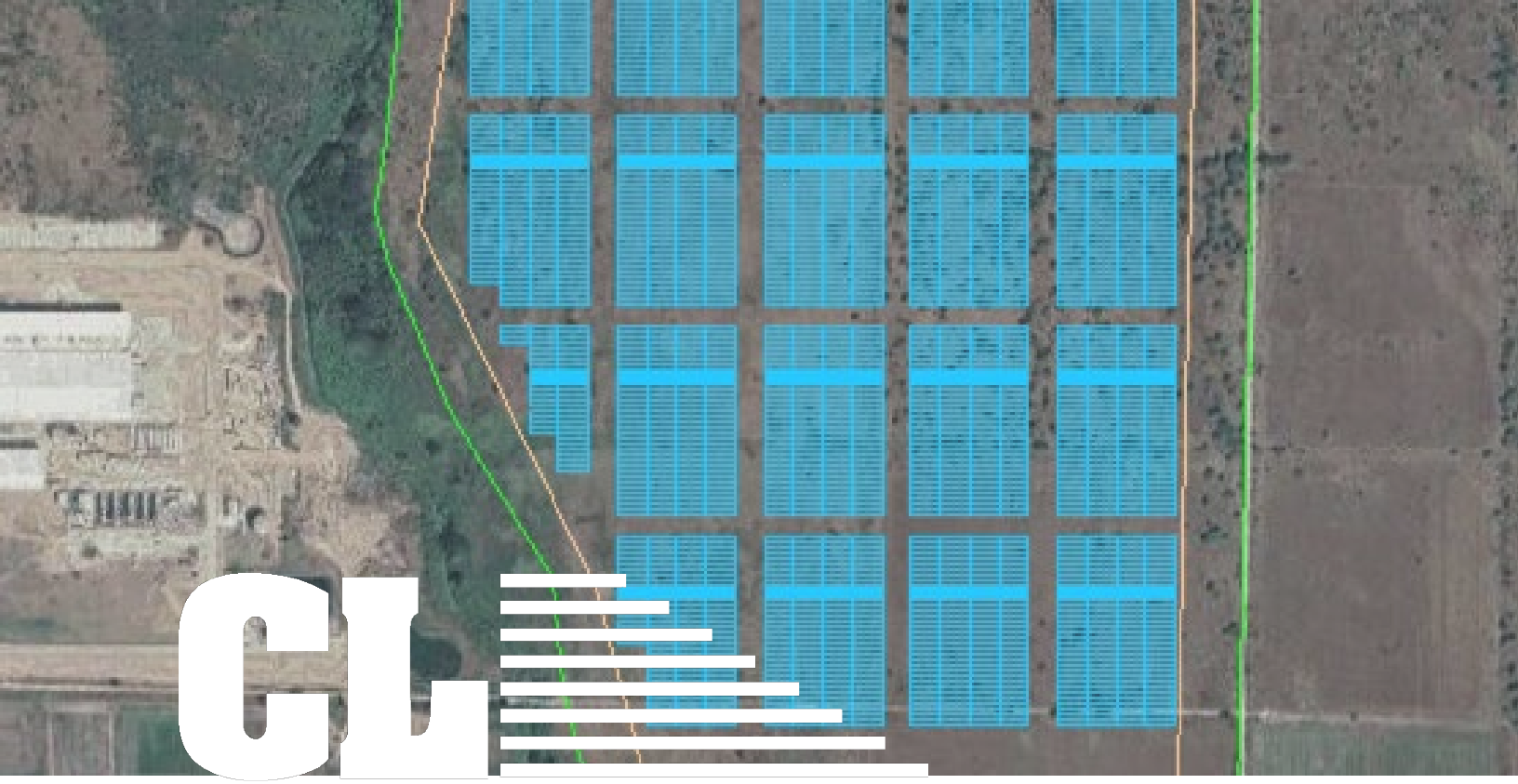

ENVIRONMENTAL

ENVIRONMENTAL CONSULTANTS

JAMAICA PUBLIC SERVICE (JPS) SOLAR FARMS AT HILL RUN, ST. CATHERINE

RAPID ENVIRONMENTAL ASSESSMENT

FINAL

DOCUMENT TITLE	**Rapid Environmental Assessment for the Jamaica Public Service (JPS) Solar Farms at Hill Run, St. Catherine**
PREPARED BY	**CL Environmental Co. Ltd.** **20 Windsor Avenue** **Kingston 5**
SUBMITTED TO	**National Environment & Planning Agency** **10 and 11 Caledonia Avenue** **Kingston 51**
DATE	**November 2023**
VERSION AND NO.	**FINAL**

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1.0 INTRODUCTION

Jamaica Public Service (JPS) Company Limited is interested in renewable energy generation for Jamaica to support the national energy policy and reduce the dependence on imported fossil fuel. Initially, potential sites for solar energy development in Jamaica were evaluated based on land space availability, energy yield potential, resource assessment and interconnection potential. Three sites were investigated, specifically in Hill Run (St. Catherine), Annotto Bay (St. Mary) and Salt River (Clarendon) (Figure 1-1).

A Rapid Environmental Assessment (REA) for the proposed renewable energy generation project was undertaken by C. L. Environmental Company Limited to provide a preliminary environmental setting for each potential site. The REA may be considered a part of initial investigations and specifically comprises a consideration of relevant national legislation, regulations/standards, policies; water quality analysis; biological surveys; and socio-economic profiling. It aims to aid in decision making regarding the selection of the project site, whilst supporting and assuring compliance with applicable environmental legislation. It must be noted that is a rapid assessment and must not be likened to an Environmental Impact Assessment (EIA), which comprises a comprehensive examination of environmental receptors and impacts and may be required by the National Environment and Planning Agency (NEPA) during the Development Assistance Centre (DAC) facilitation process.

