, however smaller than that for the parish of Trelawny. Both old age and child dependency is lower on the national and regional level for Trelawny.



	Jamaica	Trelawny	St. Ann	SIA
Child Dependency	395.4	438.8	422.8	421.2
Old Age Dependency	122.4	146.0	134.1	131.9
Societal Dependency	517.8	584.8	556.9	553.1

Source: STATIN Population Census 2011

Figure 4-62 Comparison of dependency ratios for the year 2011

Population Density

The land area within the SIA was calculated to be approximately 11.36 km². With a population of 1,074 persons, the overall population density was calculated to be 95 persons/km². This population density is considerably lower than the national level (245 persons/km²), and the Trelawny and St. Ann regional densities of 167 and 142 persons/km² respectively (Table 4-30).

Table 4-30 Comparison of population densities for the year 2011

Source: STATIN Population Census 2011

Category	Jamaica	Trelawny	St. Ann	SIA
Land Area (km²)	10,991.0	450.3	1,210.3	11.4
Population	2,697,983	75,164	172,362	1,074
Population Density	245	167	142	95

Population Growth Areas

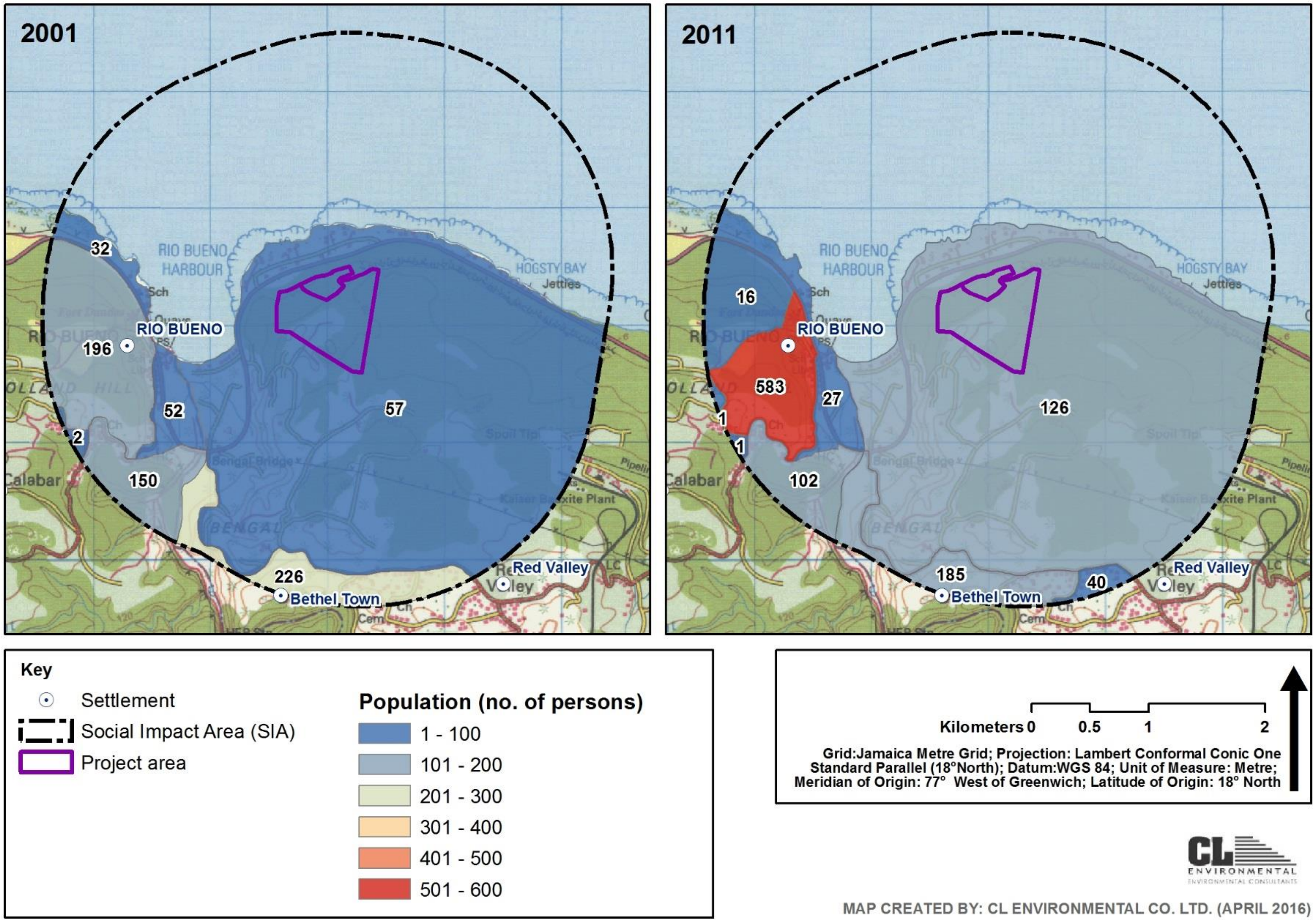
Figure 4-63 depicts the population within each enumeration district (ED) for the years 2001 and 2011. As seen here, an increase in the population occurred in the larger ED comprising the majority of the SIA and within which the project area is situated. A dramatic population increase is also seen to the west of the SIA in Rio Bueno.

4.3.1.3 Poverty

The poverty GIS dataset developed by the Planning Institute of Jamaica (PIOJ) (with contributions from STATIN, Social Development Commission (SDC) and the University of Technology), primarily identifies areas of poverty by community. As described by PIOJ, for the 2002 poverty map:

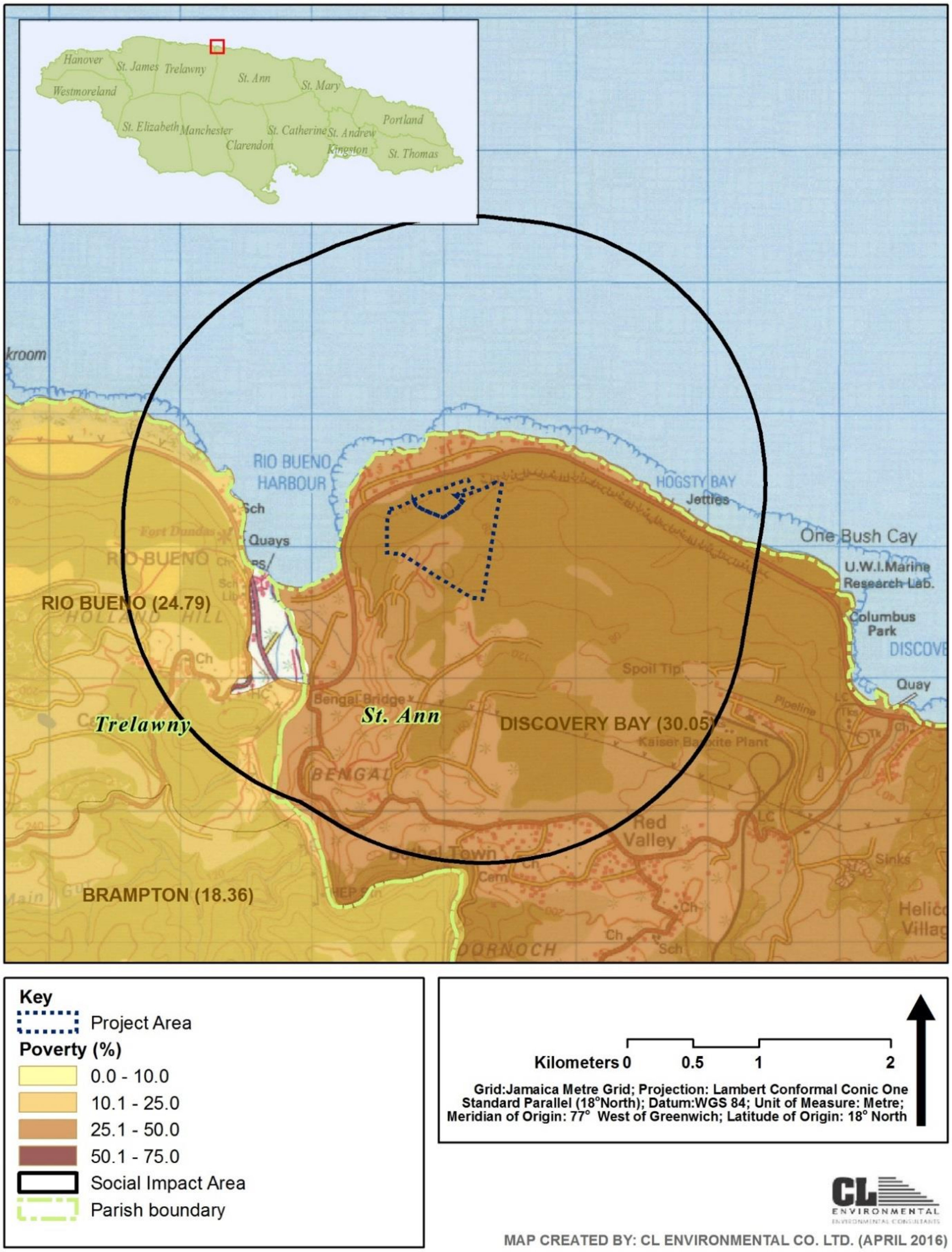
> The indicators utilized were those that best predicted per capita consumption levels in households based on data from the Jamaica Survey of Living Conditions (JSLC) 2002. Relevant variables that were common to this survey and the Population Census 2001 were selected and tested for similarity. The satisfactory variables were then applied to the census data to obtain estimates of the consumption levels of the households that had consumption levels islandwide. Members of households that had consumption levels below the poverty line for the region in which their household was located were deemed to be in poverty. The proportion of persons in poverty in each community was used to rank the 829 communities.

As seen in Figure 4-64, the SIA population generally has between 24% and 30% of persons living in poverty.



Data source: STATIN Population Census 2011 and 2001

Figure 4-63 SIA 2001 and 2011 population data represented in enumeration districts



Data source: PIOJ (with contributions from STATIN, SDC and the University of Technology

Figure 4-64 Proportion of persons in poverty in each community

4.3.1.4 Education

The highest level of educational attainment in 2011 for the national, regional and SIA extents are represented in Table 4-31. When the highest level of educational attainment within the SIA is calculated as a percentage, it becomes evident that there is a propensity towards the attainment of primary and secondary education. Forty-six percent of the SIA population attained a primary school education as the highest level, followed by 38.2% attaining secondary education. SIA secondary educational attainment is lower than the Jamaica and parish figures for Trelwany and St. Ann (45.7%, 42.5% and 42.8% respectively), whilst primary education in the SIA is greatest amongst all extents examined (Table 4-31). University attainment as the highest level of education is lowest in the SIA (1.1%), however the attainment of other tertiary education in the SIA (4.4%) is comparable to the parish Trelawny (4.3%).

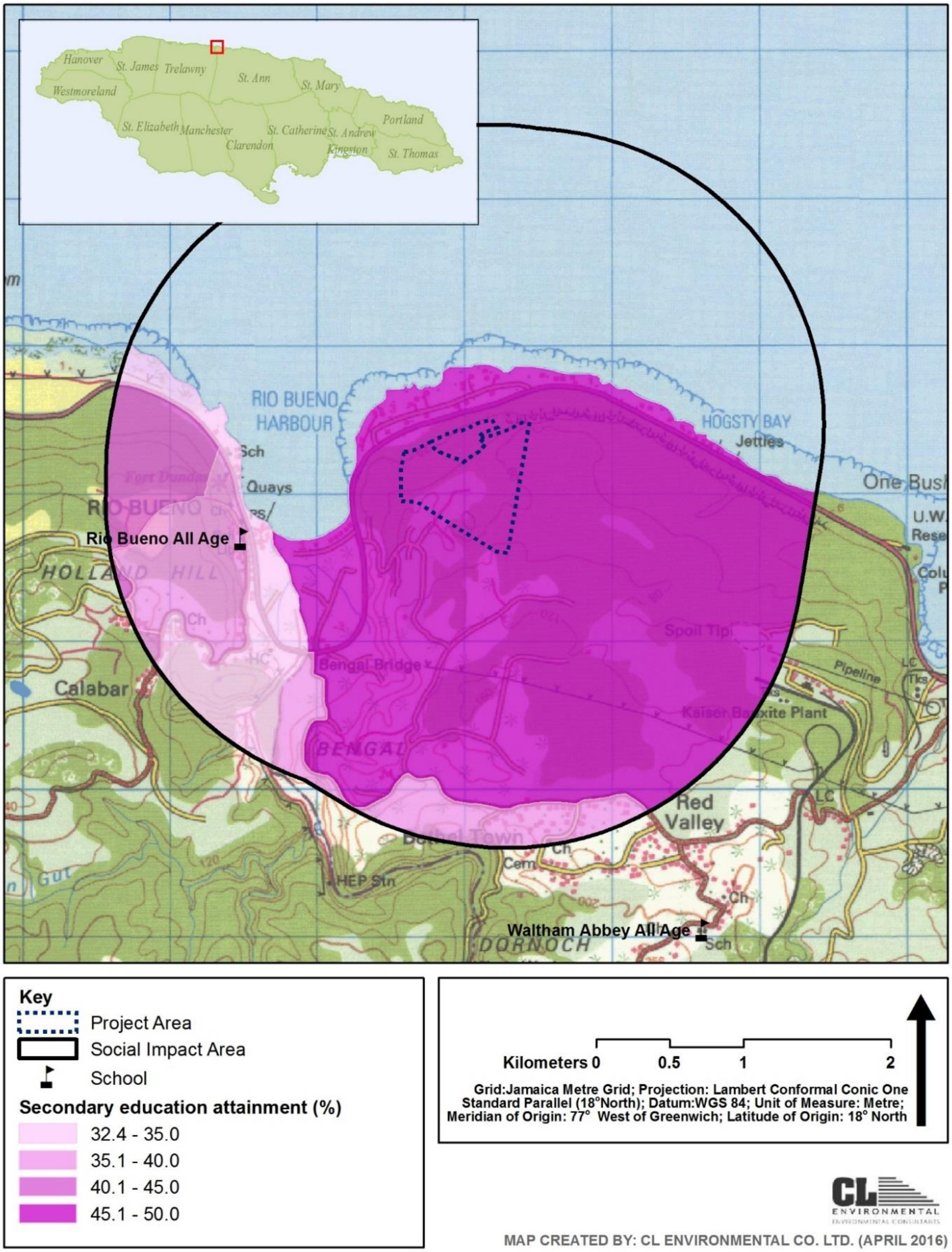
Table 4-31 Population 3 years old and over by highest level of educational attainment as a percentage, for the year 2011

	Jamaica	Trelawny	St. Ann	SIA
No Schooling	0.7%	0.9%	0.9%	0.8%
Pre Primary	4.8%	5.1%	4.9%	5.4%
Primary	34.4%	41.7%	39.2%	46.1%
Secondary	45.7%	42.5%	42.8%	38.2%
University	4.7%	2.0%	2.3%	1.1%
Other Tertiary	5.2%	4.3%	6.1%	4.4%
Other	0.5%	0.3%	0.3%	0.3%
Not Stated	0.0%	3.3%	3.5%	3.8%

Source: STATIN Population Census 2001

Figure 4-65 depicts secondary education attainment within the SIA and the location of schools in proximity to the proposed development. One school, Rio Bueno All Age is found within the 2 km buffer SIA and is located approximately 1 km west of the project area.

Although outside the boundary of the SIA, the University of the West Indies Discovery Bay Marine Laboratory exists to the east of the project site in Discovery Bay.



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

Figure 4-65 Percentage population attaining a secondary education within the SIA

4.3.1.5 Housing

Housing Units, Dwellings and Household

For the purposes of this study the definition of housing unit, dwelling and household are those used in the population census conducted by the Statistical Institute of Jamaica (STATIN). The definition states that:

- A **housing unit** is a building or buildings used for living purposes at the time of the census.
- A **dwelling** is any building or separate and independent part of a building in which a person or group of persons lived at the time of the census". The essential features of a dwelling unit are both "separateness and independence". Occupiers of a dwelling unit must have free access to the street by their own separate and independent entrance(s) without having to pass through the living quarters of another household. Private dwellings are those in which private households reside. Examples are single houses, flats, apartments and part of commercial buildings and boarding houses catering for less than six boarders.

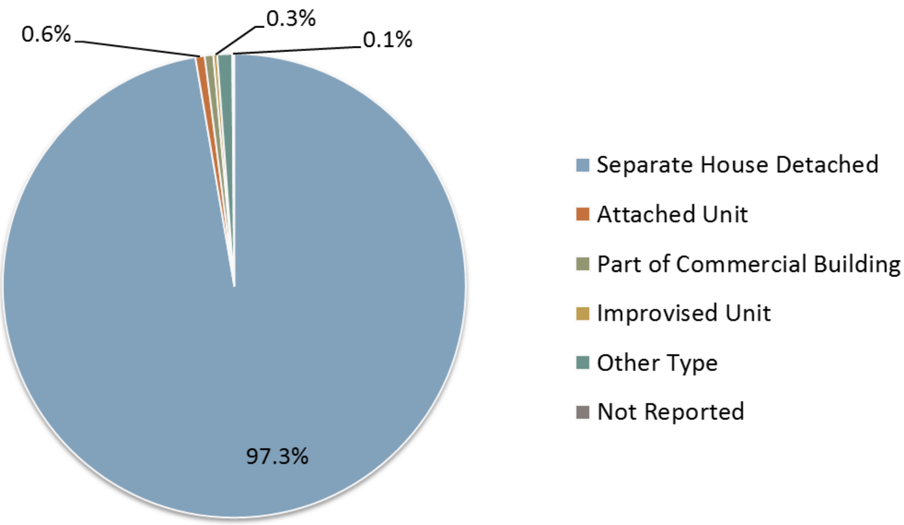
There were 365 housing units, 397 dwellings and 404 households within the SIA in 2011. The average number of dwellings in each housing unit was 1.1 and the average household to each dwelling was 1.2. The average household size in the SIA was 2.7 persons/ household (Table 4-32). Comparisons of the SIA with national and regional ratios indicate that the SIA had the greatest household/dwelling ratio and lowest average household size.

Table 4-32 Comparison of national, regional and SIA housing ratios for 2011

	Jamaica	Trelawny	St. Ann	SIA
Dwelling/Housing Unit	1.2	1.1	1.1	1.1
Household/Dwelling	1.0	1.0	1.0	1.2
Average Household Size	3.1	3.0	3.2	2.7

Source: STATIN Population Census 2001

Approximately 97.3% of the housing units in the SIA were of the separate detached type, 0.6% were attached, 0.6% part of a commercial building, 0.3% improvised unit, 1.0% other type and 0.1% not reported (Figure 4-66).

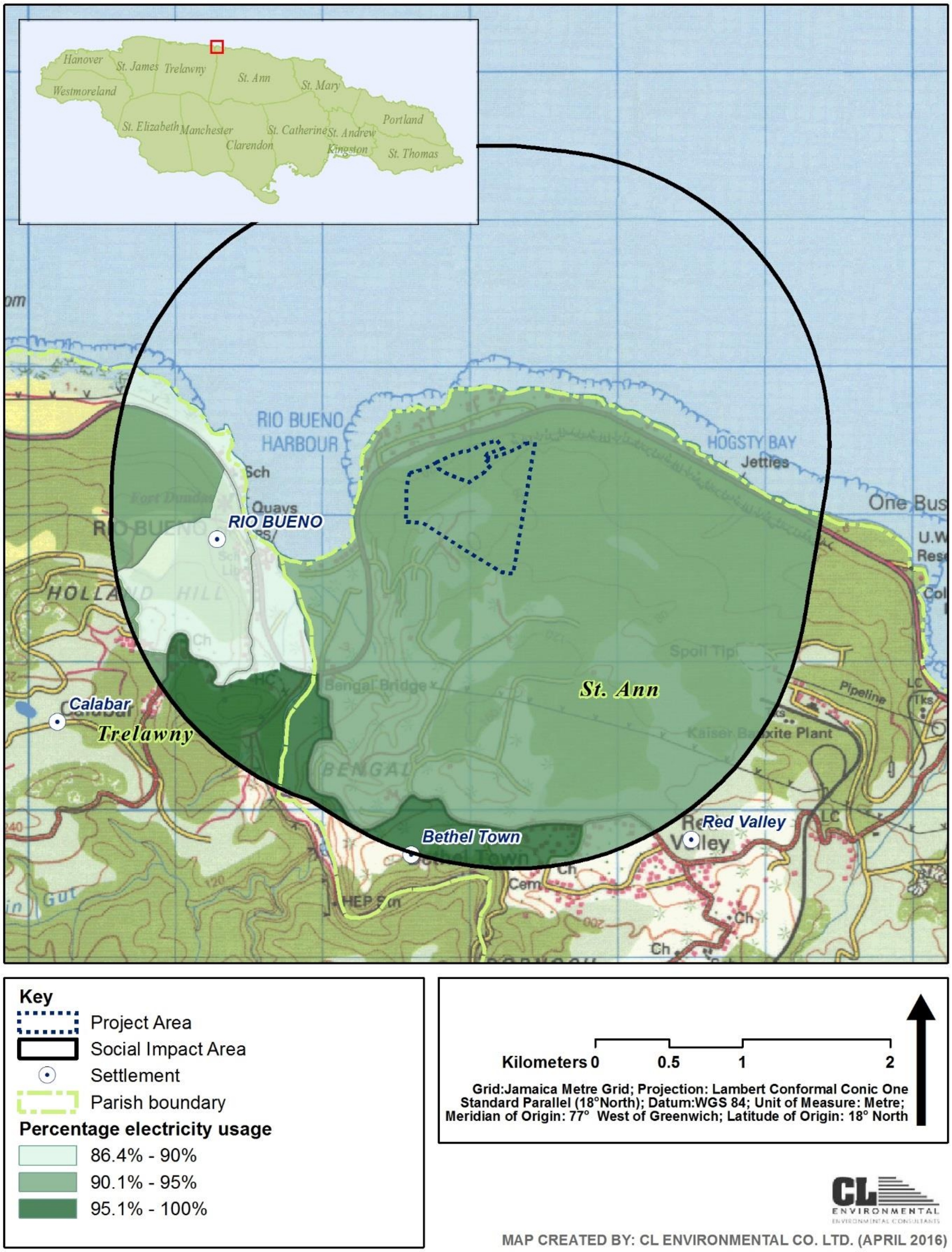


Source: STATIN Population Census 2011

Figure 4-66 Percentage of housing units by type within the SIA

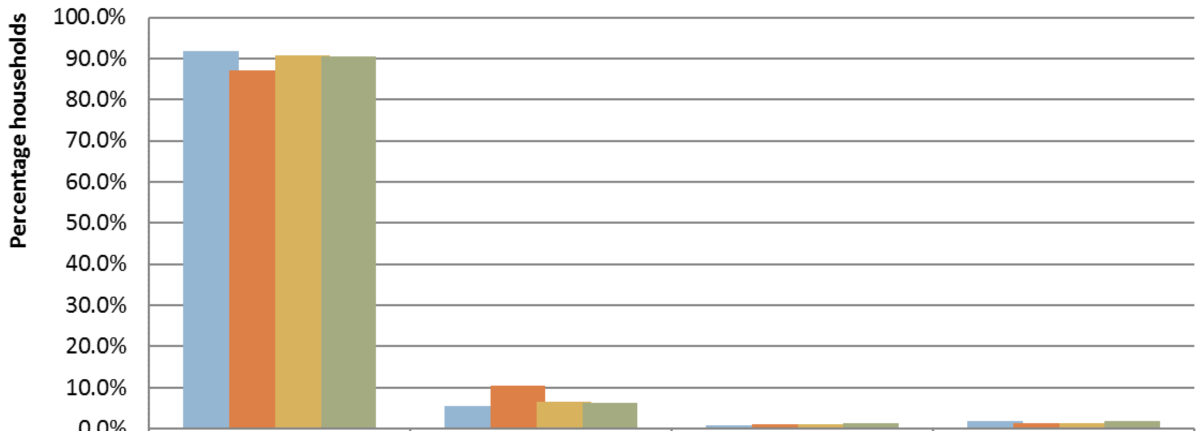
Lighting

Figure 4-67 depicts the percentage households in the SIA using electricity, whilst Figure 4-68 shows electricity usage for varying extents, along with other sources of lighting. Data for all extents (SIA, parish and national) reveal that the majority of the population utilise electricity as their main source of lighting. Approximately ninety percent (90.5%) of households within the SIA use electricity, and whilst this is greater than the Trelawny figure (87.2%), that for the SIA is comparable to the parish of St. Ann and the island. The percentage of households using kerosene as their main means of lighting in the SIA (6.3%) was comparable to that for St. Ann (6.6%); however considerably lower than that for Trelawny (10.4%) and slightly greater than the Jamaican level (5.5%). Other means of lighting were comparable for all extents and were below 2.0% of households.



Source: STATIN Population Census 2011

Figure 4-67 Percentage dwelling with electricity within the SIA for the year 2011



	Electricity	Kerosene	Other	Not Reported
Jamaica	91.9%	5.5%	0.8%	1.8%
Trelawny	87.2%	10.4%	1.1%	1.4%
St. Ann	90.8%	6.6%	1.2%	1.4%
SIA	90.5%	6.3%	1.4%	1.8%

Source: STATIN Population Census 2011

Figure 4-68 Percentage households by source of lighting

Domestic Water Supply

The National Water Commission (NWC) is the public agency responsible for providing Jamaica's domestic water supply. Only 16.5% of the households within the SIA received their domestic water supply from a public source; this is considerably lower than all extents investigated that had the majority of the population's water supply from a public source (Table 4-33). The category with the highest portion of the SIA was "other" source of water supply (44.5%), with another 32.4% of the households acquiring water privately.

Table 4-33 Percentage of households by water supply for the year 2011

Source: STATIN Population Census 2011

	Category	Jamaica	Trelawny	St. Ann	SIA
Public Source	Piped in Dwelling	49.7%	38.9%	36.9%	14.8%
	Piped in Yard	16.5%	7.5%	12.8%	0.0%
	Stand Pipe	7.1%	5.2%	14.1%	1.6%
	Catchment	2.2%	2.8%	1.8%	0.0%
Private Source	Into Dwelling	6.4%	12.4%	7.1%	13.2%
	Catchment	9.8%	26.0%	15.5%	19.2%
	Spring/ River	3.0%	3.5%	6.8%	1.6%
	Trucked Water/Water Truck	2.1%	1.0%	1.7%	3.3%
	Other	1.8%	1.7%	2.1%	44.5%
	Not Reported	1.3%	1.1%	1.2%	1.6%

Water demand for the SIA in 2016 is estimated to be 299,052.9 litres/day (~79,001.4 gals/day) and is expected to decrease to 829,351.6 litres/day (~219,091.6 gals/day) over the next twenty-five years based on population growth rates calculated previously.

Wastewater Generation and Disposal

It is estimated that approximately 239,242.3 litres/day (~63,201.1 gals/day) of wastewater is generated within the study area (for 2016) and is expected to decrease to 663,481.3 litres/day (~175,273.2 gals/day) over the next twenty-five years based on calculated growth rates.

Census 2011 data for wastewater disposal methods was not available.

Solid Waste Generation and Disposal

It is estimated that at the time of this study (2016), approximately 2,036.45 kg (~2.0 tonnes) of solid waste was being generated. The National Solid Waste Management Authority (NSWMA) is responsible for domestic solid waste collection within the study area and specifically, WPM Waste Management Ltd. covers the parish of Hanover. Presently, collection is done once per week for residential areas and is provided free (partial covered by property taxes) for households. Solid waste collection for commercial and industrial facilities is done by arrangements by these entities with private contractors.

4.3.1.6 Transportation

Road Network

As seen in Figure 4-69, a major roadway parallels the northern boundary of the project site. The site is more easily accessed at the north-western section of the property. The site access from the North Coast Highway is proposed to be placed east of the previous site access (Figure 3-13). Section 3.2.3 contains details re Site Access.

Airfields, Aerodromes and Airports

No air transport facilities exist within the SIA. Braco Airfield is the closest facility and is found approximately 4 km west of the project area. The closest international airport is the Sangster International Airport (SIA), approximately 51 km west of the development area. The SIA is the leading tourism gateway to the island of Jamaica and is the larger of two international airports in Jamaica. Approximately 95% of total passengers at SIA are passengers travelling internationally and of the approximately 1.7 million annual visitors to Jamaica, 72% use SIA as their primary airport. Peak arriving and departing capacity is 4,200 passengers per hour (MBJ Airports Limited, 2016).

Ports, Docks and Marinas

Within the SIA, the TankWeld Rio Bueno Port exists approximately 1km southwest of the project area; this port is the central logistics hub for Tank-Weld and facilitates the importation and export of break bulk building materials. Port Rhoades (bauxite export) exists just outside the SIA to the southwest.

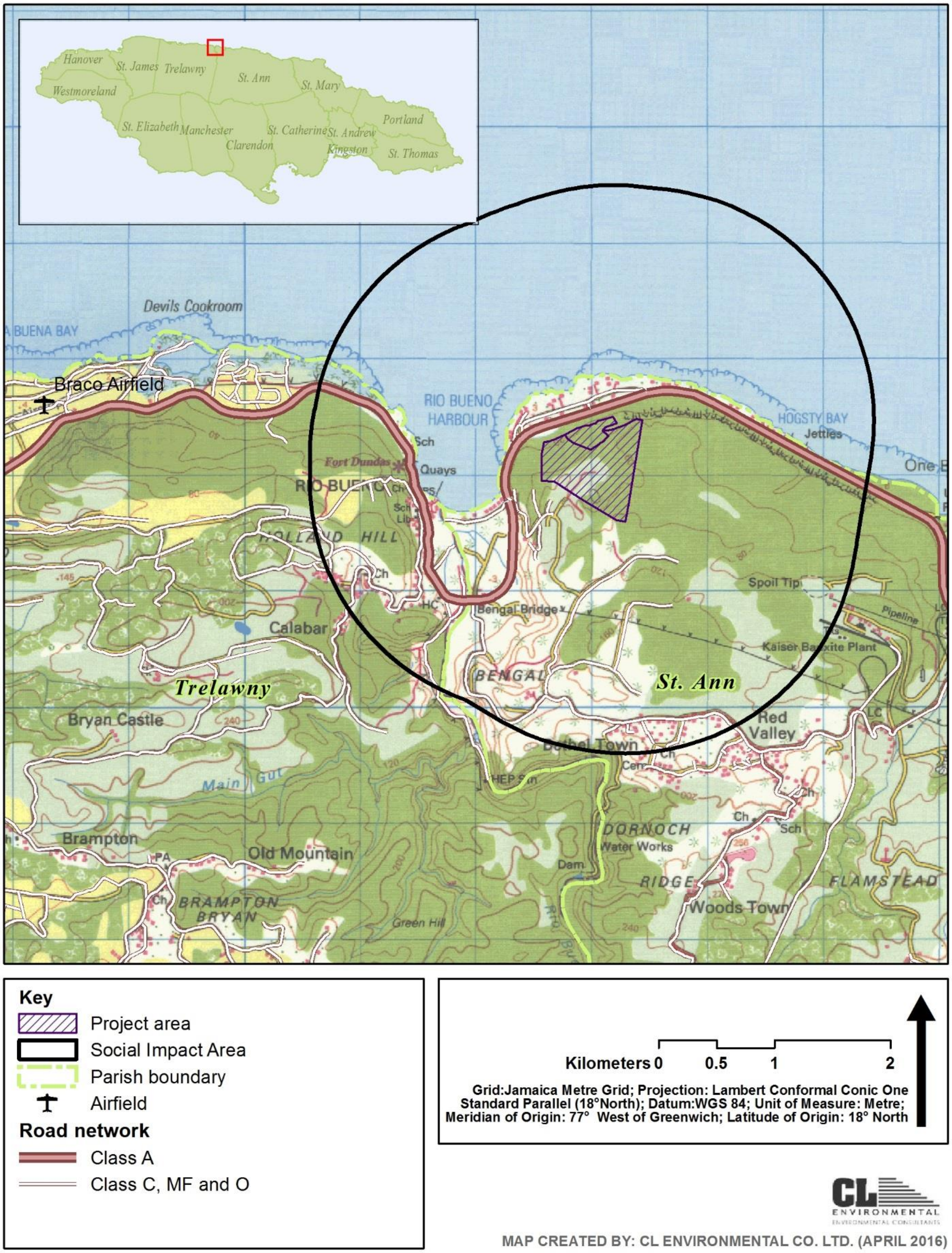


Figure 4-69 Road network and infrastructure located in the SIA

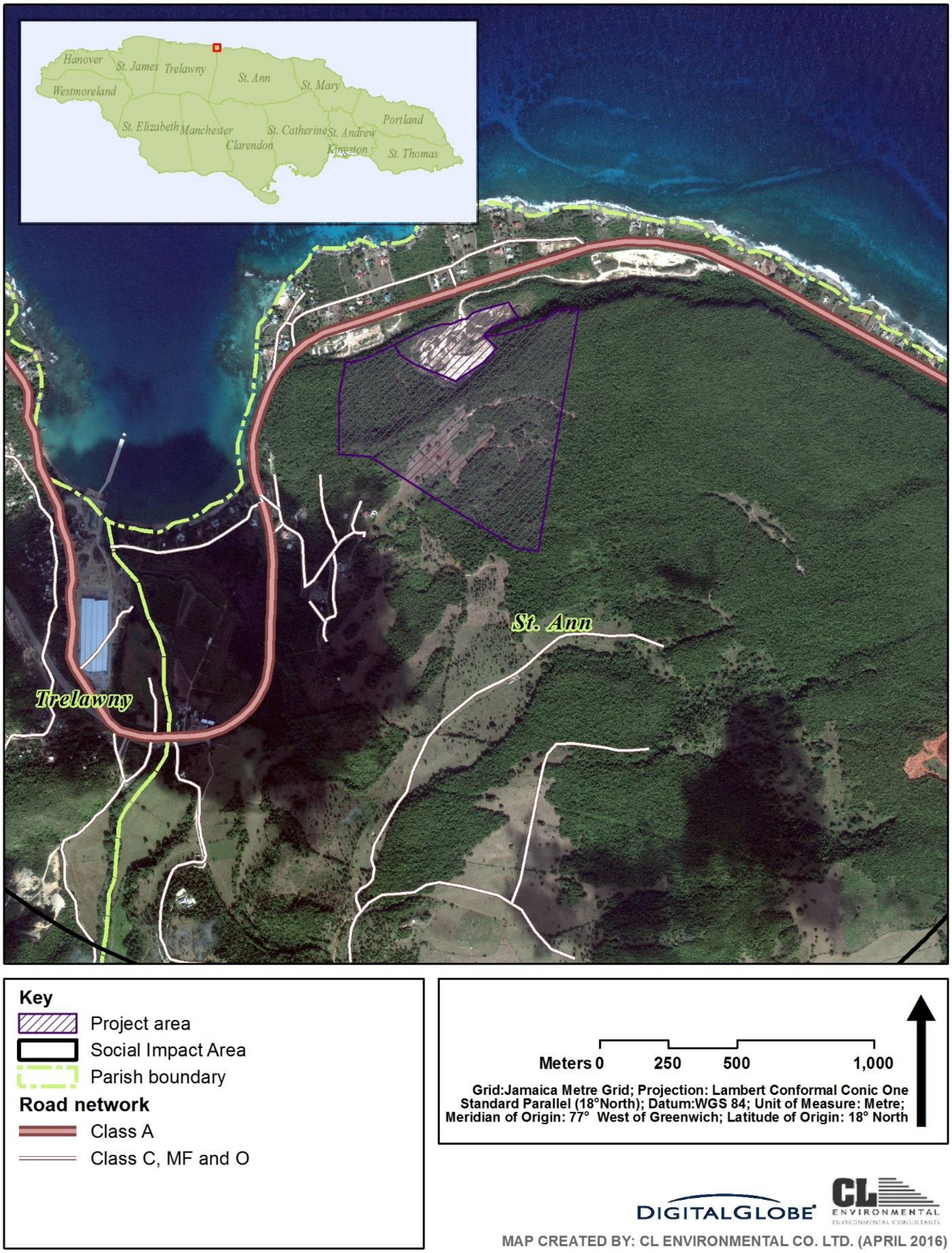


Figure 4-70 Road access to proposed site

4.3.1.7 Social and Emergency Services

Telecommunication

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

Post Offices

As seen in Figure 4-71, post offices are not found within the demarcated SIA; that found in Discovery Bay is the closest to the proposed development area (~ 4.5 km east southeast).

Health Centres

One health centre exists within the SIA (Rio Bueno Health Centre) and is situated approximately 1.4 km southwest of the development area (Figure 4-71). This health centre, along with others situated in the parish of Trelawny and depicted in Figure 4-71 fall under the responsibility of the Western Regional Health Authority (WRHA). Those situated in St. Ann however belong to the North East Regional Health Authority (NERHA). Rio Bueno Health Centre is a Type I facility; these health centre types are the smallest units that provide services and are closely integrated to the community. They are staffed by one midwife and a community health aide who deliver basic maternal and child health, nutrition, family planning and immunization services (Western Regional Health Authority). The population served is not more than 4,000 (Southern Regional Health Authority, a).

Hospitals

There are currently no public or private hospitals within the SIA. Falmouth Public General Hospital is situated 23 km west of the project area in Falmouth, Trelawny. It is a Type C, public, basic district hospital interfacing with the Primary Health Care system at parish level. Inpatient and outpatient services are provided in general medicine, surgery, child and maternity care. Basic X-ray and Laboratory services are usually available to serve hospital patients as well as those from Primary Health Care and the local private sector. Many of these hospitals also provide the services of a specialist surgeon to ensure the availability of emergency surgical services. A Type B hospital, namely St Ann's Bay Regional Hospital is found 24 km east. Type B hospitals provide inpatient and outpatient services in at least the five basic specialties – general surgery, general medicine, obstetrics and gynaecology, paediatrics and anaesthetics. X-ray and Laboratory services are usually available to serve hospital patients as well as those from Primary Health Care and the local private sector (Southern Regional Health Authority, b).

Fire Stations

Brown's Town Fire Station is the closest fire station to the proposed project site (approximately 11 km southeast) and is located outside the SIA (Figure 6 96).

Police Stations

One police station exists within the 2 km SIA, namely Rio Bueno Police Station situated 1 km west of the project site.

Data source: Mona GeoInformatics Institute

Figure 4-71 Health and emergency services located in and around the SIA

4.3.2 Land Use and Zoning

4.3.2.1 Land Cover/ Use

Historic Land Use

HISTORY OF BENGAL AREA

The first known inhabitants of the area are the Taino. The Taino middens were discovered at Bengal in 1961 by Captain Charles Sylvester Cotter and excavated 1962-1964 by Fr. Francis Osborne SJ OD. The site of the Taino settlement was surveyed in 1962 by Dr. James William Lee in conjunction with Osborne; they found that it covered two acres. The excavation uncovered a large griddle 0.9m (3 ft) in diameter, and other pottery, as well as turtle shell from the marine green turtle, and bones from the Indian coney, freshwater turtles and marine fish (including pelagic species). Charcoal remains were radiocarbon-dated by Prof. José Maria Cruxent to AD 1100 ± 100, that is, between 1160-1300 AD (Espeut forthcoming).

In 1494 Christopher Columbus in search of fresh water sailed into Discovery Bay (Dry Harbour) but found none. He proceeded to the west to the next horse -shoe shaped harbour where he discovered a fine river which he named Rio Bueno. After subduing the Taino with a few rounds of shots and a ferocious dog Columbus landed and claimed the land for God and the Queen of Spain (Morris 1995: 173). The British captured the island from the Spanish in 1655 and by 1683 the area was in cotton and provisions. The estate changed hands many times during the centuries (Table 4-34).

Table 4-34 Historic property owners

Year	Owner	No. of Enslaved Persons	No. of stock	Acres	Source
1683	Jening		-		Humphrey and Knollis map
1730-1739	Captain Fleming			-	Patrick Browne's Map
1763	Heming and Sinclair			-	Craskell and Simpson map
1804	Hon. Fullerton			-	1804 Map Robertson
1810	William Baker Utten	161	65	-	Jamaica Almanack
1817	Heirs of William Baker Utten	201	102	-	Jamaica Almanack
1831	Heirs of William Baker Utten	107	34	-	Jamaica Almanack
1844	Scharschmidt	-	-	1,582	Jamaica Almanack
1882	Utten Thomas Todd	-	-	1,582	Return of Properties
1887	Alexander Hopwood				

PROJECT AREA

In 1683 the area that became Rio Bueno and Bengal Estate was recorded as cotton and provision plantation (Plate 4-23). By 1739 a tavern existed on the property (Plate 4-24). By 1804 Bengal was a sugar estate possessing a water mill (Plate 4-25). In 1880 the number of acres in canes was 120; 1440 acres were in grass, woodland pimento. The process of manufacture was water. In 1882 of the 1,582 acres, 120 acres had sugar cane, 22 acres in ground provisions, 114 acres in Guinea grass and 254 acres in common pasture. In 1898 canes in cultivation covered 1130 acres with 1619 acres in grass, woodland and ruinate. By 1912 the estate had stopped producing sugar and had gone into cattle and bananas. In 1918, 849 acres were in grass and common and other acreage covered 900.