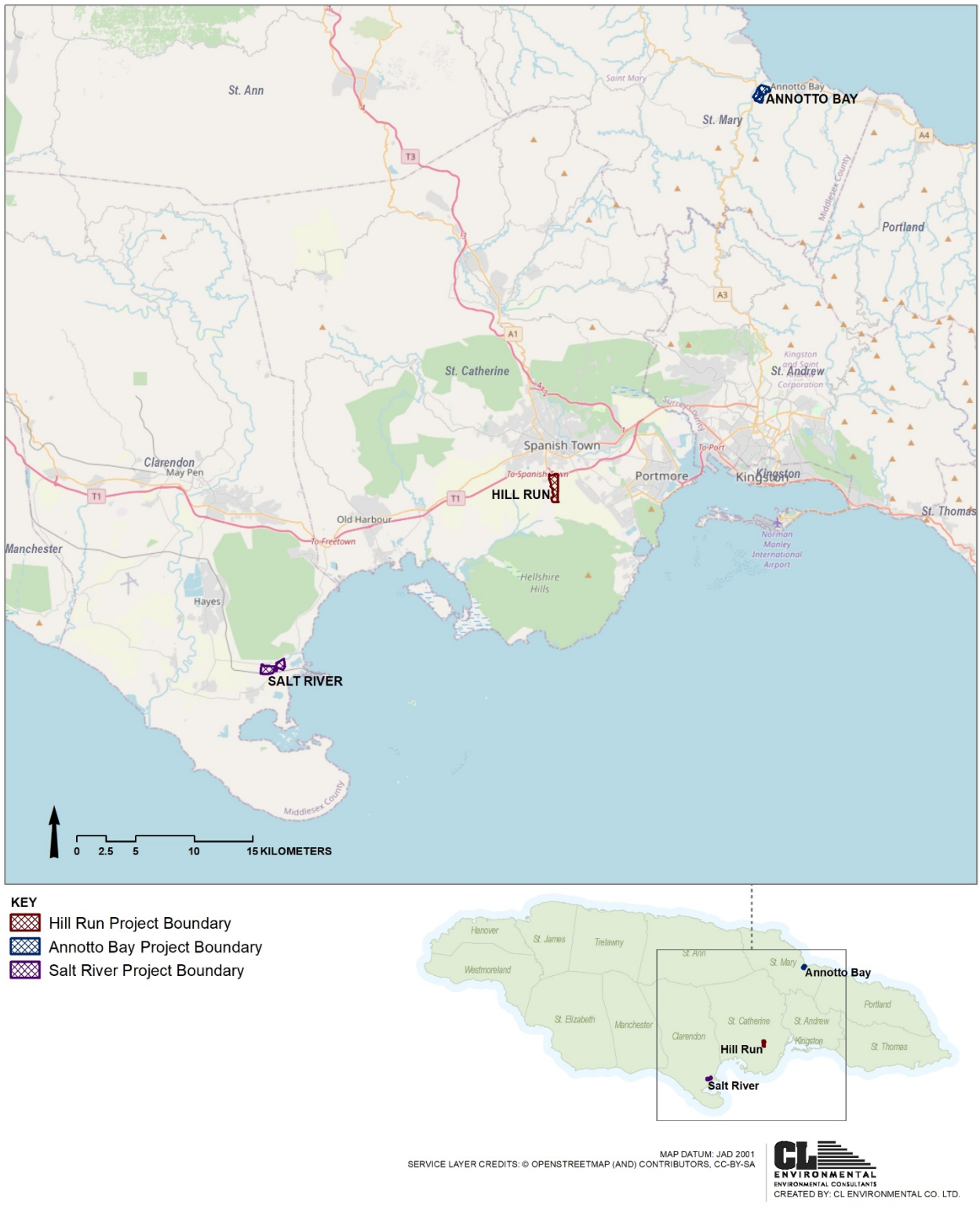


Figure 1-1 **Proposed project locations at Hill Run, Annotto Bay and Salt River**

2.0 PROJECT DESCRIPTION

2.1 LOCATION

The Hill Run site is located at the Caribbean Broiler property, south of Spanish Town in St. Catherine (Figure 2-1). Currently the land is vacant (Figure 2-2) and there is potentially 338 acres available for lease / partnership.

2.2 PRELIMINARY SITE ASSESSMENT

Potential solar land sites were evaluated in Jamaica based initially on land space availability, energy yield potential, resource assessment and interconnection potential. The Hill Run site was visited and evaluated based on:

- Initial Irradiance Level (Figure 2-4)
- Available Land space and potential ownership
- Environmental and artefacts considerations
- Transmission infrastructure
- Access Roads and transportation
- Land Ownership

Based on initial visits and evaluations, it was concluded that it is feasible to implement a 50MW Photovoltaic plant at this site. The land is gentle sloping with areas of trough and crest; with land clearance, an adequately designed drainage system and the restoration of the bridge across the Kingston gully, it was found that a 50MW plant may be facilitated. The constraint, however, is that the existing 69kV transmission line is approximately 3kM away (Figure 2-3); a transmission interconnection is needed to facilitate this project. It was further proposed that if an Agrivoltaic concept is considered by Caribbean Broilers, their farming footprint may be enhanced owing to the possibility to plant crops beneath 5MW of panels.