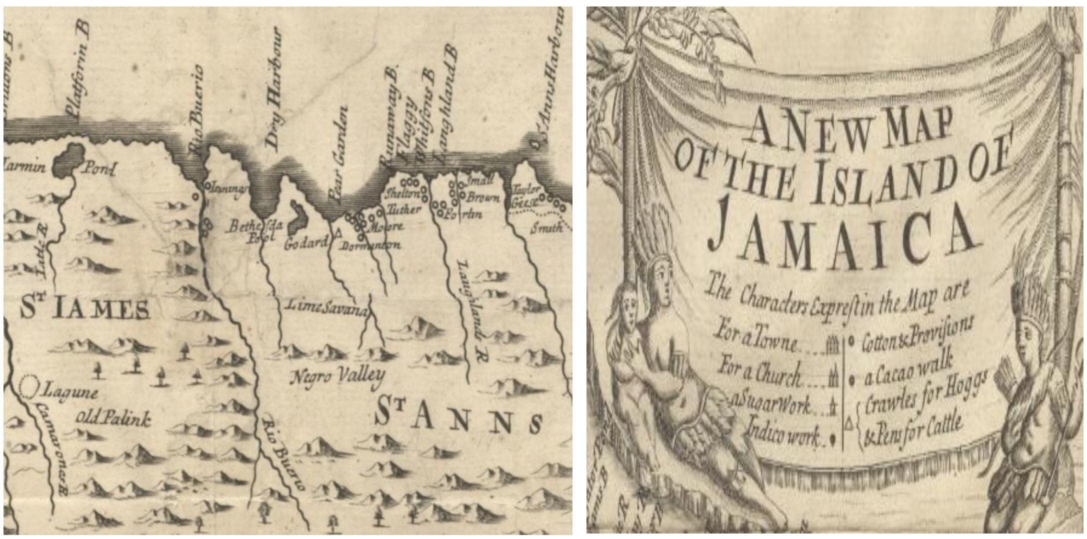


Plate 4-23 Extract from Sloane 1723 *A New Map of the Island of Jamaica* showing cotton and provision plantation at Bengal Estate

Plate 4-24 Extract of Patrick Browne map ,1739, showing tavern

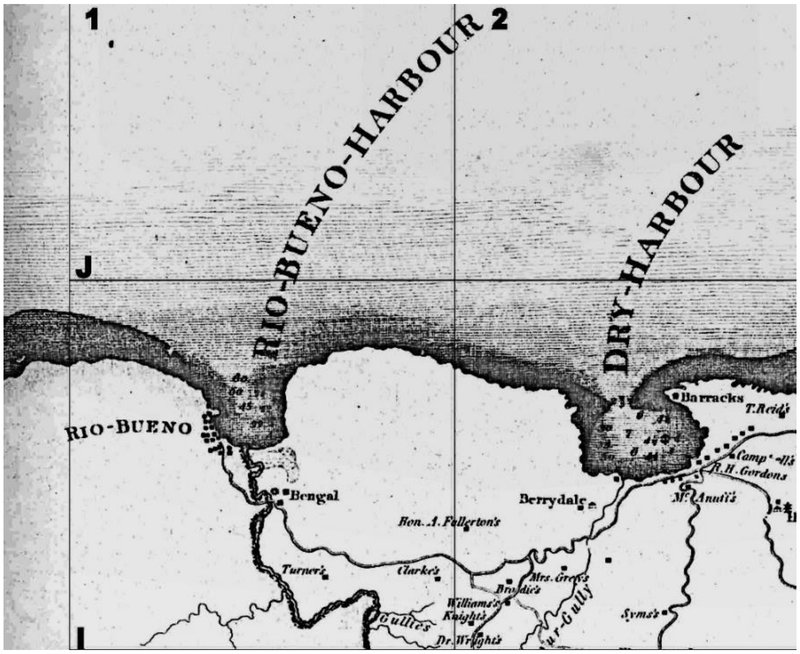


Plate 4-25 Extract from Robertson's 1804 map showing the sugar works at Bengal

In 1912 the 1,749 acre property owned by Alexander Hopwood was valued at £3, 500. By 1930 the value had increased to £7000 and by 1938 the acreage had increased to 2,336 but was still valued at £7000. Thomas Harrison's 1882 map and an undated plan noted the location of a fort at the north western edge of the property (Plate 4-26). From 2001-2008, the project property was used for quarrying and mining operations by Jose Cartellone Civiles S.A. This property yielded material that was used for the construction of The Queens Highway leg of the North Coast Highway from Montego Bay to St. Ann's Bay.

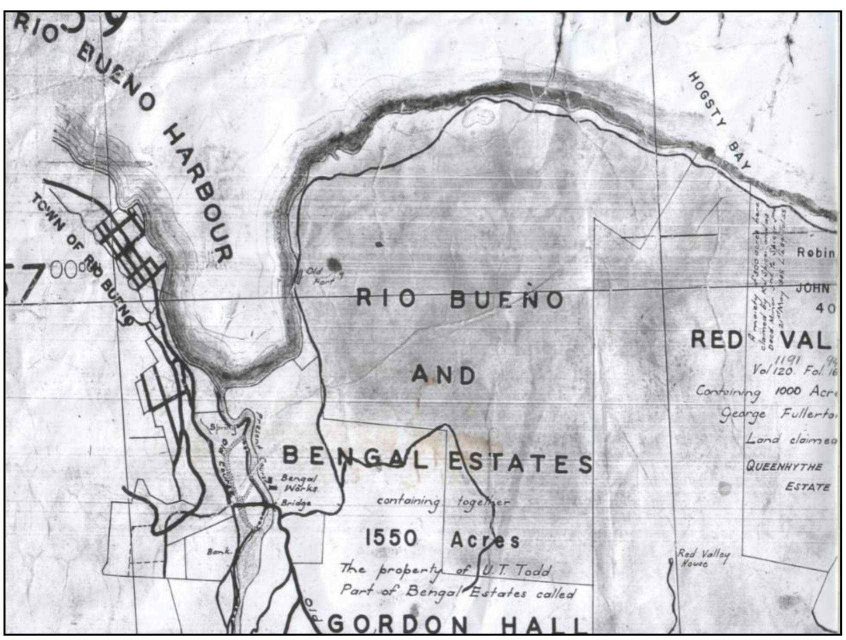


Plate 4-26 Extract of Thomas Harrison's 1882 updated 1957 map of St. Ann showing Old Fort

Present Land Use

PROJECT SITE

The project property is currently in an unused state and vegetation has overgrown most sections of the old quarry (Plate 4-27 and Plate 4-28). People also use the property located closer to the main road, as a dumping ground. Items such as old tyres, plastic bottles, food containers, paint cans and other commercial refuse were observed on property (See Section 4.1.8).

Plate 4-27 Photo of present-day quarry (taken January 21, 2016)

Plate 4-28 Photo of present-day quarry (taken January 21, 2016)

Other evidence of human activity and occupation in the proposed project area involves the type of refuse left behind such as shoes, remnant of plastic, ceramic and glass bottle, zinc, tarpaulin and rope (Plate 4-29). Numerous spent shells were also observed littering some sections of the property (Plate 4-30). This suggests that the site is being used for bird hunting. Evidence of cattle rearing was evidenced by dung scattered in the southern sector of the site (Plate 4-31).

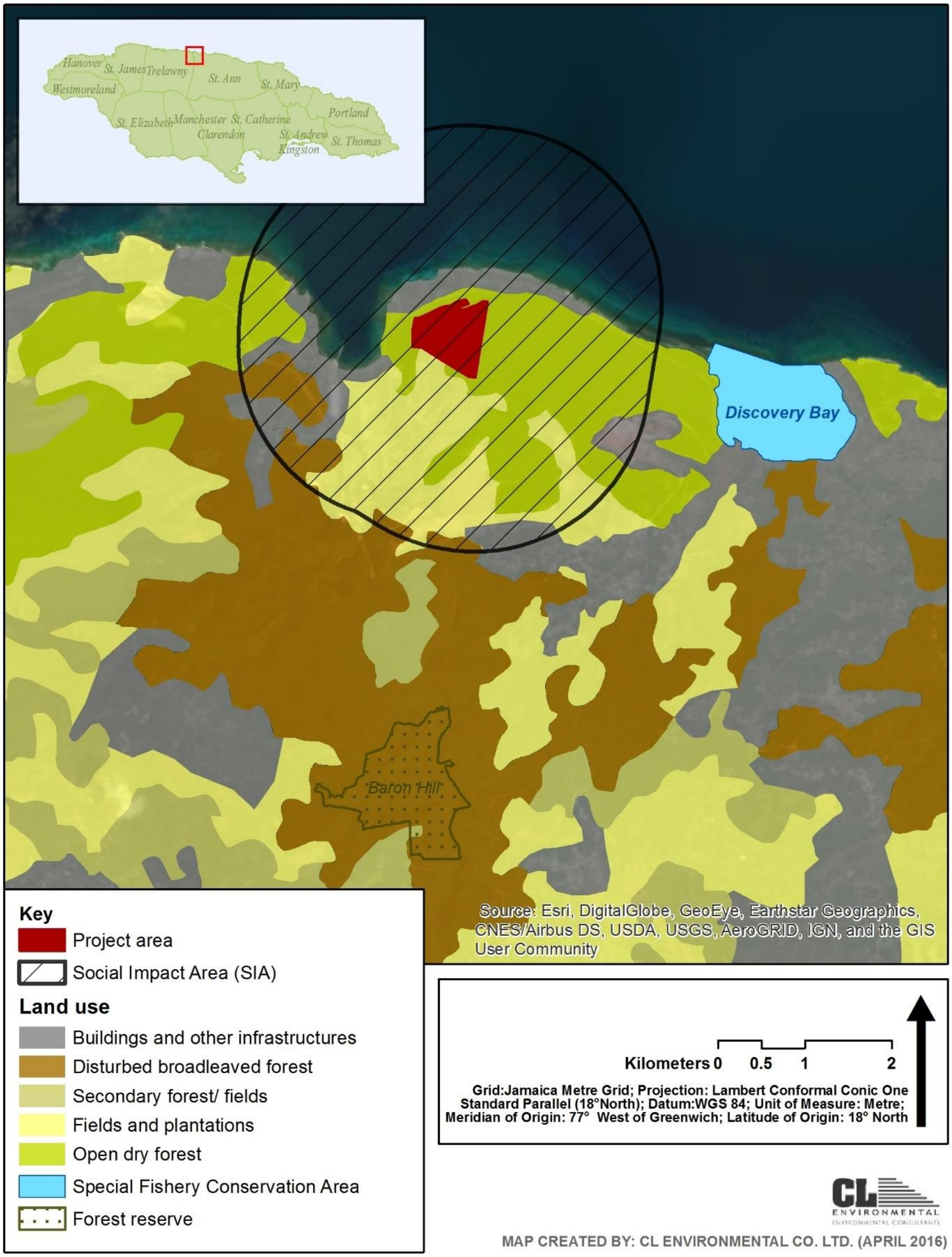
Plate 4-29 Photos showing evidence of human activity and occupation on project property

Plate 4-30 One of many spent shotgun shells showing evidence of bird hunting

Plate 4-31 Cow dung on property indicating cattle rearing

SIA AND ENVIRONS

As seen in Figure 4-72, existing land use within the surrounding SIA is mixed and includes open dry forest, disturbed broadleaf forest, fields and plantation, and buildings and infrastructure. Buildings and infrastructure north of the project site and along the coastline, as well as west of the project site in Rio Bueno are primarily residential, commercial and tourist accommodations. Discovery Bay, located approximately 3 km east of the project site, is a larger residential area in the parish of St. Ann; residential subdivisions in the area have been developed over the years, however squatting still occurs along the St. Ann coast.



Data source: Forestry Department (1998) land use data updated using satellite imagery shown in map

Figure 4-72 Land use and protected areas within the SIA

Given that the coastline of St. Ann is home to the second largest resort area in the island, namely Ocho Rios, the urban economy along St. Ann's coast is largely centred around tourism. Runaway Bay, St. Ann's Bay and Discovery Bay are the most outstanding tourism centres outside of Ocho Rios. Within that closest to the project site, Discovery Bay, numerous attractions such as Puerto Seco Beach, Green Grotto Caves and Columbus Park exist. Although the defined SIA is not considered a major tourist destination, bathing beaches at Rio Bueno and Braco, located to the west of the project site exist and are used for recreational purposes by Jamaican and visitors alike.

Agriculture, mining and quarrying play an important in the rural economy in St. Ann. Sugar cane. coconut and pimento were dominant crops; however, diversification has introduced more variety in recent years. Fishing is also an important sector of the economy; the Rio Bueno fishing beach is found closest to the site. Industrial activities are centred around the mining of Bauxite, the export of which occurs from Port Rhoades in Discovery Bay. Within the SIA, the TankWeld Rio Bueno Port exists; it acts as the central logistics hub for Tank-Weld and facilitates the importation and export of break bulk building materials.

4.3.2.2 Protected Areas

An overview of protected areas in proximity of the study area may be seen in Figure 4-72. Although not located within the SIA, the Discovery Bay SFCA to the east, and Baron Hill Forest Reserve to the south are within 5 km of the project site.

4.3.2.3 Zoning

The Town and Country Planning (St. Ann Parish) Provisional Development Order 1998 (Confirmed January 2000) is relative to this study (see Section 2.2.1.1). As seen in Figure 4-73, the project area falls within an area classified as "Undeveloped Coast" that stretches from Bengal Bridge to Discovery Bay. These undeveloped coastal areas in St. Ann consist mainly of agricultural lands and large deciduous forest stands and shrub covered areas. The objective of the policies is to protect the existing natural character of the undeveloped coastline including coastal rock formations, wetlands, flora and fauna, caves, etc. as much as possible. Specific to the project location, policies UC4 and UC5 apply:

- Policy UC 4 Only those forms of development which will not result in any significant alteration to the existing topography or any reduction in significant stands of vegetation will be permitted.
- Policy UC 5 No development will be allowed in these wooded areas which would adversely affect the homogeneity or integrity of these areas.

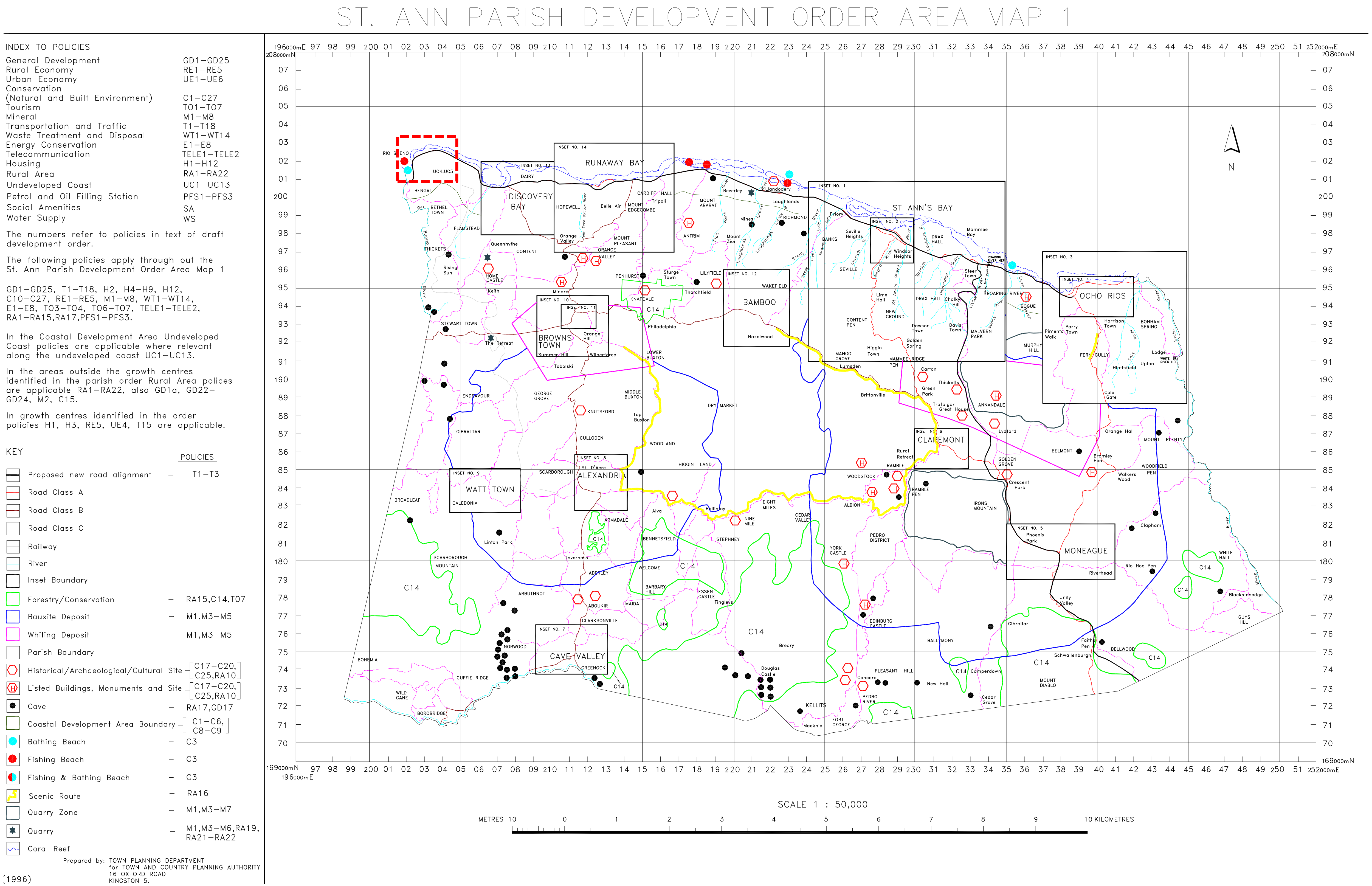


Figure 4-73 St. Ann Development Order area map (approximate project area shown by red dotted box)

4.3.3 Heritage and Culture

4.3.3.1 Methodology

The research objectives of the assessment were to ascertain the presence of historical and archaeological resources and describe the status of these resources, along with any other socio-economic attributes and appraise their worth in context of the proposed development, legislative and regulatory considerations. In addition, identification and prediction of any potential positive, negative, reversible, irreversible, short and long term impact and indication of possible mitigation to negative impacts will be conducted. Recommendations to enhance positive impacts and outlining of possible alternatives to the project and/or aspects of it will be determined. Where necessary, indication of suitable management and monitoring plan for the earth breaking stage of the project will be outlined.

The survey techniques employed in this project were dictated by the nature of the topography, vegetation cover, accessibility and time allowed for the survey. It is believed that these techniques will provide the best possible coverage and accuracy of the results. The background information on the site was derived from primary documentary sources supported by secondary narratives.

4.3.3.2 Findings

Historically, the area contains historic and archaeological sites dating back to Jamaica's first known inhabitants (The Taíno) and later those who came; the Africans and the British. The area has seen various land uses over the past centuries. Sugar production and cotton and cattle rearing were the main activities in the area during pre- and post- emancipation periods. Between the years 2001 and 2008 a limestone quarry was in operation on the northern section of the property.

Currently the section slated for quarrying and mining is in ruinate. Large deposits of limestone are present. No pre-historical material or feature was observed in the area designated for the quarry. In terms of historical and cultural material, the base of a green glass bottle was recovered. Based on the archaeological evidence available at this time, the value of the artefact assemblages observed are not significant to the point that will hamper the proposed operations in the area. The JNHT has no objection against the proposed development; however, monitoring must be conducted during the clearing stage of the site.

A detailed Archaeological Impact Assessment will be submitted as a standalone document.

5.0 PUBLIC PARTICIPATION

5.1 PURPOSE

The National Environment and Planning Agency (NEPA) recognizes the critical role played by the public, including civil society, community-based and non-governmental organizations (CBO's and NGO's). The process of public sensitization is designed to enhance the awareness of stakeholders and/or the general public in an open sphere. This helps to ensure that persons who are likely to be impacted are knowledgeable and therefore able to implement precautionary measures to safeguard their interest. It also seeks to facilitate stakeholder participation in the monitoring and enforcement of the conditions under which approvals are being granted.

5.2 COMMUNITY SURVEY

A community survey was conducted on February 17, 2016 to determine the general perception of the residents to the proposed project. The survey was conducted in the residential area directly to the north of the site, as far east as Golden Sunrise to as far west as Bengal Beach. The community perception questionnaire can be seen in Appendix 9.

A total of twenty respondents took part in the survey, 14 (72%) of which were female. The majority (16 or 83%) of the respondents were in the 36-50 year age range, with 2 (9%) being between 18-35 years and >65 years respectively. The following section outlines the major findings by community.

5.2.1 Golden Sunrise

With respect to the area to the east of the proposed site generally referred to as Golden Sunrise many of the homes are abandoned and some properties were on sale at the time of the survey. Only two properties had occupants that were available to be interviewed. One respondent had been living in the area for 6 years and did not live in the area when the previous quarry was in operation. As such this respondent had no knowledge of any environmental impacts from that operation.

The proposed project was briefly described to the respondent whose attitude was neither negative or positive regarding the proposed development, that is non-committal. However, they did indicate that noise and dust could be a concern. In conclusion, this respondent had no objection to the project if these potential impacts (dust and noise) were mitigated. The other respondent from the area had a similar response.

5.2.2 Bengal Beach

The persons interviewed from the area to the west of the site were businesses and the respondents were employees of Bengal Beach and Coconut Lounge. None of the respondents lived in the area or were aware of the previous quarry operation. Once they were provided with a brief description of the proposed project both were neutral about the prospect of such an operation in the area. In the case of one respondent there was a concern about the potential health risk associated with dust that could be generated from the proposed project.

5.2.3 Bengal Community/Queens Drive/Bengal Estate

The majority (14 or 72%) of the persons interviewed lived in the Bengal Community, which is directly opposite to the proposed project site. Many were new owners as only 5 (25%) were living in the area at the time of operation of the previous quarry. Inquiries showed that some of the owners that lived in the area when the previous quarry was in operation had died or returned to their homes overseas.

The respondents who were living in the community at the time of the previous operation were very opposed to any quarry operation in the area. These owners had damage to their property – mainly cracks in their home. When told of the proposed project the response was negative and concerns were voiced regarding noise particularly at night. Additionally, concerns were expressed about blasting and in this regard, there was a great degree of cynicism expressed on any proposed mitigation measures or oversight by environmental agencies.

Of the remaining respondents – 10 (50%) were neutral about the proposed project, 7 (33%) were open and 3 (17%) was positive. In most cases there was a NIMBY response.

With respect to specific environmental or health issues all the respondents were concerned about the dust and noise nuisance and the potential health risks. In addition, there was a concern about vibrations and possible damage to their property. One respondent had a bad experience with blasting in the United States and was sceptical about any proposed mitigation measures.

All of the respondents expressed a willingness to attend a public consultation on the proposed project.

5.2.4 Summary

Table 5-1 and Table 5-2 summarises the response to the project.

Table 5-1 Attitudes of survey respondents towards proposed project

Positive	Negative	Neutral	Open	Indifference
2 (10%)	2 (10%)	9 (45%)	4 (20%)	3 (15%)

Table 5-2 Environmental and health concerns expressed by survey respondents

Dust	Noise	Vibration
16 (81%)	13 (64%)	7 (36%)

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

Impact matrices for the Site preparation and operational phases were created utilising the following criteria taken from Ogola (2007):

- **Direction of Impact:** This describes the nature of the potential impact; positive, negative or no impact of a particular activity on a receptor.
- **Magnitude of Impact:** This is defined by the severity of each potential impact and indicates whether the impact is irreversible or, reversible and the estimated potential rate of recovery. The magnitude of an impact cannot be considered high if a major adverse impact can be mitigated.
- **Extent of Impact:** The spatial extent or the zone of influence of the impact should always be determined. An impact can be site-specific or limited to the Project Site; a locally occurring impact within the locality of the proposed project; a regional impact that may extend beyond the local area and a national impact affecting resources on a national scale and sometimes trans-boundary impacts, which might be international.
- **Duration of Impact:** Environmental impacts have a temporal dimension and needs to be considered in impact assessments. Impacts arising at different phases of the project cycle may need to be considered.
- **Significance of the Impact:** This refers to the value or amount of the impact. Once an impact has been predicted, its significance must be evaluated using an appropriate choice of criteria. The most important forms of criterion are:
    - Specific legal requirements e.g. national laws, standards, international agreements and conventions, relevant policies etc.
    - Public views and complaints
    - Threat to sensitive ecosystems and resources e.g. can lead to extinction of species and depletion of resources, which can result in conflicts.
    - Geographical extent of the impact e.g. has trans- boundary implications.
    - Cost of mitigation
    - Duration (time period over which they will occur)
    - Likelihood or probability of occurrence (very likely, unlikely, etc.)
    - Reversibility of impact (natural recovery or aided by human intervention)
    - Number (and characteristics) of people likely to be affected and their locations
    - Cumulative impacts e.g. adding more impacts to existing ones.
    - Uncertainty in prediction due to lack of accurate data or complex systems. A precautionary principle is advocated in this scenario.

In addition to the criteria listed previously for identifying potential impacts, those were supplemented by:

- The Consultants' experience,
- Documented impacts from similar projects,
- The data collected,
- Analysis of the processes in the proposed project,
- Information generated from models,
- Concerns raised from stakeholders; and
- Discussions held among the Study team.

Table 6-1 Impact assessment criteria for potential environmental impacts

SCORE	0	1	2	3
CRITERIA	Negligible	Minor	Moderate	Significant
DURATION	None	Physical impacts lasting less than a few months before recovery occurs. Impact does not persist after the activity ends.	Physical impacts lasting from a few months to two years before signs of recovery. It is not inter-generational.	Physical impact is persistent after 2 years. Impacts on a biological population over a number of recruitment cycles or generations of the population.
MAGNITUDE	No measurable change in availability of resources or function of systems. No measurable effect on people.	Changes in form and/or ecosystem function and/or a resource. The system maintains the ability to support ecosystem/ resource functions with only minor changes in community value and no overall loss/gain. Only a small fraction of the local community is affected.	Changes in form and/or ecosystem function and/or a resource. The system's ability to support ecosystem/ resource functions and economic benefit is affected but not lost. Only a moderate fraction of the local community is affected.	Changes in form and/or ecosystem function and/or a resource. The system's ability to support ecosystem/resource functions and economic benefit is highly affected. A large fraction of the local community is affected.
EXTENT	None	Isolated effects within activity site.	Localized area close to borders or offsite dispersion pathways.	Widespread: offsite regional effects

Table 6-2 Impact matrix for site preparation phase

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG				
Biological Impacts	Invertebrates	Land Clearance	Species loss, displacement and loss of habitat. *Marpesia chiron* in particular.	X				X	3	3	1	-2.33
		General Site Prep. Activity		X				X	3	3	1	-2.33
	Amphibians and Reptiles	Land Clearance	Displacement, loss of habitat and disruption of nesting. Noise Pollution.	X				X	3	2	1	-2
		General Site Prep. Activity	Displacement, loss of habitat and disruption of nesting. Noise Pollution.	X				X	1	2	1	-1.33
	Avifauna	Land Clearance	Displacement, loss of habitat and disruption of nesting. Noise pollution	X				X	3	1	1	-1.67
		General Site Prep. Activity	Increased noise pollution – displace sensitive fauna	X				X	1	1	1	-1
	Vegetation - Dry Limestone Forest	Land Clearance	Species Loss, Habitat Destruction	X				X	3	3	1	-2.33
			Soil erosion and land slippage		X			X	3	2	1	-2
		General Site Prep. Activity	Habitat loss. Dust pollution affecting remaining plants	X				X	1	1	1	-1
			Soil erosion and land slippage		X			X	3	2	1	-2
	Vegetation - Savannah	Land Clearance	Species Loss, Habitat Destruction	X				X	3	3	1	-2.33
		General Site Prep. Activity	Habitat loss. Dust pollution affecting remaining plants	X				X	1	1	1	-1
Physical Impacts	Air Shed	Land Clearance	Increased noise and dust pollution	X				X	1	1	2	-1.33
		General Site Prep. Activity	Increased noise and dust pollution	X				X	1	1	1	-1
	Hydrology and Water Resources	Land Clearance	Soil erosion and siltation from run-off and rainfall events	X				X	1	1	2	-1.67
			Increased Turbidity from run-off and rainfall events	X				X	1	1	2	-1.67
		General Site Prep. Activity	Soil erosion and siltation from run-off and rainfall events	X				X	1	1	2	-1.67
			Increased oil from vehicle and equipment maintenance	X					1	2	2	-1.67
			Increased Turbidity from run-off from run-off and rainfall events	X				X	1	1	1	-1
Social Impacts	Existing natural and social environment	Land Clearance	Increased solid waste generation	X				X	1	2	1	-1.33
			Aesthetic appeal	X			X					
		General Site Prep. Activity	Increased solid waste generation	X				X	1	2	1	-1.33

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG				
			Increased wastewater generation	X				X	1	1	1	-1
			Interrupted Traffic flow along main road	X				X	1	1	1	-1
	Labour Force/Local Economy	Land Clearance	Increased employment	X		X			1	3	3	2.33
			Increased accidental potential of labourers	X				X	1	2	1	-1.33
			Increased noise and dust exposure of labourers	X				X	1	2	1	-1.33
		General Site Prep. Activity	Increased employment	X		X			1	3	3	2.33
			Increased accidental potential of labourers	X				X	1	2	1	-1.33
			Increased noise and dust exposure of labourers	X				X	1	2	1	-1.33
	Users and Residents	Land Clearance	Noise and dust pollution	X				X	1	1	2	-1.33
		General Site Prep. Activity	Noise and dust pollution	X				X	1	1	2	-1.33
	Heritage and Cultural artefacts	Land Clearance	Potential for destruction of artefacts present	X				X	1	1	1	-1
		General Site Prep. Activity	Potential for destruction of artefacts present	X				X	1	1	1	-1

Table 6-3 Impact matrix for operational phase

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG				
Biological Impacts	Invertebrates	Blasting and Quarrying	Disturbance and displacement	X				X	3	2	1	-2
		Transport & General Operations	Disturbance	X				X	3	1	1	-1.67
	Amphibians and Reptiles	Blasting and Quarrying	Disturbance and displacement	X				X	3	2	1	-2
		Transport & General Operations	Disturbance – vibration, noise and dust	X				X	3	1	1	-1.67
	Avifauna	Blasting and Quarrying	Disturbance – vibration, noise and dust	X				X	3	2	1	-2
		Transport & General Operations	Disturbance- vibration, noise and dust	X				X	3	1	1	-1.67
	Vegetation - Dry Limestone Forest	Blasting and Quarrying	Dust pollution	X				X	3	2	1	-2
		Transport & General Operations	Dust pollution	X				X	3	1	1	-1.67
	Vegetation - Savannah	Blasting and Quarrying	Dust pollution	X				X	3	2	1	-2
		Transport & General Operations	Dust pollution	X				X	3	1	1	-1.67
Physical Impacts	Water Column	Blasting and Quarrying	Groundwater contamination-sedimentation, pollutants from site etc.		X			X	3	3	2	-2.66

	RECEPTOR	ACTIVITY	IMPACT	DIRECT/INDIRECT		DIRECTION			DURATION	MAGNITUDE	EXTENT	SIGNIFICANCE SCORE
				DIRECT	INDIRECT	POS	NONE	NEG				
	Air Shed	Blasting and Quarrying	Noise and dust pollution	X				X	3	1	1	1.67
		Transport & General Operations	Noise and dust pollution	X				X	3	1	1	-1.67
Social Impacts	Existing natural and social environment	Blasting and Quarrying	Noise and dust pollution	X				X	3	1	1	-1.67
			Solid waste generation	X				X	3	1	1	-1.67
		Transport & General Operations	Wastewater generation	X				X	3	1	1	-1.67
			Solid waste generation	X				X	3	1	1	-1.67
			Noise and dust pollution	X				X	3	1	1	-1.67
			Traffic congestion	X				X	1	1	1	-1
	Users and Residents	Blasting and Quarrying	Noise and dust pollution	X				X	3	1	1	-1.67
			Aesthetic appeal	X			X					
			Damage to property from rockfall	X				X	3	1	1	-1.67
			Vibration	X				X	3	1	1	-1.67
		Transport & General Operations	Noise and dust pollution	X				X	3	1	1	-1.67
			Aesthetic appeal				X					
			Vibration				X					
	Local Economy/Labour Force	Blasting and Quarrying	Noise and dust exposure	X				X	3	2	1	-2
			Increased employment	X		X			3	3	3	3
			Increased accident potential	X				X	3	3	1	-2.33
		Transport & General Operations	Noise and dust exposure	X				X	3	2	1	-2
			Increased employment	X		X			3	3	3	3
			Increased accident potential	X				X	3	3	1	-2.33

6.1 SITE PREPARATION

6.1.1 Physical

6.1.1.1 Drainage and Hydrology

Rainfall events may result in run-off of suspended sediments, debris flow and land erosion. Soil erosion and siltation of watercourses could have a negative impact on the flow regime and water quality within the study area. This could lead to minor negative impacts during the construction phase such as declined water quality and water transparency. It is imperative, therefore, that proper soil/construction material management practices be implemented during site clearance and site preparation phases of the project.

Recommended Mitigation

i. Storm water pollution prevention practices include: silt fence, rock check dams, and vegetation used to control erosion from storm water run-off. The use of sediment ponds permits the settling of suspended particulate matter prior to discharge.
ii. Sedimentation and erosion control practices will be implemented on site to lessen the erosion potential of exposed soil surfaces. Additional and regular site maintenance and housekeeping procedures will also minimize erosion and the adverse impacts of storm water runoff.
iii. Within the storage areas for overburden, if deemed necessary, diversion ditches will be constructed to collect storm water run-off and direct it into sediment ponds.
iv. Storm water will be treated as necessary by means of sedimentation in settling ponds. Also, used process water will be treated by means of sedimentation in settling ponds and recirculated through the processing plant after it is treated. If necessary, pit water will be pumped to a settling pond for treatment and ultimate discharge.
v. Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.

6.1.1.2 Air Quality

Site preparation has the potential to have a two-folded direct negative impact on air quality. The first impact is air pollution generated from the construction equipment and transportation. The second is from fugitive dust from the proposed construction areas and raw materials stored on site. Fugitive dust has the potential to affect the health of construction workers, the resident population and the vegetation.

Recommended Mitigation

i. Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.
ii. Minimize cleared areas to those that are needed to be used.
iii. Cover or wet construction materials such as marl to prevent a dust nuisance.
iv. Ensure that haul roads are graded and properly maintained

v. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.
vi. Being prepared to suspend or downgrade operations if winds are high and dust plumes become unavoidable.
vii. Utilizing dust screens to minimize dust blow from quarry site to surrounding residences and roads.

6.1.1.3 Noise

Site clearance activities for the proposed quarry necessitates the use of heavy equipment to carry out the job. This equipment includes bulldozers, backhoes, excavators, graders, crushers and dumper trucks etc., additionally some blasting will be carried out. They possess the potential to have a direct negative impact on the climate. Noise directly attributable to site clearance and operational activity should not result in noise levels in the residential areas to exceed 55dBA during day time (7am – 10 pm) and 50dBA during night time (10 pm – 7 am). Where the baseline levels are above the stated levels then it should not result in an increase of the baseline levels by more than 3dBA.

Recommended Mitigation

v. Use equipment that has low noise emissions as stated by the manufacturers.
vi. Use equipment that is properly fitted with noise reduction devices such as mufflers.
vii. Operate noise-generating equipment during regular working hours (e.g. 7 am – 7 pm) to reduce the potential of creating a noise nuisance during the night.
viii. Construction workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.

6.1.1.4 Landscape and Aesthetics

Due to the topography of the area, the proposed quarry is situated behind a hill, away from view of the coastal main road. Therefore, the proposed quarry is not expected to have a negative visual impact being viewed from the coastline.

6.1.1.5 Water Supply

Three options for water supply were investigated: Supply from Rio Bueno through the Dornoch Treatment Plant; Drilling an abstraction well; and Trucking water to and storing it on site. From a cost perspective, buying and storing water worked out cheaper than investing in drilling and maintaining abstraction wells. In addition, saltwater intrusion may also be an issue with drilling of wells.

A 150,000 gallon (567811.768 litres) water storage tank would be installed on property within the crushing area. Additionally, the use of a water tank on-road truck, with an approximate capacity of 20,000 litres to control the dust in the working areas and haulage roads will be a scheduled part of the daily operations. The water tank truck may load water directly from the runoff ponds or from the large storage water tank.

6.1.1.6 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, surrounding water bodies and drainage channels which lead to water bodies.

Recommended Mitigation

iii. 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.
iv. Showers should be provided for the workers.

6.1.1.7 Solid Waste Generation

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

i. From the campsite.
ii. From site clearance activities.

Recommended Mitigation

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

6.1.1.8 Storage of Raw Material and Equipment

Any raw materials used will be stored onsite. There will be a potential for them to become airborne. Stored fuels and the repair of construction equipment has the potential to leak hydraulic fuels, oils etc. and/or small spills may occur.

Recommended Mitigation

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

xv. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage.
xvi. Minor spills will be immediately cleaned or contained, this is to ensure fuel and oils do not come in contact with storm water and other surface runoff. Inspections to identify area that require maintenance will be done to mitigate leaks and spills.
xvii. All deteriorating equipment (pipes, valves, drums etc.) will be immediately replaced. Spill prevention structures will be implemented on site, for example; curbs, grading, elevated pads, drip pans, will be installed at servicing areas.
xviii. All employees will be trained in spill prevention and response procedures. This is done to provide immediate response to spills and clean-up may commence whenever identified.

6.1.1.9 Transportation of Raw Material and Equipment

The transportation and use of heavy equipment and trucks is required during site clearance activities. Trucks will transport raw materials and heavy equipment. This has the potential to directly impact traffic flow along the Queens Highway main road.

Recommended Mitigation

vii. Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.
viii. Adequate and appropriate road signs should be erected to warn road users of the activities. For example reduced speed near the entrance to the site.
ix. Raw materials should be adequately covered within the trucks to prevent any escaping into the air and near the roadway.
x. The trucks should be parked on the proposed site until they are off loaded.
xi. Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
xii. The use of flagmen should be employed to regulate traffic flow.

6.1.2 Biological

6.1.2.1 Flora

The majority of the endemics, threatened and or rare species are located within the dry limestone forest hence the proposed quarrying and mineral processing operations will result in the loss of these species due to habitat loss. The construction of the processing plant within the disturbed northern boundary will have minimal effect on the endemic, threatened and or rare species but it will however expose the ridge and allow for more access including that of heavy machinery related to the proposed quarrying and processing activities.

Additionally, the construction of the processing plant would mean that there has been prior approval for the area to be mined which would over time result in total habitat loss within the proposed dry limestone forest sub-area. This would make the impact of the construction of the processing plant on the dry limestone forest null and void but lead to the loss of the particular sub-area. The loss of this dry and limestone forest sub-area would reduce the total area of the existing dry and limestone forest and this could possibly lead to an increase in the concentration and resultant effect of anthropogenic activities within the remaining forest. The Savanna-like south-western boundary sub-area proper vegetation is without any endemic, rare or threatened species, however the transitional area houses an endemic cactus. Any development in this area would also create access to the core dry limestone sub-area which for the purpose of quarrying which would result in the loss of the habitat and species therein. The proposed area is also bordered on the east by dry limestone forest which is in a continuous block going east along the Queens Highway towards Discovery Bay town centre. The assumption is that this adjoining dry limestone forest houses the same species found in the core dry limestone sub-area and possibly others not detected during the survey conducted of the latter. It is also assumed that the disturbed northern boundary sub-area is adjoined by a continuous disturbed boundary area that is separated from the dry limestone forest by a prominent ridge also houses similar species to that of the sub-area that falls within the proposed site.

The aesthetic value of the ridge will also be lost once the quarrying and processing starts. The intrinsic values of the species within the proposed site as well as ecosystem values will also be lost.

The impacts and possible mitigations for the development are outlined below. As with any development, the options of not to develop and the use of alternate sites should always be considered.

Habitat Destruction

Creating the pits or quarries requires the removal of virtually all-natural vegetation, topsoil and subsoil to reach the aggregate underneath leading to a significant loss in plant and interdependent animal diversity. Additionally, adjacent communities may be affected by dust generated. At the end of life for the mine, the area could become more susceptible to invasive or introduced species if left fallow as well as the potential for land slippage is amplified. There would also be a permanent change in the structure, aesthetics and composition of the flora after mining operations have ceased.

RECOMMENDED MITIGATION

i. Establish a site rehabilitation plan for the site.
ii. A buffer zone of minimal to no activity should be established surrounding the proposed area. The vegetation in this area may then become a natural seed-source to the mined-out lands after closure. If considered, seedlings may also be actively transplanted from this area as well.
iii. The staged and sequential clearing of vegetation over the life of the quarry should be contemplated.
iv. Monitoring of indirect impacts on threatened plant species surrounding the site should be considered.
v. All staff on site should be made aware of the mitigation plans to be implemented.
vi. Ensure that all endemic, rare and threatened species as best as possible will be removed to the adjoining dry limestone forest area which would act as an pseudo ex situ site. This however is very difficult because of the substrate which renders the removal of some of these species without damage and loss impossible. This action would require much patience and meticulous

removal for species rooted in the limestone substrate. The substrate would have to be removed with the species in most cases.

vii. Ensure that the remaining dry limestone forests are preserved and not mined out in the future. This would allow also the loss of habitat as well as species within the core dry limestone forest of the proposed site. The justification of this would be the assumption and that the species within the proposed site are also within the adjoining dry limestone forest and in similar healthy numbers and populations.

Increased Soil/Substrate Erosion

Quarries, particularly those on steep slopes with unstable rocks, increase landslides and other mass movements with consequent destruction of natural habitats and biodiversity. Removing the topmost soil layer and surface rock material also multiplies the vulnerability of groundwater contamination (Darwish et al., 2008).

The potential for land slippage is greatly increased as a result of vegetation removal. A plant's roots act as a mesh within the substrate increasing its cohesiveness and improving water percolation and drainage. Areas where bare ground is exposed tend to erode faster than areas inhabited by plants.

RECOMMENDED MITIGATION

i. Remove trees only as necessary.
ii. A site preparation plan should be developed prior to project initiation.
iii. Leaving or planting strips of vegetation on steep slopes may help to prevent erosion.
iv. A phased approach to mining activities is recommended.

6.1.2.2 Fauna

Invertebrate fauna

The butterfly fauna was diverse and included four endemic species and five endemic subspecies (Table 6-4). Most of the butterflies are widespread across Jamaica and have not been assigned special conservation status. Two species of butterflies require special conservation consideration, *Eurytides marcellinus* and *Marpesia chiron*.

Table 6-4 Endemic Arthropods recorded from this study site

Group	Scientific name	Common name	Status
Butterflies	*Dryas iulia delila*	Julia	Endemic subspecies
	Papilio thoas melonius	Thoas Swallowtail	Endemic subspecies
	Marpesia eleucha pellenis	The Antillean Dagger Tail; Caribbean Daggerwing	Endemic subspecies
	Achylodes mithridates mithridates	Fabricius's dusky wing	Endemic subspecies
	Ephyriades brunnea jamaicensis	The Jamaican Hairy Dusky Wing	Endemic subspecies
	Phyciodes (Antillea) proclea	The Jamaican Crescent-Spot	Endemic species
	Cyclargus dominica	The Jamaican Blue	Endemic species
	Leptotes perkinsae	Miss Perkin's Blue	Endemic species
	Eurytides marcellinus	Blue Swallowtail	Endemic species
Beetle	*Colpodes darlingtoni*	Jamaican Bromeliad Carabid	Endemic species
Damselfly	*Diceratobasis macrogaster*	Jamaican Bromeliad Damselfly	Endemic species

***Eurytides marcellinus,* is protected by Jamaican law, and listed as "Vulnerable" by the IUCN.** This species therefore requires special consideration. While there have been records of swarms of adults in the area, there is no information concerning the existence of a breeding population.