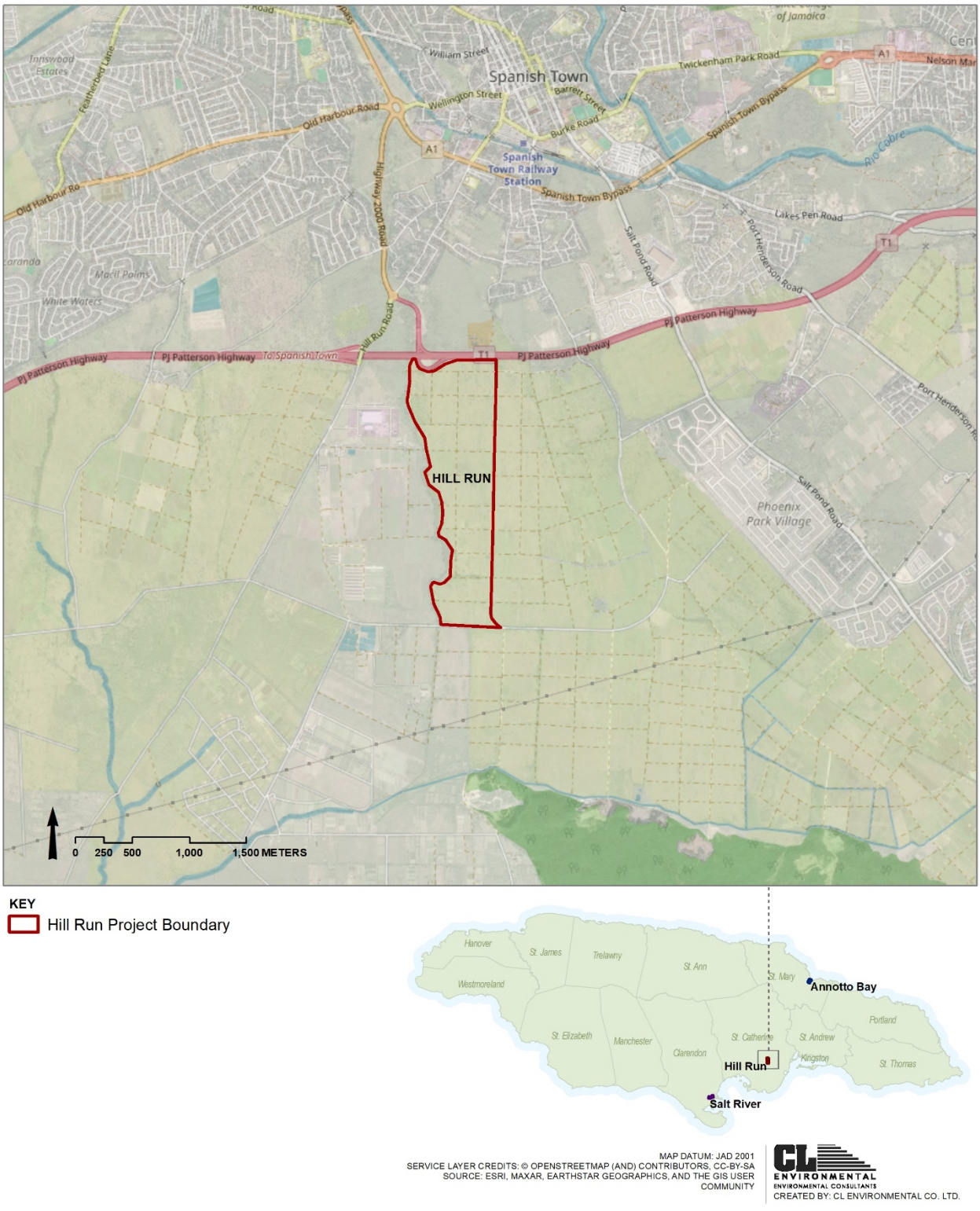


Figure 2-1 **Location of site at Hill Run, St. Catherine**

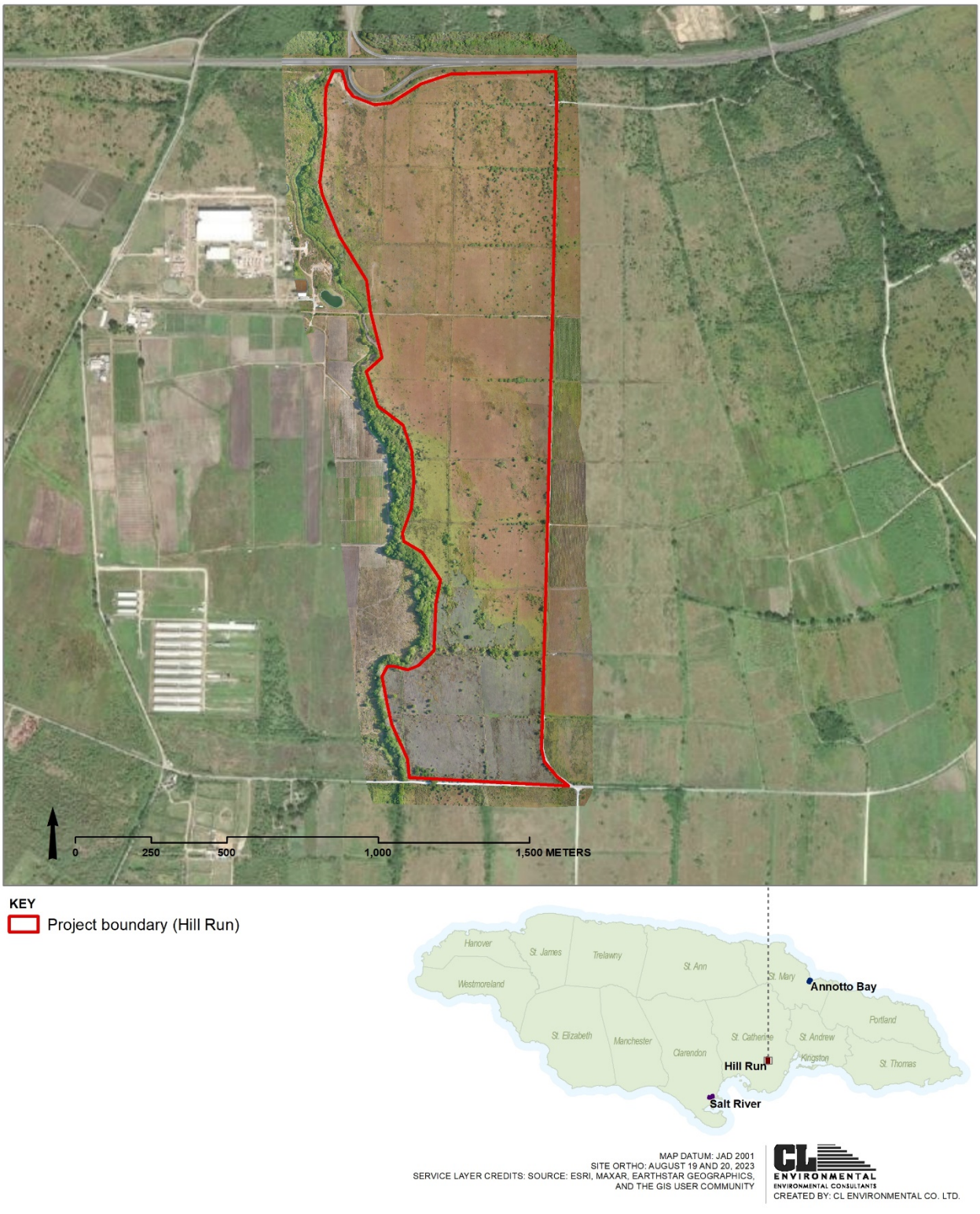


Figure 2-2 **August 2023 orthomosaic image of the Hill Run site**