The true status of *M. chiron* is unknown, questions which need to be answered include:

a) is there a resident population?
b) if the answer to (a) is yes, then is there a breeding population in the study site?

Two other insects of interest are the Jamaican Bromeliad Carabid and the Jamaican Bromeliad Damselfly, both of which are endemic and bromeliad-dependent. Both species have wide distributions but there are significant populations at this site.

AMPHIBIANS

Seven of the ten amphibian species recorded here are endemic to Jamaica. Three species are considered endangered; *Eleutherodactylus grabha, Eleutherodactylus jamaicensis,* and *Osteopilus crucialis,* and special consideration should be given to these. All three endangered species are associated with bromeliads.

Many of the amphibians utilize bromeliads as habitats, even being obligate in some cases. The bromeliad population in this site is extensive; while an estimate of the density of plants was not conducted by this team, bromeliads form a significant part of the ground cover. This area is likely to be an important part of the geographic range of some amphibians.

REPTILES

Nineteen (19) species of reptiles were recorded, eighteen (18) of which are endemic to Jamaica, the other being introduced. One species has been considered for special conservation status, *Epicrates subflavus*, the Jamaican Boa. **This species is protected under Jamaican law and is also listed on CITES Appendix I.** While the species is fairy widely distributed the species is vulnerable and any loss of population is therefore important.

AVIFAUNA

Sixteen of the thirty endemic birds of Jamaica were recorded in the area; 7 species are forest dependent and 10 were generalists (Table 6-5). None of the species of birds recorded have been listed as requiring special conservation status, however, the area is home to many forest dependent species. Many of the species recorded are likely to occur in sites adjacent to the proposed mining area. Removal of vegetation will negatively affect the bird populations as it will result in reduction in available habitat.

Table 6-5 Endemic birds identified in the study

Scientific Name	Common Name	Habitat Type observed	DAFOR	Forest dependent
Todus todus	Jamaica Tody	*DLF;W*	*R*	No
Corvus jamaicensis	Jamaican Crow	*DLF;W*	*R*	Yes
Myiopagis cotta	Jamaican Elania	*W; DLF*	*E*	Yes
Euphonia Jamaica	Jamaican Euphonia	*DNB;S;DLF*	*A*	No

Scientific Name	Common Name	Habitat Type observed	DAFOR	Forest dependent
Saurothera vetula	Jamaican Lizard Cuckoo	*DNB;SW*	*R*	No
Anthracothorax mango	Jamaican Mango	*DLF;W*	*R*	No
Icterus leucopteryx	Jamaican Oriole	*DNB;DLF;W*	*F*	No
Contopus pallidus	Jamaican Pewee	*DLF;W*	*R*	Yes
Spindalis nigricephala	Jamaican Stripe-Headed Tanager	*DNB;DLF;W*	*O*	Yes
Vireo modestus	Jamaican Vireo	*DNB;W*	*R*	No
Melanerpes radiolatus	Jamaican Woodpecker	*DLF*	*O*	No
Euneornis campestris	Orange Quit	*DNB;DLF;W*	*R*	Yes
Trochilus polytmus	Red-billed Streamertail	*DNB;DLF;W*	*O*	No
Myiarchus barbirostris	Sad Flycatcher	*DNB;DLF;W*	*O*	Yes
Turdus aurantius	White-chinned Thrush	*W; DLF*	*R*	Yes
Loxipasser anoxanthus	Yellow-Shouldered Grassquit	*S; DNB;DLF;W*	*O*	No

S = Savanna-like Area; DNB = Disturbed Northern Boundary sub area; W = Woodland; DLF = Dry Limestone Forest

Recommended Mitigation

i. A study should be carried out to ascertain the status of *Marpesia chiron*:
   (a) Is there a resident population?
   (b) If the answer to (a) is yes, then is there a breeding population in the study site?
ii. A study should be conducted to determine if the area is a breeding site of the Blue Swallowtail Butterfly. This study should be carried out at the next swarming (likely after the rains of April-May) when breeding is taking place.
iii. The Jamaican Boa or Coney must be relocated if encountered. However, it will be difficult since both species are very secretive in nature and they are also nocturnal.
iv. Attempts should be made to rehabilitate the soil of the Disturbed Northern boundary sub area mine, followed by replanting of vegetation. This could be done for the floor regions but might not be possible for the almost vertical walls; these vertical areas will be recolonized naturally over time. The high diversity of animals in the present abandoned mine is an indication that these areas have the potential to return to being sites of high biodiversity.

6.1.3 Human/ Social/ Cultural

6.1.3.1 Employment

There is the potential for increased employment during the site clearance phase. It is anticipated that approximately 18 persons will be employed directly for site preparation (e.g. excavator operator, bushing etc.), It is anticipated that some labourers will be from sourced from nearby communities.

Recommended Mitigation

No mitigation available.

6.1.3.2 Health and Safety Concerns

Public Health Issues

Fugitive dust has the potential to affect the health of the resident population.

RECOMMENDED MITIGATION

Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.

Occupational Health and Safety

Workers will be exposed to high noise and dust levels during site preparation activities. The potential for accidents on any construction site is high given the use of heavy equipment and machinery.

RECOMMENDED MITIGATION

Construction workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.

Adequate communication with workers and signage should be put in place to alert/inform workers of potential dangers. Personal Protective Equipment (Hard hat, steel-toe shoes, reflective vests, safety glasses etc.) should be worn by all workers. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.

6.1.3.3 Heritage

The proposed project area has very dense vegetation cover in some areas. When this vegetation is removed from the proposed site, there is a probability of finding prehistoric and historic cultural material. However, there is the possibility that they may be destroyed by heavy machinery and equipment during the site clearance process.

RECOMMENDED MITIGATION

Care should be taken during land clearance and the site preparation stages so that any historical artefacts observed can be recovered by the JNHT.

6.2 OPERATION

6.2.1 Physical

6.2.1.1 Air Quality

The main potential direct impact from the proposed quarry operations as it relates to air quality is dust emissions. Fugitive dust has the potential to affect the health of workers, the resident population and the vegetation.

Air Quality Consultants Limited (AQC) was contracted to undertake an air dispersion modelling exercise to determine the impact of criteria air pollutants on ambient air quality from the operations of proposed Bengal Quarry. A determination was also made whether a significant air quality impact will be created based on the incremental contribution of the proposed quarry to the cumulative air quality impact.

According to the Natural Resources Conservation Authority (Air Quality) Regulations, 2006, a "significant air quality impact", means:

(a) the increment in the predicted average concentration of sulphur dioxide (SO_2), total suspended particulates (TSP), particulate matter less than ten microns (PM_{10}) or nitrogen dioxide (NO_2) is greater than an annual average of 21 $\mu g/m^3$ or a 24-hour average concentration of 80 $\mu g/m^3$.

Assessment Methodology

The assessment methodology for the air dispersion modeling exercise follows the guidance specified in the Natural Resources Conservation Authority (NRCA) Ambient Air Quality Guideline Document of 2006.

The detailed model recommended in the Ambient Air Quality Guideline Document is AERMOD. The model of selection was the commercially available AERMOD View air dispersion model (version 9.1) that is developed by Lakes Environmental, and is based on modifications as recommended by the United States Environmental Protection Agency (USEPA) that was released in May 2014. This model is used extensively to assess pollution concentration and deposition from a wide variety of sources. AERMOD View is a true, native Microsoft Windows application and runs in Windows applications. The AMS/EPA Regulatory Model (AERMOD) was specially designed to support the EPA's regulatory modeling programs. AERMOD is a regulatory steady-state plume modeling system with three separate components: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD Terrain Preprocessor), and AERMET (AERMOD Meteorological Preprocessor). The AERMOD model includes a wide range of options for modeling air quality impacts of pollution sources, making it a popular choice among the modeling community for a variety of applications. Some of the modeling capabilities of AERMOD include the following:

- The model may be used to analyze primary pollutants and continuous releases of toxic and hazardous waste pollutants.
- Source emission rates can be treated as constant or may be varied by month, season, hour-of-day, or other optional periods of variation. These variable emission rate factors may be specified for a single source or for a group of sources. For this project all emission rates were treated as constant.
- The model can account for the effects of aerodynamic downwash due to buildings that are nearby point source emissions.
- Receptor locations can be specified as gridded and/or discrete receptors in a Cartesian or polar coordinate system.
- For applications involving elevated terrain, the U.S. EPA AERMAP terrain preprocessing program is incorporated into the model to generate hill height scales as well as terrain elevations for all receptor locations.
- The model contains algorithms for modeling the effects of settling and removal (through dry and wet deposition) of large particulates and for modeling the effects of precipitation scavenging for gases or particulates.

- AERMOD requires two types of meteorological data files, a file containing surface scalar parameters and a file containing vertical profiles. These two files are provided by the U.S. EPA AERMET meteorological preprocessor programme.

SOURCE EMISSIONS

A critical step for conducting the air dispersion modelling is to quantify the emissions from the air pollutant sources at the proposed quarry (Figure 6-1). The emission rates for the sources identified were derived from the use of USEPA AP42 emission factors and project data and these are displayed in Table 6-6 with calculations displayed in Table 6-7.

Source information data for the other nearby air pollutant sources are shown in Table 6-8. Emission rates and stack parameters for the nearby air pollutant sources at the Noranda Jamaica Bauxite Partners were obtained from a Stack Emission Testing Report for dated December 2014 (for the powerhouse and boiler stacks) and using USEPA AP42 emission factors for the dryers.

Table 6-6 Source Information Data for Bengal Quarry

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Release Height, m	Length of Side, m	Vertical Dimension, m	Length of Y Side, m	TSP Emission (g/s)	PM_{10} Emission (g/s)
HAUL	LINE VOLUME	Processing Plant Road with loaded trucks	241768.9	2044644.8	13.3	8.5				0.168	0.0479
HAULE	LINE VOLUME	Processing Plant Road with empty trucks	241768.9	2044644.8	13.3	8.5				0.126	0.0359
HAUL1	LINE VOLUME	Haul Road 1 with loaded trucks	241532.2	2044412.9	26.0	8.5				0.353	0.1
HAUL1E	LINE VOLUME	Haul Road 1 with empty trucks	241532.2	2044412.9	26.0	8.5				0.265	0.0753
HAUL2	LINE VOLUME	Haul Road 2 with loaded trucks	242068.4	2043857.4	81.3	8.5				0.32	0.091
HAUL2E	LINE VOLUME	Haul Road 2 with empty trucks	242068.4	2043857.4	81.3	8.5				0.24	0.0683
LOAD1	VOLUME	Loading trucks at Quarry	241505.0	2044348.0	30.3	10	20	10		0.36	0.17
UNLOAD1	VOLUME	Unloading at Storage Pile	241822.0	2044195.0	53.6	10	20	10		0.36	0.17
LOAD2	VOLUME	Loading trucks at Quarry	242118.0	2043832.0	85.5	10	20	10		0.36	0.17
UNLOAD2	VOLUME	Unloading at Storage Pile	242000.0	2044176.0	55.0	10	20	10		0.36	0.17
LSP	AREA	Limestone Storage Pile	241865.7	2044266.8	55.8	18	101		149	0.2207	0.2207
CRUSH	VOLUME	Processing Plant	241928.0	2044534.0	27.0	5	130	5		0.125	0.0465

Table 6-7 Emissions Calculations for Bengal Quarry

Proposed Bengal Quarry Emission Estimates

Emission Estimates for Haul Roads and Loading Operations

Emission Factor Summary	Source ID#	PM_{10}				PM			
		PM_{10} EF	lb/yr	Tpy	g/s	PM EF	lb/yr	Tpy	g/s
Road Emissions (Loaded)	HAUL	3.92 lb/VMT	1,823	0.83	0.05	13.78 lb/VMT	6,412	2.91	0.17
Road Emissions (Empty)	HAULE	2.94 lb/VMT	1,368	0.62	0.04	10.34 lb/VMT	4,812	2.18	0.13
Road Emissions (Loaded)	HAUL1	3.92 lb/VMT	3,823	1.73	0.10	13.78 lb/VMT	13,445	6.10	0.35
Road Emissions (Empty)	HAUL1E	2.94 lb/VMT	2,869	1.30	0.08	10.34 lb/VMT	10,089	4.58	0.26
Road Emissions (Loaded)	HAUL2	3.92 lb/VMT	3,467	1.57	0.09	13.78 lb/VMT	12,191	5.53	0.32
Road Emissions (Empty)	HAUL2E	2.94 lb/VMT	2,601	1.18	0.07	10.34 lb/VMT	9,148	4.15	0.24
Loading trucks at Quarry	LQ	1.478E-02 lb/ton	13,004.7	5.90	0.34	3.125E-02 lb/ton	27,495.7	12.47	0.72
Unloading at Storage Pile	USP	1.478E-02 lb/ton	13,004.7	5.90	0.34	3.125E-02 lb/ton	27,495.7	12.47	0.72
Total			41,962	19	1.10		111,090	50	2.92

Emission Factor Equation and Data for Road Emissions, November 2006 AP-42

$E\ (lb/VMT) = k * (s/12)^a * (w/3)^b$

Where:

s = silt content, % (may be measured by % that passes through 200 mesh screen)
w = Weight of transport truck, loaded or unloaded, tons
k=1.5, a=0.9, b=and 0.45 are constants from EPA AP-42 Table 13.2.2-2 for PM_{10} emissions
k=4.9, a=0.7, and b=0.45 are constants from EPA AP-42 Table 13.2.2-2 for PM_{30} emissions

Unpaved Road Emission Factors were calculated based on Equation (1a) in EPA section 13.2.2 relating to Unpaved Roads
The constants for the equation above are from Table 13.2.2-2 relating to PM emissions.

Emission Factor Equation and Data for Loading Emissions, November 2006 AP-42

$E\ (lb/ton) = k * (0.0032) * (u/5)^{1.3} * (m/2)^{1.4}$

Where:

u = mean windspeed, miles per hour
m = material moisture content, %
k=0.35 is the particle sized multiplier for particles < 10um
k=0.74 is the particle sized multiplier for particles < 30um

Loading emission factors were calculated based on Equation (1) in EPA section 13.2.4 relating to Aggregate Handling and Storage Piles. The Particle Size Multipliers are based on 10 and 30 micron diameters.

Project Data

Mass of limestone Loaded/Unloaded =	880,000	tons/yr (based on 800,000 tons finished products)
Days of Operation per Year =	300	days/year
Typical Limestone Moisture Content =	0.7	% (from Table 13.2.4-1 USEPA AP42)
Particle Size Multiplier (10 microns) =	0.35	(USEPA AP42 page 13.2.4-4)
Particle Size Multiplier (30 microns) =	0.74	(USEPA AP42 page 13.2.4-4)
Mean Wind Speed =	11.7	miles per hour - 5.25 m/s from 2010 to 2014 MM5 Data for Pseudo Met Station on Bengal Property
Approximate Silt Content of road bed =	8.3	% (from Table 13.2.2-1 USEPA AP42)
Number of Days with measurable Rainfall =	142	# (using 2014 MM5 data for Bengal Pseudo Station)
Hours of Operation per day =	16	

Unpaved Road Emission Caclulation Data

Unpaved Road Silt Loading =	8.3	% (mean value for Stone Quarrying and Processing - EPA Table 13.2.2-1)
Control Efficiency (roads are sprayed with water) =	90	% (from EPA Figure 13.2.2-2, M = 4.25)
Transport Truck Speed =	15	miles per hour
Transport Truck Distance Traveled on HAUL =	0.13	miles/trip (based on average distance from active footprint to processing plant)
Transport Truck Distance Traveled on HAUL1 =	0.28	miles/trip (based on average distance from active footprint to processing plant)
Transport Truck Distance Traveled on HAUL2 =	0.25	miles/trip (based on average distance from active footprint to processing plant)
Number of Transport Truck Trips =	117	one-way trip/day (3 trucks, 39 one-way trip/day/truck)
Loaded Vehicle Miles Traveled on HAUL =	4,652	miles/year
Empty Vehicle Miles Traveled on HAUL =	4,652	miles/year
Loaded Vehicle Miles Traveled on HAUL1 =	9,755	miles/year
Empty Vehicle Miles Traveled on HAUL1 =	9,755	miles/year
Loaded Vehicle Miles Traveled on HAUL2 =	8,845	miles/year
Empty Vehicle Miles Traveled on HAUL2 =	8,845	miles/year
Average Weight of UnLoaded Truck =	28.0	tons (truck weight only--assumed)
Average Weight of Loaded Truck =	53.0	tons (truck weight and aggregate)

Other Calculations

Tpy = (lb/y) * (ton/2000 lb) * (tonne/1.102311 ton)
g/s = Tpy * (y/365d) * (d/24h) * (h/3600s) *(1E6g/tonne)

Emission Estimates for Quarry Storage Pile

Emission Factor Equation and Data

E = 1.9 * (s/1.5) * 365 * (365-p)/235 * (f / 15)

Where:
E = emissions, kg/ha/yr
s = silt content, % (may be measured by % that passes through 200 mesh screen)
p = number of days with > 0.25mm rainfall
f = % time that the wind is greater than 5.4 m/s

Source: (1) National Pollutant Inventory, "Emission Estimation Technique Manual for Mining Version 2.3". December 2001, Environment Australia, pp. 41.
(2)NPI references AP-42 equations for Wind Erosion (1998, Fourth Edition)

Storage Pile and Atmospheric Data

Storage Pile Description	Source ID#	Height (m)	Length (m)	Width (m)	Area (m2)	Area (ha)
Limestone Storage Pile	LSP	18	95	60.00	15,034	1.50

1.6	= s, approximate Silt Content (%) of the crushed limestone
142	= p, number of days with > 0.25mm rainfall
291	= number of days with an average windspeed > 5.4 m/s
79.73	= f, % of time the windspeed is > 5.4 m/s

Emissions Estimate

Storage Pile Description	Source ID#	PM/PM10 EF (kg/ha/yr)	PM/PM10 Emissions (kg/yr)	PM/PM10 Emissions (tpy)	PM/PM10 Emissions (lb/hr)	PM/PM10 Emissions (g/s)
Limestone Storage Pile	LSP	3,731	5,609	6.2	1.77	0.22

Emissions lb/hr = (Tonne/year) * (2000lb/ton) / (hours disturbance/year)
Hours Disturbance/year = 8,760 hours/yr * % Windspeed is > 5.4 m/s

Emission Estimates for Crushing Operations

Emission factors obtained from USEPA AP42 Table 11.19.2-2

Source ID	Source Description	PM EF (lb/ton)	PM10 EF (lb/ton)	PM Emissions (Tpy)	PM Emissions (g/s)	PM10 Emissions (Tpy)	PM10 Emissions (g/s)
F1	Vibrating Grizzly and Hopper		1.60E-05	0.0000	0.0000	0.0064	0.0004
CR1	Primary Crusher[1]	0.0012	0.00054	0.3353	0.0213	0.1509	0.0096
C1	Conveyor Transfer to Primary Screen	0.00014	4.60E-05	0.0391	0.0025	0.0129	0.0008
S1	Primary Screen	0.0022	0.00074	0.6147	0.0390	0.2068	0.0131
CR2	Secondary Crusher[1]	0.0012	0.00054	0.2203	0.0140	0.0992	0.0063
C2	Conveyor Transfer to Sand Storage Pile	0.00014	4.60E-05	0.0011	0.0001	0.0004	0.00002
C3	Conveyor Transfer to 3/8" Storage Pile	0.00014	4.60E-05	0.0117	0.0007	0.0039	0.0002
C5	Conveyor Transfer to 3/4" Storage Pile	0.00014	4.60E-05	0.0117	0.0007	0.0039	0.0002
C6	Conveyor Transfer to 1" Storage Pile	0.00014	4.60E-05	0.0117	0.0007	0.0039	0.0002
C4	Conveyor Transfer to Secondary Crusher	0.00014	4.60E-05	0.0257	0.0016	0.0084	0.0005
S2	Secondary Screen	0.0022	0.00074	0.4040	0.0256	0.1359	0.0086
C7	Conveyor Transfer to Sand Pile	0.00014	4.60E-05	0.0011	0.0001	0.0004	0.00002
C8	Recycle conveyor to Primary Crusher	0.00014	4.60E-05	0.0017	0.0001	0.0006	0.0000
RC1	Reclaim conveyor to Reclaim Screen	0.00014	4.60E-05	0.0168	0.0011	0.0055	0.0003
S3	Reclaim Screen	0.0022	0.00074	0.2634	0.0167	0.0886	0.0056
RC2	Reclaim conveyor to Dump Storage	0.00014	4.60E-05	0.0156	0.0010	0.0051	0.0003
RC3	Reclaim conveyor from S3 to C8	0.00014	4.60E-05	0.0011	0.0001	0.0004	0.00002
	Totals				0.1253		0.0465

Emissions Tpy = (lb/ton) * throughput (ton/year) * (ton/2000lb) * (tonne/1.102311ton)

[1]Assume emission factors for tertiary crusher

Table 6-8 Source Information for Noranda Jamaica Bauxite Partners

Source Description	Source ID	X Coord, m	Y Coord, m	Base Elev, m	Release Height, m	Stack Dia., m	Stack Vel., m/s	Stack Temp., K	TSP/PM_{10}*** g/s
Diesel Generator at Powerhouse*	6401	244444.0	2042686.0	107.0	8.2	0.432	31.7	674	0.06
Diesel Generator at Powerhouse*	6407	244441.0	2042688.0	107.0	8.2	0.483	33.2	536	0.07
Diesel Generator at Powerhouse*	6428	244459.0	2042694.0	107.0	7.9	0.559	37.95	645	0.14
Boiler*	BOILER	244104.0	2043019.0	91.2	10.7	0.61	5.9	428	0.02
Bauxite Dryer**	5040	244083.0	2043025.0	92.9	22.9	2.438	7.77	333	38.76
Bauxite Dryer**	5030	243981.0	2043044.0	94.8	23.5	1.727	8.26	335	14.9
Bauxite Dryer**	5020	243962.0	2043045.0	95.4	22.4	2.438	8.63	331	57.4
Bauxite Dryer**	5010	243951.0	2043062.0	94.9	27.4	2.438	6.37	340	18.1

** Air emissions data based on Stack Emission Test Report for Noranda Jamaica Bauxite Partners dated December 2014*

*** Air emissions data based on USEPA AP-42 Emission Factors, Table 11.24-1*

**** PM_{10} assumed to be equal to TSP*

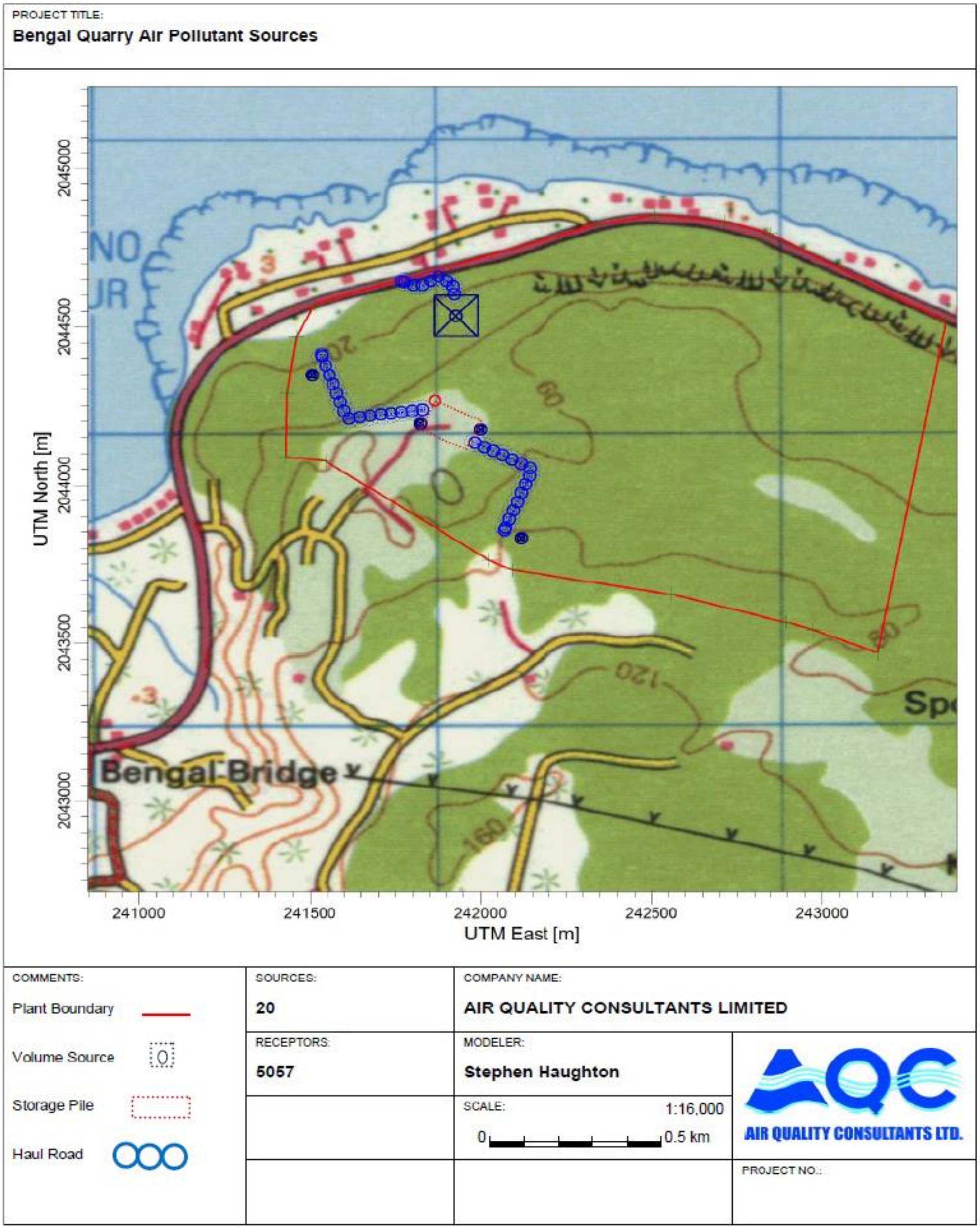


Figure 6-1 Map showing Bengal Quarry Air Pollutant Sources

COMPARISON OF PROPOSED QUARRY EMISSION RATES WITH EMISSION STANDARDS

According to the Natural Resources Conservation Authority (Air Quality) Regulations, there are no specific mass-based emission limits for quarry operations. Hence, no direct comparison can be made with the emission rates for the proposed quarry operation at Bengal.

BUILDING DOWNWASH EFFECTS

Buildings located close to point sources at a facility may significantly affect the dispersion of the pollutants from the source. If the point source is relatively low, the air pollutants released may be trapped in the wake zone of nearby obstructions (structures or terrain features) and may be brought down to ground level in the immediate vicinity of the release point (down-wash). It is therefore necessary to determine if such effects are present for each point source.

The "Good Engineering Practice" (GEP) height is defined as the height necessary to ensure that point source emissions do not result in excessive pollutant concentrations in the immediate vicinity of the source. These excessive concentrations may be the result of atmospheric downwash, eddies, or wakes that may be created by the source itself, nearby structures, or nearby terrain obstacles. If a point source is below the GEP height, then the plume entrainment must be taken into account by modifying certain dispersion parameters used in the dispersion model. However, if the point source height meets GEP, then entrainment within the wake of nearby obstructions is unlikely and need not be considered in the modeling.

The GEP height formula is: $Hg = H + 1.5*L$ where Hg is the GEP height measured from ground level elevation at the base of the point source, H is the height of nearby structure(s) measured from the ground level elevation at the base of the point source, and L is the lesser dimension, height or projected width, of the nearby structure(s). This definition will allow the consideration of all stacks up to a height of 65 m.

A building or structure is considered sufficiently close to a point source to cause wake effects when the minimum distance between the point source and the building is less than or equal to five times the lesser of the height or projected width of the building (5L). This distance is commonly referred to as the building's "region of influence." If the source is located near to more than one building, each building and point source configuration would have to be assessed separately. If a building's projected width is used to determine 5L, then the apparent width of the building must be determined. The apparent width is the width as seen from the source looking toward either the wind direction or the direction of interest. For example, for short-term modeling, the AERMOD model requires the apparent building widths (and also heights) for every 10 degrees of azimuth around each source. The AERMOD model also contains algorithms for determining the impact of downwash on ambient concentration and was used for determining predicted maximum estimates.

There are a number of buildings nearby the point sources that were identified in the modeling project and these are sufficiently close to cause wake effects for the plumes. The dimensions of the various buildings as well as the parameters for the various point sources were inputted into the Building Profile Input Program (BPIP) to generate the necessary building heights and widths.

The USEPA BPIP was designed to incorporate the concepts and procedures expressed in the GEP technical support document (EPA, 1985), the Building Downwash guidance (Tikvart 1988, Tikvart 1989, and Lee 1993), and other related documents into a program that correctly calculates building heights (BHs) and projected building widths (PBWs). The BPIP model is divided into two parts.

Part one (based on the GEP technical support document) is designed to determine whether or not a stack is subject to wake effects from a structure or structures. Values are calculated for GEP stack height and GEP-related BHs and PBWs. Indication is given to which stacks are being affected by which structure wake effect. Part two calculates building downwash BHs and PBWs values based on references Tikvart, 1988, Tikvart 1989, and Lee 1993, which can be different from those calculated in part one. Part two only performs the calculations if structure wake effects are influencing a particular stack.

No building downwash effect was considered for the proposed quarry since there was no point source included at the proposed location.

METEOROLOGICAL DATA

The AERMOD model requires hourly surface data values for wind speed, wind direction, temperature, rainfall, relative humidity, pressure, cloud cover and ceiling height and solar radiation and at least once daily mixing height data. Both surface and upper air data were obtained as modeled meteorological data for years 2010 through 2014 based on a mesoscale numerical weather prediction model. These data were submitted directly into the AERMET meteorological preprocessor programme, which uses three stages to process the data. The first stage extracts meteorological data and assesses data quality through a series of quality assessment checks. The second stage merges all data available for 24-hour periods and writes these data together in a single intermediate file. The third and final stage reads the merged meteorological data and estimates the necessary boundary layer parameters for dispersion calculations by AERMOD.

The surface parameters within a 3 km radius around the centre of the modeling domain that were applied to the AERMET processor are listed in Table 6-9.

Table 6-9 Surface Parameters for AERMET Processor

Sector (angle from north)	Land Use	Albedo	Bowen Ratio	Surface Roughness
0 – 118°	Water	0.14	0.45	0.0001
118 – 160°	Deciduous Forest	0.215	0.875	0.9
160 – 185°	Urban	0.2075	1.625	1
185 – 285°	Deciduous Forest	0.215	0.875	0.9
285 – 360°	Water	0.14	0.45	0.0001

The preprocessed modeled meteorological data was used to determine its corresponding Wind Rose plot (Figure 6-2). The Wind rose show that the most predominant wind direction blows from the east-northeast, with the secondary wind direction being from the east. This means that the emissions plume will be dispersed mainly in the west-southwestern direction, and secondarily in the western direction from the proposed quarry. For the five years' data that were modeled, the average wind speed was determined to be 5.25 m/s.

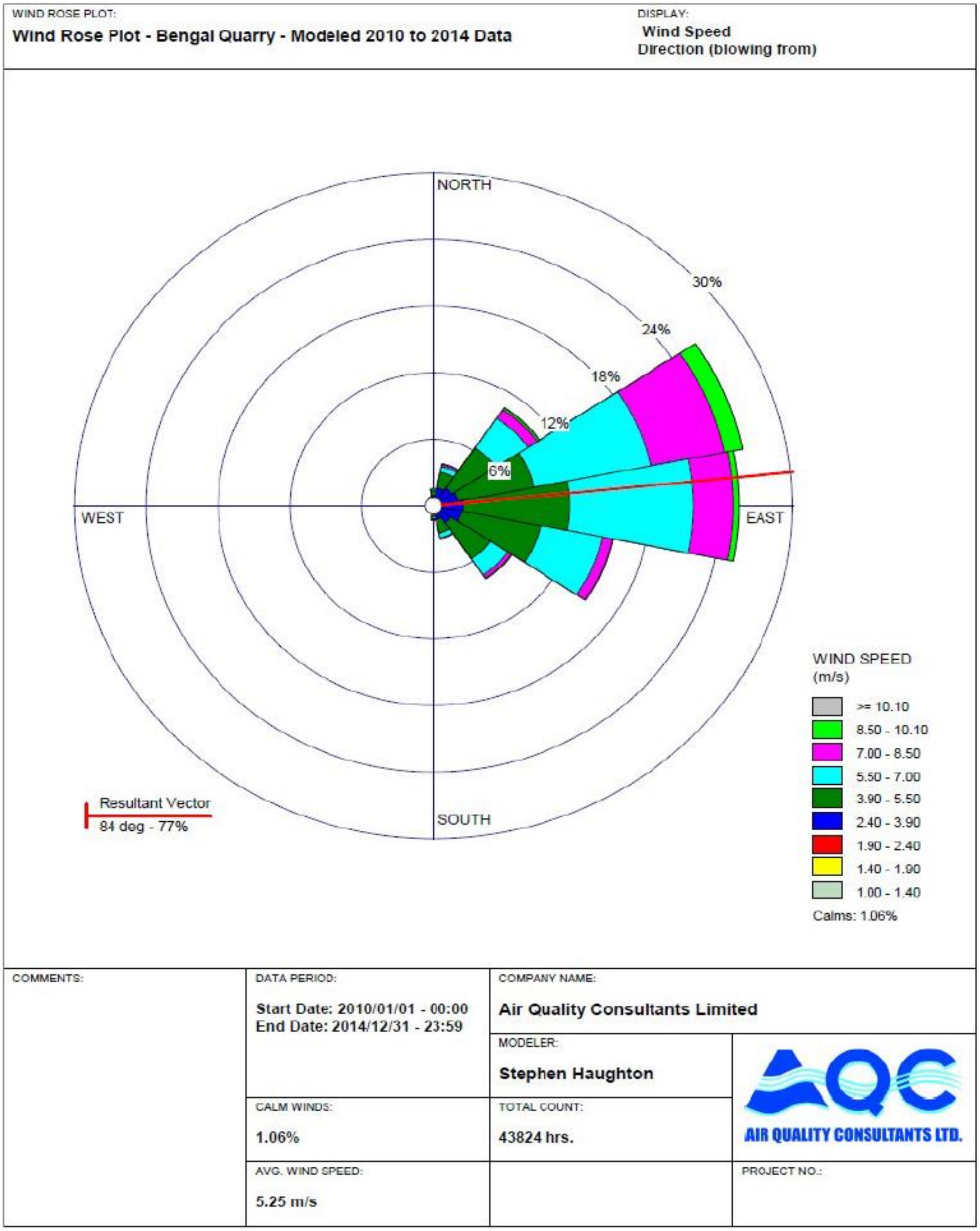


Figure 6-2 Wind Rose Plot – 2010-2014 Modeled Met Data for Proposed Quarry Site

MODEL DOMAIN, RECEPTOR NETWORK AND TERRAIN CONSIDERATIONS

The selected model domain was 10 km in the north-south direction and 10 km in the east-west direction, with the centre of the domain being the centroid of quarry sources at (UTME 242572 and UTMN 2044320). Figure 6-3 shows part of the model domain with the receptor grid and the plant boundary. The model domain is overlain on a Jamaica Metric Grid 1:50,000 topographic map.

RECEPTOR NETWORK

The selection and location of the receptor network are important in determining the maximum impact from a source and the area where there is significant air quality impact. Impacts were assessed at locations beyond the facility fence line. Consequently, the receptor locations were selected as a multi-tier grid that is defined by discrete Cartesian receptors, square in shape, and with origin at the centroid of the quarry sources. Certain special receptor locations were also defined, including schools, attractions, a post office, a library, an air strip, a park, and a marine lab were also included as part of the receptor network.

The entire receptor network locations include the following:

- A 100-meter spaced grid within 3 km from the subject source;
- A 500-meter spaced grid between 3 and 10 km of the subject source;
- A total of 11 special receptors that include schools, attractions, a post office, a library, an air strip, a park, and a marine lab (Table 6-10); and
- A total of 78 plant boundary receptors

A total of 5,057 receptors were considered, and some of these are graphically depicted in Figure 6-3.

Table 6-10 Special Receptors

Description	X Coordinate, m	Y Coordinate, m	Elevation, m
Brown's Town Community College	246874	2042376	32.03
Green Grotto Cave	249274	2042805	27.04
Grand Bahia Principe	251833	2042927	49.37
Columbus Park	244928	2043436	60.34
Discovery Bay Library	246403	2042775	30.7
Bamboo River Rafts	241781	2040189	161.18
TankWeld	240568	2043466	630.72
Grand Lido Braco	239000	2045180	388.18
Braco Air Strip	237170	2044781	345.83
Discovery Bay Marine Laboratory	244930	2043760	886.3
Discovery Bay Post Office	246742	2042887	883.88

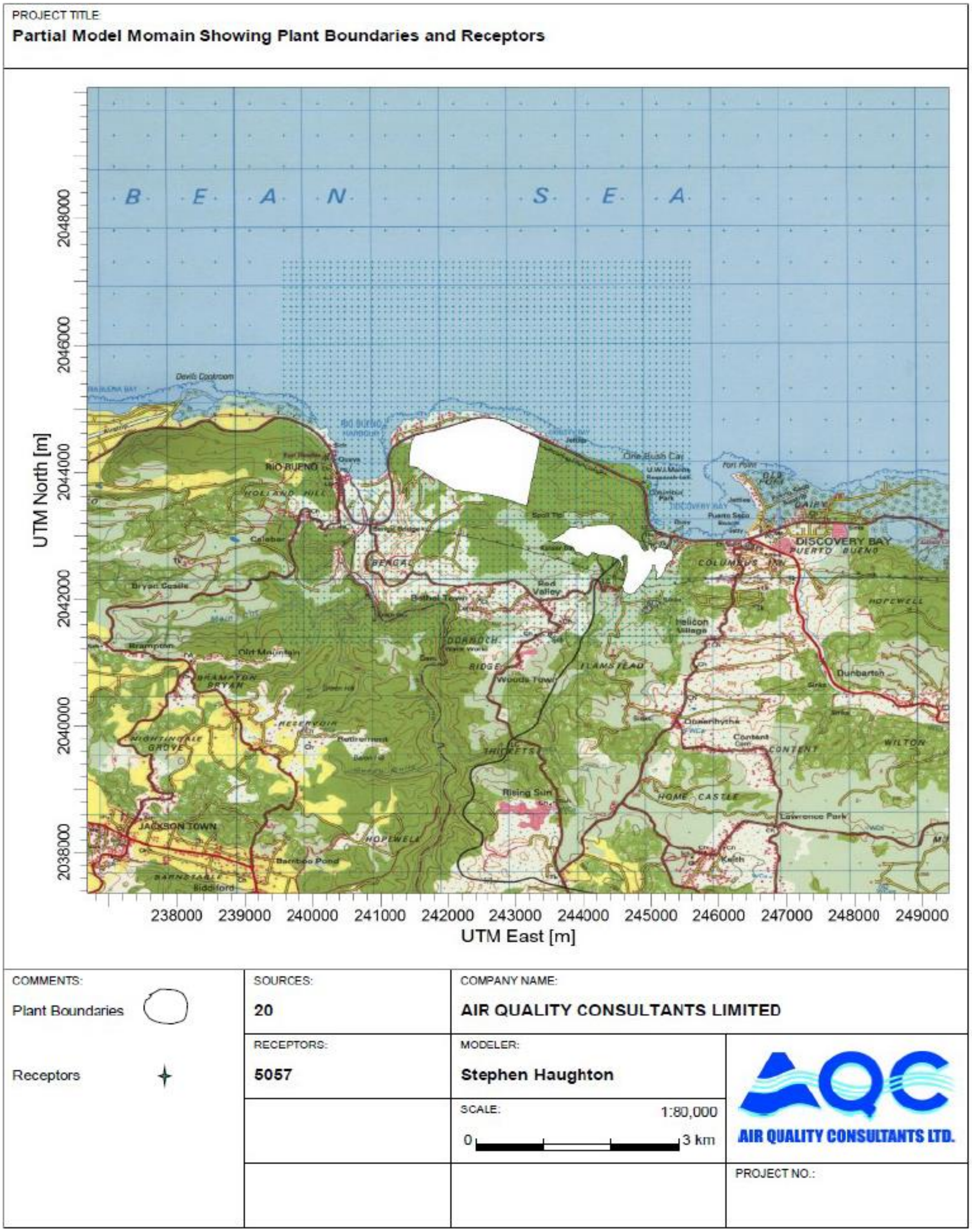


Figure 6-3 Model Domain showing the Receptor Grid

TERRAIN CONSIDERATIONS

The classification of the land use in the vicinity of the proposed facilities was needed for the model runs because dispersion rates differ between urban and rural areas. In general, urban areas cause greater rates of dispersion because of increased turbulent and buoyancy-induced mixing. This is due to the combination of greater surface roughness caused by more buildings and structures and greater amounts of heat released from concrete and similar surfaces. The USEPA guidance provides two procedures to determine whether the character of an area is predominantly urban or rural. One procedure is based on land-use type, and the other is based on population density. Both procedures require an evaluation of characteristics within a 3-km radius from the subject source, but the land-use methodology is considered more accurate. Hence, this method was applied and it was determined that the urban dispersion coefficient be selected for this modeling project.

According to the land-use type methodology, a 3 km radius circle was circumscribed about the boiler B1 stack. Then using the Auer land use types, about 7% (less than the 50% threshold) of the 3 km radius area around the project site matches the urban zones of I1, I2, C1, and R2 (Table 6-11), and hence the rural option was selected.

Table 6-11 Land Use Categories

Type	Land Use and Structure	Vegetation
I1	Heavy Industrial	Grass and tree growth extremely rare; <5% vegetation
	Major chemical, steel and fabrication industries; generally, 3-5 story buildings, flat roofs	
I2	Light-moderate industrial	Very limited grass, trees almost totally absent; <5% vegetation
	Rail yards, truck depots, warehouse, industrial parks, minor fabrications; generally, 1-3 story buildings, flat roofs	
C1	Commercial	Limited grass and trees; <15% vegetation
	Office and apartment buildings, hotels; >10 story heights, flat roofs	
R2	Compact Residential	
	Single, some multiple, family dwelling with close spacing; generally, <2 story, pitched roof structures; garages (via alley), no driveways	Limited lawn sizes and shade trees; <30% vegetation

Source: Auer, A. H. 1978. Correlation of Land Use and Cover with Meteorological Anomalies, Journal of Applied Meteorology, 17:636-643

Additionally, the topography in the region of the proposed quarry is defined as either simple terrain (terrain lying below the stack top elevation) or complex terrain (terrain above the top of release heights). Measurements of the terrain in the area surrounding the facility were obtained using Shuttle Radar Topography Mission terrain data files.

It was determined that the topographic area generally range from 0m to about 578m in terrain elevation (Figure 6-4). Therefore, since some terrain elevations extend above the highest release heights, complex terrain algorithms were included as part of the air dispersion modeling analyses.

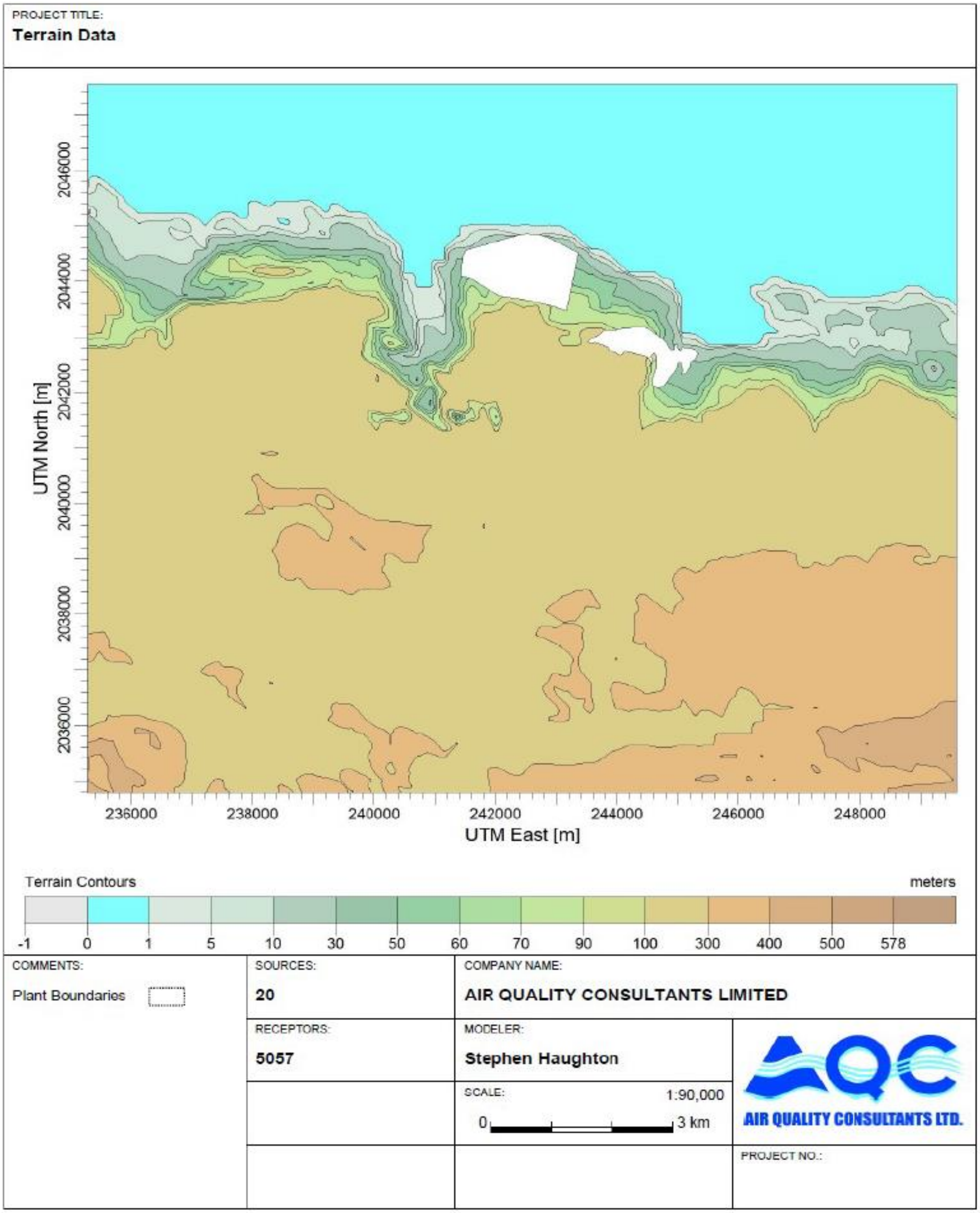


Figure 6-4 Project Terrain Data

Model Results for Proposed Quarry

With the various sources identified, a model domain established of 10 km in the east-west direction and 10 km in north-south direction with its centre at the centroid of quarry sources, and the necessary input files created, model predictions were made for the pollutants TSP and PM_{10} for averaging periods for which there are JNAAQS. Model runs were conducted for the proposed air pollutant sources alone at the quarry site, as well as the cumulative air quality impact in combination with the other defined sources within the air shed.

Table 6-12 summarizes the maximum predicted concentrations for the proposed quarry's air pollutant sources, as well as their comparison with the JNAAQS and SIC. The maximum annual fall out for TSP and PM10 occurred at the same coordinates, with the higher value for TSP. Annual background for TSP is 20 ug/m^3 and for PM_{10} is 13 ug/m^3. The average of lowest 24hr background TSP values at Farm Town, Old Folly, Bengal, Clinic, Rosseau and average PM10 at Queens, is 43 ug/m^3 (TSP) and 25 ug/m^3 (PM_{10}) respectively. **The results revealed total compliance (24-hr and annual) with the JNAAQS and SICs for all averaging periods for the various pollutants analysed (TSP and PM_{10}).**

Table 6-12 Model Results for Proposed Bengal Quarry

Pollutant	Avg. Period	Recommended Background (µg/m³)	Significant Impact Concentration (µg/m³)	Jamaican AAQS (µg/m³)	Proposed Quarry		
					Max Conc (µg/m³)	UTME (m)	UTMN (m)
TSP	24-hr	43	80	150	70.1	241372	2044220
	Annual	20	20	60	19.7	241431.85	2044290.65
PM_{10}	24-hr	25	80	150	31.8	241772	2043920
	Annual	13	20	50	7.1	241431.85	2044290.65

Figure 6-5 through Figure 6-8 show the pollutant contour plot-files for TSP and PM_{10} for the proposed quarry. These plot files show the most impacted areas based on the predicted pollutant concentrations generated by the model runs. The colour coded scale in the figures indicates the various impact concentrations obtained up to the predicted maximum concentrations achieved.

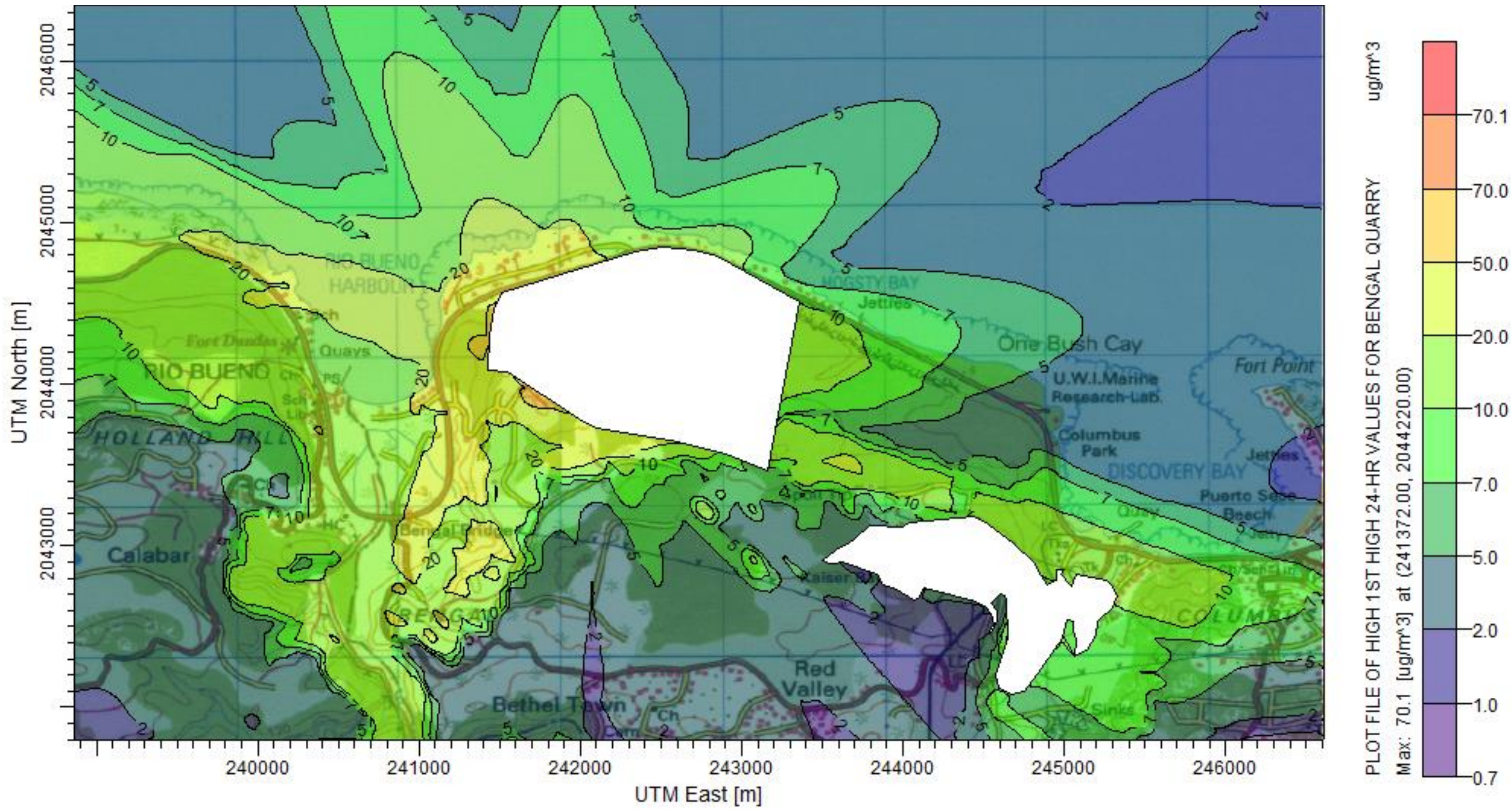


Figure 6-5 Predicted 24-h TSP Concentrations – Proposed Quarry

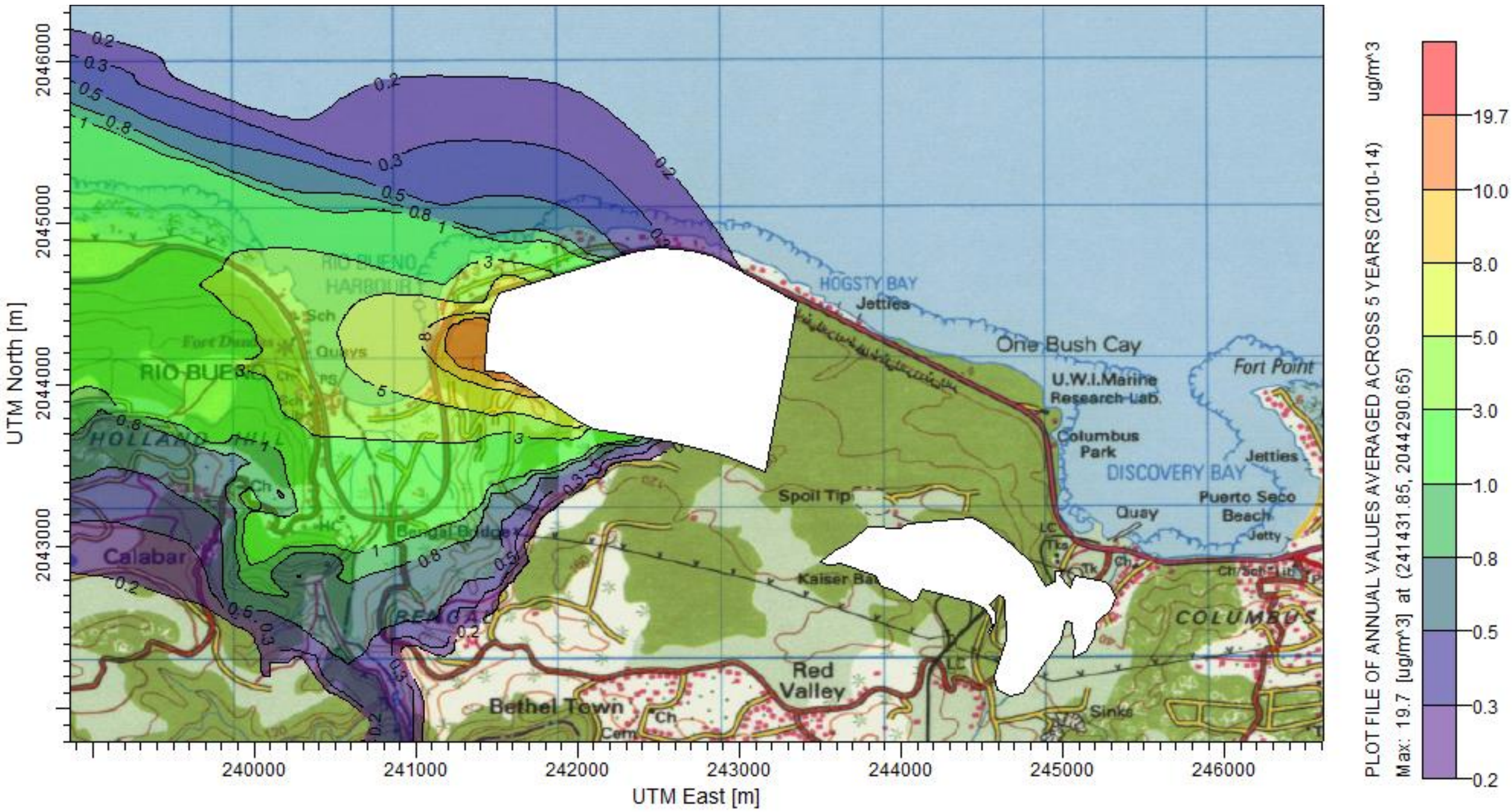


Figure 6-6 Predicted Annual TSP Concentrations – Proposed Quarry

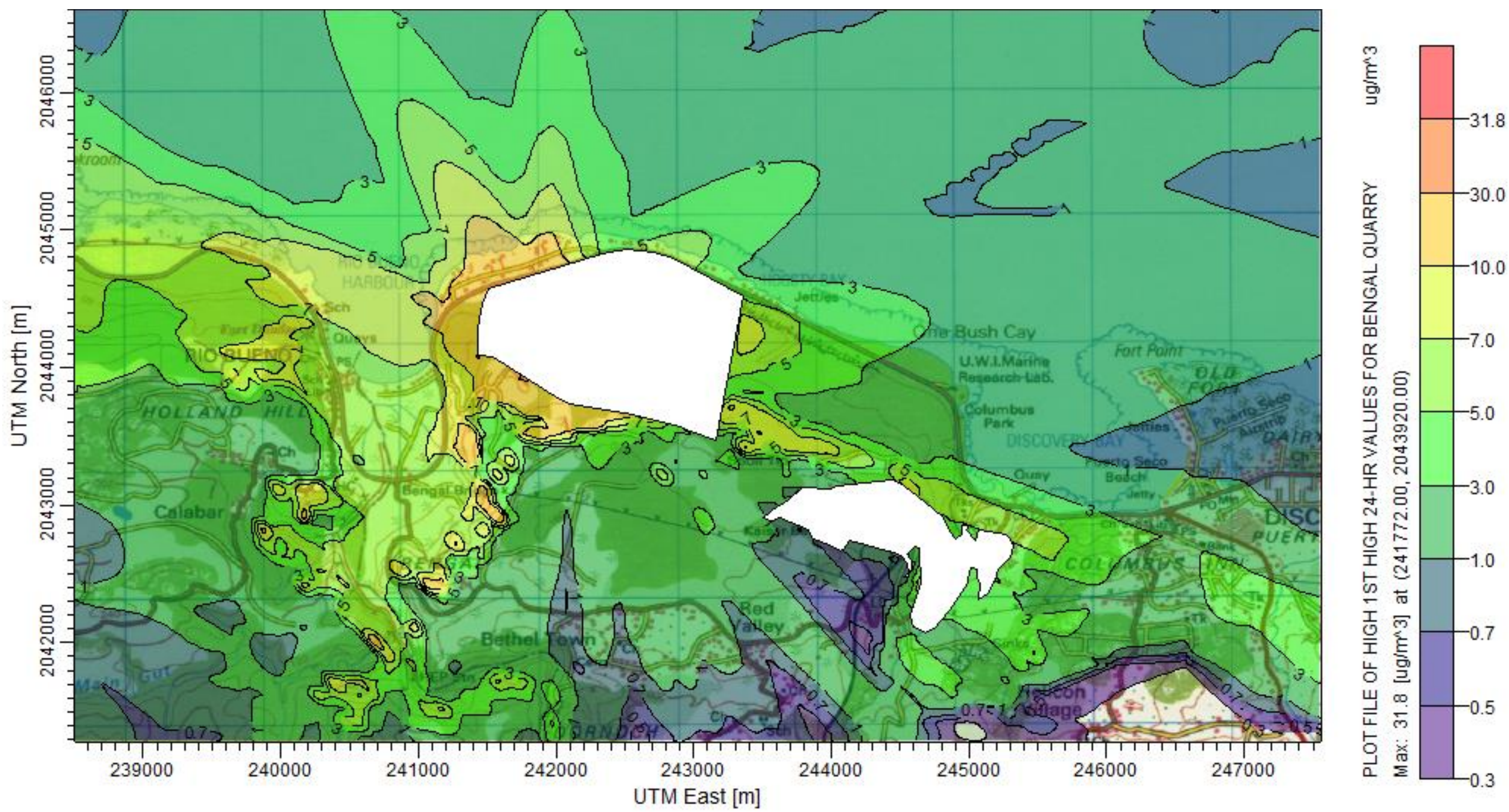


Figure 6-7 Predicted 24-h PM_{10} Concentrations – Proposed Quarry

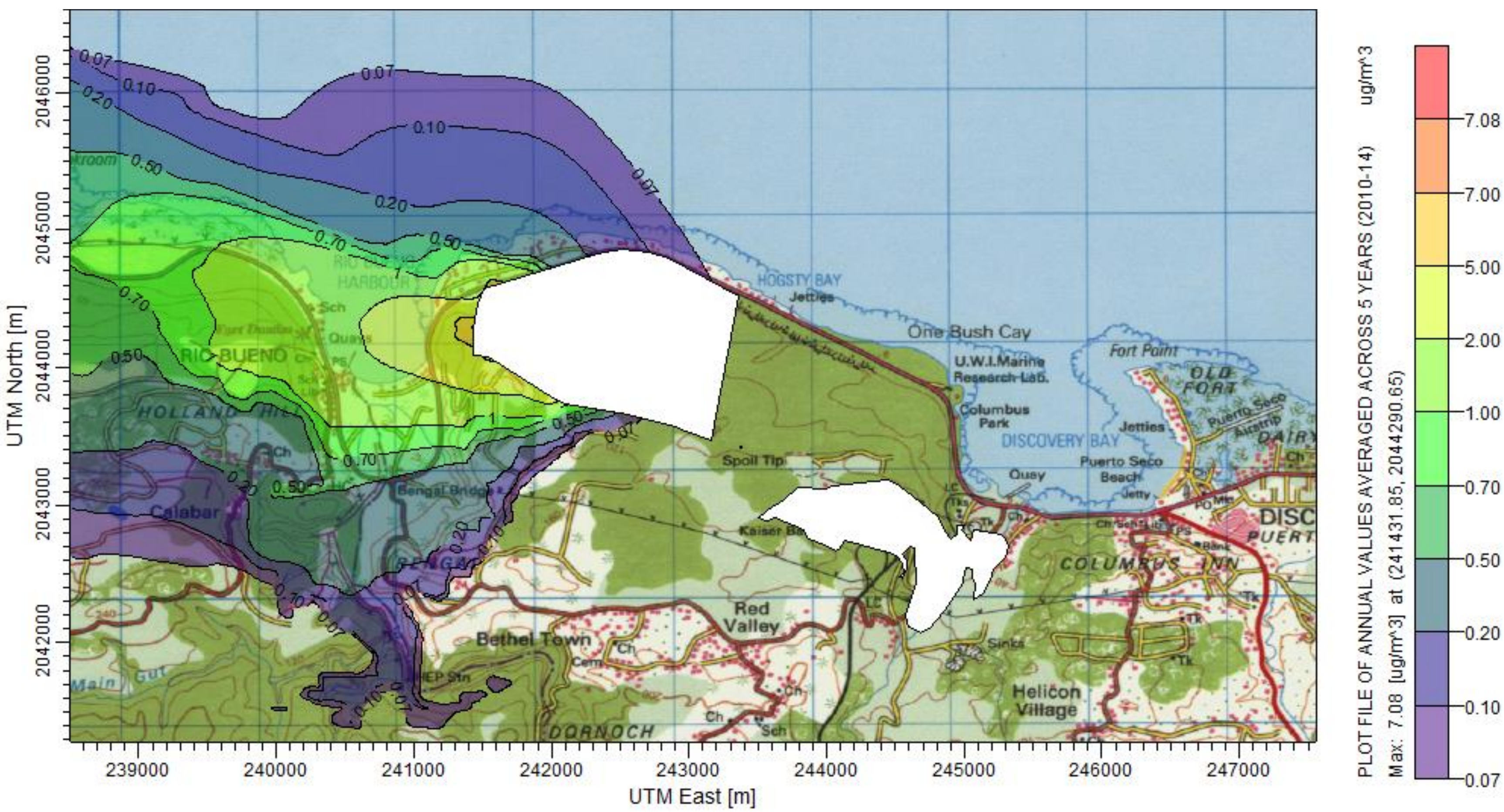


Figure 6-8 Predicted Annual PM_{10} Concentrations – Proposed Quarry

Recommended Mitigation

i. Ensure that equipment are properly maintained so as to reduce air emissions.
ii. Haul trucks must maintain speeds at 25 km/h or less.
iii. Quarry areas and roadways should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.

6.2.1.2 Noise Pollution

Noise from haul trucks, blasting, crushing and grinding activities may have potential negative impact on surrounding residents. To determine the potential impacts from the operation of the quarry, noise modelling was conducted.

Methodology

Modelling has been used to theoretically predict real life situations using set parameters. Predictive noise modelling is being used throughout the world to estimate/project noise impacts from sources.

SoundPlan 8.0 was used to conduct the noise modelling for the potential impacts from the operation of the Bengal Quarry. This is an internationally accepted model used in over 50 countries by over 5000 users. It was developed in 1986 by Braunstein + Berndt GmbH in Germany and has over the years provided very accurate noise predictions. It fulfils nearly 50 different regional and international standards.

Within SoundPlan, the Industrial Noise Module was used to conduct the predictions. The first step was to select the standards that were going to be used to run the model. The ISO 9613-2: 1996 Prediction Method and Concawe Method were used for the modelling exercises. Within the standards, temperature was set at 27.96 oC, the relative humidity at 87.8 % and air pressure 1013.3 mbar. These numbers were selected as they represented the averages obtained from the Meteorological Service of Jamaica (January to November 9, 2016).

In the Concawe standard wind speed and Pasquill Stability Class were also added. The average wind speed of 3.11 m s-1 was used and the most frequent wind direction was used to analyse the effects on noise levels. This was the North East (note the direction of the wind is the direction to which it is heading). The wind speed and directions were obtained from Meteorological Service of Jamaica (January 6, 2011 to August 9, 2013). A Pasquill Stability Class of D was used.

The tendency of the atmosphere to resist or enhance vertical motion and thus turbulence is termed stability. It is related to both the change of temperature with height (the lapse rate) driven by the boundary layer energy budget and wind speed together with surface characteristics (roughness). An unstable atmosphere enhances turbulence, whereas a stable atmosphere inhibits mechanical turbulence. A neutral atmosphere neither enhances nor inhibits mechanical turbulence. It is for this reason that the Stability Class D (neutral) was chosen for the noise modelling exercise.

The results of the calculation runs were initially visualized in the SoundPlan programme Graphics section and then the contours (lines and areas) exported to ArcGIS 10.6 for final map creation and visualization.

The results are compared with the NEPA Day Time standard only as the quarry will be operated during day time hours.

Model Predictions

ISO 9613-2: 1996

LAeq amongst the station ranged from a low of 34.9 dBA (Station 6) to high of 75.8 dBA (Station 2) (Table 6-13 and Figure 6-9). Only stations 2 and 8 were non-compliant with the NEPA Day Time standard. Station 2 is located on the Quarry property and not at the boundary, so technically compliant. Station 8 however, is located in a residential area north of the proposed quarry.

Table 6-13 Predicted LAeq during Quarry Operations compared with the NEPA Day Time Standard

STATION	PREDICTED LAeq (12hr)	NEPA DAY TIME STD. (dBA)	ABOVE NEPA STD. (dBA)
1	54.5	75	-
2	75.8	75	0.8
3	72.6	75	-
4	66.3	75	-
5	45.6	55	-
6	34.9	55	-
7	45.6	55	-
8	57.8	55	2.8
9	52.5	55	-

NB: Numbers highlighted in red are non-compliant with NEPA Day Time standards

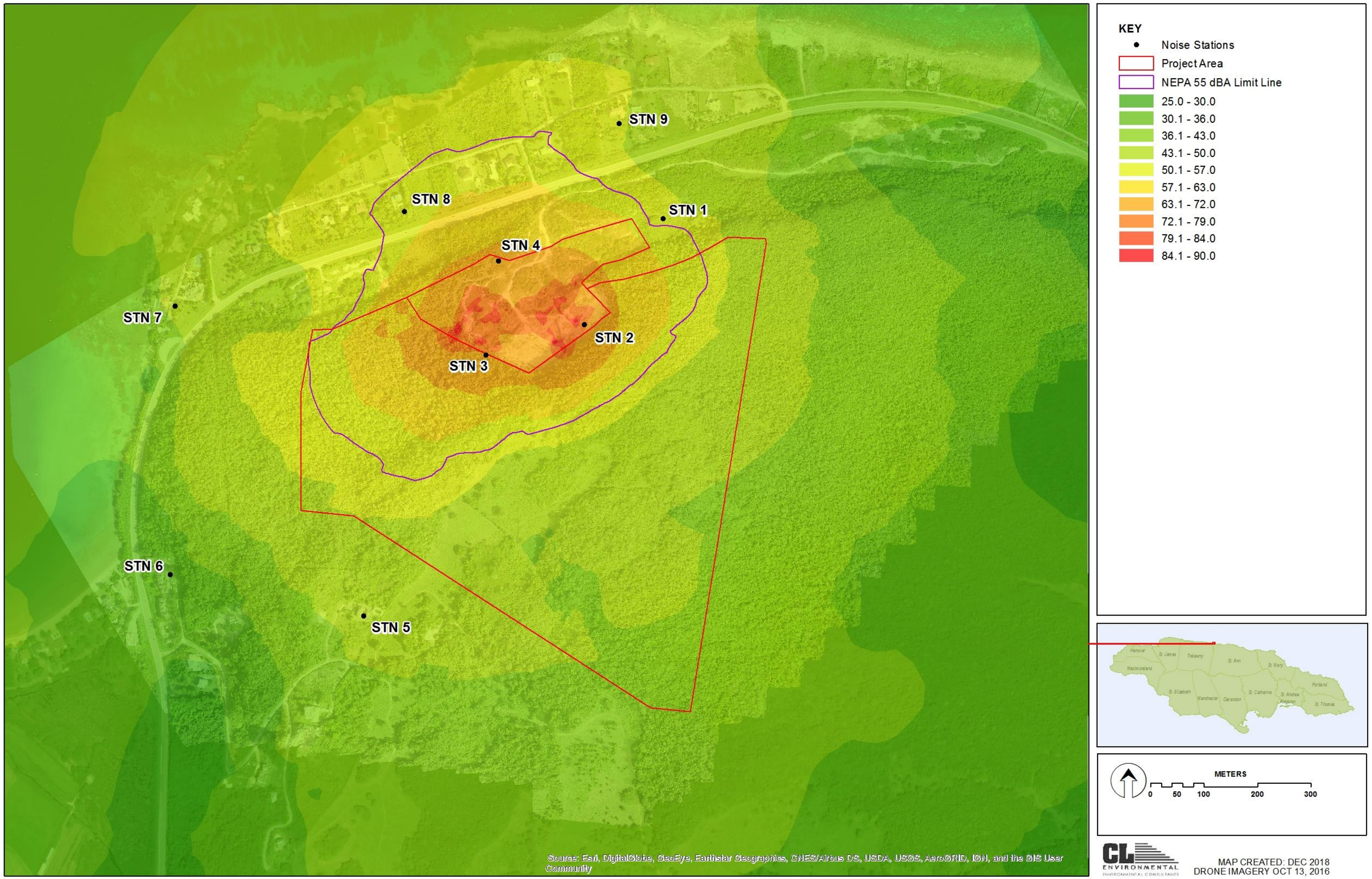


Figure 6-9 Predicted noise emissions from the quarry operations using ISO 9613-2: 1996 Prediction Method

CONCAWE MODEL

The Concawe model was used to determine if and what changes to the noise level would occur when wind speed and direction (wind blowing from the southwest) was taken into account with the other meteorological parameters (temperature, relative humidity and atmospheric pressure).

LAeq amongst the station ranged from a low of 21.9 dBA (Station 6) to high of 79.3 dBA (Station 2) (Table 6-14 and Figure 6-10). Stations 2, 3, 8 and 9 were non-compliant with the NEPA Day Time standard. Station 2 is located on the Quarry property and not at the boundary, so technically compliant. Station 8 however, is located in a residential area north of the proposed quarry.

Table 6-14 Predicted LAeq during Quarry Operations compared with the NEPA Day Time Standard (Concawe)

STATION	PREDICTED CONCAWE SW LAeq (12hr)	NEPA DAY TIME STD. (dBA)	ABOVE NEPA STD. (dBA)
1	60.3	75	-
2	79.3	75	4.3
3	75.9	75	0.9
4	69.6	75	-
5	40.8	55	-
6	21.9	55	-
7	42.0	55	-
8	59.8	55	4.8
9	57.0	55	2.0

NB: Numbers highlighted in red are non-compliant with NEPA Day Time standards

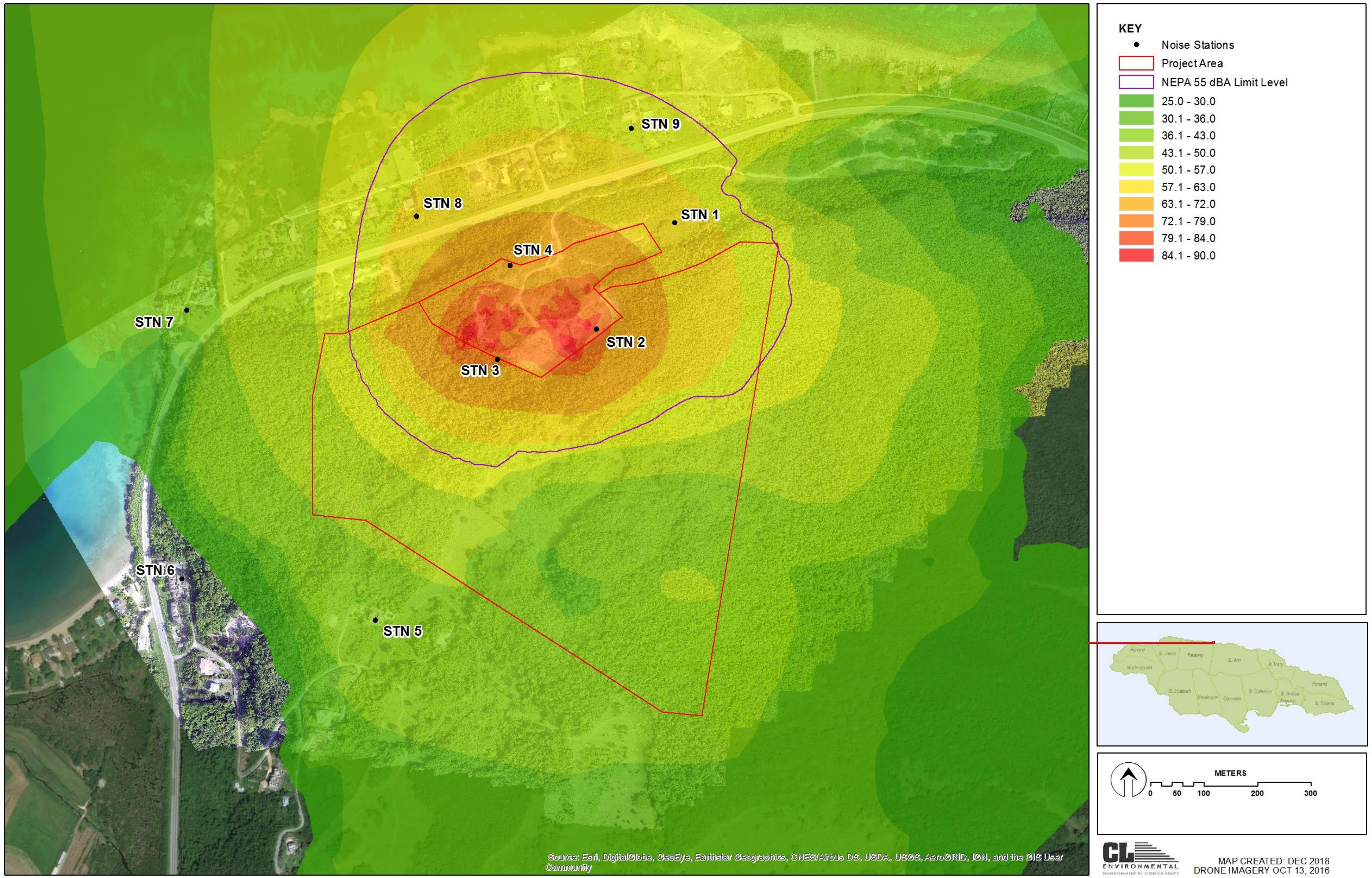


Figure 6-10 Predicted noise emissions from the quarry operations using Concawe Prediction Method (wind from the southwest)

Recommended Mitigation

i. Ensuring that equipment used are properly fitted with noise reduction devices such as mufflers.
ii. Reduce unnecessary revving of vehicular engines.
iii. Use equipment that has low noise emissions as stated by the manufacturers.
iv. Use equipment that is properly fitted with noise reduction devices such as mufflers.
v. Operate noise-generating equipment during regular working hours (e.g. 7 am – 7 pm) to reduce the potential of creating a noise nuisance during the night.
vi. Workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.

The following mitigations were employed to reduce the noise levels to within the NEPA Day Time standards:

1. Semi enclose the Primary Impactors (enclosed the sides and tops)
2. Installing noise walls to the north of the facility. These walls are of varying heights as depicted in Figure 6-11, Figure 6-12 and Figure 6-12.

The results of the mitigation measures are reported in Table 6-15 and Table 6-16. The only station to be in non-compliance with NEPA standard, however, technically because it is not on the boundary of the property this non-compliance can be ignored.

The noise emission from the quarry operations with the mitigation measures are illustrated in Figure 6-11 and Figure 6-12.

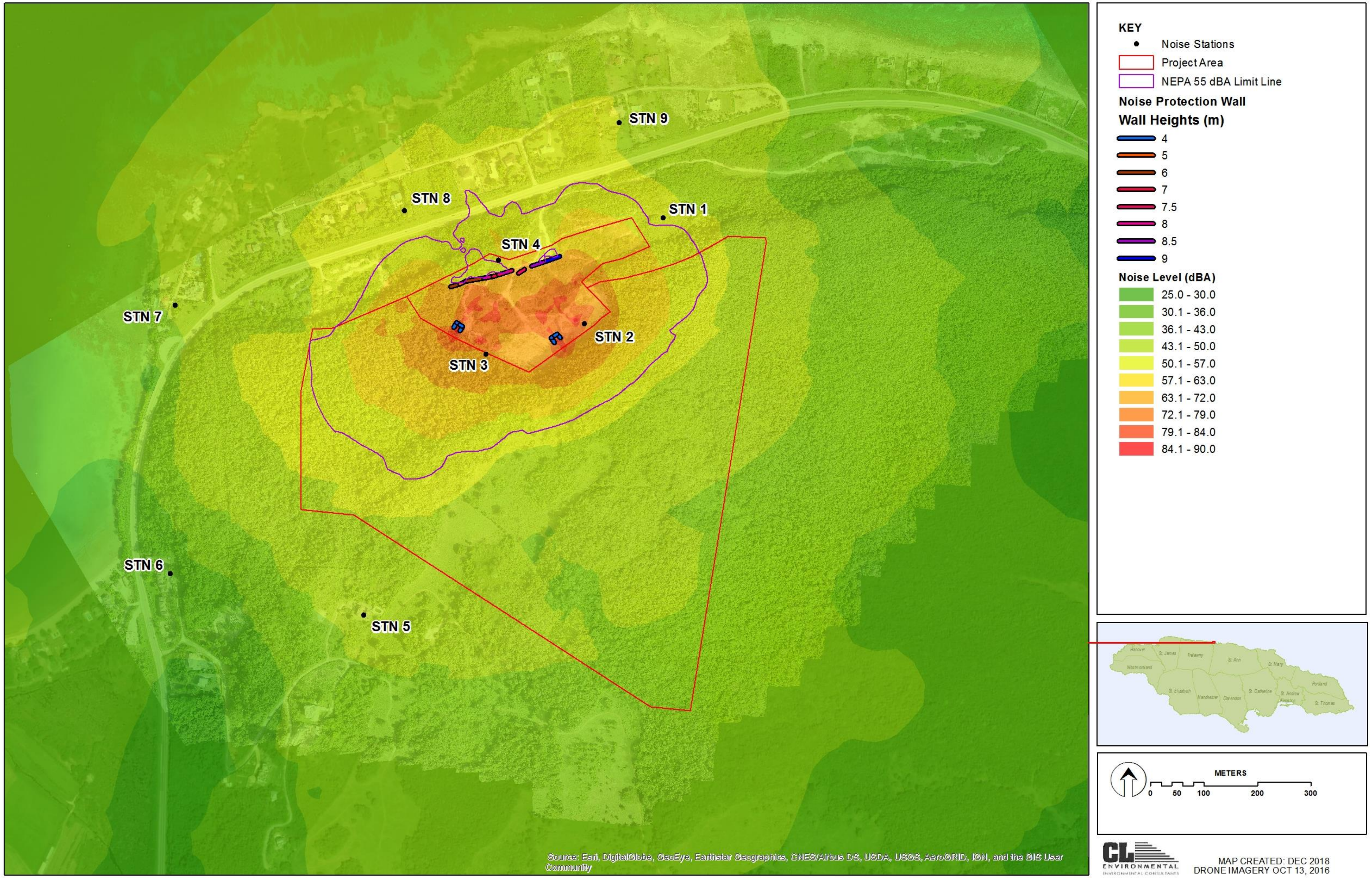


Figure 6-11 Predicted noise emissions from the quarry operations with mitigation using ISO 9613-2: 1996 Prediction Method

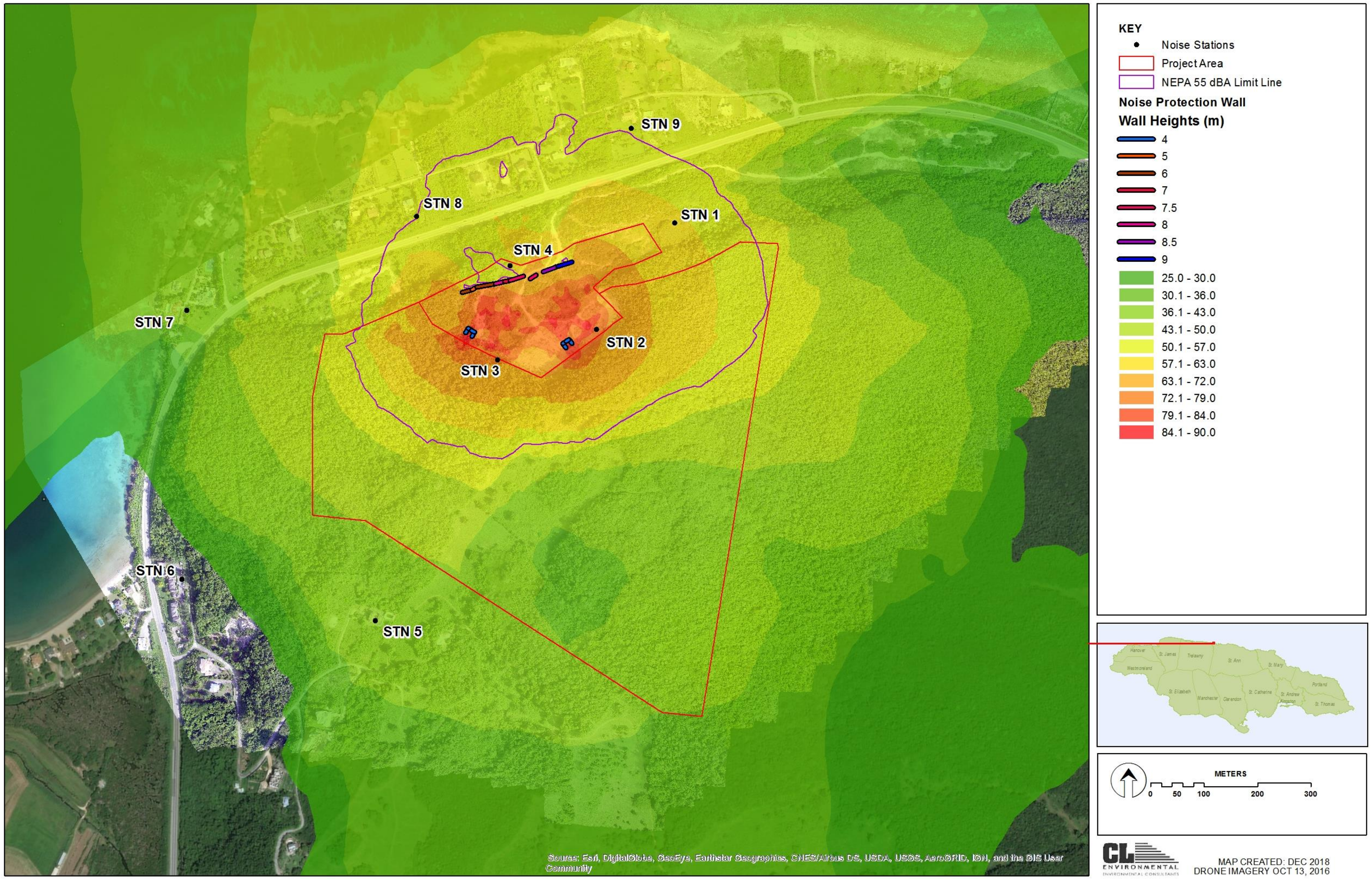


Figure 6-12 Predicted noise emissions from the quarry operations with mitigation using Concawe Prediction Method (wind from the southwest)

Table 6-15 Predicted LAeq with mitigation measures during Quarry Operations compared with the NEPA Day Time Standard

STATION	PREDICTED LAeq (12hr)	NEPA DAY TIME STD. (dBA)	ABOVE NEPA STD. (dBA)
1	53.3	75	-
2	75.2	75	0.2
3	71.5	75	-
4	56.5	75	-
5	45.5	55	-
6	34.8	55	-
7	44.5	55	-
8	53.2	55	-
9	51.2	55	-

Table 6-16 Predicted LAeq with mitigation measures during Quarry Operations compared with the NEPA Day Time Standard (Concawe)

STATION	PREDICTED CONCAWE SW LAeq (12hr)	NEPA DAY TIME STD. (dBA)	ABOVE NEPA STD. (dBA)
1	58.9	75	-
2	78.6	75	3.6
3	74.8	75	-
4	57.7	75	-
5	39.8	55	-
6	21.9	55	-
7	40.4	55	-
8	55.0	55	-
9	54.8	55	-

6.2.1.3 Rock Blasting

Blasting is expected to occur. As a result:

- Fragments of rocks will be propelled into the air by explosions on site. These rocks will create hazards if they are propelled into nearby residences resulting in harm or death.
- Fumes (toxic and non-toxic) are released into the atmosphere as a result of using explosives for blasting. Residences may be temporarily affected by dust and fumes within 100 metres.
- Deposited dust may affect local residents as cars, homes or any surface may have visible deposition.