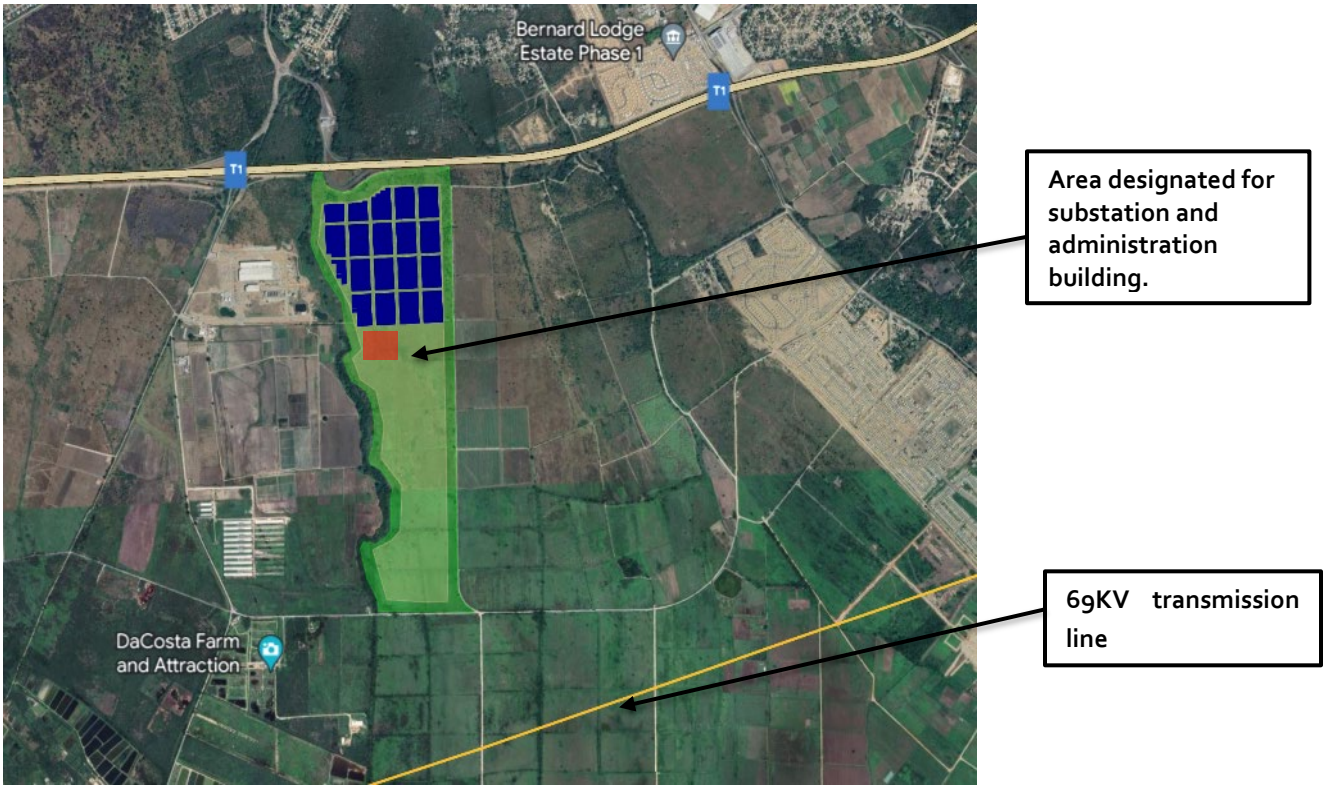


Figure 2-3 Proposed layout of solar farm at Hill Run site

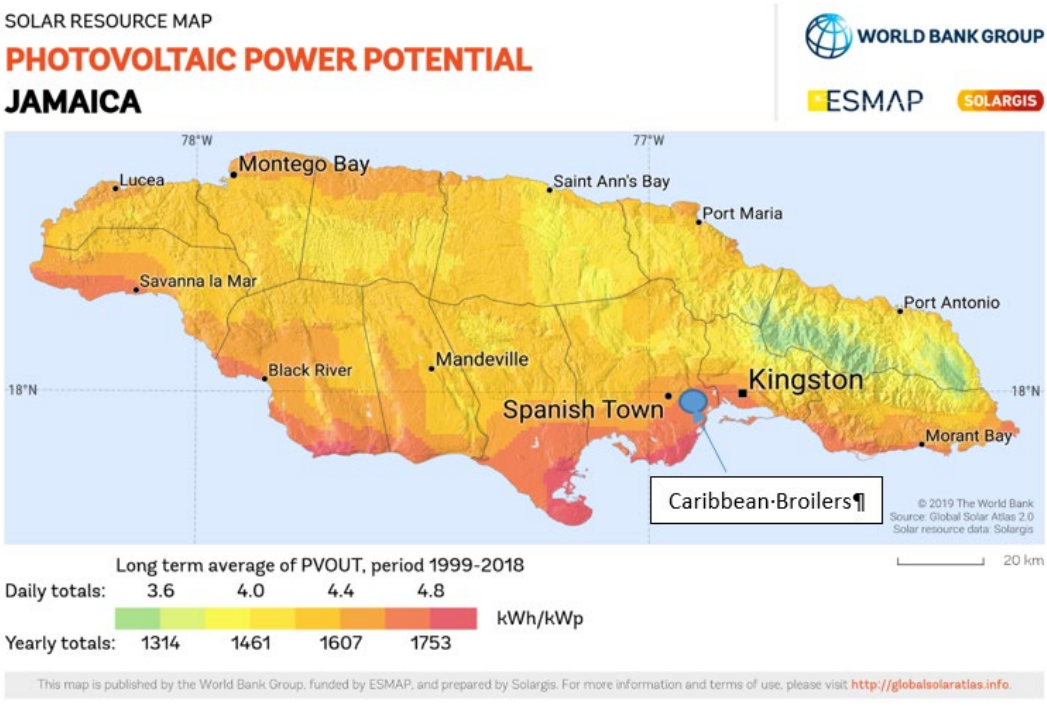


Figure 2-4 Irradiance level at Caribbean Broilers location (Hill Run)