Recommended Mitigation

These blasting practices will be kept to a minimum and will involve directional, controlled blasts, using mats where possible. The following procedures are also recommended to mitigate or minimize the potential for dangers including:

- Conducting pre-blast crack surveys which documents the existing status of structures (homes and residences).

- Executing pre-blast tests to monitor effects, measure attenuation characteristics and minimize vibration impacts. Predictions are evaluated using actual data and adjustments are made during the blasting program. This is monitored using instruments placed at the nearest structure in every direction.
- Implementing rockfall catchment fences. These mechanisms help to contain fragmented pieces of stones (fly-rock) from impacting nearby settlements.

6.2.1.4 Vibration

Quarrying and mining activities often generate vibration complaints from nearby residences. This may be as a result of interfering with persons normal routines/activities. This can become more acute if the community has no understanding of the extent and frequency and times of operational activities. This can lead to misunderstandings by the communities if the contractor is insensitive although he may believe he is in compliance with the required conditions/ordinances.

Quarrying and mining activities can result in various degrees of ground vibration. This is dependent on the type of equipment used and the methodologies employed.

Various governmental agencies have criteria regarding architectural and structural damage, as well as annoyance and acceptability of vibration. In general, most of the criteria specify that for a PPV less than approximately 3.048 mms-1 (0.12 inches per second), then the potential for architectural damage due to vibration is unlikely. A PPV of approximately 3.048 mms-1 (0.12 inches per second) to 12.7 mms-1 (0.50 inches per second) there is potential for architectural damage due to vibration, and for a PPV greater than approximately 12.7 mms-1 (0.50 inches per second) the potential for architectural damage due to vibration is very likely.

Human beings are known to be very sensitive to vibration, the threshold of perception being typically in the PPV range of 0.14 mms-1 to 0.3 mms-1 (British Standard BS 5228-2:2009). An indication of the effects of ground vibration on humans is detailed by the standard and detailed in Table 6-17.

Table 6-17 Guidance on the effects of vibration (British Standard BS 5228-2:2009)

VIBRATION LEVEL	EFFECT
0.14 mms^{-1}	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mms^{-1}	Vibration might be just perceptible in residential environments.
1.0 mms^{-1}	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mms^{-1}	Vibration is likely to be intolerable for any more than a brief exposure to this level.

The effects of vibration (both on humans and buildings) is also summarized in Table 6-18.

Table 6-18 Effects of Construction Vibration

PEAK PARTICLE VELOCITY (mm/sec)	EFFECTS ON HUMANS	EFFECTS ON BUILDINGS
< 0.127	Imperceptible	No effect on buildings

PEAK PARTICLE VELOCITY (mm/sec)	EFFECTS ON HUMANS	EFFECTS ON BUILDINGS
0.127 – 0.381	Barely perceptible	No effect on buildings
0.508 – 1.27	Level at which continuous vibrations begin to annoy in buildings	No effect on buildings
2.54 – 12.7	Vibrations considered unacceptable for people exposed to continuous or long-term vibration	Minimal potential for damage to weak or sensitive structures
12.7 – 25.4	Vibrations considered bothersome by most people, however tolerable if short-term in length	Threshold at which there is a risk of architectural damage to buildings with plastered ceilings and walls. Some risk to ancient monuments and ruins.
25.4 – 50.8	Vibrations considered unpleasant by most people	U.S. Bureau of Mines data indicates that blasting vibration in this range will not harm most buildings. Most construction vibration limits are in this range.
>76.2	Vibration is unpleasant	Potential for architectural damage and possible minor structural damage

Vibrations from various types of equipment under a wide range of activities have been measured by the Federal Transit Administration (FTA) in the United States. The data in Table 6-19 provides a reasonable estimate for a wide range of soil conditions. Additional data on other equipment are represented in Table 6-20, which were obtained from measurements on several projects including the Central Artery/Tunnel Project in Boston and from several published sources including the FTA Manual and Dowding's Textbook.

Table 6-19 Vibration source levels for equipment (from measured data)

Table 12-2. Vibration Source Levels for Construction Equipment (From measured data.[7,8,9,10])

Equipment		PPV at 25 ft (in/sec)	Approximate L_v† at 25 ft
Pile Driver (impact)	upper range	1.518	112
	typical	0.644	104
Pile Driver (sonic)	upper range	0.734	105
	typical	0.170	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Vibratory Roller		0.210	94
Hoe Ram		0.089	87
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

† RMS velocity in decibels (VdB) re 1 micro-inch/second

Source: FTA (2006)

To predict the vibration at a receptor from the operation of the equipment listed in Table 6-19, the following equation is used:

$$PPV_{equip} = PPV_{ref} \text{ x } (25/D)^{1.5}$$

where: PPV (equip) is the peak particle velocity in in/sec of the equipment adjusted for distance

PPV (ref) is the reference vibration level in in/sec at 25 feet from Table 12-2

D is the distance from the equipment to the receiver.

Table 6-20 Equipment Vibration Emission Levels

Equipment Description	Vibration Type Steady or transient	Ref PPV at 100 ft.
Auger Drill Rig	Steady	0.011125
Backhoe	Steady	0.011
Bar Bender	Steady	N/A
Boring Jack Power Unit	Steady	N/A
Chain Saw	Steady	N/A
Compactor	Steady	0.03
Compressor	Steady	N/A
Concrete Mixer	Steady	0.01
Concrete Pump	Steady	0.01
Concrete Saw	Steady	N/A
Crane	Steady	0.001
Dozer	Steady	0.011
Dump Truck	Steady	0.01
Excavator	Steady	0.011
Flat Bed Truck	Steady	0.01
Front End Loader	Steady	0.011
Generator	Steady	N/A
Gradall	Steady	0.011
Grader	Steady	0.011
Horizontal Boring Hydraulic Jack	Steady	0.003
Hydra Break Ram	Transient	0.05
Impact Pile Driver	Transient	0.2
Insitu Soil Sampling Rig	Steady	0.011125
Jackhammer	Steady	0.003
Mounted Hammer hoe ram	Transient	0.18975
Paver	Steady	0.01
Pickup Truck	Steady	0.01
Pneumatic Tools	Steady	N/A
Scraper	Steady	0.000375
Slurry Trenching Machine	Steady	0.002125
Soil Mix Drill Rig	Steady	0.011125
Tractor	Steady	0.01
Tunnel Boring Machine (rock)	Steady	0.0058
Tunnel Boring Machine (soil)	Steady	0.003
Vibratory Pile Driver	Steady	0.14
Vibratory Roller (large)	Steady	0.059
Vibratory Roller (small)	Steady	0.022
Welder	Steady	N/A
Concrete Batch Plant	Steady	N/A
Pumps	Steady	N/A
Blasting	Transient	0.75
Clam Shovel	Transient	0.02525
Rock Drill	Steady	0.011125
3-ton truck at 35 mph	Steady	0.0002

To predict the vibration at a receptor from the operation of the equipment listed in Table 6-20, the following equation is used:

$$PPV_{equipment} = PPV_{ref}\,(100/D_{rec})^{n}$$

Where:

PPV_{ref} = reference PPV at 100 ft.
D_{rec} = distance from equipment to the receiver in ft.
n = 1.1 (the value related to the attenuation rate through ground)

The closest residential receptors to the proposed quarrying and mining location are:

- Residence 1 (house): 136 metres (446 feet) south-west of the proposed quarry.
- Residence 2 (house): 345 metres (1,132 feet) south-west of the proposed quarry.

The vibration impact was predicted on these closest receptors with the use of six (6) primary pieces of equipment, including a blasting scenario (Table 6-21 and Table 6-22).

Table 6-21 Predicted vibration levels at Residence 1 in PPV in/sec and PPV mm/sec in brackets

EQUIPMENT	RECEPTOR VIBRATION
Large Bulldozer	0 (0.002)
Rock Drill	0.002 (0.054)
Dump Truck	0.002 (0.049)
Frontend Loader	0.002 (0.053)
Grader	0.002 (0.053)
Dynamite Blasting	0.145 (3.678)

For Residence 1, as seen in Table 6-21, comparing these levels with the British Standard from a human standpoint, all equipment used (except for dynamite blasting) would result in vibration which is imperceptible. From a building standpoint, the vibration levels predicted (excluding blasting) will have no effect on the building structure.

With regard to blasting, vibrations are considered to be intolerable and unacceptable for people exposed to continuous or long-term vibration of this magnitude. From a building standpoint, there is minimal potential for damage to weak or sensitive structures.

Table 6-22 Predicted vibration levels at Residence 2 in PPV in/sec and PPV mm/sec in brackets

EQUIPMENT	RECEPTOR VIBRATION
Large Bulldozer	0 (0.00006)
Rock Drill	0.001 (0.019)
Dump Truck	0.001 (0.017)

EQUIPMENT	RECEPTOR VIBRATION
Frontend Loader	0.001 (0.019)
Grader	0.001 (0.019)
Dynamite Blasting	0.052 (1.32)

For Residence 2, as seen in Table 6-22, comparing these levels with the British Standard from a human standpoint, all equipment used (except for dynamite blasting) would result in vibration which is imperceptible. From a building standpoint, the vibration levels predicted (excluding blasting) will have no effect on the building structure.

With regard to blasting, vibrations are considered to be intolerable and unacceptable for people exposed to continuous or long-term vibration of this magnitude. From a building standpoint, there is minimal potential for damage to weak or sensitive structures. Blasting is not a continuous process and therefore should be tolerable for these short periods.

Recommended Mitigation

i. Avoid night time activities. People are more aware of vibration in their homes during the night time hours.
ii. Have regular community meetings or devise a communication strategy to inform the residents of dates and times which blasting is scheduled to occur, as well as the duration.
iii. Conduct pre-project crack surveys at residences in the area so that the existing status of structures (homes and residences) is documented.
iv. Execute pre-blast tests to monitor effects, measure attenuation characteristics and minimize vibration impacts. Predictions are evaluated using actual data and adjustments are made during the blasting program. This is monitored using instruments placed at the nearest structure in every direction.

6.2.1.5 Drainage and Water Quality

i. Hope Gate formation: Exhibit extensive microkarst, local karst collapse features, and locally extensive horizontal (water-table) caves which display multiple levels of occupation. Karst Hydrology Vulnerability to contamination: Contaminants can easily enter karst aquifers through thin soils or via swallow holes (sinks). Inside the aquifer, contaminants can quickly spread over large distances, due to rapid and turbulent flow in the conduit network. Natural attenuation processes, such as filtration and retardation, are often less effective than in other aquifers.

   Water suppliers prefer water sources with stable discharge and water quality, but karst springs often show high variations of both. Periods of excellent water quality may be interrupted by short contamination events.

Recommended Mitigation:

The following are measures that may be used to prevent or minimize contamination of the karst aquifer:

a) Water pollution prevention practices include: silt fence, rock check dams, and vegetation used to control erosion from storm water run-off. The use of sediment ponds on site permits the settling of suspended particulate matter prior to discharge.
b) Within the storage areas for overburden, if deemed necessary, diversion ditches will be constructed to collect storm water run-off and direct it into sediment ponds.
c) Storm water will be treated as necessary by means of sedimentation in settling ponds. Also, used process water will be treated by means of sedimentation in settling ponds and recirculated through the processing plant after it is treated. If necessary, pit water will be pumped to a settling pond for treatment and ultimate discharge.
d) Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.

ii. Access to water: Due to the high degree of heterogeneity, it is difficult to drill a successful water supply well into a karst aquifer. In mountainous karst regions, the water table is often very deep below land surface, sometimes hundreds of metres. Karst springs are typically very large, but also quite rare. Even in humid regions, there are often large areas without any accessible water because surface water runoff and rainfall quickly infiltrate into the karst aquifer and flow to distant springs.
No Mitigation Required

6.2.1.6 Water Supply

Three options for water supply were investigated: Supply from Rio Bueno through the Dornoch Treatment Plant; Drilling an abstraction well; and Trucking water to and storing it on site. From a cost perspective, buying and storing water worked out cheaper than investing in drilling and maintaining abstraction wells. In addition, saltwater intrusion may also be an issue with drilling of wells.

A 150,000 gallon (567811.768 litres) water storage tank would be installed on property within the crushing area. Additionally, the use of a water tank on-road truck, with an approximate capacity of 20,000 litres to control the dust in the working areas and haulage roads will be a scheduled part of the daily operations. The water tank truck may load water directly from the runoff ponds or from the large storage water tank.

6.2.1.7 Wastewater Generation and Disposal

There will be the need to provide workers with showers and sanitary conveniences. The improper disposal of the wastewater generated at the proposed quarry has the potential to have a minor negative impact on groundwater, surrounding water bodies and drainage channels which lead to water bodies.

Recommended Mitigation

A wastewater treatment facility will be located on site. Details can be seen in Section 3.2.1.4.

6.2.1.8 Storage of Raw Material and Equipment

Any raw materials used will be stored onsite. There will be a potential for them to become airborne. Stored fuels and the repair of construction equipment has the potential to leak hydraulic fuels, oils etc. and/or small spills may occur.

Recommended Mitigation

i. A central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of chemicals into the sediment.
ii. Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne.
iii. Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.
iv. Raw material should be placed on hardstands surrounded by berms.
v. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff.
vi. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage.
vii. Minor spills will be immediately cleaned or contained, this is to ensure fuel and oils do not come in contact with storm water and other surface runoff. Inspections to identify area that require maintenance will be done to mitigate leaks and spills.
viii. All deteriorating equipment (pipes, valves, drums etc.) will be immediately replaced. Spill prevention structures will be implemented on site, for example; curbs, grading, elevated pads, drip pans, will be installed at servicing areas.
ix. All employees will be trained in spill prevention and response procedures. This is done to provide immediate response to spills and clean-up may commence whenever identified.

6.2.1.9 Transportation of Material

The transportation and use of heavy equipment and trucks is required during operational activities. Trucks will transport materials from site to port. This has the potential to directly impact traffic flow along the Queens Highway main road.

Recommended Mitigation

i. Adequate and appropriate road signs should be erected to warn road users of the activities. For example, reduced speed near the entrance to the site.
ii. Raw materials should be adequately covered within the trucks to prevent any escaping into the air and near the roadway.
iii. The trucks should be parked on the proposed site until they are ready to go to port.
iv. The use of flagmen should be employed to regulate traffic flow where necessary
v. It should also be considered that the crushed material be transported by conveyor to the plant or to key points and not by trucks. These measures should substantially reduce the traffic as well as dust emissions.

6.2.2 Biological

6.2.2.1 Flora

Dust is normally generated as a result of blasting, loading and vehicle movement in the quarry. The major environmental hazard from the quarry, especially on the flora surrounding the site, is the effect of dust (Lameed & Ayodele 2010).

Dust particles have the potential to block and damage the stomata of plants, impairing photosynthesis and respiration. Other effects are shading and light scattering by airborne particulates, which may also lead to a reduction in photosynthetic capacity. Over time even the cuticles and underlying layers may become worn due to abrasion (Lameed & Ayodele 2010; Langer 2001). Airborne pollutants will be produced at the quarry and these may get deposited on the plants and affect their physiology; leading to retarded growth and death (Lameed & Ayodele 2010).

Recommended Mitigation

i. It should be investigated if the mechanical crusher to be employed can accommodate a filter-system.
ii. It should also be considered that the crushed material be transported by conveyor to the plant or to key points and not by trucks. These measures should substantially reduce the dust emissions; however, it is understood that some vehicular movement around the site will be necessary.
iii. Water (recycled if possible) should also be used for dust suppression where required.
iv. Vegetation and soil should be removed together (mixed) so that the plant matter helps to hold the soil. Alternatively, vegetation can be stripped and stockpiled and then spread over the newly made stockpiles of soil.
v. Where practical, rehabilitation of the quarry should be progressive: proceeding after the closure of mined out sections.
vi. In terms of aesthetics, natural vegetation surrounding the quarry should be retained (such as in a buffer area) so as to help minimise dust emissions.
vii. Vegetation should only be cleared where it is absolutely necessary for operation.
viii. As the quarry expands, the time between clearing and quarrying should not be protracted.
ix. When trucking material it should be covered for the duration of the trip and when idle.

6.2.2.2 Fauna

Fauna (invertebrates, birds, reptiles) on and surrounding the proposed quarry site may be disturbed and displaced due to noise, dust and vibration from quarrying activities such as blasting, haul trucks, crushing and other activities.

Recommended Mitigation

Due to its rare sightings and conservation significance, signage showing photographs of the butterfly *Marpesia chiron* should be placed at various locations around the site so that it can be identified easily and if observed, it can be reported to the biodiversity branch at NEPA. Sensitization and education of employees on site re *Marpesia chiron* should be conducted by qualified personnel (from NEPA or other).

6.2.3 Human/Social/Cultural

6.2.3.1 Employment

There is the potential for employment during the operational phase. It is anticipated that between 50-100 persons will be employed to the quarry operations. This includes, quarry managers, truck drivers, machinery operators, maintenance workers, office attendants, secretary's accountants, procurement officers, security guards will be employed directly for operations. It is anticipated that some labourers will be from sourced from nearby communities.

Recommended Mitigation

No mitigation available.

6.2.3.2 Aesthetics

The most conspicuous impact any quarry is the scaring of the landscape caused by the large-scale removal of material. The visual and aesthetic impacts are inherent to the quarry developments and are to some extent unavoidable. Nevertheless, these impacts can be significantly mitigated through a smart design of the quarry and a restoration program that is implemented in step with the quarrying development. The main receptors for this type of impact would be the public which uses the Highway Corridor and the owners and occupants of the resort / residential development of the Bengal subdivision.

A buffer zone is proposed to minimize the visual and aesthetic impacts of the proposed quarry for these receptors. The eastern section of the cliff, along the Queen's Highway up to the eastern boundary of the Old Quarry, is located in the proposed buffer zone and will not be touched by the quarry operations.

All quarrying activities even in the later phases of the quarry development will take place behind the cliff and will not be visible from anywhere along the highway corridor or from the Bengal subdivision. The closed processing facility in front of the cliff is also located in the buffer zone. That entire area will not only be excluded from the proposed quarry operation but is also slated for restoration to its natural state. The escarpment associated with the 15m terrace level near the NW boundary of the property, is located in the buffer zone and will not be modified by the quarry operation. The escarpment and its vegetation form a visual barrier blocking the view of the old quarry from the highway corridor.

Recommended Mitigation

To maintain the scenic value of the western section of the corridor the quarry operators will also have to be careful with the height and location of the infrastructure they may deploy in the old quarry area and verify that there is no view shed infringement for potential receptor in the highway corridor and the Bengal subdivision. Appropriate camouflage techniques could be used when infringement is unavoidable. Overall, if the buffer zone is adhered to and dust emission is adequately controlled, the quarry development is expected to have no significant impact on the scenic quality of the highway corridor.

6.2.3.3 Health and Safety Concerns

Public Health Issues

Fugitive dust has the potential to affect the health of the resident population. In addition, the quarry's location along the main thoroughfare (Queens Highway) increases the risk of accidents on this stretch of road during peak hours.

RECOMMENDED MITIGATION

Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.

Consideration should be given to putting in place a conveyor system. This would transport material from the site to the port that is located less than a kilometre away: Further reducing traffic congestion and the risk of traffic accidents.

Occupational Health and Safety

Workers will be exposed to high noise and dust levels during quarry operations.

RECOMMENDED MITIGATION

Workers operating equipment that generates noise should be equipped with noise protection. A guide is workers operating equipment generating noise of ≥ 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.

Where unavoidable, workers working in dusty areas should be provided and fitted with N95 respirators.

7.0 RESIDUAL AND CUMULATIVE ENVIRONMENTAL IMPACTS

7.1 RESIDUAL IMPACTS

Sections 6.0 (Identification and Assessment of Potential Direct and Indirect Impacts and Recommended Mitigation) described the potential impacts that would occur as a result of different phases of the project and how the proposed mitigation measures would contribute to minimising or eliminating the impacts. Not all impacts can be fully mitigated and therefore residual impacts will be experienced by the environmental and social receptors affected by the project.

7.1.1 Site Preparation and Construction

7.1.1.1 Noise

The proposed project has the potential to be a noise nuisance during the site preparation and construction phase. Even with the proper mitigative steps, short-term noise impacts of varying duration such as blasting which is a high-noise activity, as well as the general movement of heavy equipment and trucks will be a nuisance to nearby residential communities.

7.1.1.2 Air Quality

Fugitive dust has the potential to affect the health of the resident population and the surrounding vegetation. Both types of impacts will be of moderate intensity but of relatively short duration.

7.1.1.3 Heritage and Cultural

The proposed project area has very dense vegetation cover. When this vegetation is removed from the proposed site, there is a probability of finding prehistoric and historic cultural material. However, there is the possibility that they may be destroyed by heavy machinery and equipment during the site clearance process. Care should be taken during land clearance and the site preparation stages so that any historical artefacts observed can be recovered by the JNHT.

7.1.2 Operation

7.1.2.1 Noise

The proposed project has the potential to be a noise nuisance during the operational phase. Even with the proper mitigative steps, short-term noise impacts of varying duration such as blasting which is a high-noise activity, will be a nuisance to nearby residential communities.

7.1.2.2 Socioeconomic

Unmet Employment Expectations

Because of the high unemployment rate in the island in general, residents in directly affected communities who are unsuccessful in their job application are likely to become frustrated when they do not gain employment on the proposed project. This could create resentment and possibly hostility towards those who are successful in getting jobs, and even towards the Client.

Accidents involving community members

The possibility exists that accidents involving community members will occur at some stage during site preparation or operation. This could be traffic-related, blasting-related or other accidents. A residual impact is created in terms of diminishing the standard of living for a person, negatively impacting his or her household.

7.1.2.3 Closure

Mining is an intrinsically destructive process where there are a number of environmental impacts that remain after a project site has been mined such as erosion, siltation of watercourses and permanent visual effects (“scarring”). Although land can rarely be returned to its former state, efforts should be made to address potential residual impacts during the closure process. A Quarry Rehabilitation Plan must be developed in order to address this.

Historically, rehabilitation was typically limited to the removal of equipment following the termination of activities. This proved unacceptable from a community and environmental standpoint. Some measures to employ during closure to assist with this are:

- Operations are ended efficiently and cost effectively – all infrastructures and equipment should be removed from site;
- All proposed extractive development proposals must be accompanied by a detailed restoration plan;
- The site is rehabilitated and returned to a safe and stable state – Native species of trees and shrubs should be planted to create food reserves for wildlife; tree, hedgerow and under-storey planting enhances visual amenity;
- The final land use conforms to the concept of sustainable development.

7.1.2.4 Aesthetics

There are various mitigation measures that can be employed, across a range of timescales, to mitigate the potential impacts of the proposed quarry on the landscape and visual amenity. The long-term mitigation measures will include restoring the landscape to enhance character and visual amenity.

7.2 CUMULATIVE IMPACTS

7.2.1 Air Quality

As part of the air dispersion modeling analyses, a determination of the cumulative impact on ambient air quality of the nearby and the proposed quarry's air pollutant sources was made. Table 7-1 shows the model results for the proposed quarry and the All Sources category. The results for the 'All Sources' category revealed maximum predicted concentrations that exceed the 24h and annual TSP and PM_{10} ambient air quality standards.

It should be observed that the predicted concentrations for TSP and PM_{10} are identical since all PM_{10} data were assumed as TSP. Additionally, based on the prevailing measured TSP and PM_{10} ambient air quality concentrations highlighted in Table 4-4 and Table 4-5, it may be deduced that the model may have over-predicted the maximum concentrations. It could be also inferred that the use of the USEPA AP42 emission factors in determining the emission rates for the dryers at the Noranda facility, may have resulted in the over-estimation of the emission rates, and hence the consequent maximum predicted concentrations.

Table 7-1 Model Results – Proposed Quarry and All Sources

Pollutant	Avg. Period	Recommended Background (µg/m³)	Jamaican NAAQS (µg/m³)	Proposed Quarry Sources			All Sources		
				Max Conc (µg/m³)	UTME (m)	UTMN (m)	Max Conc (µg/m³)	UTME (m)	UTMN (m)
TSP	24-hr	43	150	70.1	241372	2044220	**3948.8**	243172	2042620
	Annual	20	60	19.7	241431.85	2044290.65	**191.1**	242972	2042820
PM_{10}	24-hr	25	150	31.8	241772	2043920	**3948.8**	243172	2042620
	Annual	13	50	7.1	241431.85	2044290.65	**191.1**	242972	2042820

Bold type indicate exceedance above the standard or Guideline Concentration

7.2.2 Noise Levels

The calculated cumulative noise levels depicted in Table 7-2 indicated that Stations 6, 8 and 9 were non-compliant with the NEPA Day Time noise standard. These stations are located in residential areas. It is important to note that all three stations baseline noise levels were all exceeding the NEPA Day Time noise standards (Table 7-2). The change in the baseline noise levels are more relevant at these stations since they are already in non-compliance. The IFC 3 dBA rule would apply, which states that the change in the ambient noise levels at the nearest receptor (in this instance Station 8) should not exceed 3dBA to be considered compliant. A 3-dBA increase is a doubling of the noise level due to the logarithmic scale. The results in Table 7-2 is compliant with this rule.

If this is extended to Station 5 which is also a residential area, the change was 4.1 dBA which would be non-compliant. Therefore, additional mitigation may be required. In the interim discussions should be had with the owner of the property and also noise monitoring should be conducted to verify if the operations of the quarry are having a negative impact on the noise climate at the location. This is necessary as the noise model is conservative.

Table 7-2 Predicted cumulative LAeq with mitigation measures during Quarry Operations compared with the NEPA Day Time Standard and changes in baseline (ambient) noise levels

STATION	BASELINE LAeq (16hr)	PREDICTED LAeq (12hr)	PREDICTED CONCAWE SW LAeq (12hr)	CUMULATIVE (dBA)	CUMULATIVE CONCAWE SW (dBA)	NEPA DAY TIME STD. (dBA)	ABOVE NEPA STD. (dBA)	ABOVE NEPA STD. CONCAWE SW (dBA)	CHANGE IN BASELINE NOISE LEVELS (dBA)	CHANGE IN BASELINE NOISE LEVELS CONCAWE SW (dBA)
1	46.2	53.3	58.9	54.1	59.1	75	-	-	+7.9	+12.9
2	N/A	75.2	78.6	75.2	78.6	75	0.2	3.6	N/A	N/A
3	45.1	71.5	74.8	71.5	74.8	75	-	-	+26.4	+29.7
4	45.3	56.5	57.7	56.8	57.9	75	-	-	+11.5	+12.6
5	43.6	45.5	39.8	47.7	45.1	55	-	-	+4.1	+1.5
6	56.8	34.8	21.9	56.8	56.8	55	1.8	1.8	0.0	0.0
7	51.4	44.5	40.4	52.2	51.7	55	-	-	+0.8	+0.3
8	57.2	53.2	55.0	58.7	59.2	55	3.7	4.2	+1.5	+2.0
9	59.3	51.2	54.8	59.9	60.6	55	4.9	5.6	+0.6	+1.3

NB: Numbers in blue represents anticipated cumulative noise as there was no baseline noise measurements due to failure of the noise meter.
Numbers highlighted in red are non-compliant with NEPA Day Time standards

8.0 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

8.1 BACKRGOUND

The discussion and analysis of alternatives in Environmental Impact Assessments should consider other practicable strategies that will promote the elimination of negative environmental impacts identified. This section is a requirement of the National and Environment and Planning Agency (NEPA) and is critical in consideration of the ideal development with minimal environmental disturbance.

This report has identified the major environmental impacts, both adverse and beneficial noted by scientific experts. The project team and the consulting scientists worked together, utilizing findings of these impacts to analyse possible options for the final project. In addition to examining the advantages and disadvantages of potential project alternatives over that which is proposed, the ability to meet project objectives and the feasibility of each were additional evaluation criteria.

The alternatives listed below are discussed in detail in subsequent subsections:

1) The “No-Action” Alternative
2) The Project as Proposed as described in the EIA
3) The Project as Proposed but allowing for removal and relocation of some flora.
4) The Project as Proposed but only using specific areas for quarrying and mining purposes.
5) Use of the Proposed Project site for Eco-Tourism related activities.
6) Declaration of the proposed site as a private forest reserve under the Forest Act, 1996.
7) The Project as Proposed with conversion into a Renewable Energy Source upon decommissioning.

8.2 DESCRIPTION OF ALTERNATIVES

8.2.1 No Action Alternative

The “no action” alternative is required to ensure the consideration of the original environment without any development/altering. This is necessary for the decision-makers in considering all possibilities.

Positive Impacts:

This option is one which would allow the core dry limestone forest to remain as is and in so doing protect the endemic and threatened species within. It would also protect and preserve the ecosystem services provided by the forest within the proposed site. Ecosystem services includes, among other things, the provision of habitat for fauna, carbon sequestration, provision of oxygen, filtration of water draining to the sea and subsequent reef systems.

Negative Impacts:

- Inability to meet demand for construction aggregates in the north-western end of the island.
- Loss of potential employment opportunities.

8.2.2 The Project as Proposed as described in the EIA

Previous mining operations conducted on the project property by Jose Cartellone Civiles S.A. yielded material that was used for the construction of The Queens Highway leg of the North Coast Highway from Montego Bay to St. Ann's Bay. Though not suitable for wearing course applications, the road base and fill applications requires strong, resistant material for the road type that was constructed. With its use in construction already illustrated, the proponent seeks to further extract material from this area for applications within this area and other value-added applications. Due to its high calcium carbonate composition, this deposit has far greater value than mere aggregate usage. This realization has stimulated the proponents, Jamaica World Mining, to further pursue a quarry licenses for its extraction.

The area proposed for a limestone quarry is based on the extent of limestone deposits, land ownership and the operational feasibility for the area of interest. With the chemical and physical quality of material here found to be amongst the highest for limestone on island, its extraction and utilization for aggregates and value-added applications would be significantly profitable.

Positive Impacts:

- Ability to meet demand for construction aggregates in the north-western end of the island.
- Potential employment opportunities.

Negative Impacts:

The disadvantages of this option would include resultant habitat loss of the core dry limestone forest and all endemic, rare and threatened species within. Ecosystem services provided by the dry limestone forest (such as the provision of habitat for fauna, carbon sequestration, provision of oxygen, filtration of water draining to the sea and subsequent reef systems) would also be lost.

8.2.3 The Project as Proposed, but allowing for removal and relocation of some flora

This alternative would include the project as proposed but allowing for removal and relocation of rare and threatened floral species to the adjoining dry limestone forest outside of the project footprint.

Positive Impacts:

This would allow these threatened, rare and endemic species to continue to thrive within the dry limestone forest.

Negative Impacts:

This option, however, is very difficult because of the substrate which renders the removal of some of these species impossible, without damage and loss. This action would require much patience and meticulous removal for species rooted in the limestone substrate. The substrate itself would have to be removed as part of the individual organism, with the rooting and base intact. In addition, the justification for this would be the assumption that the species within the project footprint are also within the adjoining dry limestone forest and in similar healthy numbers and populations.

8.2.4 The Project as Proposed, but only using specific areas for quarrying and mining purposes

This alternative explores the project as proposed, but only using the Disturbed Northern Boundary sub-area and Savanna-like south-western boundary sub-area for quarrying and mining purposes (Figure 8-1, Table 8-1).

Table 8-1 Bounding coordinates (approximate) of core dry limestone forest to be left intact in project alternative "The Project as Proposed, but only using specific areas for quarrying and mining purposes"[4]

	X	Y
1	703280.465345	702690.943082
2	703324.428156	702706.027046
3	703336.151760	702710.164788
4	703362.012736	702720.074134
5	703383.005820	702727.860280
6	703425.476160	702744.085446
7	703457.902922	702764.375693
8	703462.612944	702766.728909
9	703545.603961	702773.153494
10	703490.961313	702445.297606
11	703408.064427	702484.586581
12	703232.096830	702456.429975
13	703146.718670	702445.402789
14	703019.302107	702380.700297
15	702856.641624	702325.422578
16	702671.643544	702252.746418
17	702674.670520	702471.444774
18	702697.065187	702582.100778
19	702745.366960	702590.877140
20	702761.759248	702596.219412
21	702790.531763	702607.429194
22	702812.864146	702618.514959
23	702890.537069	702636.050321
24	702982.885064	702571.107081
25	703047.520574	702526.518848
26	703100.966048	702509.786185
27	703221.033856	702587.822336
28	703241.649213	702626.290665
29	703238.325579	702678.560430
30	703258.774251	702686.876002

Positive Impacts:

The northern area is already a mined-out quarry that was operational in past years. Evidence also shows that it is a dump site for industrial, domestic and agricultural waste. The south western savanna-like area is predominantly grassy with interspersed shrubs and trees and is without any endemic, rare or threatened species. Species loss and loss of ecosystem services will therefore be minimal with this alternative. The core dry limestone forest would be left intact and undisturbed with the transitional area acting as a buffer zone to the south-western end and the ridge acting as a buffer on the northern side of the proposed site.

Negative Impacts:

Because of the reduced mining area, there would be less material to be mined from operations and possibly less employment opportunity.

[4] These are approximate locations given that the exact extent of the dry limestone forest was not mapped with a GPS in the field.

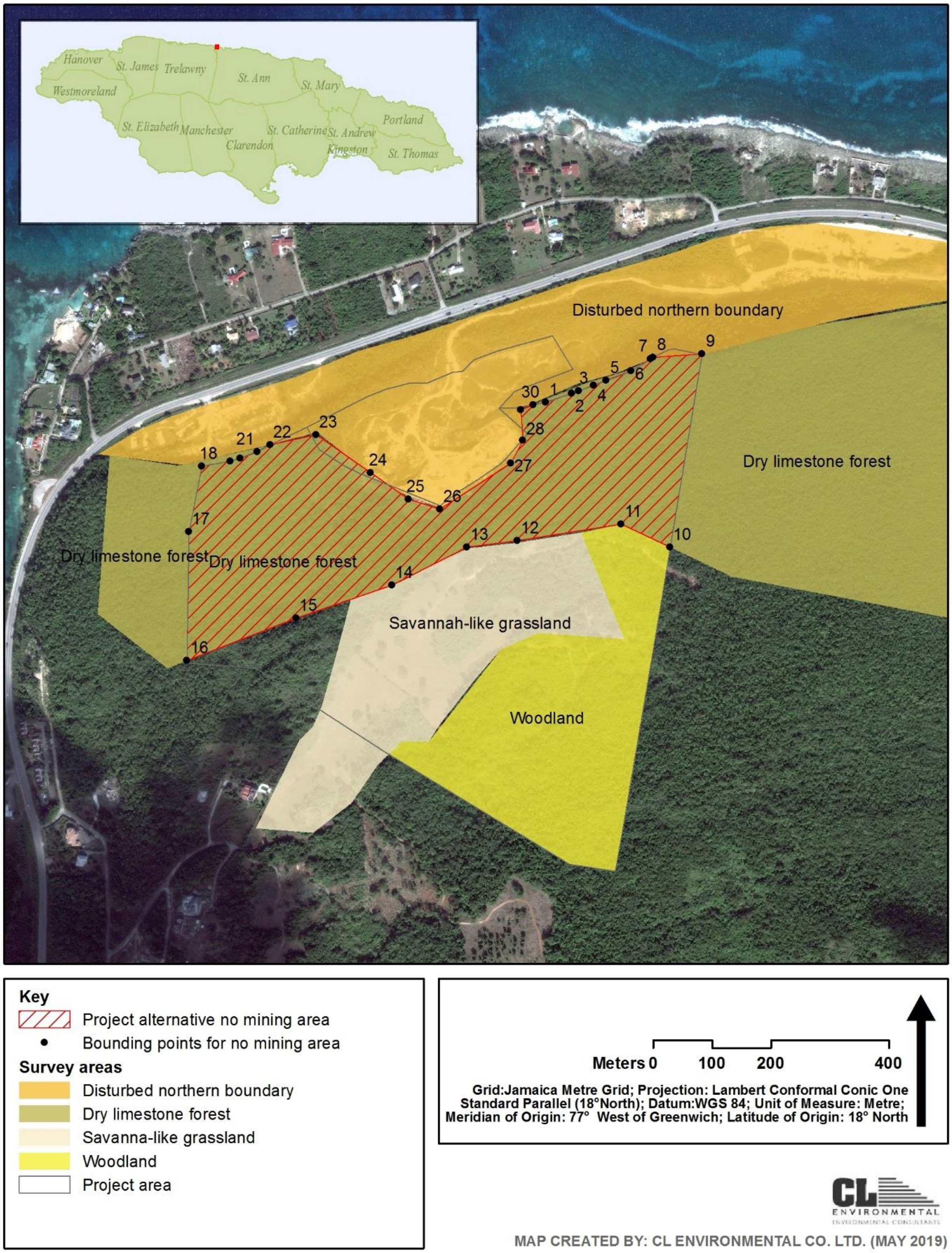


Figure 8-1 Project alternative "The Project as Proposed, but only using specific areas for quarrying and mining purposes" showing approximate extent of core dry limestone forest within project area as a no mining zone

8.2.5 Use of the Proposed Project site for Eco-Tourism related activities

This alternative explores the use of the proposed site as a site for eco-tourism related activities such as hiking, birdwatching and zip lining. The terrain is conducive to hiking and the topography is conducive to zip lining.

Positive Impacts:

As a result, the core dry limestone forest would be left intact and undisturbed. Figure 4-57 illustrates the boundary of the limestone forest. Other already disturbed areas such as the northern boundary could be used as locations for necessary facilities such as buildings, bathrooms, refreshment areas, car park etc.

Negative Impacts:

- Inability to meet demand for construction aggregates in the north-western end of the island.

8.2.6 Declaration of the proposed site as a private forest reserve under the Forest Act, 1996

This alternative explores the use of the proposed project site as a private forest reserve under the Forest Act of 1996.

Positive Impacts:

Not only would the core dry limestone forest be left intact and undisturbed, but a detailed rehabilitation exercise could be undertaken for the disturbed mined-out northern boundary area.

Negative Impacts:

- This rehabilitation exercise will require major funding.
- Inability to meet demand for construction aggregates in the north-western end of the island.
- Loss of potential employment opportunities.

8.2.7 The Project as Proposed, with conversion into a Renewable Energy Source upon Decommissioning

This alternative would include the project as proposed. Upon completion of mining and quarrying operations, the site would be rehabilitated according to the Rehabilitation Plan as outlined in the EIA document. The site would then be used for renewable energy projects, for example, solar energy or wind energy or a combination of both.

Positive Impacts:

- Ability to meet demand for construction aggregates in the north-western end of the island.
- Potential employment opportunities.
- Use of renewable energy sources for power generation resulting in decreased carbon footprint and reduced greenhouse gas emissions.

- Sustainable energy production in keeping with the country's Vision 2030 goal of reduced dependency on fossil fuels.

Negative Impacts:

- The disadvantages of this option would include resultant habitat loss of the core dry limestone forest and all endemic, rare and threatened species within. Ecosystem services provided by the dry limestone forest (such as the provision of habitat for fauna, carbon sequestration, provision of oxygen, filtration of water draining to the sea and subsequent reef systems) would also be lost, despite rehabilitation of the site upon completion of mining and quarrying operations.

8.3 THE PREFERRED ALTERNATIVE

The preferred alternative is the Project as proposed with conversion into a renewable energy source upon decommissioning (outlined in Section 8.2.7).

9.0 ENVIRONMENTAL MANAGEMENT AND MONITORING

An Environmental Management System (EMS) is an important tool which can be used to assist operations managers in meeting current and future environmental requirements and challenges. It can be used to measure a company's operations against environmental performance indicators, thereby helping the company to reach its environmental targets. A good management system will integrate environmental management into a company's daily operations, long-term planning and other quality assurance systems.

It is therefore recommended that several parameters be monitored before, during, after the project implementation and during decommissioning/closure, to record any negative impacts and to propose corrective or mitigation measures. The suggested parameters include but not limited to the following:

1) Water quality to include but not be limited to:
    a. pH
    b. electrical conductivity
    c. turbidity
    d. BOD
    e. COD
    f. Total Suspended solids (TSS)
    g. Grease and Oils
    h. Faecal Coliform
    i. Nitrates and Phosphates
2) Noise
3) Dust (PM_{10})
4) Traffic
5) Solid Waste Generation and Disposal
6) Sewage Generation and Disposal
7) Equipment Maintenance

9.1 PHASED RECOMMENDATIONS

9.1.1 Site Preparation and Construction Phase

- Daily inspections to ensure that site clearance and preparation activities are not being conducted outside of regular working hours (e.g. 7 am – 7 pm). In addition, a one-off noise survey should be undertaken to determine workers exposure and construction equipment noise emission.
  The Client's project engineer / site supervisor should monitor the work hours. NEPA should conduct spot checks to ensure that the hours are being followed.

- Daily inspection of site clearance activities to ensure that they are following the proposed plan and to ensure that site drainage system are not impacting on any waterways. Check and balance can be provided by NEPA.
  Person(s) appointed by NWA may perform this exercise.
- Undertake monthly water quality monitoring to ensure that the site clearance works are not negatively impacting the aquatic environment quality. The parameters that should be monitored are temperature, salinity, dissolved oxygen, pH, turbidity, TDS, BOD, nitrate, phosphate, total suspended solids, FOG and faecal coliform. This is estimated to cost approximately **J$200,000** per sampling event. NEPA will determine the frequency of sampling.
- Daily monitoring to ensure that the activity is not creating a dust nuisance. The Client's project engineer / construction site supervisor should monitor the site clearance. Particulate measurements should be taken especially during the excavation activity and compared with the baseline data outlined in this report to ensure that residents or workers are not being exposed to excessive dust. NEPA should conduct spot checks to ensure that this stipulation is followed. This is estimated to cost approximately **J$280,000** per sampling event. NEPA will determine the frequency of sampling.
- Background readings should be taken of all water quality parameters prior to site clearance. Readings should be conducted monthly.
- Conduct daily inspections to ensure that flagmen where necessary are in place and that adequate signs are posted along the roadways where heavy equipment interact with existing roads. This is to ensure that traffic have adequate warnings and direction.
- Undertake daily assessment of the quantity of solid waste generated and keep records of its ultimate disposal. Additionally, solid waste generation and disposal of the campsite should also be monitored.
- 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.
- 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.
- Traffic should be monitored to ensure approved traffic management plans at critical areas are being followed. NEPA and The Client should perform spot checks to ensure compliance. Monitoring should be conducted daily to ensure major disruption to the public transport is avoided. Reports should be made to The Client on a fortnightly basis.
- Where possible, construction crews should be sourced from within the study area. This will ensure that the local community will benefit from the investment.
- Ensure proper training of staff members and that personal protective equipment (PPE) is supplied and utilized throughout the process.

9.1.2 Operational Phase

- During operation noise, dust and water quality monitoring should be conducted on a quarterly basis. Noise monitoring is estimated to cost approximately **J$375,000** per sampling event. Dust monitoring is estimated to cost approximately **J$280,000** per sampling event. Water quality monitoring is estimated to cost approximately **J$200,000** per sampling event.
- Ensure proper training of staff members and that personal protective equipment (PPE) is supplied and utilized throughout the process.
- Where possible, staff members and tradesmen and equipment (trucks and heavy equipment used) should be sourced from within the study area. This will ensure that the local community will benefit from the investment.
- 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.
- Inspections to ensure that quarrying and operational activities are not being conducted outside of regular working hours.

9.1.3 Decommissioning/Closure Phase

- Ensure notification to relevant local and government authorities of change in status of the facility (from Operational to Closed).
- Ensuring adherence to the Re-vegetation and Rehabilitation Plan. Person(s) appointed by The Client may perform this exercise. NEPA should conduct spot check to ensure that this stipulation is followed.
- Monitoring of the levelling and stabilizing of the rock faces as well as reclamation of mined out pits using overburden material. Person(s) appointed by The Client may perform this exercise. NWA should conduct spot check to ensure that this stipulation is followed.
- Conduct daily inspections to ensure that flagmen where necessary are in place and that adequate signs are posted along the roadways where heavy equipment interact with existing roads. This is to ensure that traffic have adequate warnings and direction. Signage will be clearly posted at the entrance of the facility alerting the public that the facility is “Closed” and the area is “Restricted.”
- Undertake daily assessment of the quantity of solid waste generated and keep records of its ultimate disposal. Person(s) appointed by The Client may perform this exercise. NEPA should conduct spot check to ensure that this stipulation is followed.
- Ensure only authorized licenced scrap metal dealers are hired to collect scrap metal debris.
- Ensure that a Health Safety Security and Environment (HSSE) orientation of all personnel is performed before the decommissioning activities commence.
- Ensure that personal protective equipment (PPE) is supplied and utilized throughout the closure process.

9.2 DRAFT EMP REPORTING REQUIREMENTS

9.2.1 Noise Assessment

9.2.1.1 Ambient

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 (Leq), Lmin and Lmax and wind speed and 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. Evaluation of data, discussions and statement giving a professional opinion of the noise impact of the quarry.

The report shall be submitted to the Client or his designate within two weeks after completion of testing.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that emissions do not meet the required criteria (NRCA Noise Guidelines), 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 for a minimum of three years.

9.2.2 Air Emissions

It is recommended that a PM_{10} monitor be installed downwind of the proposed facility, possibly at the location of the highest predicted maximum PM_{10} concentration. The purpose of the monitor would be to measure PM_{10} concentration throughout the life of the quarry facility in order to track the effectiveness of the watering control for the haul roads.

The report will summarize the results of ambient air quality monitoring.

i. Dates, times and places of test.
ii. Test Methods used.
iii. Copies of instrument calibration certificates.
iv. A defined map of each sampling location with distance clearly outlined in metric
v. Evaluation of data, discussions and statement giving a professional opinion of the impact of the quarry.

The report shall be submitted to Client or his designate within four weeks after completion of testing.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that emissions do not meet the required criteria (NRCA Ambient Air Quality Particulate Matter Guidelines), 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.

9.2.3 Water Quality

A report shall be prepared by the Contacted party. It shall include the following data:

i. Dates, times and places of test.
ii. Weather condition.
iii. A defined map of each location with distance clearly outlined in metric.
iv. Test Method used.
v. Parameters measured
vi. Results
vii. Conclusions

The report will be submitted to the Client or his designate within two weeks of the monitoring being completed.

The Client shall distribute the report within four (4) weeks of testing being completed to NEPA.

In the event that the water quality does not meet the required criteria (NRCA Groundwater and/or Ambient Freshwater Guidelines), 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.

9.2.4 Other Monitoring Aspects

Other EMP monitoring aspects will include:

1) Traffic (presence and effectiveness of flagmen and appropriate warning and safety signage)
2) Solid Waste Generation and Disposal (ticketing system, daily quantities etc.)
3) Sewage Generation and Disposal (ticketing system, ratio of portable toilets per worker)
4) Equipment Maintenance (to be done on hardstands etc.)

10.0 REFERENCES

Adams, C.D. 1972. Flowering plants of Jamaica. University of the West Indies. 848 pp.

Air Quality Consultants Limited. December 2014. *Stack Emission Test Report for Noranda Jamaica Bauxite Partners*.

Auer, A.H., 1978. *Correlation of Land Use and Cover with Meterological Anomalies*. Journal of Applied Meterology, 17:636-643

Brown, F.M. and B. Heineman. 1972. Jamaica and its butterflies. E.W. Classey, London. 478 pp.

Collins, N.M. and M.G. Morris. 1985. Threatened swallowtail butterflies of the world. The IUCN Red Data Book. IUCN. 401 pp.

Davis, Claude. November 2006. *Natural Resources Conservation Authority Ambient Air Quality Guideline Document*.

Downer, A. and R. Sutton. 1990. Birds of Jamaica. Cambridge: Cambridge University Press. 152 pp.

Dudley, R. and R.B. Srygley. 2008. Airspeed adjustment and lipid reserves in migratory neotropical butterflies. Functional ecology, 22: 264–270.

Frank, H. and L.P. Lounibos. 2009. Insects and allies associated with bromeliads: a review. Terrestrial Arthropod Reviews. 1: 125-153.

Garraway, E. and A.J. Bailey. 2005. Butterflies of Jamaica. Mcmillan Caribbean. 122 pp.

Garraway, E., A.J.A. Bailey, T. Farr and J. Woodley. 1993. Studies on the Jamaican Kite Swallowtail , *Eurytides* (*Protesilaus*) *marcellinus* (Lepidoptera: Papilionidae). Tropical Lepidoptera 4: 151-154.

Geological Survey Department. *Jamaica Metric Grid Map for Kingston*

Hedges, B., S. Koenig, and B. Wilson. 2004. *Eleutherodactylus grabhami*. The IUCN Red List of Threatened Species 2004:e.T56625A11508558.http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.*T56625A11508558*.en. Accessed on March 20, 2016.

Hedges, B., S. Koenig, and B. Wilson. 2004. *Eleutherodactylus jamaicensis*. The IUCN Red List of Threatened Species 2004: e.T56681A11504189.http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T56681A11504189.en. Accessed on March 20, 2016.

Hedges, B., S. Koenig, and B. Wilson. 2004. *Osteopilus crucialis.* The IUCN Red List of Threatened Species 2004: e.T55807A11366434. http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T55807A11366434.en. Accessed on March 20, 2016.

Johnson, N.F. and C.A. Triplehorn. 2005. Borror and DeLong's introduction to the study of insects. Brooks Cole. 888 pp.

Kapos, V. 1986. Dry limestone forests of Jamaica. In Forests of Jamaica. Ed. D.A. Thompson, P.K. Bretting and M. Humphreys. JSST, Kingston, Jamaica.

Kitching. R.L. 2001. Food webs in phytotelemata: "Bottom-Up" and "Top-Down" Explanations for Community Structure. Annual Review of Entomology. 46: 729-760.

Lakes Environmental Software. 1996-2016 *User's Guide for ISC-AERMOD View*.

Lewis, C.B. 1954. *Papilio marcellinus* (= *Papilio sinon*) in 1954. Nat. Hist. Notes, Nat. Hist. Soc. Jamaica (Kingston). 7: 114.

MBJ Airports Limited, 2016. Airport Facts & Statistics. [Online] Available: http://www.mbjairport.com/history-facts [Accessed 1 April 2016]

Murphy, C. 2004. The Taxonomy and Biodiversity of Jamaica's Arctiid moths. University of the West Indies, Mona. 785 pp.

National Environment & Planning Agency. March 2013. The *Annual Ambient Air Quality Report 2012*.

National Environment & Planning Agency. March 2012. The *Annual Ambient Air Quality Report 2011*.

National Environment & Planning Agency. March 2011. The *Annual Ambient Air Quality Report 2010*.

Raffaele, J. 1998. A Guide to the Birds of the West Indies. Princeton University Press. 511 pp.

Riley, N.D. 1975. A field guide to butterflies of the West Indies. Collins, London. 224 pp.

Rosenberg G. and Igor V. Muratov 2006. Status Report on the Terrestrial Mollusca of Jamaica. Proceedings of the Academy of Natural Sciences of Philadelphia. 155: 117-161

Schwartz A. and R.W. Henderson. 1988. West Indian Amphibians and Reptiles: A checklist. Milwaukee Public Museum, Contributions in biology. No. 74.

Smith, D.S., L.D. Miller, and J.Y. Miller. 1994. The Butterflies of the West Indies and South Florida. Oxford University Press. 264 pp.

Southern Regional Health Authority, a. Health Center Clasification. [Online] Available: http://www.srha.gov.jm/?page_id=25

Southern Regional Health Authority, b. Hospital Clasification. [Online] Available: http://www.srha.gov.jm/?page_id=137

Srygley, R.B., Dudley, R., E.G. Oliveira and A.J Riveros. 2014. El Nino, Host Plant Growth, and Migratory Butterfly Abundance in a Changing Climate. Biotropica, 46: 90–97.

Thé, J.L., Lee, R., and Brode, R.W. *Worldwide Data Quality Effects on PBL Short-Range Regulatory Air Dispersion Models*

United States Environmental Protection Agency. 1985. *Guideline for Determination of Good Engineering Practice Stack Height*, EPA-450/4-80-023r, June, 1985

United States Environmental Protection Agency. 1995a. *User's Guide to the Building Profile Input Program*. EPA-454/R-93-038, U.S. EPA, Research Triangle Park, NC

U.S. Geological Survey. December 2015. *Global Data Explorer* – Shuttle Radar Topography Mission Data.

U.S. Environmental Protection Agency, 1998. *Revised Draft User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*. U. S. Environmental Protection Agency, Research Triangle Park, NC.

United States Environmental Protection Agency. January 1995. *Metallic Minerals Processing*. Chapter 11.24, AP42 Document

United States Environmental Protection Agency. August 2004. *Crushed Stone Processing and Pulverized Mineral Processing*. Chapter 11.19.2, AP42 Document

United States Environmental Protection Agency. November 2006. *Unpaved Roads*. Chapter 13.2.2, AP42 Document

U. S. Environmental Protection Agency, 2006. *Addendum User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*. EPA-454/B-03-002. Office of Air Quality Planning and Standards, Research Triangle Park, NC

Western Regional Health Authority, a. Western Regional Health Authority Profile. [Online] Available: http://www.wrha.gov.jm/content/wrha_profile.html

Wunderle, J. M. 1994. Census methods for Caribbean land birds. Gen. tech, S0-98

11.0 APPENDICES

Appendix 1 – Terms of Reference

TERMS OF REFERENCE
For An
ENVIRONMENTAL IMPACT ASSESSMENT

For The

Proposed Quarrying and Mineral Processing

At

Rio Bueno Quarry, Dry Harbour Mountain, Discovery Bay, St. Ann

By

Bengal Development Limited

NATIONAL ENVIRONMENT & PLANNING AGENCY
NOV 20 2015
REGISTRY

Date: 10 November 2015
Submitted by: Denise Forrest/Forrest & Associates
Prepared by: Denise Forrest

TABLE OF CONTENTS

NATIONAL ENVIRONMENT & PLANNING AGENCY REGISTRY NOV 20 2015

Foreword

The purpose of this document is to establish the Terms of Reference (TOR) for the EIA. The Terms of Reference (ToRs) outlines the aspects of an Environmental Impact Assessment which when thoroughly addressed, will provide a comprehensive evaluation of the proposed site, in terms of predicted environmental impacts, required mitigation strategies and potentially viable alternatives to the proposed development/project.

Please be advised that consultations should also be had with the Mines and Geology Division (MGD) with respect to the requirements for a Quarry Licence. These requirements include, but are not limited to, a Business Development Plan and Sensitivity Report.

The EIA report must be produced in accordance with the approved TOR.

Where the need arises to modify the TOR, the required amendments/modifications are to be made and submitted to the Agency. Approval for the TOR must be obtained from the Agency, in writing, prior to the commencement of the EIA study.

The National Environment and Planning Agency and the Natural Resources Conservation Authority reserves the right to reproduce, transfer and disclose any and all contents contained in the submitted environmental impact assessment report without the written consent of the proponent, consultants and/or its agents.

The Terms of Reference to conduct the Environmental Impact Assessment are as follows:

1. Executive Summary

Provide a brief statement on the content of the EIA report. The executive summary should provide a comprehensive overview and objectives for the project proposal, natural resources, justification for the project etc. In addition, it should include relevant background information and provide a summary of the main findings, including but not limited to main impacts and mitigation measures, analyses and conclusions in the report.

2. Introduction

Provide the context of the project and the EIA, the delineation and justification of the boundary of the study area, general methodology, assumptions and constraints of the study.

The study area shall include at least the area within 1km radius of the boundaries of the proposed site.

3. Legislation and Regulatory Consideration

Outline the pertinent regulations, standards, government policies and legislation 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 Natural Resources Conservation Authority Act, the Public Health Act, the Town and Country Planning Act, Building Act and Codes and Standards and any Regulations promulgated under any of the previously mentioned Acts, Development Orders and Plans and all appropriate international convention/protocol/treaty where applicable. Describe traditional land use and advise of any prescriptive rights including public access rights.

4. Project Description

The description should detail the elements of the development/project, highlighting the activities which will be involved in all the major aspects of the development/project. Therefore activities which will be involved in the construction, operation, decommissioning and rehabilitation phases should be addressed. These may include but are not limited to the following:

- ***Pre-operation***: exploration drilling and trenching; location of stockpiles, general access to site and access to extraction/dig sites, plant and accommodation/administrative office during initial development phase, duration, timing and working hours of the initial phase, comprehensive drainage assessment and design, method of sewage treatment and disposal, traffic impact assessment, road construction plan and methods to be employed, source(s) of potable water, electricity, solid waste disposal for site operations.
- ***Operation:*** actual quarry site, quarrying rate, quarrying method, processing methods, plant, machinery and auxiliary facilities e.g. fuel storage, generators etc., duration and phasing, nature and quantity of material to be extracted, expected final depth of quarry area, methods for stabilization of quarry faces, storage area(s) (quarry material, spoils, overburden/topsoil), frequency of blasting and predicted vibration levels, dust generation and control (air quality), noise generation and control, drainage control, fuel and other chemical storage, power supply, transportation (internal and external), safety (worker), fencing and security and storage and disposal of excess topsoil, waste disposal (rock, boulders and unmarketable products).
- ***Decommissioning:*** long term pollution potential and control (water), removal of administrative buildings, plant and machinery, monitoring and management and land use options after closure.
- ***Rehabilitation:*** methods for long term quarry face stabilization, methods and strategies for site rehabilitation, re-vegetation plan, list of species to be used in proposed rehabilitation, top soil cover to be used, monitoring and management for rehabilitated areas, including potential use of the rehabilitated area.

In light of the above, a comprehensive and detailed description of the proposed development/project should be provided. This section will provide information on the proposed project and should include but not be limited to:

- History and background of the project,
- A location map at a scale of 1:12,500 (or an appropriate scale)
- The total area of the site to be considered. It should clearly demarcate the exact location of the proposed development/project and should clearly identify the areas which will be used for quarrying, those which will be used for mineral processing (crushing plant) and those which will be used for the storage and stockpiling of material.

- A site layout plan showing the various components and design elements of the proposed development.
- The spatial allotments for the various design elements of the project.
- Buffers and areas to be preserved in their natural state should be clearly identified.
- Clearly indicate what is the intended use for the final quarried material (i.e. local market distribution and sale versus export and transportation to said destination), including destination.
- Expected project components, i.e. pre-operation, operation, decommissioning and rehabilitation **(see above for details)**.
- Schematic plans, diagrams and drawings.
- A detailed restoration plan highlighting grading and proposed changes in topography, as well as including proposed landscaping.
- Details of proposed access(es) to the site to be used for pre-construction, construction and operational phases
- Details on infrastructure development including design plans for all components of the development including the proposed wastewater/sewage treatment system and disposal of treated effluent must be clearly outlined.
- A comprehensive drainage assessment. This assessment should take into consideration existing natural drainage channels, proposed man-made drainage/water features or any proposed changes in topography. Potential issues of increased surface runoff and sediment loading must also be addressed. Special emphasis should also be placed on the storm water run-off, drainage patterns, characteristics of the aquifer, including the level and status of the groundwater.
- In addition plans for providing utilities, particularly details relating to the source of potable water and electricity generation, roads and other services should be clearly stated.
- A Waste Management Plan which clearly outlines expected quantities of construction waste during the construction phase, general waste arising from material consumption of the workforce, as well as, all expected waste during the operational phase should be completed. Details should also be provided for any central disposal area(s) being considered to serve the proposed development
- Details of equipment and machinery to be involved, how these will be mobilized and areas to be used for storage of machinery and material should be clearly indicated.
- Details of workforce, including proposals for mobilization and accommodation should be indicated.
- All phases of the project should be clearly defined, the relevant time schedules provided and phased maps, diagrams and appropriate visual aids included in the Environmental Impact Assessment report.
- The study area should be clearly delineated and referenced. Taking into account the types of resources located in the area and the magnitude of the associated impacts, the study area should be large enough to include all valued resources that might be significantly affected by the project.

If there is potential room for growth or expansion with respect to the area, output or further processing then this should be discussed. Associated or ancillary activities/ developments should also be discussed. These may include machinery maintenance, haulage enterprises and the final repository of material.

It should be noted that the description 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, operation, decommissioning and rehabilitation plans. For projects to be done on a phased basis, all phases must be clearly defined and the relevant time schedules provided and phased maps, diagrams and appropriate visual aids included.

5. Description of the Environment

This section involves the generation of baseline data which is used to describe the study area as follows:

i) physical environment
ii) biological environment
iii) socio-economic and cultural environment

The methodologies employed to obtain baseline and other data should be clearly detailed in the EIA. The methodologies should be conducted for both the wet and dry seasons where applicable. This information will form the basis upon which impacts of the project will be assessed.

The following aspects should be described in this section:

5.1 Physical Environment

i. a detailed description of the existing
   a) **geology** – rock type and formation, faults, slope stability issues
   b) **geomorphology** – identified geomorphological features e.g. caves, caverns, soil type
   c) **hydrology** – special emphasis should be placed on drainage patterns.
ii. Air quality in the area of influence including air emissions (e.g. TSP, PM10, NOx, SOx) from stationary or mobile sources, climatic conditions inclusive of wind speed and direction, precipitation, relative humidity and ambient temperatures. (A review of the Natural Resources Conservation Authority Air Quality Regulations and the implications of the regulations on the proposed project should be conducted and ascertained).
iii. **Water quality** of any existing wells, rivers, ponds, streams or coastal waters in the vicinity of quarrying and crushing activities. Quality Indicators should include but not necessarily be limited to nitrates, phosphates, faecal coliform, biochemical oxygen demand, suspended solids, dissolved solids and turbidity.
iv. Noise levels of undeveloped site and the ambient noise in the area of influence.
v. Sources of pollution existing and extent of contamination.

5.2 Ecological Services

- A statement of whether or not any percentage of the ecological services currently being offered by the site will remain or be recovered subsequent to quarrying.

5.3 Natural Hazards

Vulnerability assessment of the development in relation to the following must be undertaken:-

- Hurricanes, Earthquakes
- Natural hazard vulnerability assessment should take in account climate change projections.

5.4 Biological Environment

Present a detailed description of the flora and fauna (terrestrial) of the area, with special emphasis on rare, endemic, protected or endangered species. In this section the emphasis is on a description of habitats, flora and fauna surveys inclusive of a species list; commentary on the ecological health, function and value in the project area, threats and conservation significance.

This should include:

- A detailed qualitative and quantitative assessment of terrestrial habitats in and around the proposed project sites and the areas of impact. This must also include flora and fauna surveys and should include species lists.
- Special emphasis should be placed on rare, endemic, protected or endangered species. Migratory species should also be considered. There may be the need to incorporate micro-organisms to obtain an accurate baseline assessment.
- Species dependence, niche specificity, community structure, population dynamics, species richness and evenness (a measure of diversity) ought to be evaluated.

The field data collected should include, but not be limited to:

- Vegetation profile
- Species lists must be provided for each community
- A habitat map of the area

5.5 Heritage

- An assessment of artifacts, archaeological, geological and paleontological features for the site.

5.6 Socio-economic Environment

Demography, regional setting, location assessment and current and potential land-use patterns (of neighbouring properties); description of existing infrastructure such as transportation, electricity, water and telecommunications, and public health safety; cultural peculiarities, aspirations and attitudes should be explored; and other material assets of the area should also be examined. A socio-economic survey to determine public perception of the project should also be complete and this should include but not be limited to potential impacts on social, aesthetic and historical/ cultural values.

The historical importance of the area should also be examined including identification of culturally significant features e.g. archaeological finds. While this analysis is being conducted, it is expected that an assessment of public perception of the proposed development will be conducted and the use/benefit/value of the existing site will be explored/explained. This assessment may vary with community structure and may take multiple forms such as public meetings or questionnaires.

6. Public Participation

Describe the public participation methods, timing, type of information provided and collected from public and stakeholder target groups meetings. The instrument used to collect the information must be included in the appendix. It may be useful and necessary to hold stakeholder meetings to inform the public of the proposed development and the possible impacts. This will also gauge the feeling/response of the public toward the development.

The issues identified during the public participation process should be summarized and public input that has been incorporated or addressed in the EIA should be outlined.

Public Meetings should be held in accordance with the Guidelines for Conducting Public Presentation at a time and location signed off by the National Environment and Planning Agency (NEPA). A public meeting will be held to present the findings of the EIA once the EIA is completed and submitted for consideration. All relevant documents are required to be made available to the public. In addition, any material change to the design of the project will require a further public meeting to be undertaken by the developer and all changes made to the document. should be clearly outlined to the public.

7. Impact Identification and Assessment/ Analysis of Potential Impacts

A detailed analysis of the project components should be done in order to: identify the major potential environmental and public health impacts of the project; distinguish between levels of impact, significance of impact (a ranking from major to minor/significant to insignificant should be developed), positive and negative impacts, duration of impacts (long term or short term or immediate), direct and indirect and impacts, reversible or irreversible, long term and immediate impacts and identify avoidable impacts.

Cumulative impacts should also be evaluated taking into account previous developments and any proposed development immediately adjacent to the subject development within the area. The identified impacts should be profiled to assess the magnitude of the impacts. The major concerns surrounding environmental and public health issues should be noted and their relative importance to the design of the project and the intended activities indicated. The extent and quality of the available data should be characterized, explaining significant information deficiencies and any uncertainties associated with the predictions of impacts. A major environmental issue is determined after examining the impact (positive and negative) on the environment and having the negative impact significantly outweigh the positive. It is also determined by the number and magnitude of mitigation strategies which need to be employed to reduce the risk(s) introduced to the environment. Project activities and impacts should then be ranked as major, moderate and minor and presented in separate matrices for all the phases of the project (i.e. preconstruction, construction, operational and decommissioning/closure). The potential impacts may be subdivided into Physical Impacts, Biological Impacts and Socio-economic and Cultural Impacts. All impacts should be listed, ranked and assessed.

The impacts to be assessed will include but not be limited to the following:

7.1 Physical

In general, for this proposed development, the physical impacts may include the effect on soil and geology (site clearance, storm water runoff, loss of topsoil, potential erosion, change in drainage patterns, flooding risks (as it pertains to the site and the surrounding environs/communities), air, particularly in the context of the potential impact that the proposed development may have on communities (generation of dust from processing, drilling, transportation, material storage and handling, fly rock from surface workings); water (possible contamination of surface and subsurface resources from improper waste disposal, storm water runoff); the landscape (loss of character of the area, impact of excavation); material assets (effects of vibration on surface structures as it pertains to the site and the surrounding environs/communities, damage to roads during transportation). The physical impacts should explore, but not be limited to the following:

- Impacts of construction activities such as site clearance, earthworks and spoil disposal.
- Impacts of accidental oil and chemical spills
- Impacts on Air Quality
- Impacts on Water Quality (pollution of potable, coastal, surface and ground waters)
- Impacts/demands/requirements of the following must be quantified
    - Water Supply
    - Drainage
    - Sewage Treatment and Disposal - Empirical data must be provided to show that the sewage treatment facility has the capacity to remove the nutrients to meet the Natural Resources Conservation Authority's Sewage Effluent Standards;
    - Wastewater Disposal
    - Trade Effluent Discharges and the Treatment and Disposal of same - Empirical data must be provided to show that the sewage treatment facility has the capacity to remove the nutrients to meet the Natural Resources Conservation Authority's Trade Effluent Standards;
    - Solid Waste Disposal
    - Electrical Power (fossil fuels, wind, sun, wave and tidal)
    - Communications and other utility requirements
    - Transport Systems and supporting infrastructure required
- Operation and maintenance – waste disposal, site drainage, sewage treatment and disposal solution, and air quality;
- Impacts on visual aesthetics and landscape
- Noise
- Dust
- Vibration
- Change in drainage pattern
- Carrying capacity of the proposed site

7.2 *Natural Hazard*

Impact of natural hazards including but not limited to hurricanes, earthquakes, landslides and flooding potential.

7.3 *Biological*

Direct and indirect impact and associated risks on ecology of the terrestrial and marine habitats, where relevant. Emphasis should be placed on any rare, endemic, protected or endangered species found. This should include habitat loss and fragmentation, loss of species, niches and natural features due to construction and operation. The impact of noise, dust and vibration on floral and faunal species should be explored.

7.4 *Heritage*

Loss of and damage to artifacts, archaeological, geological and paleontological features

7.5 *Human/Social/Cultural*

Effects on the socio-economic status such as changes to public access and recreational use; impacts on existing and potential economic activities; contribution of the development to the national economy and development of surrounding communities should be examined. Socio-economic and cultural impacts to include land use/resource effects, health and safety of the potential workers as well as the residents of the surrounding environs should be described. Public perception as it relates to loss of property value, loss of aesthetic enjoyment among other things should be explored.

7.6 *Public Health Issues of Concern*

The impact of the proposed development particularly in the context of the potential impacts on human health, that is, air quality, noise pollution, water quality e.g. possible respiratory effects) should be examined, in terms of what is the identified impact and proposed mitigation.

7.7 *Risk Assessment*

Analyze the risks to the safety of the workers and persons within the sphere of influence related to the projected impacts identified during the studies. This should include: 1) Identifying the hazards 2) Assessing the potential consequences 3) Assessing the probability of the consequences and 4) Characterizing the risk and uncertainty.

8. Impact Mitigation

The mitigation measures should endeavour to avoid, reduce and remedy the potential negative effects while at the same time enhancing the positive impacts projected. Mitigation and abatement measures should be developed for each potential negative impact identified. This should include recommendations for the enhancement of beneficial impacts and quantify and assign financial and economic values to mitigating methods. Green technology should be examined. A statement is to be made on strategies that will be used to conserve energy and water in relation to this development.

9. Residual Impacts

Identify any residual negative impacts that potentially have no solution for mitigation, for example, change in aesthetics, habitat loss, etc.

10. Analysis of Alternatives

Alternatives to the proposed development/project including the no-action alternative should be examined. These should be assessed according to the physical, ecological and socio-economic parameters of the site. This examination of alternatives should incorporate the use of the history of the overall area in which the site is located and previous uses of the site itself. Alternatives should also address specific aspects of the project such as methods proposed in the execution of the project (works) that have been identified as being causes of major impacts.

A rationale for the selection of any project alternative should be provided.

11. Environmental Monitoring and Management

An environmental monitoring and management plan should be developed which will detail the requirements for construction, operational and decommissioning/closure phases of the project. This should include, but not be limited to training for staff, as well as include recommendations to ensure the implementation of mitigation measures and long term minimization of negative impacts

A draft environmental monitoring programme should be included in the EIA, and a detailed version submitted to NEPA for approval after the granting of the permit and prior to the commencement of the development.

At the minimum the monitoring programme should include:

- Introduction outlining the need for a monitoring programme
- The activity(ies) being monitored and the parameters for monitoring and reference standards.
- The area(s) being monitored (should incorporate a control site), the methodology and frequency of monitoring recommended.
- The name and qualifications of the person(s) proposed to undertake the monitoring programme
- Frequency of reporting to NEPA
- A sample of the report that is to be submitted

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.

12. List of References

13. Appendices

The appendices should include but not be limited to the following documents:

13.1 Reference documents
13.2 Photographs/ maps
13.3 Data Tables
13.4 Glossary of Technical Terms used
13.5 Terms of Reference
13.6 Composition of the consulting team, team that undertook the study/assessment, including name, qualification and roles of team members
13.7 Notes of Public Consultation sessions
13.8 Instruments used in community surveys

14. ACTIVITIES

In order to effectively and efficiently conduct the Environmental Impact Assessment it will be necessary to carry out various activities which include:

14.1 Documentation Review

All documentation pertaining to the development will need to be reviewed. These should include, but not limited to, the project profile, site plan, drainage plan, vegetation clearance plan, applications made for financing or planning approval, and any technical and engineering studies that have been done.

14.2 Analysis of Alternatives

Alternatives to the site location, project design and operation conditions will be analyzed including the "no-action" alternative. These alternatives will be assessed based on the physical, ecological and socio-economic parameters of the site identified. The physical, biological and sociological settings will provide the framework in which to assess the different project alternatives. This would clarify, for instance, whether the site could be used for other purposes as well as whether there are any particular aspects of the development that can be sited differently, operated differently, etc.

14.3 Impact Assessment

The consultant should carry out a detailed impact assessment of the project components (preconstruction, construction, operational and decommissioning/closure stages) in order to identify the potential impacts (positive, negative and cumulative impacts) that will be associated with the project. The significance and magnitude (major, moderate and minor) of the impacts identified will also be evaluated through the use of a weighted matrix.

The impacts to be assessed will include but not limited to the following:

- Effects of project design and engineering;
- Effects on visual aesthetics and landscape;
- Effect of noise and vibration;
- Effects of operation activities such as site clearance and geological formation, earthworks, hurricanes, access routes, transportation networks and spoil disposal;

- Effects of operation and maintenance activities such as waste disposal, traffic management, site drainage, sediment, sewage, public access and air quality; and
- Effects on ecology including effect on terrestrial and other habitats
- Emphasis should be placed on any rare, endangered, and endemic species found
- Effects on socio-economic status such as changes to public access, recreational use, existing and potential agricultural activities, contribution of development to national economy and development of surrounding communities.

All findings must be presented in the EIA report and must reflect the headings in the body of the TORs, as well as, references. GIS references should be provided where applicable. One hard copy and an electronic copy must be submitted to NEPA for review after which ten (10) hard copies and an electronic copy of the report should be submitted. One copy of the document should be perfect bound.

The report should include appendices with items such as maps, site plans, the study team and their individual qualifications, photographs, and other relevant information. All of the foregoing should be properly sourced and credited.

Appendix 2 – Study Team

- **CL Environmental Co. Ltd.:**
    - Carlton Campbell, Ph.D., CIEC (Project Coordinator, Noise)
    - Matthew Lee, M.Sc. (Water Quality, Air Quality, Climate, Hazards, Pollution Sources)
    - Rachel D'Silva, B.Sc. (Water Quality, Ecological Function)
    - Karen McIntyre-Chin, M.Sc. (Legislation, Human and Social, GIS)
    - Errol Harrison (Field Technician – Air Quality and Noise)
    - Glen Patrick (Field Technician – Air Quality and Noise)

- **Forrest and Associates Ltd:**
    - Denise Forrest, M.Sc., MBA, (Client Liaison, Community Perception Survey, Hydrology & Drainage)

- **Associate Consultants:**
    - Stephen Haughton, M Eng. (Air Emissions and Air Dispersion Modelling)
    - Eric Garraway, Ph.D. (Faunal Survey)
    - Damion Whyte, M. Phil (Faunal Survey)
    - Philip Rose, Ph.D. (Vegetation Survey)
    - Marc Rammelaere, M.Sc. (Geology, Geomorphology)

Appendix 3 – NEPA Guidelines for Public Participation

SECTION 2

PUBLIC CONSULTATIONS GUIDELINES
FOR
ENVIRONMENTAL IMPACT ASSESSMENTS

SECTION 2 - TABLE OF CONTENTS

CHAPTER 1: GENERAL GUIDELINES

1.0 Introduction

There are two levels of public consultation involved in the Environmental Impact Assessment (EIA) process. The first is direct involvement of the affected public or community in public consultations during the EIA study. These consultations allow the developer to provide information to the public about the project and to determine what issues the public wishes to see addressed. The extent and results of these consultations are included in the documented EIA report.

The second level of involvement takes place after the EIA report is prepared in the form of a public meeting and the submission and review of comments on the EIA report. This occurs after the applicant has provided the information needed for adequate review by the public.

1.1 Purpose

These guidelines are prepared in relation to the second level of consultation outlined above for the use of the applicant and the public.

CHAPTER 2: SPECIFIC GUIDELINES FOR PUBLIC MEETING FOR ENVIRONMENTAL IMPACT ASSESSMENTS (EIAS)

2.1 Requirements

Arrangements for the public consultation, in particular the public meeting, must be made in discussion with NEPA in respect of date, time, venue, chairperson, specially invited participants and length of time for the submission of comments.

A permanent record of the meeting is required hence, the applicant must submit to NEPA a copy of the verbatim report of the public meeting within seven (7) days of the date of the meeting.

2.2 Public Notification

The public must be notified at least three (3) weeks before the date of the public meeting. The applicant must seek to ensure that in addition to specific invitation letters, at least **three (3)** notices are placed in the most widely circulated newspapers advertising the event; one (1) notice per week. A copy of the notice shall be forwarded to NEPA for approval prior to publication in the newspapers. The NEPA will also post a copy of the Notice on its Website once it has been approved. To ensure that the Notice is distributed as widely as possible, at least two (2) other methods of notification such as community notice boards, flyers, town criers etc. shall be utilized. In addition, specific notice to relevant local NGOs and community groups should be made by the applicants. Evidence of the two (2) additional methods of notification and specific notices must be submitted to the NEPA.

The notices should indicate that:-

-the EIA has been submitted to NEPA;
- the purpose of the meeting;
- how to access the EIA report for review;
- the date, time and venue of the public presentation;
- contact information (NEPA/NRCA/TCPA and the APPLICANT).

The public meeting should be conducted no less than 3 weeks after the EIA has been accepted for posting and has been made available to the public and no less than 3 weeks after the first notice announcing public meeting has been published by the applicant. ***(A typical notice is in***

Appendix 1).

2. 3 Responsibility of Applicant

The applicant is responsible for distribution of copies of the EIA Report to make them available to the public at least three (3) weeks before the public meeting. Copies should be placed in the Local Parish Library and the Parish Council Office as well as the NEPA Documentation Centre, NEPA Regional Office nearest to the project site and other community locations as agreed upon. A summary of the project components and the findings of the EIA in non-technical language should also be prepared for distribution at the public meeting.

2.4 Conduct of the Meeting

With respect to the conduct of the meeting, the chairperson should be independently selected so as to ensure his/her neutrality. NEPA should be consulted regarding the selection of a chairperson. The role and responsibilities of the chairperson are outlined in ***Appendix 3***.

2.5 The Presentation

The technical presentation by the applicant should be simple, concise and comprehensive. The main findings of the EIA including adverse and beneficial impacts identified and analyzed should be presented. **(A typical agenda for a meeting is given in Appendix 2)**

Mitigation measures and costs associated with these measures should be presented. The meeting should inform the public on how they will get access to monitoring results during the construction and operational phases of the project, as it seeks to facilitate their participation in the monitoring and enforcement of the conditions under which approvals may being granted. Graphic and pictorial representations should support the technical presentation.

Presenters are advised to keep the technical presentation simple and within a time limit of 20-30 minutes depending on the complexity of the project and to allow a minimum of 30 minutes for questions. ***(A typical outline of a Project presentation is given in Appendix 4)***

2.6 Submission of Verbatim Report

The applicant will submit to NEPA a copy of the verbatim report of the public meeting within seven (7) days of the date of the meeting.

2.7 Submission of Public Comments

Please note that the public will be given a period of twenty-one (21) days after the public meeting to submit written comments to NEPA.

APPENDICES

APPENDIX 1

NOTIFICATION OF PUBLIC MEETING

THERE WILL BE A PUBLIC CONSULTATION ON THE ENVIRONMENT IMPACT ASSESSMENT REPORT

OF:

VENUE:

DATE:

TIME:

THE PUBLIC IS INVITED TO PARTICIPATE IN THE CONSULTATION BY WAY OF ASKING QUESTIONS RELATING TO THE PROPOSED PROJECT.

A COPY OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT MAY BE CONSULTED AT THE
____________________ PARISH LIBRARY
____________________ PARISH COUNCIL OFFICE
NEPA'S Documentation Centre at 11 Caledonia Avenue, Kingston 5
____________________ NEPA Website: www.nepa.gov.jm
For further information contact:

10

APPENDIX 2

AGENDA

1. WELCOME AND INTRODUCTION

2. STATEMENT BY THE NATIONAL ENVIRONMENT & PLANNING AGENCY

3. PRESENTATION OF EIA FINDINGS AND MEASURES TO MINIMIZE IMPACTS

4. QUESTION AND ANSWER SESSION

5. CLOSING REMARKS

APPENDIX 3

ROLE AND RESPONSIBLITIES OF THE CHAIRPERSON

The chairperson has the main role of guiding the conduct of the meeting and seeing to it that the concerns of the public are adequately aired and addressed by the proponent/consultants.

The responsibilities of the chairperson include explaining the NEPA approval process, that is, the steps involved and the role of the NEPA at these public presentations. In other words, the chairperson should explain the context within which the meeting is taking place.

The chairperson should ensure that adequate time is allowed for questions and answers, and must understand clearly and communicate the purpose of the meeting to the audience. The chairperson is responsible for introducing the presenters.

The chairperson should contribute to but not monopolize the meeting.

APPENDIX 4

STRUCTURE OF PRESENTATION

1. DETAILED DESCRIPTION OF PROJECT PROPOSAL
2. DETAILS OF IMPACTS IDENTIFIED
3. DESCRIPTION OF PROPOSED MITIGATION MEASURES
4. RESPONSE TO ANY ISSUES RAISED PRIOR TO PUBLIC CONSULTATION (MEDIA, WRITTEN QUERY ETC.)

Appendix 4 – Drainage Estimation Report

JAMAICA WORLD
Connecting your world to our world, Jamaica World

Drainage Estimation

Bengal Limestone Quarry

Drainage Estimation

Projects Development Department
EPSA

Reference No. JM-18145
Revision. 01
April 2019

1. Peak Discharge Estimation

1.1. Runoff

The *runoff* model is the mathematical model describing the rainfall - runoff relations of a rainfall catchment area, drainage basin or watershed. More precisely, it produces the surface runoff hydrograph as a response to a rainfall hydrograph as input. In other words, the model calculates the conversion of rainfall into runoff.