3.0 LEGISLATION AND REGULATORY CONSIDERATION

3.1 NATIONAL LEGISLATION

3.1.1 Development Control

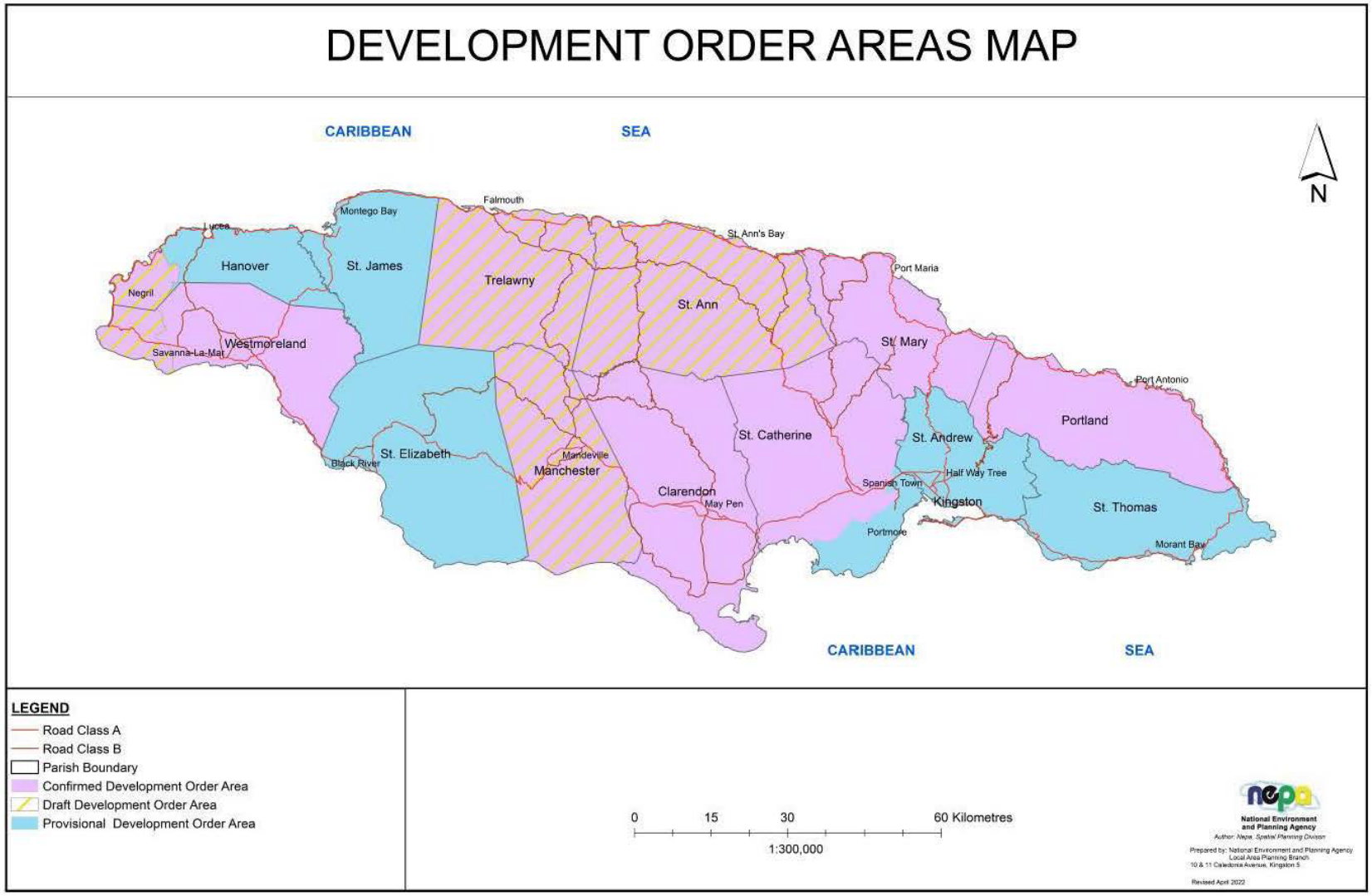
The Town and Country Planning Act (TCP Act) 1957 (Amended 1987) provides the statutory requirements for the orderly development of land through planning, as well as guidelines for the preparation of Development Orders. A Development Order is a legal document which is used to guide development in the 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. The TCP Act also establishes the Town and Country Planning Authority (TCPA), which in conjunction with the Local Planning Authorities (Municipal Corporations and formerly Parish Councils), are responsible for land use zoning and planning regulations as described in their local Development Orders. The TCP Act is also administered by the National Environment and Planning Agency (NEPA)[1].

The Development Orders and local authorities with jurisdiction over the proposed project sites are outlined in Table 3-1 (those for Hill Run are shaded in grey), and Figure 3-1, which gives detailed descriptions and illustrations of the zoning associated with each Development Order.

Table 3-1 Development Orders and Local Planning Authorities relevant to each project site

Project Site	Development Order	Local Planning Authority
Hill Run	Town And Country Planning (Saint Catherine Parish) Provisional Development Order, 2017 Town And Country Planning (Saint Catherine Parish) Provisional Development Order, 2017 (Confirmation) Notification, 2019	St. Catherine Municipal Corporation (SCMC)
Annotto Bay	Town and Country Planning (St. Mary) Provisional Development Order, 2017	St. Mary Municipal Corporation (SMMC)
Salt River	Town and Country Planning (Clarendon) Provisional Development Order, 2017	Clarendon Municipal Corporation (CMC)

[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.



Source: National Environment and Planning Agency

Figure 3-1 Development Order Areas in Jamaica

In addition to the Development Orders, the proposed project may be subject to technical and application requirements for planning and building permissions, and environmental permits and licenses outlined by NEPA. These include, but are not limited to the following:

1. Planning Permission
    - The Town and Country Planning Act, 1957
    - Local Governance Act, 2016
    - Development and Investment Manual, 2006
2. Building Permission
    - Parish Councils Building Act, 1908
    - Parish Councils Act, 1901 (Amended 2007)
    - Development and Investment Manual, 2006
3. Environmental Permits and Licenses
    - The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development Order) 1997
    - The Natural Resources Conservation (Permits and Licences) Regulations, 1996
    - Natural Resources Conservation (Permits and Licences) (Amendment) Regulations, 2004
    - The Natural Resources Conservation Authority Act, 1991
    - Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013
    - Beach Control Act 1956 and the Beach Control (Amendment) Act 2004
    - The Beach Control Regulations, 1956

3.1.2 Environmental Conservation

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. 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.

Existing protected area categories in Jamaica are listed in Table 3-2, Table 3-3 and Table 3-4 and illustrated in Figure 3-2 and Figure 3-3. The NRCA/NEPA is responsible for areas declared/designated under the acts it administers, including the Wildlife Protection and Natural Resources Conservation Authority Acts. In addition, 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.

Please refer to sections 4.3.3.2 for detailed accounts of the protected areas within the study area.

Table 3-2 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
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	Wildlife Protection Act, 1945
Game Reserve	NEPA (NRCA): MWLECC	Wildlife Protection Act, 1945

Table 3-3 Existing categories of protected areas in Jamaica (as of 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 3-4 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