Runoff equation is:

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

Where:

- Q : Runoff
- P : Rainfall (weather station data)
- I_a : Initial abstraction (see section 1.1.a. of this document)
- S : Potential maximum retention after runoff begins (see section 1.1.b. of this document)

1.1.1. Initial abstraction (I_a):

'I_a' is all losses before runoff begins. It includes water retained in surfaced depressions, water intercepted by vegetation, evaporation and filtration. 'I_a' is highly variable but generally is correlated with soil and cover parameters.

'I_a' is related with 'S' (Potential maximum retention after runoff begins) by the next equation:

$$I_a = 0.2 \cdot S$$

Therefore the *runoff* equation becomes:

$$Q = \frac{(P - 0.2 \cdot S)^2}{(P + 0.8 \cdot S)}$$

1.1.2. Potential maximum retention after runoff begins, (S):

At the same time (S), Potential maximum retention after runoff begins, is related with (CN) by the next equation:

$$S = \frac{1{,}000}{CN} - 10$$

Where:

CN: Curve number (see Tables 1 to 3)

The major factors that determine CN are hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC).

'CN' has a range from 30 to 100; lower numbers indicate low runoff potential while larger numbers are for increasing runoff potential. The lower the curve number, the more permeable the soil is.

Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected).

The next tables shown the *'Runoff curve numbers'* for different type of soils:

Runoff curve numbers for urban areas 1/

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area 2/	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) 3/:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) 4/		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) 5/		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

Table 1: 'Runoff curve numbers for urban areas'

Runoff curve numbers for cultivated agricultural lands 1/

Cover type	Treatment 2/	Hydrologic condition 3/	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

Table 2: 'Runoff curve numbers for cultivated agricultural lands"

Runoff curve numbers for other agricultural lands 1/

Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. 2/	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. 3/	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 4/	48	65	73
Woods—grass combination (orchard or tree farm). 5/	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. 6/	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 4/	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

Table 3: " Runoff curve for other agricultural

The different types of soils in the tables above are described as following:

- **Group A** soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr). ***Soil Texture: Sand, loamy sand, or sandy loam***

- **Group B** soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr). **Soil Texture: Silt loam or loam**

- **Group C** soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr). **Soil Texture: Sandy clay loam**

- **Group D** soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr). **Soil Texture: Clay loam, silty clay loam, sandy clay, silty clay, or clay**

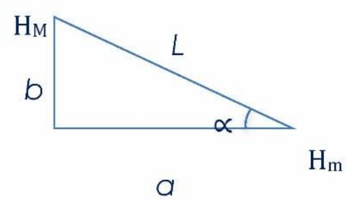
1.2. Drainage Zone

1.2.1. Drainage area (A_m)

The drainage area (A_m) is the entire surface where water is going to reach the same point of discharge.

1.2.2. Flow length (L)

The flow length (L) is the total distance where the water runoff since the more far point of the drainage area until the point of discharge.



$$L = \sqrt{a^2 + b^2}$$

Where:

H_M : Maximum Point Elevation (topography data)

H_m : Minimum Point Elevation (topography data)

b : Height difference; $b = H_M - H_m$

a : Horizontal Flow length)

L: Flow real length

i: Channel slope

1.2.3. Channel slope (i):

Channel slope (i) is the slope which represents the average slope of the flow length.

According to the above scheme we can define the channel slope according to the next equation:

$$i = tg \propto = \frac{sen \propto}{\cos \propto} = \frac{b}{a}$$

1.2.4. Time of concentration (T_c):

Time of concentration (T_c) is the time for runoff to travel from the hydraulic most distance point of the watershed to a point of interest in the watershed.

Time of concentration (T_c) is calculated according to the empiric formula:

$$Tc = 0.30 \cdot \left(\frac{L^*}{\sqrt[4]{i}}\right)^{0.76}$$

*Note: 'L' must be in kilometres (km).

1.2.5. Average Velocity (V_D):

The average velocity across the worst channel in the basin to the discharge point selected, expressed by the next equation:

$$V_D = \frac{L}{(3{,}600 \cdot T_c^{\,*})}$$

*Note: 'Tc' must be in hours *(h)*.

1.3. Peak Discharge

The peak discharge is the maximum quantity of water discharged in a selected point, defined by the next equation:

$$q_p = q_u \cdot A_m \cdot Q \cdot F_p$$

Where:

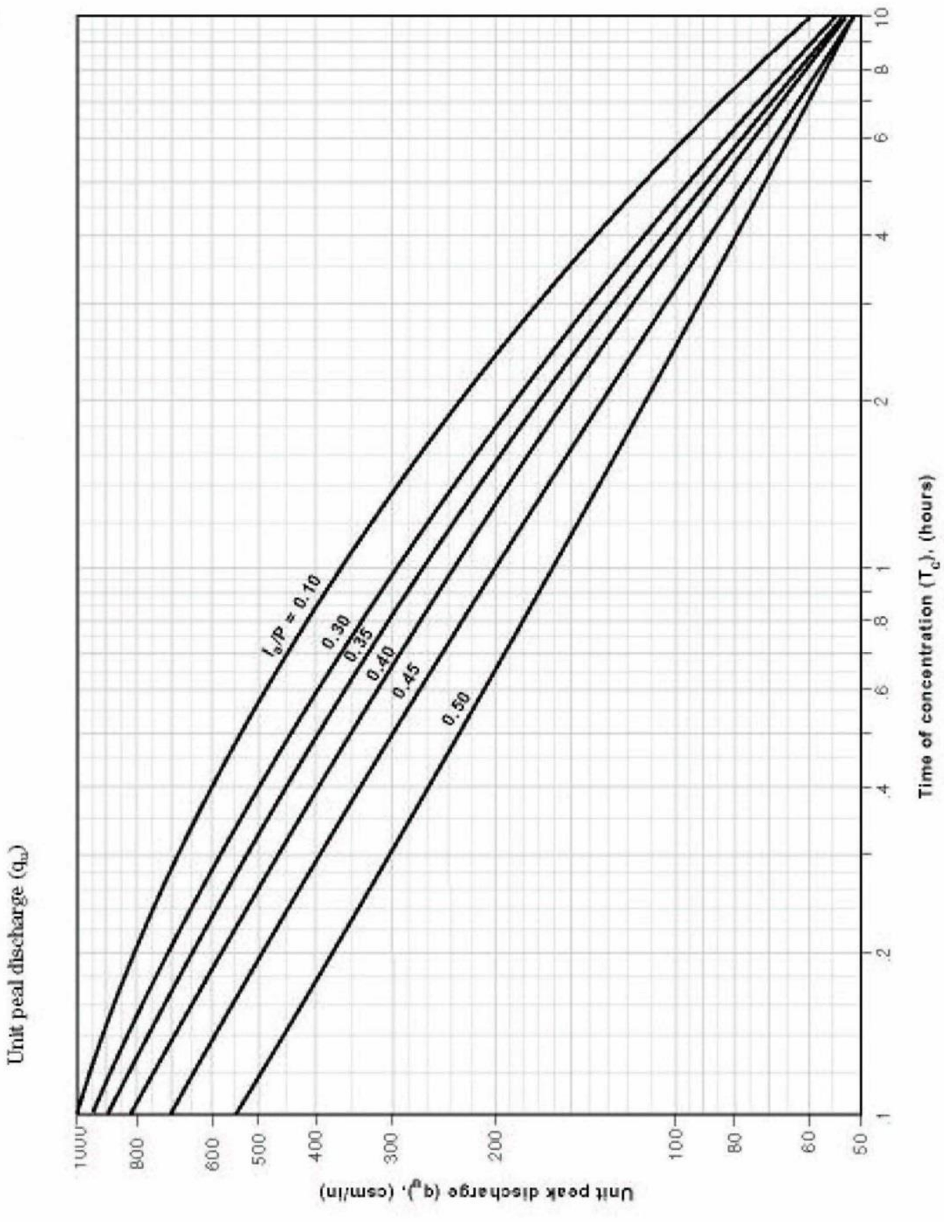
q_p :	Peak discharge
q_u :	Unit peak discharge (see section 1.3.1. of this document)
A_m :	Drainage Area (see 1.2.1. of this document)
Q :	Runoff (See section 1.1. of this document)
F_p:	Pond and swamp adjustment factor (see 1.3.2. of this document)

1.3.1. Unit peak discharge (q_u) estimation:

Defining the peak discharge (q_u) we use the next table.

We introduce the values of Tc (see section 1.2.2 of this document) and crossed with the ratio line defined by Ia (Initial abstraction, see section 1.1.1. of this document) and P (rainfall, weather station data).

See '*Graphic 1*' in next page.



Graphic 1: “ Unit peak discharge”

1.3.2. Pond and swamp adjustment factor (F_p):

The pond and swamp adjustment factor is defined by the percentage of pond and swamp areas in basin object of study.

If it cannot estimate the percentage it must use the factor F_p=1.00. as a safety measure.

Adjustment factor (F_p) for pond and swamp areas that are spread throughout the watershed

Percentage of pond and swamp areas	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

Table 4: 'Pond and swamp adjustment factor'

2. Drainage solution for Bengal Quarry

2.1. Weather

Weather External Idle Time is the time in which equipment is scheduled to work but is unable to work as result of wet weather, sandstorm, lightning, visibility issues or weather conditions.

For making an analysis of the weather data expected in the Project, we based our calculations on average historic values measured in Runaway Bay:

		UTM Coordinates		Geographic Coordinates	
Location:	Runaway Bay	X	Y	Latitude	Longitude
Region:	Saint Ann	253743.84 m E	2042686.73 m N	18°27'36.63"N	77°19'54.48"O
Country:	Jamaica				

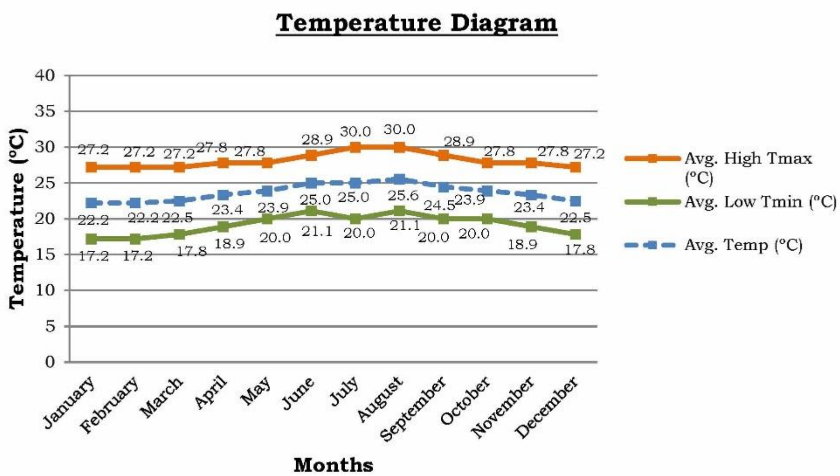
12 Km eastern from de Project site

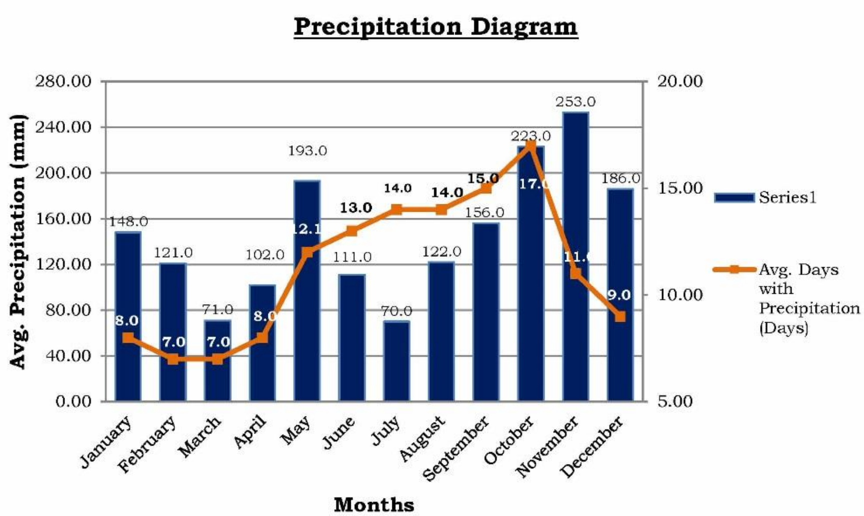
Average historical data obtained in the Project Area are:

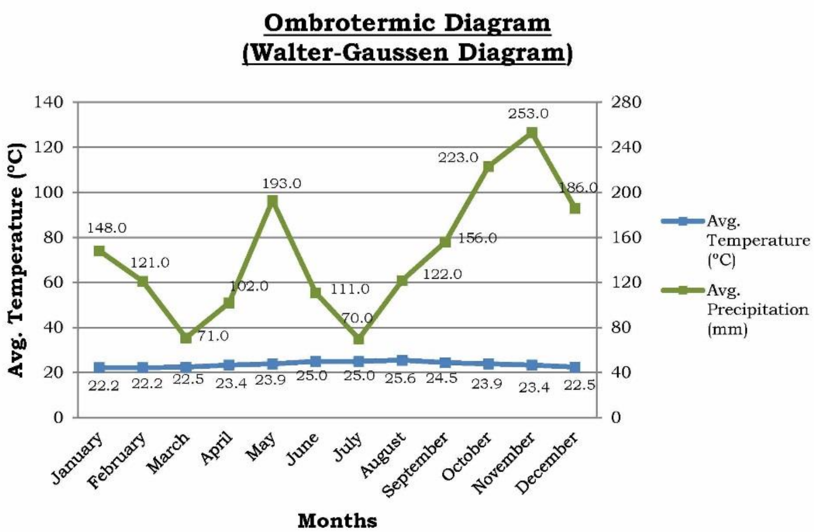
Runaway Bay
Historic Average Weather Data

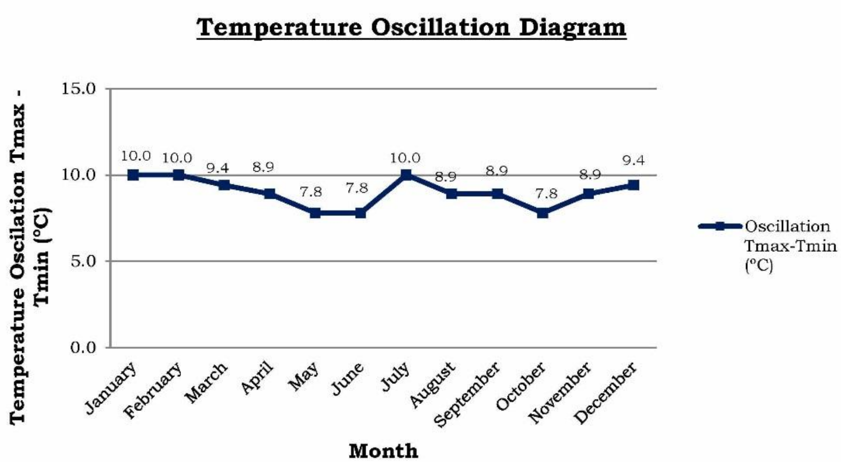
Months	Avg. High Temperature (ºC)	Avg. Low Temperature (ºC)	Avg. Precipitation (mm)	Avg. No. Days with Precipitation
January	27.20	17.20	148.00	8.00
February	27.20	17.20	121.00	7.00
March	27.20	17.80	71.00	7.00
April	27.80	18.90	102.00	8.00
May	27.80	20.00	193.00	12.00
June	28.90	21.10	111.00	13.00
July	30.00	20.00	70.00	14.00
August	30.00	21.10	122.00	14.00
September	28.90	20.00	156.00	15.00
October	27.80	20.00	223.00	17.00
November	27.80	18.90	253.00	11.00
December	27.20	17.80	186.00	9.00
			1756.0	**135**

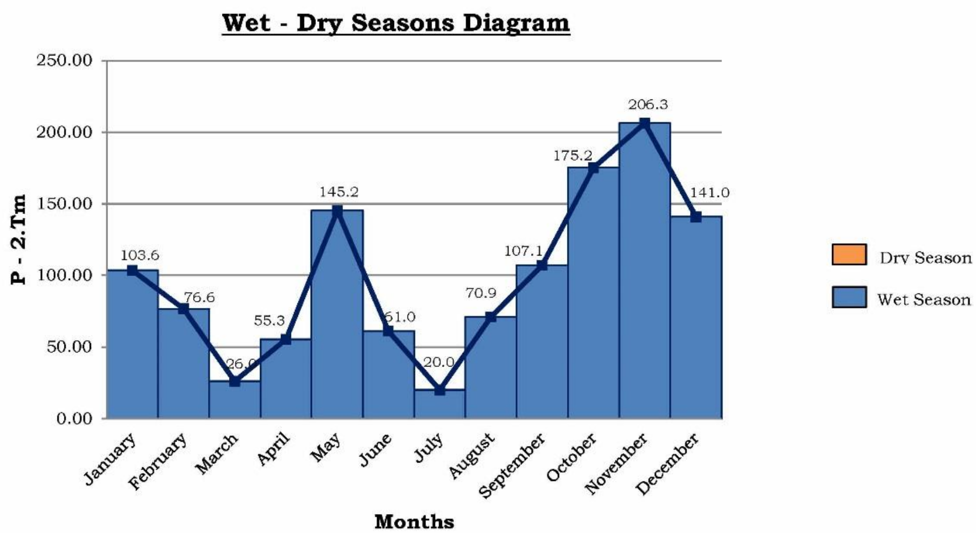
Based on the above data average temperature, temperature oscillation and other variables can be established. These can be represented graphically and will help us understand the area's weather conditions:

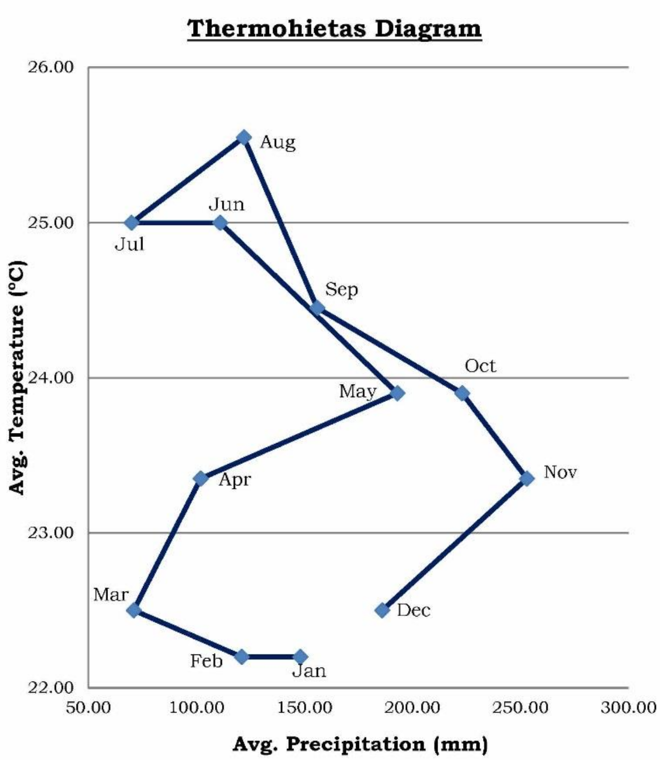

Temperature Diagram
Temperature (°C)
Months
Avg. High Tmax (°C)
Avg. Low Tmin (°C)
Avg. Temp (°C)
January February March April May June July August September October November December


Precipitation Diagram
Avg. Precipitation (mm)
Months
Series1
Avg. Days with Precipitation (Days)
January February March April May June July August September October November December


Ombrotermic Diagram
(Walter-Gaussen Diagram)
Avg. Temperature (°C)
Months
Avg. Temperature (°C)
Avg. Precipitation (mm)
148.0 121.0 71.0 102.0 193.0 111.0 70.0 122.0 156.0 223.0 253.0 186.0
22.2 22.2 22.5 23.4 23.9 25.0 25.0 25.6 24.5 23.9 23.4 22.5
January February March April May June July August September October November December

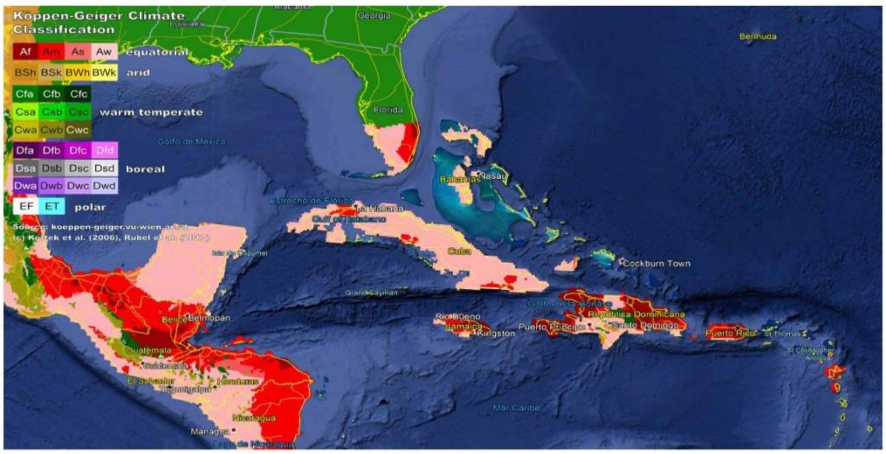

Temperature Oscillation Diagram
Temperature Oscilation Tmax - Tmin (°C)
Month
Oscillation Tmax-Tmin (°C)
10.0 10.0 9.4 8.9 7.8 7.8 10.0 8.9 8.9 7.8 8.9 9.4
January February March April May June July August September October November December


Wet - Dry Seasons Diagram
P - 2.Tm
250.00
200.00
150.00
100.00
50.00
0.00
103.6
76.6
26.0
55.3
145.2
61.0
20.0
70.9
107.1
175.2
206.3
141.0
January
February
March
April
May
June
July
August
September
October
November
December
Months
Dry Season
Wet Season


Thermohietas Diagram
Avg. Temperature (°C)
26.00
25.00
24.00
23.00
22.00
Aug
Jun
Jul
Sep
Oct
May
Apr
Nov
Mar
Dec
Feb
Jan
50.00
100.00
150.00
200.00
250.00
300.00
Avg. Precipitation (mm)

Köppen climate classification

The Köppen climate classification allows assigning certain climatic characteristics to a specific geographical location. This information cannot be distinguished in a simple table of precipitations and temperatures but refers to the qualitative behavior of these climatic variables.



Because the quarry is located in a storm zone *(Am – Tropical Monsoon)*, we are going to consider an extreme case in which all the precipitation of a month fell in the form of a storm in one hour. In this way we ensure that the drainage system is able to work correctly for any possible situation.

Runaway Bay
Precipitacion Data

Months	Avg. Precipitation (mm)	Avg. No. Days with Precipitation	Avg. Precipitation per Day (mm)	Avg. Precipitation per Hour (mm)	Avg. Precipitation per Event (mm)
January	*148.00*	8.00	18.50	0.77	18.50
February	*121.00*	7.00	17.29	0.72	17.29
March	*71.00*	7.00	10.14	0.42	10.14
April	*102.00*	8.00	12.75	0.53	12.75
May	*193.00*	12.00	16.08	0.67	16.08
June	*111.00*	13.00	8.54	0.36	8.54
July	*70.00*	14.00	5.00	0.21	5.00
August	*122.00*	14.00	8.71	0.36	8.71
September	*156.00*	15.00	10.40	0.43	10.40
October	*223.00*	17.00	13.12	0.55	13.12
November	*253.00*	11.00	23.00	0.96	**23.00**
December	*186.00*	9.00	20.67	0.86	20.67
	1756.0	**135**			

Therefore, the rainfall that we will use for the sizing of the drainage system will be 23 mm

2.2. Drainage Areas

The layout of the quarry intercepts 5 drainage areas, which we have called 'a', 'b', 'c', 'd' and 'e'. These drainage areas are external to the pit. By studying topography of the land, it can be observed that only 2 drainage areas will drain inside the pit. These drainage areas are those called 'a' and 'b'.

Then, following the calculation methodology explained before, we will calculate the peak discharges for both drainage areas, and we will use the highest value obtained for the sizing of the ditches.

On the other hand, in addition to the drainage areas outside the pit, the water inside the pit must also be taken into account, so ditches must also be designed to manage the water inside the pit.

Inside the pit there are two drainage areas which we have named 'P1' and 'P2'.

Therefore, the peak discharges of 4 drainage areas must be estimated: 'a', 'b', 'P1' and 'P2'

2.3. Peak Discharge

Peak discharge has been calculated according to the method included in section1 of this document.

Calculated values for Peak discharge estimation are shown as following:

2.3.1. Runoff

		Drainage AREA a	Drainage AREA b	Drainage AREA P1	Drainage AREA P2
SI METRIC					
Rainfall (mm/h)	P (mm)	23	23	23	23
Runoff Curve Number	CN	36	36	49	49
Potential maximum retention after runoff begin (mm)	S (mm)	17.78	17.78	10.41	10.41
Initial Abstraction (mm)	I_a (mm)	3.56	3.56	2.08	2.08
Runoff (mm)	Q (mm)	10.16	10.16	13.97	13.97
US METRIC					
Rainfall (in/h)	P (in)	0.91	0.91	0.91	0.91
Potential maximum retention after runoff begin (in)	S (in)	0.70	0.70	0.41	0.41
Initial Abstraction (in)	I_a (in)	0.14	0.14	0.08	0.08
Runoff (in)	Q (in)	0.40	0.40	0.55	0.55

2.3.2 Drainage Zone

		Drainage AREA a	Drainage AREA b	Drainage AREA P1	Drainage AREA P2
SI METRIC					
Drainage area (Km²)	A_m (Km²)	0.5108	0.2522	0.0017	0.1017
Flow Length (Km)	L_D (Km)	0.95	0.48	0.31	0.59
Maximum Point Elevation (m)	H_M (m)	126.56	77.86	63.56	63.56
Minimum Point Elevation (m)	H_m (m)	63.56	71.44	25	25
Height Difference (m)	ΔH (m)	63	6.42	38.56	38.56
Channel Slope (m/m)	i (m/m)	0.0661	0.0134	0.1223	0.0653
Time of Concentration (h)	T_c (h)	0.48	0.39	0.18	0.34
Average Velocity (m/s)	V_D (m/s)	0.54	0.34	0.46	0.48
US METRIC					
Drainage area (mi²)	A_m (mi²)	0.20	0.10	0.00	0.04
Flow Length (ft)	L_D (ft)	3,120.08	1,574.80	1,026.90	1,932.41
Maximum Point Elevation (ft)	H_M (ft)	415.12	255.38	208.48	208.48
Minimum Point Elevation (ft)	H_m (ft)	208.48	234.32	82.00	82.00
Height Difference (ft)	ΔH (ft)	206.64	21.0576	126.4768	126.4768
Channel Slope (ft/ft)	i (ft/ft)	0.0661	0.0134	0.1222	0.0653
Time of Concentration (h)	T_c (h)	0.48	0.4	0.2	0.3
Average Velocity (ft/s)	V_D (ft/s)	1.79	1.12	1.54	1.59

2.3.3. Peak Discharge

US METRIC		Drainage AREA a	Drainage AREA b	Drainage AREA P1	Drainage AREA P2
Drainage area (mi^2)	A_m (mi^2)	0.20	0.10	0.00	0.04
Runoff (in)	Q (in)	0.40	0.40	0.55	0.55
Pond and Swamp adjustment Factor	F_p	1.00	1.00	1.00	1.00
Initial Abstraction (in)	I_a (in)	0.14	0.14	0.08	0.08
Rainfall (in/h)	P (in)	0.91	0.91	0.91	0.91
Coefficient Ia/P	I_a / P	0.15	0.15	0.09	0.09
Time of Concentration (h)	T_c (h)	0.5	0.4	0.2	0.3
Unit Peak Discharge (csm/in)	q_u (csm/in)	500	550	800	650
Peak Discharge per Drainage Area (ft^3/s)	$q_{p\ AREA\ i}$ (cfs)	39.40	21.40	0.29	14.02
SI METRIC					
Peak Discharge per Drainage Area (m^3/s)	$q_{p\ AREA\ i}$ (m^3/s)	1.06	0.58	0.01	0.38

Peak discharge for culvert estimation was:

$$q_p = 39.40 \text{ cfs}$$

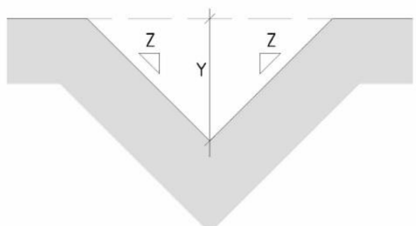
or:

$$q_p = 1.06 \text{ m}^3/\text{s}$$

4. Ditch Estimation

For the sizing of the drainage ditch, different types of cross sections (trapezoidal, triangular, rectangular, oval, etc.) must be tested with different widths and depths, which are capable of draining the peak discharge calculated previously and which are the cheapest and simplest to build.

For the sizing of the drainage ditch we have opted for a triangular cross section because the peak discharge is relatively low and because this type of ditches are easy to build and maintain and it means that they are a very economical solution



The drainage capacity of the ditch can be calculated using the following Manning's formula:

$$q_p = \frac{1}{n} \cdot S \cdot R^{2/3} \cdot J^{1/2}$$

Where:

q_p :	Peak Discharge
n :	Manning's Roughness Coefficient
S :	Cross Section Area of the ditch
R :	Hydraulic Radio
J:	Drainage inclination of the ditch

Taking into account that the cross section of the ditch is triangular according to the previous scheme;

$$S = z \cdot y^2$$

$$R = \frac{z \cdot y}{2\sqrt{1+z^2}}$$

Substituting these values in the Manning's formula, we can calculate the depth that the ditch should have:

$$y = \frac{2^{2/3} \cdot (1+z^2)^{1/3} \cdot n \cdot q_p}{z^{5/3} \cdot J^{1/2}}$$

The Manning's Roughness Coefficient can be chosen in the table below, according to the drainage conditions.

Material	Typical Manning roughness coefficient
Concrete	0.012
Gravel bottom with sides	
- concrete	0.020
- mortared stone	0.023
- riprap	0.033
Natural stream channels	
Clean, straight stream	0.030
Clean, winding stream	0.040
Winding with weeds and pools	0.050
With heavy brush and timber	0.100
Flood Plains	
Pasture	0.035
Field crops	0.040
Light brush and weeds	0.050
Dense brush	0.070
Dense trees	0.100

The roughness coefficient must refer to the interior of the ditch, that is, the coefficient must define the surface in contact with the water inside the ditch and should not be confused with the coefficient that defines the contact surface of the water on the outside of the ditch calculated previously (Runoff Curve Number).

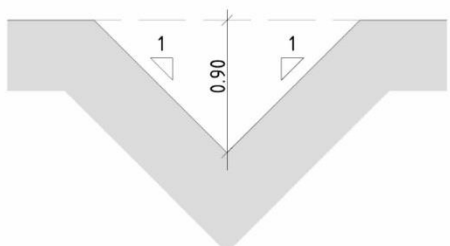
In this case, we are going to select a value of 0.035

For the interior slopes of the ditch we will select the value of Z = 1, which defines an angle of 45°. A higher value of Z would give us a very small value of 'y'. On the other hand, a higher value of Z would give us a very small ditch width. In both cases and taking into account the relatively low value of the peak discharge, we would obtain difficult ditches to build.

Finally, to select the value of the drainage inclination of the ditch, we must take into account the topography of the land where the ditch will be built. Taking into account the great existing differences un the elevations, we can take the value of 1%, that is, J = 0.01, which will provide a quick discharge.

Substituting all these values, the depth of the triangular ditch would be y = 0.90 m

So the cross section completely calculated would be the following:



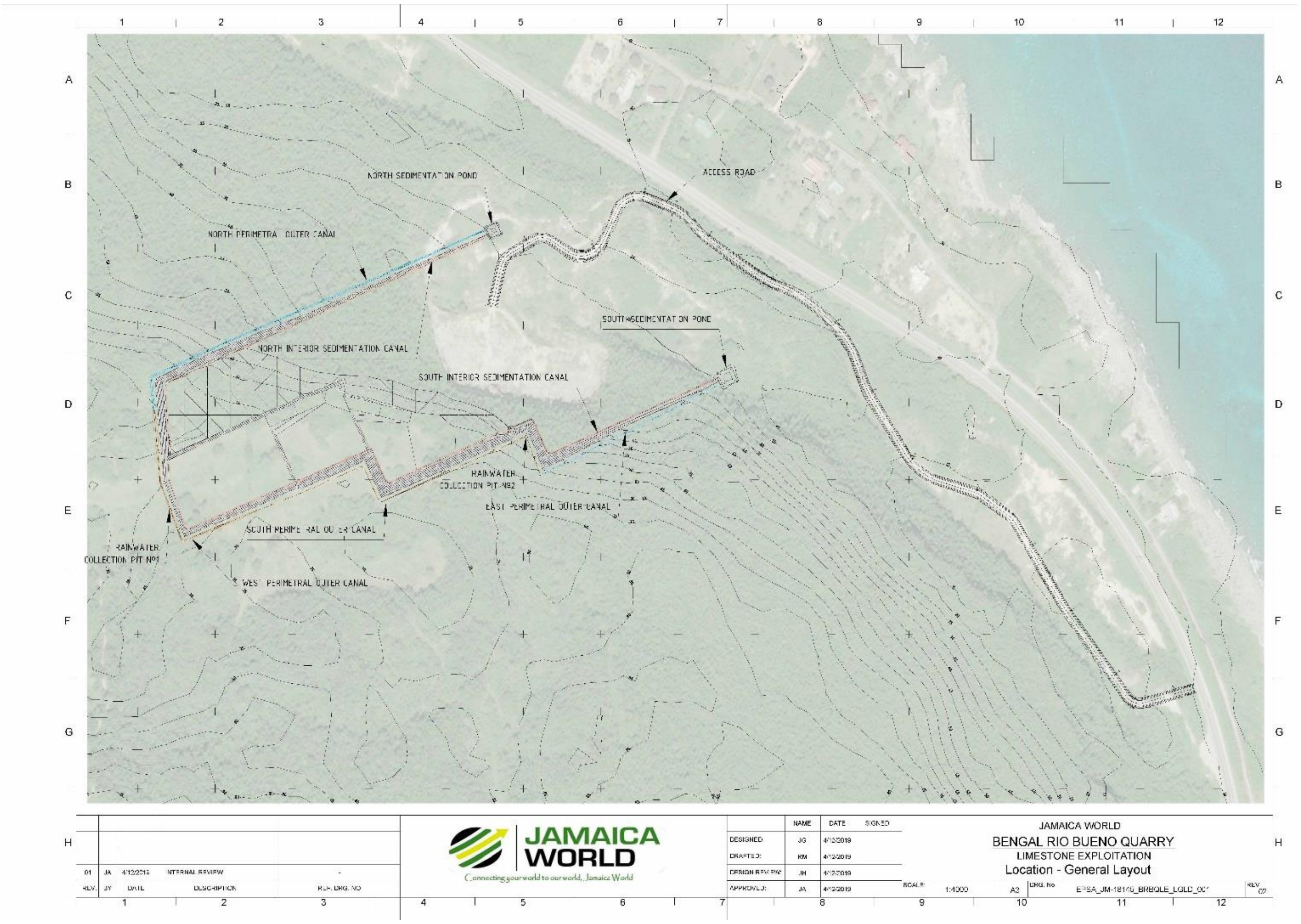
4. Appendixes

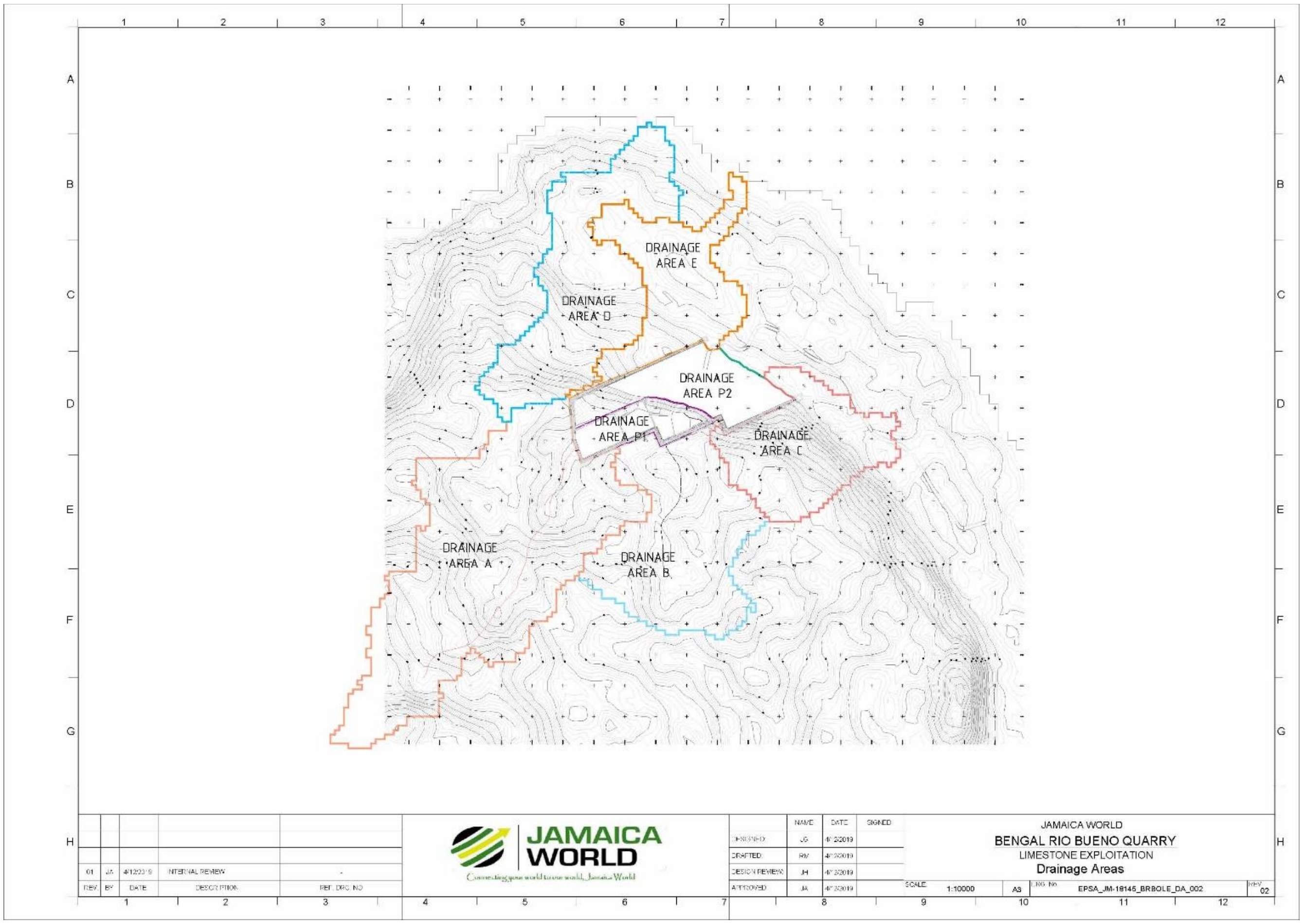
Appendix 1. Drainage System

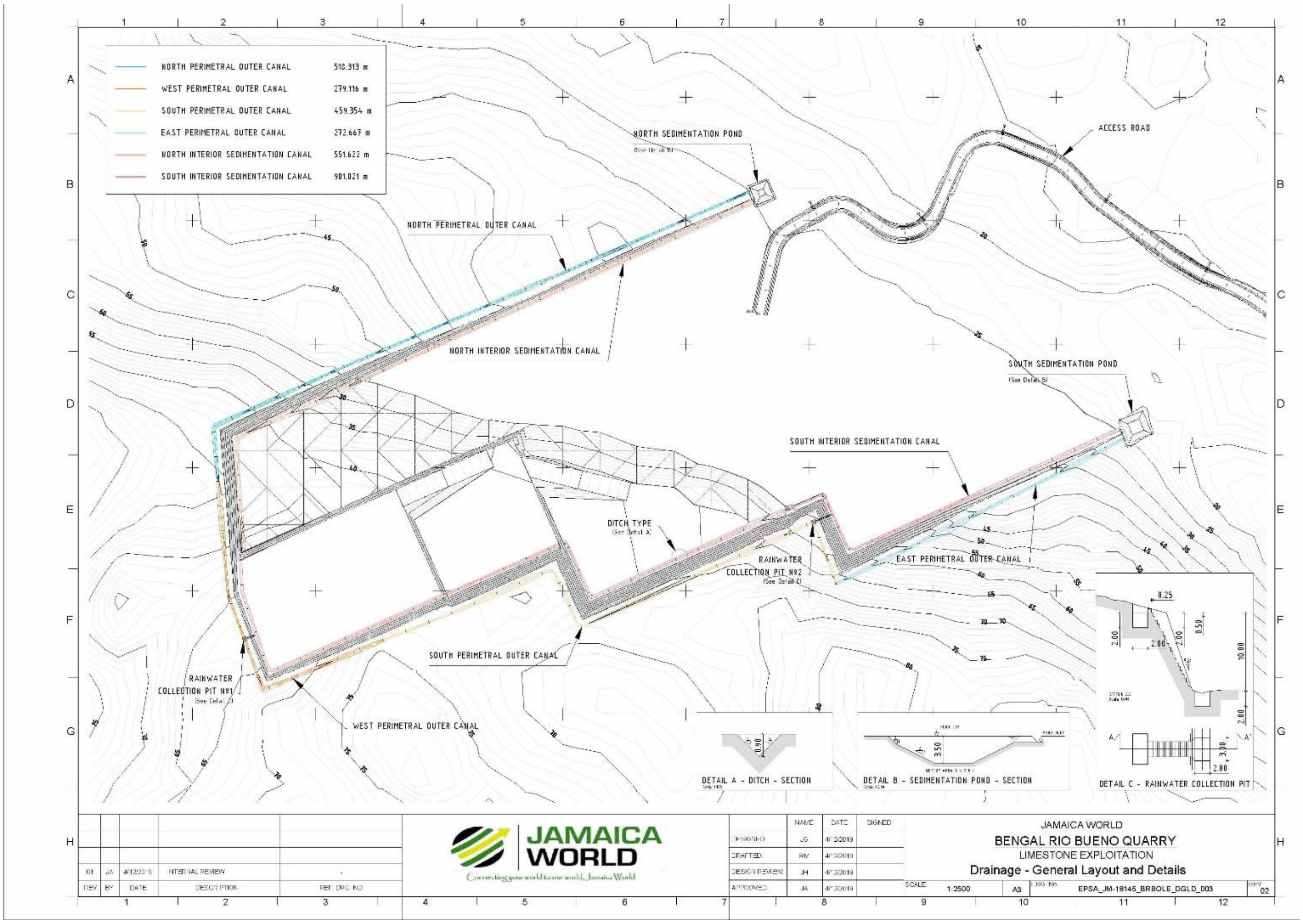
APPENDIX 1

Drainage System Drawings

JAMAICA WORLD
Connecting your world to our world, Jamaica World


NORTH SEDIMENTATION POND
ACCESS ROAD
NORTH INTERIOR SEDIMENTATION CANAL
SOUTH INTERIOR SEDIMENTATION CANAL
RAINWATER COLLECTION PIT Nº2
EAST PERIMETRAL OUTER CANAL
RAINWATER COLLECTION PIT Nº1
WEST PERIMETRAL OUTER CANAL
JAMAICA WORLD
Connecting your world to our world, Jamaica World
NAME
DATE
SIGNED
DESIGNED
JG
4/12/2019
DRAFTED:
RM
4/12/2019
DESIGN REVIEW
JH
4/12/2019
APPROVED:
JA
4/12/2019
01
JA
4/12/2019
INTERNAL REVIEW
REV.
BY
DATE
DESCRIPTION
REF. DRG. NO
JAMAICA WORLD
BENGAL RIO BUENO QUARRY
LIMESTONE EXPLOITATION
Location - General Layout
SCALE:
1:4000
A3
DRG. No
REV.