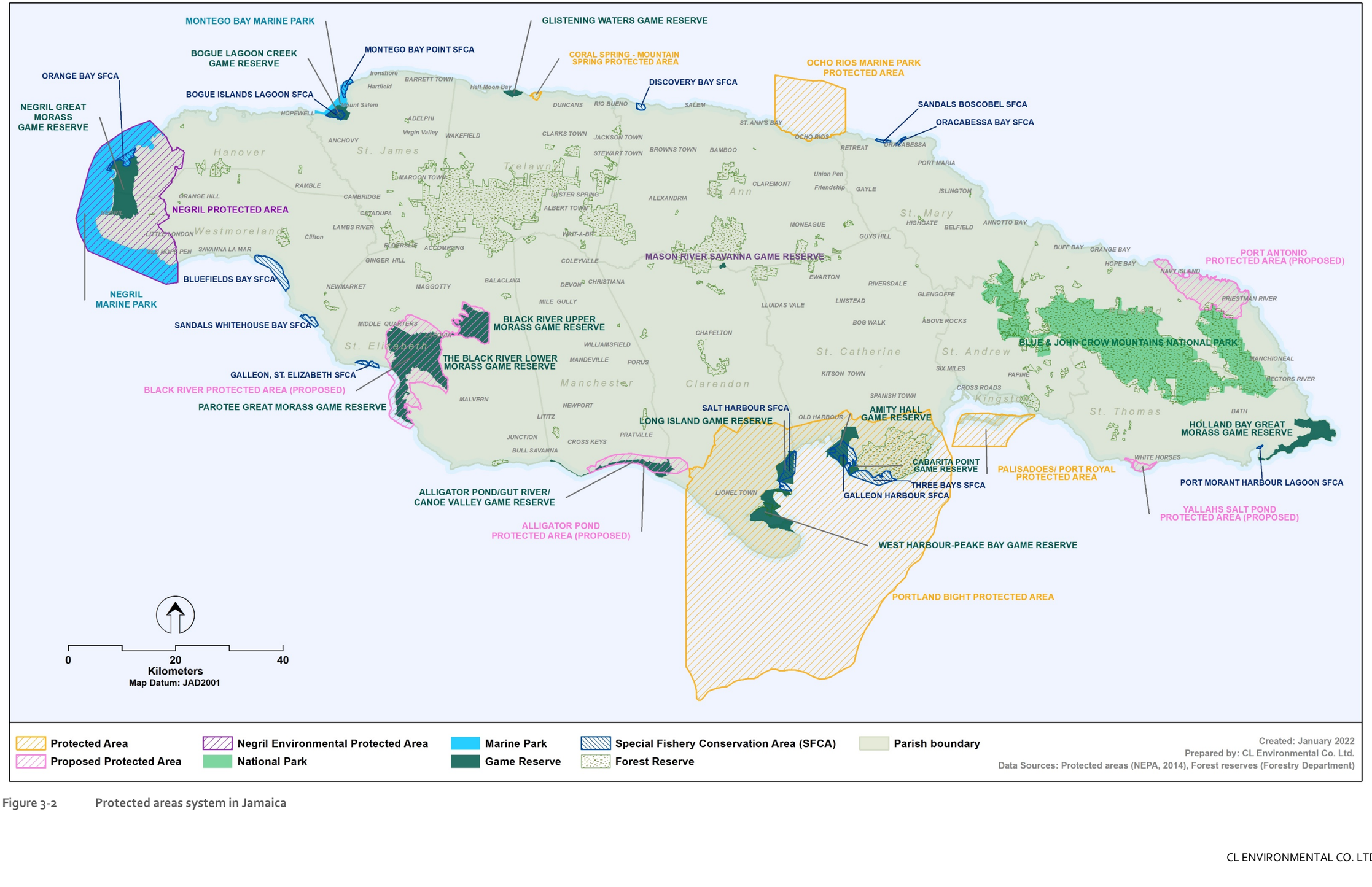
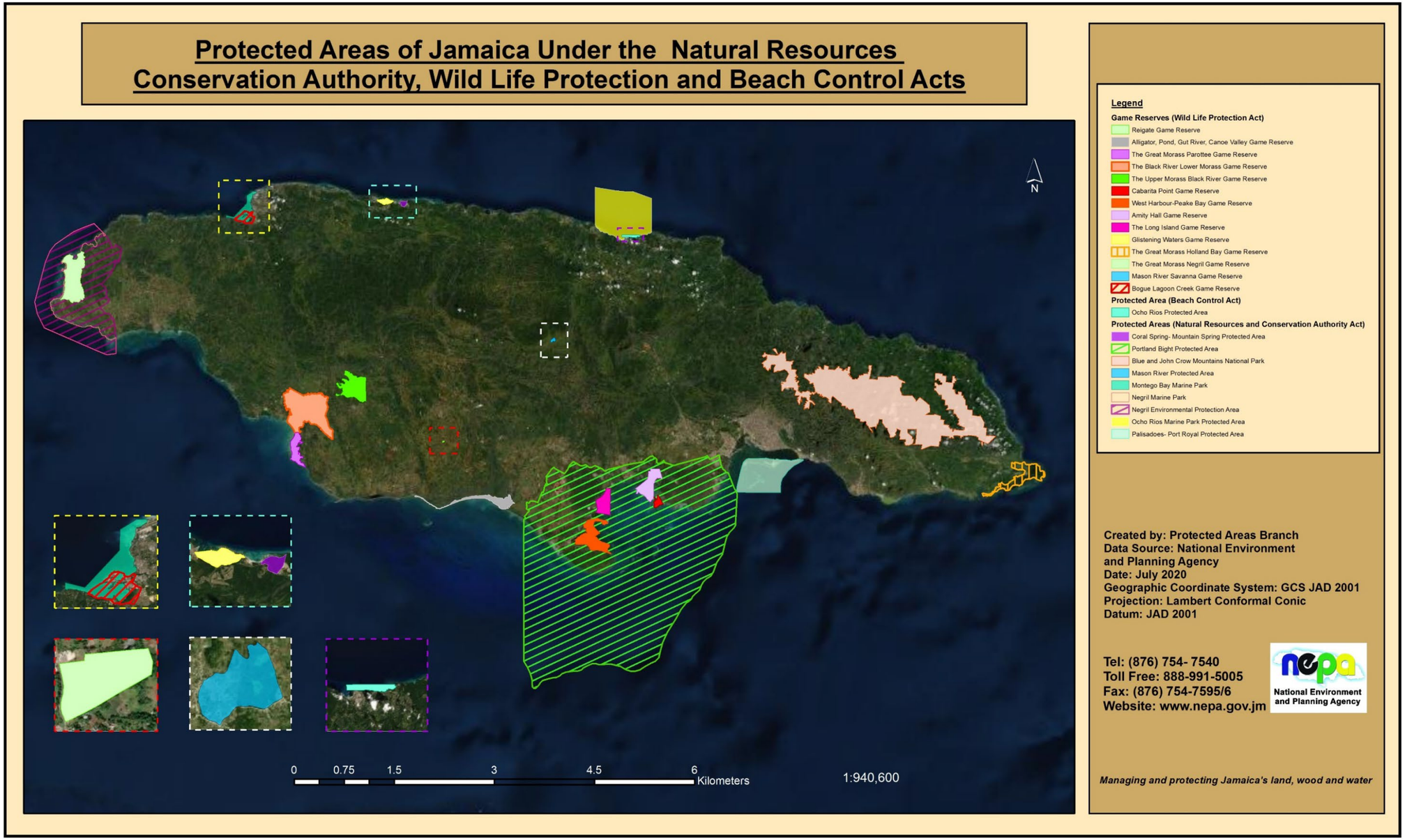


Figure 3-2 Protected areas system in Jamaica



Source: National Environment and Planning Agency, 2020

Figure 3-3 Protected areas of Jamaica under the Natural Resources Conservation Authority, Wildlife Protection and Beach Control Acts

Other Acts, regulations and policies focused on environmental conservation are:

- 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
- The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order 1996 and (Amendment) Order 2015
- Policy for the National System of Protected Areas 1997
- Wildlife Protection Act 1945 and Wildlife Protection (Amendment of Second and Third Schedules) Regulations 2016
- Beach Control Act 1956 and the Beach Control (Amendment) Act 2004
- The Fisheries Act 2018
- The Forest Act 1996
- The Endangered Species (Protection, Conservation and Regulation of Trade) Act 2000 (Amended 2015)
- Water Resources Act 1995
- National Policy for the Conservation of Seagrasses 1996
- Draft Policy and Regulation for Mangrove & Coastal Wetlands Protection
- Coral Reef Protection and Preservation – Draft Policy and Regulations 1996
- Towards an Ocean and Coastal Zone Management Policy in Jamaica 2000
- The Jamaica National Heritage Trust Act 1985

3.1.3 Public Health & Waste Management

Acts, standards, and regulations governing health and waste management are:

- Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013
- Noise Abatement Act 1997
- The Natural Resources Conservation Authority (Air Quality) Regulations, 2002
- The Clean Air Act 1964
- Public Health Act 1985
- The National Solid Waste Management Authority Act 2001
- The Natural Resources (Hazardous Waste) (Control of Transboundary Movement) Regulations 2003

3.1.3.1 Water Quality Standards

The NRCA has primary responsibility for control of water pollution in Jamaica. National standards for ambient marine water and freshwater are shown in Table 3-5 and Table 3-6 respectively. For drinking water, World Health Organisation (WHO) standards are utilized, and these are regulated by the National Water Commission (NWC).