DRAINAGE AREA E
DRAINAGE AREA D
DRAINAGE AREA P2
DRAINAGE AREA P1
DRAINAGE AREA C
DRAINAGE AREA A
DRAINAGE AREA B
JAMAICA WORLD
JAMAICA WORLD
BENGAL RIO BUENO QUARRY
LIMESTONE EXPLOITATION
Drainage Areas
NAME
DATE
SIGNED
DRAFTED
RM
DESIGN REVIEW
JH
APPROVED
JA
SCALE 1:10000
A3
EPSA_JM-18145_BRBOLE_DA_002
REV 02
INTERNAL REVIEW
REV
BY
DATE
DESCRIPTION
REF. DRG. NO


NORTH PERIMETRAL OUTER CANAL 518.313 m
WEST PERIMETRAL OUTER CANAL 279.116 m
SOUTH PERIMETRAL OUTER CANAL 459.354 m
EAST PERIMETRAL OUTER CANAL 272.667 m
NORTH INTERIOR SEDIMENTATION CANAL 551.622 m
SOUTH INTERIOR SEDIMENTATION CANAL 901.021 m
NORTH SEDIMENTATION POND
ACCESS ROAD
NORTH PERIMETRAL OUTER CANAL
NORTH INTERIOR SEDIMENTATION CANAL
SOUTH SEDIMENTATION POND
SOUTH INTERIOR SEDIMENTATION CANAL
DITCH TYPE
RAINWATER COLLECTION PIT Nº2
EAST PERIMETRAL OUTER CANAL
SOUTH PERIMETRAL OUTER CANAL
RAINWATER COLLECTION PIT Nº1
WEST PERIMETRAL OUTER CANAL
DETAIL A - DITCH - SECTION
DETAIL B - SEDIMENTATION POND - SECTION
DETAIL C - RAINWATER COLLECTION PIT
JAMAICA WORLD
JAMAICA WORLD
BENGAL RIO BUENO QUARRY
LIMESTONE EXPLOITATION
Drainage - General Layout and Details
SCALE 1:2500
A3
EPSA_JM-18145_BRBOLE_DGLD_003
02

Appendix 5 – Hydrolab Calibration Certificate

OTT Hydromet

Certificate of Instrument Performance

Company Name: CL ENVIRONMENTAL Certification for Job#: 4802458

Part/Model Number: DATASONDE – 5 Serial Number: 48757

RECEIVED CONDITION: *(One must be checked)*
- [x] Within Tolerance
- [ ] Within Tolerance but Limited *(*see service report)*
- [ ] Out of Tolerance (**see service report)*

RETURNED CONDITION: *(One must be checked)*
- [x] Within Tolerance
- [ ] Within Tolerance but Limited (**see service report)*

Test Equipment Used, (ID#): N.I.S.T. - traceable glass thermometer (H-B Thermometer, Serial ***2Z9208)*** and a Cole-Parmer "*PolyStat*" Constant Temperature Circulator

Environmental Conditions:

Actual Temperature:	Instrument Reading:	Error
10 °C	10.00°C	0.00°C
20 °C	20.00°C	0.00°C
30 °C	29.98°C	0.02°C

OTT Hydromet does hereby certify that the above listed equipment meets or exceeds all Manufacturers' Service Specifications (unless limited conditions apply). Test equipment used for performance verification are calibrated using standards traceable to the National Institute of Standards and Technology (NIST). Where such standards do not exist, the basis for calibration is documented. The proper operation of the above instrument was established at the time of certificate issuance. To insure continued performance, user must adhere to all requirements listed in the instrument manual.

Certified by: Chad Fletcher

Title: Certified Instrument Service Technician

Certification Date: 7/28/2015

5600 Lindbergh Drive • Loveland, CO 80538
(800) 949-3766 / FAX (970) 461-3921

ADCON TELEMETRY OTT HYDROLAB

Appendix 6 – Noise Calibration Certificate

3M Oconomowoc
Personal Safety Division

3M Detection Solutions
1060 Corporate Center Drive
Oconomowoc, WI 53066-4828
www.3M.com/detection
262 567 9157 800 245 0779
262 567 4047 Fax

Page 1 of 2

3M

Certificate of Calibration

Certificate No: 5510375QII050083

Submitted By: CL ENVIRONMENTAL COMPANY LIMITED
22 FORT GEORGE HEIGHTS
KINGSTON 9, JAMAICA

Serial Number: QII050083
Customer ID:
Model: QC-10 CALIBRATOR

Date Received: 4/2/2015
Date Issued: 4/3/2015
Valid Until: 4/3/2016

Test Conditions:

Temperature: 18°C to 29°C
Humidity: 20% to 80%
Barometric Pressure: 890 mbar to 1050 mbar

Model Conditions:

As Found: IN TOLERANCE
As Left: IN TOLERANCE

SubAssemblies:
Description:
Serial Number:

Calibration Procedure: 56V981

Reference Standard(s):

I.D. Number	Device	Last Calibration Date	Calibration Due
ET0000556	B&K ENSEMBLE	6/19/2014	6/19/2015
T00230	FLUKE 45 MULTIMETER	2/14/2014	2/14/2016

Measurement Uncertainty:

+/- 1.1% ACOUSTIC (0.1DB) +/- 1.4% VAC +/- 0.012% HZ
Estimated at 95% Confidence Level (k=2)

Calibrated By: Paul M. Wegmann — PAUL WEGMANN, **Service Technician** 4/3/2015

Reviewed/Approved By: **Technical Manager/Deputy** 4/3/2015

This report certifies that all calibration equipment used in the test is traceable to NIST or other NMI, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of 3M Detection Solutions.

098-393 Rev. B

An ISO 9001 Registered Company
ISO 17025 Accredited Calibration Laboratory

A2LA ACCREDITED Calibration Laboratory CERT#1326.01

Appendix 7 – Flora Species List

Checklist of plant species observed within the proposed quarrying and mineral processing site.

Habit	H=Herbaceous	T=Tree	V=Vine	S=Shrub
DAFOR scale (Site specific)	**D**= Dominant **A**=Abundant **F**=Frequent **O**=Occasional **R**=Rare			
Status	** = Endemic			

	Taxonomy Treatment	Common Name	Habit	DAFOR Ranking
	Amaranthaceae			
1	Achyranthes aspera L. var. aspera	Devil's Horsewhip	H	R
	Anacardiaceae			
2	Comocladia sp. Britton	Maiden Plum	T	A
3	Comocladia pinnatifolia L.	Maiden Plum	T	A
4	Mangifera indica L.	Mango	T	R
5	Metopium brownii (Jacq.) Urb.	Hog Doctor	T	A
	Annonaceae			
6	Oxandra lanceolata (Sw.) Baill.	Black Lancewood	T	F
	Apocynaceae			
7	Echites umbellatus Jacq. subsp. umbellatus	Deadly nightshade	V	R
8	Nerium oleander L.	Oleander	S	F
9	Pentalinon luteum (L.) B.F. Hansen & Wunderlin	Nightshade	V	O
10	Plumeria obtusa L.	Wild Frangipani	T	O
11	Tabernaemontana laurifolia L.	Milkwood	S	R
	Araceae			
12	Anthurium grandifolium (Jacq.) Kunth	Wild Coco	H	O
13	Philodendron lacerum (Jacq.) Schott	Wicker	H	O
14	Syngonium auritum (L.) Schott	Five Finger	H	O
	Arecaceae			

	Taxonomy Treatment	Common Name	Habit	DAFOR Ranking
15	Thrinax parviflora Sw. subsp. parviflora **	Thatch pole	T	F
	Asparagaceae			
16	Agave morrisii Baker	Agave, Maypole	H	A
	Asteraceae			
17	Bidens pilosa L. var. pilosa.	Spanish Needle	H	O
18	Emilia sonchifolia (L.) DC. var. sonchifolia		H	O
19	Eupatorium sp.		S	O
20	Parthenium hysterophorus L.	Wild wormwood	H	F
21	Sphagneticola trilobata (L.) Pruski	Creeping Ox-eye	H	F
22	Spilanthes urens Jacq.	Pigeon coop	H	O
23	Zemisia discolor (Sw.) B. Nord.	Whiteback	S	F
	Bignoniaceae			
24	Crescentia cujete L.	Calabash	T	R
25	Tabebuia heterophylla (DC.) Britton	White cedar	T	F
26	Tecoma stans (L.) Kunth		S	O
	Boraginaceae			
27	Heliotropium indicum L.	Clary	H	O
28	Myriopus volubilis (L.) Small		V	R
29	Tournefortia astrotricha DC. var. astrotricha		S	R
30	Varronia bullata L. subsp. humilis	Gout tea	S	R
	Bromeliaceae			
31	Hohenbergia penduliflora (A. Rich.) Mez.	Tank Bromeliad	H	A
32	Tillandsia balbisiana J.A. & J.H. Schult.		H	R
33	Tillandsia fasciculata Sw. var. fasciculata		H	F
34	Tillandsia utriculata L.		H	O
	Burseraceae			
35	Bursera simaruba (L.) Sarg.	Red Birch	T	D

	Taxonomy Treatment	Common Name	Habit	DAFOR Ranking
	Cactaceae			
36	Hylocereus triangularis (L.) Britton & Rose **	God Okra	V	O
37	Selenicereus grandiflorus (L.) Britton & Rose	Queen-of-the-night	V	R
38	Stenocereus fimbriatus (Lam.) Lourteig	Dildo pear	H	O
	Capparaceae			
39	Cynophalla flexuosa (L.) L.J. Presl	Bottle-cod root	S	F
40	Quadrella cynophallophora (L.) Hutch.	Black Willow	T	O
	Celastraceae			
41	Colubrina asiatica (L.) Brongn.	Hoop with	S	O
42	Crossopetalum rhacoma Crantz	Poison Cherry	S	O
43	Schaefferia frutescens Jacq.		S	O
	Clusiaceae			
44	Clusia sp.	Tar Pot	T	O
	Combretaceae			
45	Terminalia catappa L.	Almond	T	R
	Commelinaceae			
46	Tradescantia spathacea Sw.	Moses-in-the-bulrushes	H	R
	Convolvulaceae			
47	Ipomoea tiliacea (Willd.) Choisy	Wild slip	V	R
	Cucurbitaceae			
48	Cucumis anguria L.	Wild Cucumber	V	O
49	Melothria pendula L.		V	R
	Cyperaceae			
50	Cyperus lithosperma (L.) Sw.	Razor grass	H	O
	Erythroxylaceae			
51	Erythroxylum areolatum L.		T	O

	Taxonomy Treatment	Common Name	Habit	DAFOR Ranking
	Euphorbiaceae			
52	Adelia ricinella L.	Wild lime	S	O
53	Croton cascarilla (L.) L.	Rosemary	S	A
54	Croton sp.		H	F
55	Euphorbia punicea Sw.**		T	A
56	Gymnanthes lucida Sw.	Crabwood	T	O
57	Jatropha gossypiifolia L. var. gossypiifolia	Belly-ache Bush	H	R
58	Lasiocroton sp.		S	O
59	Ricinus communis L.	Castor Oil Tree	S	R
	Lamiaceae			
60	Ocimum campechianum Mill.	Basil	H	F
61	Petitia domingensis Jacq.		T	F
	Lauraceae			
62	Nectandra sp.	Sweetwood	T	F
	Leguminosae			
63	Bauhinia divaricata L. var. divaricata	Bull Hoof	T	F
64	Centrosema pubescens Benth.		V	O
65	Clitoria ternatea L.	Blue pea	V	O
66	Desmodium sp.		H	O
67	Erythrina corallodendrum L.	Spanish machete	T	R
68	Haematoxylum campechianum L.	Logwood	T	R
69	Leucaena leucocephala (Lam.) De Wit subsp. leucocephala	Lead Tree	T	F
70	Piscidia piscipula (L.) Sarg.	Dogwood	T	O
71	Samanea saman (Jacq.) Merr.	Guango	T	R
72	Stylosanthes hamata (L.) Taub.	Donkey weed	H	F
	Loranthaceae			

	Taxonomy Treatment	Common Name	Habit	DAFOR Ranking
73	Psittacanthus martinicensis (Presl) Eichler	Mistletoe	H	R
	Malpighiaceae			
74	Malpighia sp.	Wild Cherry	S	R
	Malvaceae			
75	Abutilon sp.		S	F
76	Ceiba pentandra (L.) Gaertn.	Silk Cotton tree	T	R
77	Guazuma ulmifolia Lam.	Bastard Cedar	T	O
78	Helicteres jamaicensis Jacq.	Screw tree	S	A
79	Sida abutifolia Mill.		H	F
80	Waltheria indica L.	Raichie	H	F
	Menispermaceae			
81	Cissampelos pariera L.	Velvet leaf	V	R
	Moraceae			
82	Ficus citrifolia Mill.	Fig	T	F
83	Trophis racemosa (L.) Urb.	Ramoon	T	F
	Myrtaceae			
84	Calyptranthes sp.		T	O
85	Eugenia sp. A		T	F
86	Eugenia sp. B			
	Nyctaginaceae			
87	Pisonia aculeata L.	Cockspur	T	F
	Orchidaceae			
88	Brassavola subulifolia Lindl.**	Orchid	H	F
89	Broughtonia sanguinea (Sw.) R. Br.**	Blood Red Broughtonia	H	A
90	Habenaria floribunda Lindl.	Orchid	H	R
91	Oeceoclades maculata (Lindl.) Lindl.	Monk orchid	H	F
92	Trichocentrum undulatum (Sw.) Ackerman &	Brown Gal	H	O

	Taxonomy Treatment	Common Name	Habit	DAFOR Ranking
	M.W. Chase			
	Passifloraceae			
93	Passiflora foetida L. var. foetida	Wild Passion	V	O
94	Passiflora perfoliata L. var. perfoliata**		V	R
95	Turnera ulmifolia L.	Ramgoat Dash-along	H	R
	Phyllanthaceae			
96	Astrocasia tremula (Griseb.) G.L. Webster		S	F
97	Phyllanthus amarus Schumach. & Thonn.	Carry-me-seed	H	O
98	Phyllanthus arbuscula (Sw.) J.F. Gmel**		T	F
	Picramniaceae			
99	Picramnia antidesma Sw.	Majoe bitter	T	O
	Piperaceae			
100	Peperomia clusiifolia (Jacq.) Hook.**	Jackie's Saddle	H	O
101	Piper amalago L. var amalago	Jointer	S	R
	Plumbaginaceae			
102	Plumbago scandens L.	Wild plumbago	H	R
	Poaceae			
103	Cynodon dactylon (L.) Pers.var. dactylon	Bermuda grass	H	O
104	Eleusine indica (L.) Gaertn.	Yard grass	H	F
105	Lasiacis divaricata (L.) Hitchc.		H	O
106	Themeda arguens	Piano grass	H	O
	Polygonaceae			
107	Antigonon leptopus Hook. & Arn.	Coralita	V	O
108	Coccoloba sp.	Mountain Grape	T	O
109	Coccoloba uvifera (L.) L.	Sea Grape	T	R
	Primulaceae			
110	Ardisia sp.		S	O

	Taxonomy Treatment	Common Name	Habit	DAFOR Ranking
	Rhamnaceae			
111	Krugiodendron ferreum (Vahl) Urb.	Black Ironwood	T	O
	Rubiaceae			
112	Spermacoce laevis Lam.	Button weed	H	F
113	Chiococca alba (L) Hitchc.	David's Root	S	R
114	Morinda royoc L.	Red Gal	S	O
115	Phialanthus myrtilloides Griseb.		S	R
116	Portlandia grandiflora L.**	Bell flower	T	O
117	Randia aculeata L. aculeata	Indigo Berry	S	O
	Rutaceae			
118	Amyris elemifera L.	Torchwood	T	A
119	Zanthoxylum spinosum (L.) Sw.**	Lignum rorum	T	O
	Sapindaceae			
120	Allophylus cominia (L.) Sw. var. cominia		T	R
121	Blighia sapida F.D. Koenig	Ackee	T	R
122	Cardiospermum halicacabum L. var. microcarpum	Balloon vine	V	R
123	Melicoccus bijugatus Jacq.	Guinep	T	R
124	Serjania laevigata Radlk.		S	R
	Schlegeliaceae			
125	Schlegelia parasitica (Sw.) Miers ex Griseb.**		V	R
	Scruphulariaceae			
126	Capraria biflora L.	Goatweed	H	O
	Smilacaceae			
127	Smilax regelii (Killip) & C.V. Morton	Jamaican Sarsaparilla	V	R
	Solanaceae			
128	Solanum bahamense L.	Canker Berry	H	O

	Taxonomy Treatment	Common Name	Habit	DAFOR Ranking
129	Solanum sp.	Wild Susumber	S	O
	Urticaceae			
130	Cecropia peltata L.	Trumpet Tree	T	O
	Verbenaceae			
131	Citharexylum spinosum L..	Yellow Fiddlewood	T	O
132	Lantana camara L.	Wild Sage	S	O
133	Lantana trifolia L.		S	O
134	Stachytarpheta jamaicensis (L.) Vahl	Vervine	H	F
	Vitaceae			
135	Cissus trifoliata (L.) L.	Sorrel vine	V	O
	Zamiaceae			
136	Zamia erosa O.F. Cook & G.N. Collins	Zamia	H	F
	Polypodiaceae			
137	Polypodium polypoides (L.) Andrews & Windham	Resurrection fern	H	O

Appendix 8 –Special Report - Investigation on the Presence of *Marpesia Chiron* in Eastern Jamaica

INVESTIGATION ON THE PRESENCE OF *MARPESIA CHIRON* IN EASTERN JAMAICA

Eric Garraway, Damion Whyte, Catherine Murphy

September 2016

This objective of this study was to determine the occurrence of *Marpesia chiron* in eastern Jamaica. The work was centred around Bath, parish of St. Thomas since it had previously been reported from this area (Brown and Heineman 1972).

Eight field trips were carried out between May and August 2016 (Table 1). The trip to Bath yielded no positive results. However, a visit to Caymanas revealed a very active population. Following the discovery of the Caymanas population a further five trips (previously unplanned) were conducted to ascertain the status of this population. Finally, a trip was carried out to the high biodiversity hot spot, Ecclesdown in the parish of Portland. However, no *M. chiron* were observed

Table 1. Sites visited, and sightings of *Marpesia chiron* in Eastern Jamaica

Sites visited	Parish	Date	Presence/ Absence	Comments	Latitude	Longitude
Bath	St Thomas	May 21, 2016	Absent		17.960513°	76.356288°
Caymanas	St Catherine	May 19, 2016	Present	Abundant	18.048040°	76.912836°
		May 23, 2016	Present	Abundant	18.024037°	76.918939°
		June 09, 2016	Absent		18.024037°	76.918939°
		July 08, 2016	Absent		18.024037°	76.918939°
		August 25, 2016	Present	Several	18.024037°	76.918939°
		August 28, 2016	Present	Several	18.024037°	76.918939°
Ecclesdown	Portland	August 14, 2016	Absent		18.090342°	76.344893°

The Caymanas population

The adults observed at Caymanas showed a wide range of wing wear, from no observable damage to highly damaged with scales missing and several chips to the margin of the wing. Undamaged wing is generally used as an indicator of recently emerged adults, i.e. a reproductive population. The composition of the Caymanas population, i.e., adults of various ages (measured by the extent of wing-wear) is what is expected in a breeding population.

The likely sources of migrants to Jamaica are all to the north of the island and it is extremely unlikely that adults will consistently arrive at Caymanas, southern Jamaica, in mint condition, so consistently. The Caymanas population is therefore likely to be a resident population.

Figure 11-1 Map showing search sites for *M. chiron* in eastern Jamaica

Figure 11-2 Map of the Caymanas area showing sites at which M. chiron was recorded

Figure 11-3 Photograph of *M. chiron* from Caymanas showing wing in perfect condition.

GENERAL CONCLUSIONS ON THE OCCURRENCE OF *MARPESIA CHIRON* IN JAMAICA

The following conclusions are based on all our studies so far (including the July 2016 report and the present study)

1. A breeding population of *M. chiron* occurs in Trewlany, centered around Rio Bueno and Baron Hill.
2. A second breeding population of *M. chiron* exists in the Caymanas area of St Catherine.
3. The negative results recorded from some areas do not necessarily indicate that populations do not exists in such places, rather, it might be an artefact of the limited work done in these areas.
4. There is a resident population of *M. chiron* in Jamaica, and not a migrant population as previously surmised. This population occurs across Jamaica as sub-populations in small patches where it might be locally common.
5. The individual small sub-populations are dynamic and changes occur in space and time, i.e., changes in locality depending on the availability of resources. It is therefore possible to visit the same area repeatedly and find several individuals one month and no individuals the following month.

Reference cited

Brown F.M. and B. Heineman. 1972. Jamaica and its butterflies. E.W. Classsey.

Appendix 9 – Community Perception Survey Questionnaire

Bengal Development
Community Survey
February 17, 2016

Location: Gender: F/M Age: 18-35 36-50 51-65 >65 years

1. Did you live in the area when previous quarry (Rio Bueno) was operational? Y N

2. Were impacted by the operation? Y N

3. What were your concerns?

   Noise Dust Vibration Traffic Night Noises

   Environmental damage ---

   Other---

4. A new quarry is being proposed. It will not be visible from the highway. It will be a wet crushing plant. It is being sited in a previously mined out area within an enclave to mitigate noise and dust and the operators have plans to rehabilitate mined out areas. What are your initial thoughts? Negative Positive Neutral Open Indifference

5. Do you foresee any issues that would affect the community? ---------------------------------------

   ____

   ____

6. Any concerns about previous experience

   Noise Dust Vibration Traffic Night Noises

   Environmental damage ---

   Other---

7. If these issues were addressed would you have any objections? Y N
   If Yes why? --

   ____

   ----

8. There are thoughts to rehabilitate a mined out area for a community activity. What would be most useful? --

9. Any other comments?

10. There will be a public consultation. Will you attend? Y N

11. Please provide email address…………………………….. or telephone -------------------------------

Appendix 10 –Glossary of Technical Terms

A

ALLUVIAL DEPOSIT
Detrital material which is transported by a river and deposited – usually temporarily – at points along the flood plain of a river. Commonly composed of sands and gravels.

AMPLITUDE, WAVE
(1) The magnitude of the displacement of a wave from a mean value. An ocean wave has an amplitude equal to the vertical distance from still-water level to wave crest. For a sinusoidal wave, the amplitude is one-half the wave height. (2) The semi range of a constituent tide.

B

BAY
A recess in the shore or an inlet of a sea between two capes or headlands, not as large as a gulf but larger than a cove. See also BIGHT, EMBAYMENT.

BED
The bottom of a watercourse, or any body of water.

BENEFITS
The asset value of a scheme, usually measured in terms of the cost of damages avoided by the scheme, or the valuation of perceived amenity or environmental improvements

BENTHIC
Pertaining to the sub-aquatic bottom.

BIOLOGICAL OXYGEN DEMAND (BOD)
The amount of oxygen taken up by aerobic microbes that decompose organic matter in a unit volume of water over a given time. It is used as a measure of the degree of organic pollution of water. The more organic matter the water contains, the more oxygen is used by microorganisms.

BOULDER
A rounded rock more than 256 mm (10 inch) in diameter; larger than a cobblestone. See SOIL CLASSIFICATION.

C

CALCAREOUS

Containing calcium carbonate (CaCO3), chiefly as the minerals calcite and aragonite. When applied to rock, it implies that as much as 50 percent of the rock is carbonate (e.g., calcareous sand).

CHANNEL

(1) A natural or artificial waterway of perceptible extent which either periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. (2) The part of a body of water deep enough to be used for navigation through an area otherwise too shallow for navigation. (3) A large strait, as the English Channel. (4) The deepest part of a stream, bay, or strait through which the main volume or current of water flows.

CHART DATUM

The plane or level to which soundings (or elevations) or tide heights are referenced (usually LOW WATER DATUM). The surface is called a tidal datum when referred to a certain phase of tide. To provide a safety factor for navigation, some level lower than MEAN SEA LEVEL is generally selected for hydrographic charts, such as MEAN LOW WATER or MEAN LOWER LOW WATER. See DATUM PLANE.

CHLORINATION CHAMBER

Chlorination chamber is a baffled basin that provides sufficient detention time of chlorine contact with wastewater for disinfection to occur.

CHLOROPHYLL A

A type of chlorophyll that is most common and predominant in all oxygen-evolving photosynthetic organisms such as higher plants, red and green algae. It is best at absorbing wavelength in the 400-450 nm and 650-700 nm of the electromagnetic spectrum.

CLAY

A fine grained, plastic, sediment with a typical grain size less than 0.004 mm. Possesses electromagnetic properties which bind the grains together to give a bulk strength or cohesion. See SOIL CLASSIFICATION.

CLIFF

A high, steep face of rock; a precipice.

CLIMATE

The characteristic weather of a region, particularly regarding temperature and precipitation, averaged over some significant internal of time (years).

COASTLINE

(1) Technically, the line that forms the boundary between the coast and the shore. (2) Commonly, the line that forms the boundary between the land and the water, esp. the water of a sea or ocean. The SHORELINE.

COHESIVE SEDIMENT
Sediment containing significant proportion of clays, the electromagnetic properties of which cause the sediment to bind together.

CONSOLIDATION
The gradual, slow compression of a cohesive soil due to weight acting on it, which occurs as water is driven out of the voids in the soil. Consolidation only occurs in clays or other soils of low permeability.

CONSTRUCTED WETLAND
Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality.

CONTOUR
A line on a map or chart representing points of equal elevation with relation to a DATUM. It is called an ISOBATH when connecting points of equal depth below a datum. Also called DEPTH CONTOUR.

CYCLONE
A system of winds that rotates about a center of low atmospheric pressure. Rotation is clockwise in the Southern Hemisphere and anti-clockwise in the Northern Hemisphere. In the Indian Ocean, the term refers to the powerful storms called HURRICANES in the Atlantic.

D

DATUM
Any permanent line, plane or surface used as a reference datum to which elevations are referred.

DATUM, CHART
See CHART DATUM.

DECIBELS (dB)
Is a dimensionless unit used to report sound pressure level (SPL or Lp). Decibels are used to represent the wide pressure range a human ear can detect. It is a logarithmic scale is used to report sound pressures.

DEGRADATION
The geologic process by means of which various parts of the surface of the earth are worn away and their general level lowered, by the action of wind and water.

DELTA
(1) An ALLUVIAL DEPOSIT, usually triangular or semi-circular, at the mouth of a river or stream. The delta is normally built up only where there is no tidal or current action capable of removing the sediment at the same rate as it is deposited, and hence the delta builds forward from the coastline. (2) A TIDAL DELTA is a similar deposit at the mouth of a tidal INLET, the result of TIDAL CURRENTS that flow in and out of the inlet.

DENSITY

Mass (in kg) per unit of volume of a substance; kg/m3. For pure water, the density is 1000 kg/m3, for seawater the density is usually more. Density increases with increasing salinity, and decreases with increasing temperature. More information can be found in "properties of seawater". For stone and sand, usually a density of 2600 kg/m3 is assumed. Concrete is less dense, in the order of 2400 kg/m3. Some types of basalt may reach 2800 kg/m3. For sand, including the voids, one may use 1600 kg/m3, while mud often has a density of 1100 - 1200 kg/m3.

DEPENDENCY RATIOS

It is the portion of a population which is composed of dependents (people who are too young or too old to work). The dependency ratio is equal to the number of individuals aged below 15 or above 64 divided by the number of individuals aged 15 to 64, expressed as a percentage.

DEPRESSION

A general term signifying any depressed or lower area in the ocean floor.

DEPTH

The vertical distance from a specified datum to the sea floor.

DESIGN STORM

A hypothetical extreme storm whose waves coastal protection structures will often be designed to withstand. The severity of the storm (i.e. return period) is chosen in view of the acceptable level of risk of damage or failure. A DESIGN STORM consists of a DESIGN WAVE condition, a design water level and a duration.

DISCHARGE

The volume of water per unit of time flowing along a pipe or channel.

E

ECOSYSTEM

The living organisms and the nonliving environment interacting in a given area, encompassing the relationships between biological, geochemical, and geophysical systems.

ELEVATION

The vertical distance from mean sea level or other established datum plane to a point on the earth's surface; height above sea level. Although sea floor elevation below msl should be marked as a negative value, many charts show positive numerals for water depth.

EL NIÑO

Warm equatorial water which flows southward along the coast of Peru and Ecuador during February and March of certain years. It is caused by poleward motions of air and unusual water temperature patterns in the Pacific Ocean, which cause coastal downwelling, leading to the reversal in the normal north-flowing cold coastal currents. During many El Niño years, storms, rainfall, and other meteorological phenomena in the Western Hemisphere are measurably different than during non-El Niño years.

EROSION
The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.

F

FAECAL COLIFORM
A group of bacteria normally present in large numbers in the intestinal tracts of humans and other warm-blooded animals. Frequently used as an indicator of sewage pollution.

FAUNA
The entire group of animals found in an area.

FILTER
Intermediate layer, preventing fine materials of an underlayer from being washed through the voids of an upper layer.

FLOOD
(1) Period when tide level is rising; often taken to mean the flood current which occurs during this period (2) A flow beyond the carrying capacity of a channel.

FLORA
The entire group of plants found in an area.

FLUVIAL
Of or pertaining to rivers; produced by the action of a river or stream (e.g.,fluvial sediment).

FOCUS GROUP
It is an organised discussion with a selected group of individuals to gain information about their views and experiences of a topic. The main purpose of focus group research is to draw upon respondents' attitudes, feelings, beliefs, experiences and reactions in a way in which would not be feasible using other methods, for example observation, one-to-one interviewing, or questionnaire surveys.

G

GAUGE (GAGE)
Instrument for measuring the water level relative to a datum or for measuring other parameters.

GEOGRAPHICAL INFORMATION SYSTEM (GIS)
Database of information which is geographically referenced, usually with an associated visualization system.

GEOMORPHOLOGY
(1) That branch of physical geography which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc. (2) The investigation of the history of geologic changes through the interpretation of topographic forms.

GDP
Gross domestic product is the market value of all officially recognized final goods and services produced within a country in a given period of time (normally a year).

GLOBAL POSITIONING SYSTEM (GPS)
A navigational and positioning system developed by the U.S. Department of Defense, by which the location of a position on or above the Earth can be determined by a special receiver at that point interpreting signals received simultaneously from several of a constellation of special satellites.

GRADIENT
(1) A measure of slope (soil- or water-surface) in meters of rise or fall per meter of horizontal distance. (2) More general, a change of a value per unit of distance, e.g. the gradient in longshore transport causes erosion or accretion. (3) With reference to winds or currents, the rate of increase or decrease in speed, usually in the vertical; or the curve that represents this rate.

GRADING
Distribution, with regard to size or weight, of individual stones within a bulk volume; heavy, light and fine grading are distinguished.

GRAVEL
Unconsolidated natural accumulation of rounded rock fragments coarser than sand but finer than pebbles (2-4 mm diameter).

H

HACH HYDROLAB DATASONDE-5
A tethered device used to measure various water quality parameters.

HARBOUR
Any protected water area affording a place of safety for vessels. See also PORT. A harbor may be natural or man-made.

HERTZ (Hz)
The time that it takes for a vibrating particle to complete one vibration is known as the time period. The number of vibrations (pressure variations) per second is called the frequency of the sound, and is

measured in Hertz (Hz). The frequency of a sound produces its distinctive tone. Thus, the rumble of distant thunder has a low frequency, while a whistle has a high frequency.

HISTORIC EVENT ANALYSIS
Extreme analysis based on hindcasting typically ten events over a period of 100 years.

HURRICANE
An intense tropical cyclone in which winds tend to spiral inward toward a core of low pressure, with maximum surface wind velocities that equal or exceed 33.5 m/sec (75 mph or 65 knots) for several minutes or longer at some points. TROPICAL STORM is the term applied if maximum winds are less than 33.5 m/sec but greater than a whole gale (63 mph or 55 knots). Term is used in the Atlantic, Gulf of Mexico, and eastern Pacific.

HURRICANE PATH or TRACK
Line of movement (propagation) of the eye through an area.

HYDROGRAPHY
(1) The description and study of seas, lakes, rivers and other waters. (2) The science of locating aids and dangers to navigation. (3) The description of physical properties of the waters of a region.

K

KINEMATIC VISCOSITY
KNOT
The unit of speed used in navigation equal to 1 nautical mile (6,076.115 ft or 1,852 m) per hour.

L

LANDMARK
A conspicuous object, natural or artificial, located near or on land, which aids in fixing the position of an observer.

M

MANGROVE
A tree or shrub which grows in tidal, chiefly tropical, coastal swamps, having numerous tangled roots that grow above ground and form dense thickets.

MOUTH
Entrance to an inland water body (e.g., river).

MUD
A fluid-to-plastic mixture of finely divided particles of solid material and water.

N

NISKIN
Device used to collect water samples at discrete depths in the water column.

NOISE
Noise is unwanted sound without agreeable musical quality. It is unwanted /undesired sound or sound in the wrong place at the wrong time. It is considered a pollutant and can be measured.

NUMERICAL MODELING
Refers to analysis of coastal processes using computational models.

O

OUTCROP
A surface exposure of bare rock, not covered by soil or vegetation.

P

PHOTOSYNTHETICALLY ACTIVE RADIATION (PAR)
The amount of light available for photosynthesis, which is light in the 400 to 700 nanometer wavelength range.

PHYTOPLANKTON
Microscopic plant-like organisms that inhabit oceans and bodies of freshwater requiring sunlight in order to live and grow.

PIER
A structure, usually of open construction, extending out into the water from the shore, to serve as a landing place, recreational facility, etc., rather than to afford coastal protection or affect the movement of water. In the Great Lakes, a term sometimes improperly applied to jetties.

PM 10
These are airborne particles that fall between 2.5 and 10 micrometers in diameter. They are considered coarse particles which are generated from sources such as crushing or grinding operations, and dust stirred up by vehicles traveling on roads.

PM 2.5

These are airborne particles that have diameters below 2.5 micrometres. Sources of these fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

POORLY-SORTED (POORLY-GRADED)

Said of a clastic sediment or rock that consists of particles of many sizes mixed together in an unsystematic manner so that no one size class predominates.

POPULATION DENSITY

The number of persons per square kilometre or acre of land area.

PORE PRESSURE

The interstitial pressure of water within a mass of soil or rock.

POROSITY

Percentage of the total volume of a soil sample not occupied by solid particles but by air and water, $\eta = V_v/V_T \times 100$

PROBABILITY

The chance that a prescribed event will occur, represented by a number (p) in the range 0 - 1. It can be estimated empirically from the relative frequency (i.e. the number of times the particular event occurs, divided by the total count of all events in the class considered).

PROPAGULE

A vegetative structure that can become detached from a plant and give rise to a new plant, e.g. a bud, sucker, or spore.

Q

QUARRY RUN

Waste of generally small material, in a quarry, left after selection of larger grading.

QUARRYSTONE

Any stone processed from a quarry.

R

RETURN PERIOD

Average period of time between occurrences of a given event.

RISK ANALYSIS

Assessment of the total risk due to all possible environmental inputs and all possible mechanisms.

ROCK WEATHERING
Physical and mineralogical decay processes in rock brought about by exposure to climatic conditions either at the present time or in the geological past.

ROCK
(1) An aggregate of one or more minerals; or a body of undifferentiated mineral matter (e.g., obsidian). The three classes of rocks are: (a) Igneous – crystalline rocks formed from molten material. Examples are granite and basalt. (b) Sedimentary – resulting from the consolidation of loose sediment that has accumulated in layers. Examples are sandstone, shale and limestone. (c) Metamorphic – formed from preexisting rock as a result of burial, heat, and pressure. (2) A rocky mass lying at or near the surface of the water or along a jagged coastline, especially where dangerous to shipping.

S

SALIENT
A bulge in the coastline projecting towards an offshore island or breakwater, but not connected to it as in the case of a TOMBOLO. Developed by WAVE REFRACTION and diffraction and long shore drift.

SALINITY
Number of grams of salt per thousand grams of sea water, usually expressed in parts per thousand (symbol: ‰).

SAND
Sediment particles, often largely composed of quartz, with a diameter of between 0.062 mm and 2 mm, generally classified as fine, medium, coarse or very coarse. Beach sand may sometimes be composed of organic sediments such as calcareous reef debris or shell fragments.

SEDIMENT
(1) Loose, fragments of rocks, minerals or organic material which are transported from their source for varying distances and deposited by air, wind, ice and water. Other sediments are precipitated from the overlying water or form chemically, in place. Sediment includes all the unconsolidated materials on the sea floor. (2) The fine grained material deposited by water or wind.

SEWAGE TREATMENT
Sewage treatment, or domestic wastewater treatment, is the process of removing contaminants from wastewater, both runoff (effluents) and domestic. It includes physical, chemical and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge suitable for discharge or reuse back into the environment.

SHORELINE
The intersection of a specified plane of water with the shore or beach (e.g., the high water shoreline would be the intersection of the plane of mean high water with the shore or beach). The line delineating

the shoreline on National Ocean Service nautical charts and surveys approximates the mean high water line (United States).

SILT
Sediment particles with a grain size between 0.004 mm and 0.062 mm, i.e. coarser than clay particles but finer than sand. See SOIL CLASSIFICATION.

SLOPE
The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25, indicating one unit rise in 25 units of horizontal distance; or in a decimal fraction (0.04). Also called GRADIENT.

SLUMP
In mass wasting, movement along a curved surface in which the upper part moves vertically downward while the lower part moves outward.

SOCIAL IMPACT AREA (SIA)
Estimated spatial extent of the proposed project's effect on surrounding communities, demarcated as a buffer of specified distance, e.g. 2 km from the proposed project.

SOIL
A layer of weathered, unconsolidated material on top of bed rock; in geologic usage, usually defined as containing organic matter and being capable of supporting plant growth.

SOIL CLASSIFICATION (size)
An arbitrary division of a continuous scale of grain sizes such that each scale unit or grade may serve as a convenient class interval for conducting the analysis or for expressing the results of an analysis. There are many classifications used.

SORTING
Process of selection and separation of sediment grains according to their grain size (or grain shape or specific gravity).

SPECIFIC GRAVITY
The ratio of the weight of unit volume of any material to the weight of unit volume of water at 4 deg C, $G_s = \gamma_s/\gamma_w$. Typical values of Gs for soil solids are 2.65 to 2.72.

SPL (Sound Pressure Level)
A ratio of one sound pressure to a reference pressure.

SPL = 20 log (L/Lr) dB   where Lr is the reference pressure

STONE
Quarried or artificially-broken rock for use in construction, either as aggregate or cut into shaped blocks as dimension stone.

SURVEY, CONTROL
A survey that provides coordinates (horizontal or vertical) of points to which supplementary surveys are adjusted.

SURVEY, TOPOGRAPHIC
A survey which has, for its major purpose, the determination of the configuration (relief) of the surface of the land and the location of natural and artificial objects thereon.

T

TOPOGRAPHIC MAP
A map on which elevations are shown by means of contour lines.

TOPOGRAPHY
The configuration of a surface, including its relief and the positions of its streams, roads, building, etc.

TOTAL DISSOLVED SOLIDS (TDS)
Compounds in the water that cannot be removed by a traditional filter and are made up of salts or compounds which dissociate in water to form ions.

TOTAL PETROLEUM HYDROCARBON (TPH)
A mixture of chemicals made mainly from hydrogen and carbon.

TOTAL SUSPENDED SOLIDS (TSS)
Solid materials, including organic and inorganic, that are suspended in the water.

TROPICAL CYCLONE
See HURRICANE

TROPICAL STORM
A tropical cyclone with maximum winds less than 34 m/sec (75 mile per hour). Compare with HURRICANE (winds greater than 34 m/sec).

TROUGH
A long and broad submarine DEPRESSION with gently sloping sides.

TROUGH OF WAVE
The lowest part of a waveform between successive crests. Also, that part of a wave below still-water level.

TSUNAMI
A long-period water wave caused by an underwater disturbance such as a volcanic eruption or earthquake. Also SEISMIC SEA WAVE. Commonly miscalled "tidal wave."

TURBIDITY
(1) A condition of a liquid due to fine visible material in suspension, which may not be of sufficient size to be seen as individual particles by the naked eye but which prevents the passage of light through the liquid. (2) A measure of fine suspended matter in liquids.

U

UPLIFT
The upward water pressure on the base of a structure or pavement.

UPSTREAM
Along coasts with obliquely approaching waves there is a longshore (wave-driven) current. For this current one can define an upstream and a DOWNSTREAM direction. For example, on a beach with an orientation west-east with the sea to the north, the waves come from NW. Then the current flows from West to East. Here, upstream is West of the observer, and East is DOWNSTREAM of the observer.

W

WETLANDS
Lands whose saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities that live in the soil and on its surface (e.g. Mangrove forests).

WELL-SORTED
Clastic sediment or rock that consists of particles all having approximately the same size. Example: sand dunes.