Table 3-5 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 3-6 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

Standards for industrial (trade effluent) and sewage discharge into rivers and streams are stipulated within the Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013 (Table 3-7, Table 3-9 and Table 3-10).

Table 3-7 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 3-8 Sewage Effluent Standards for plants other than existing plants

Parameter	Effluent Limit
BOD_5	20 mg/L
TSS	20 mg/L
Total Nitrogen	10 mg/L
Phosphates (PO4-P)	4 mg/L
COD	100 mg/L
pH	6-9 pH
Faecal Coliform	200 MPN/100mL
Residual Chlorine	1.5 mg/L
Floatables	not visible

Table 3-9 Sewage Effluent Standards for use in Irrigation

Parameter	Effluent Limit
Oil and Grease	10 mg/L
Total Suspended Solids (TSS)	15 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 3-10 Industrial Trade Effluent Standards

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

3.1.3.2 Noise Guidelines

National guidelines (NRCA) used for noise levels are an adaptation from the Jamaica's National Noise Standards, 1999 and are shown in Table 3-11; values for commercial, industrial, and residential areas are specified.

Table 3-11 NRCA guidelines for daytime and night-time noise in various zones

ZONE	NRCA Daytime Guideline (dBA)	NRCA Night-time Guideline (dBA)
Commercial	65	60
Industrial	75	70
Residential	55	50

3.1.3.3 The Natural Resources Conservation Authority (Air Quality) Regulations 2006

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 (2006) 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 refers to the stack emission targets, standards and guidelines.

According to the Natural Resources Conservation Authority (Air Quality) Regulations, 2006, a "significant air quality impact", means:

(a) the increment in the predicted average concentration of sulphur dioxide (SO_2), total suspended particulates (TSP), particulate matter less than ten microns (PM_{10}) or nitrogen dioxide (NO_2) is greater than an annual average of 20 µg/m^3 or a 24-hour average concentration of 80 µg/m^3; or
(b) the increment in the predicted average concentration of CO is greater than 500 µg/m^3 as an 8-hour average or 2000 µg/m^3 as a 1-hour average.

Table 3-12 summarizes the Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations (GC).

Table 3-12 Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations (GC) for air quality

Pollutant	Avg. Period	Significant Impact Concentration (µg/m^3)	Jamaican NAAQS or GC (µg/m^3)
PM_{10}	24-hr	80	150
	Annual	20	50
TSP	24-hr	80	150
	Annual	20	60
NO_2	1-hr	N/A	400
	24-hr	80	N/A
	Annual	20	100
SO_2	1-hr	N/A	700
	24-hr	80	280

Pollutant	Avg. Period	Significant Impact Concentration (µg/m³)	Jamaican NAAQS or GC (µg/m³)
	Annual	20	60
CO	1-hr	2000	40000
	8-hr	500	10000
1,3 Butadiene	1-hr	N/A	0.04
Acetaldehyde	1-hr	N/A	1250
	24-hr	N/A	500
Acrolein	1-hr	N/A	58.75
	24-hr	N/A	23.5
Benzene	Annual	N/A	1
Benzo (a) pyrene	1-hr	N/A	0.00275
	24-hr	N/A	0.0011
Carbon Tetrachloride	1-hr	N/A	6
	24-hr	N/A	2.4
Chloroform	1-hr	N/A	1250
	24-hr	N/A	500
Ethylene Dibromide	1-hr	N/A	7.5
	24-hr	N/A	3
Formaldehyde	1-hr	N/A	162.5
	24-hr	N/A	65
Methylene Chloride	1-hr	N/A	550
	24-hr	N/A	220
Styrene	1-hr	N/A	2500
	24-hr	N/A	1000
Xylenes	1-hr	N/A	5750
	24-hr	N/A	2300
Vinyl Chloride	24-hr	N/A	1
	Annual	N/A	0.2
Arsenic	1-hr	N/A	0.75
	24-hr	N/A	0.3
Beryllium	Annual	N/A	0.0013
Cadmium	1-hr	N/A	5
	24-hr	N/A	2
Chromium	1-hr	N/A	3.75
	24-hr	N/A	1.5
Cobalt	24-hr	N/A	0.12
Copper	1-hr	N/A	125
	24-hr	N/A	50
Lead	1-month	N/A	N/A
	3-month	N/A	2
Manganese	Annual	N/A	119
Mercury	1-hr	N/A	5
	24-hr	N/A	2
Nickel	1-hr	N/A	5
	24-hr	N/A	2
Selenium	24-hr	N/A	25
	Annual	N/A	10
Zinc	24-hr	N/A	12

In 1987, U.S. Environmental Protection Agency replaced TSP with PM_{10} as the indicator for both the annual and 24-hour health-related standards. The reason for this is because exposure to PM_{10} particles may cause serious health/respiratory related issues as these particles are retained deep in the lungs. The 24-hour NEPA standards for PM_{10} are shown in Table 1 4. However, the 24-hour US EPA standards are used for $PM_{2.5}$ and TSP:

- TSP = 150 µg/m^3
- $PM_{2.5}$ = 35 µg/m^3

Other legalisation relating to health and waste management:

- The Clean Air Act 1964
- Public Health Act 1985
- Public Health Act (Air, Soil and Water Pollution) Regulations 1976
- The National Solid Waste Management Authority Act 2001

3.2 REGIONAL AND INTERNATIONAL LEGISLATIVE AND REGULATORY CONSIDERATIONS

International agreements of interest include:

- United Nations Convention on Biological Diversity
- Convention on Wetlands of International Importance especially as Waterfowl Habitat, "Ramsar Convention" 1971
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

4.0 DESCRIPTION OF ENVIRONMENT

4.1 PHYSICAL

4.1.1 Climate and Meteorology

4.1.1.1 Rainfall

Depth of rainfall for various return periods was provided by the National Meteorological Service of Jamaica for the gauges across the island. Synthetic mass-curves (SCS type 3) were used for this study. The overall approach to defining the metrological conditions was as follows:

1. Evaluate the existing Meteorological Service data
2. Define the present climate 24-hour rainfall depths for the 25-year, 50-year, and 100-year RP

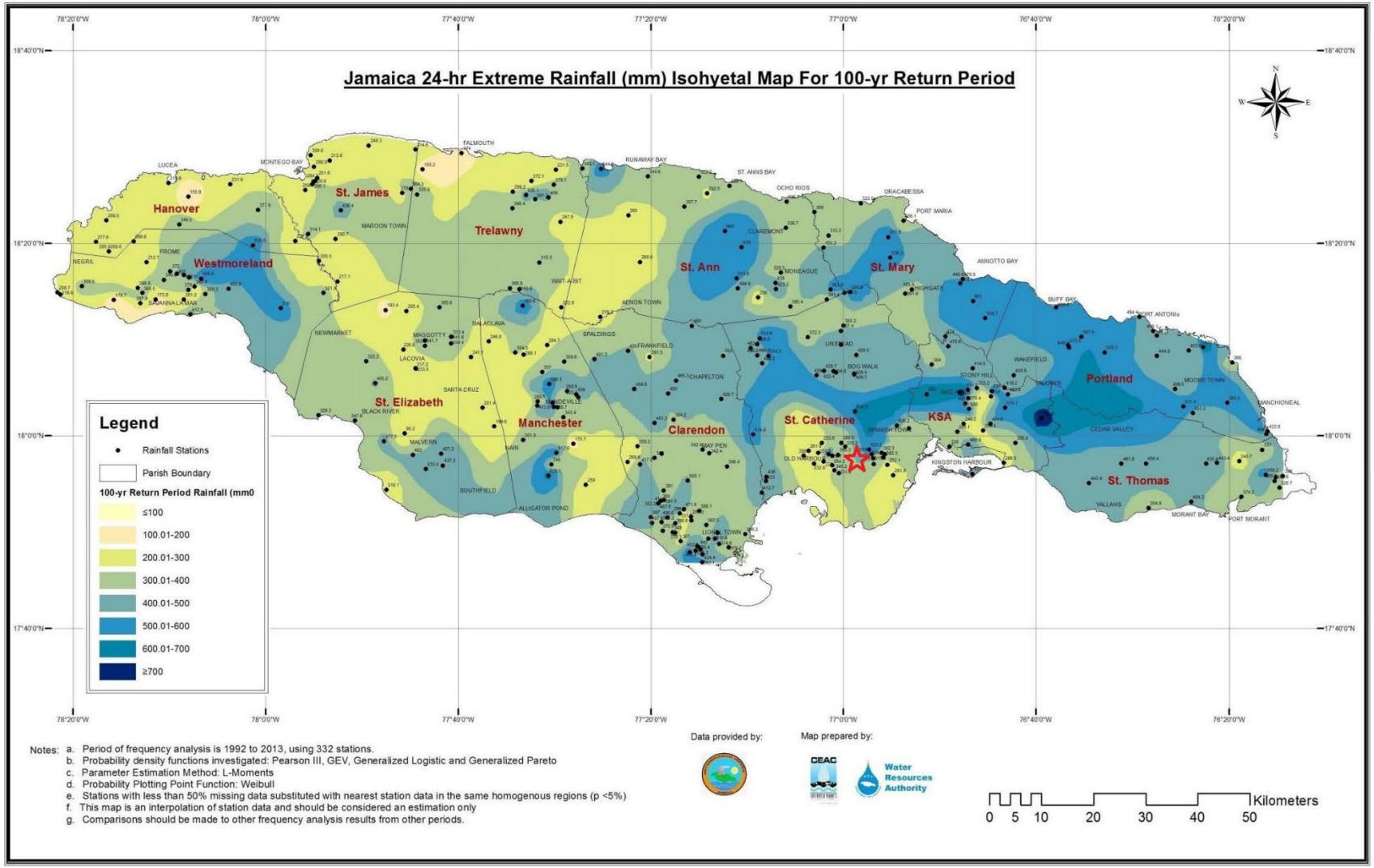


Figure 4-1 100-year RP Isohyet map of Jamaica, showing location of project area (red marker)

Depth of rainfall for various return periods was provided by the National Meteorological Service of Jamaica for the closest gauges to the Hill Run proposed site, which was the March Pen and Warwick Castle rain gauge stations. These stations are within approximately 3 km of the project area, and the rainfall depths can be viewed in Table 4-1.

Table 4-1 Summary of 24-Hour Rainfall Depths (mm) for the two (2) closest rain gauge station to the proposed site (Source: Met. Service).

Return period (years)	Rainfall Depths (mm)	
	March Pen	Warwick Castle #1
10-Year	203	202
25-Year	231	238
50-Year	250	264
100-Year	269	289

Figure 4-2 Location of rainfall gauge stations relative to project area

The following sections were taken from the Environmental Impact Assessment for Caribbean Broilers Hill Run Development" Hybrid Growth Centre "The Nest", prepared by Environmental Solutions Limited (Environmental Solutions Limited, 2018).

The island typically has bimodal rainfall with an initial peak in May and a later peak in October. The drier period is December to March where the long-term average rarely exceeds 100 mm. The long term (1951-1980) mean monthly parish rainfall for St. Catherine is 119 mm. Mean totals range between a low of 50 mm and a high of 238 mm.

Based on the location of the site, it has one long wet period with two distinctive rainfall peaks (May and October). During these rainfall peaks soil moisture content is high and consequently runoff is also high due to antecedent conditions. Closer to the Town Gully and in other parts of the nearby Hill Run community saturated soil conditions remain for extended periods of time, increasing in size with the high rainfall periods in May and October.

During the period June to November each year extreme weather conditions can be influenced by tropical systems that develop in the North Atlantic and Caribbean Basins. These systems are typically tropical storms and hurricanes that move westwards through the Caribbean region generating intense rainfall of long duration.

4.1.1.2 Temperature

The climate of the general St. Catherine area, like the rest of Jamaica, is subtropical with gentle to moderate north easterly prevailing winds and average daily temperatures varying from 23°C in January to about 28°C in July (Environmental Solutions Limited, 2018).

4.1.1.3 Relative Humidity

Relative Humidity ranges from 66% to 87% with a significant diurnal variation resulting in high morning humidity dropping off significantly in the afternoon (Environmental Solutions Limited, 2018).

4.1.2 Hydrology

Currently, the stormwater runoff from the compound is uncontrolled and sheet flows across the proposed site. There are instances of small swales which evidently have been used for irrigation purposes. These swales, however, are confined to the site and do not discharge into any form of regional drainage infrastructure. The proposed site is bounded in the east by an earth drain which eventually discharges along the south coast in the vicinity of Old Harbour. (See Figure 4-3).

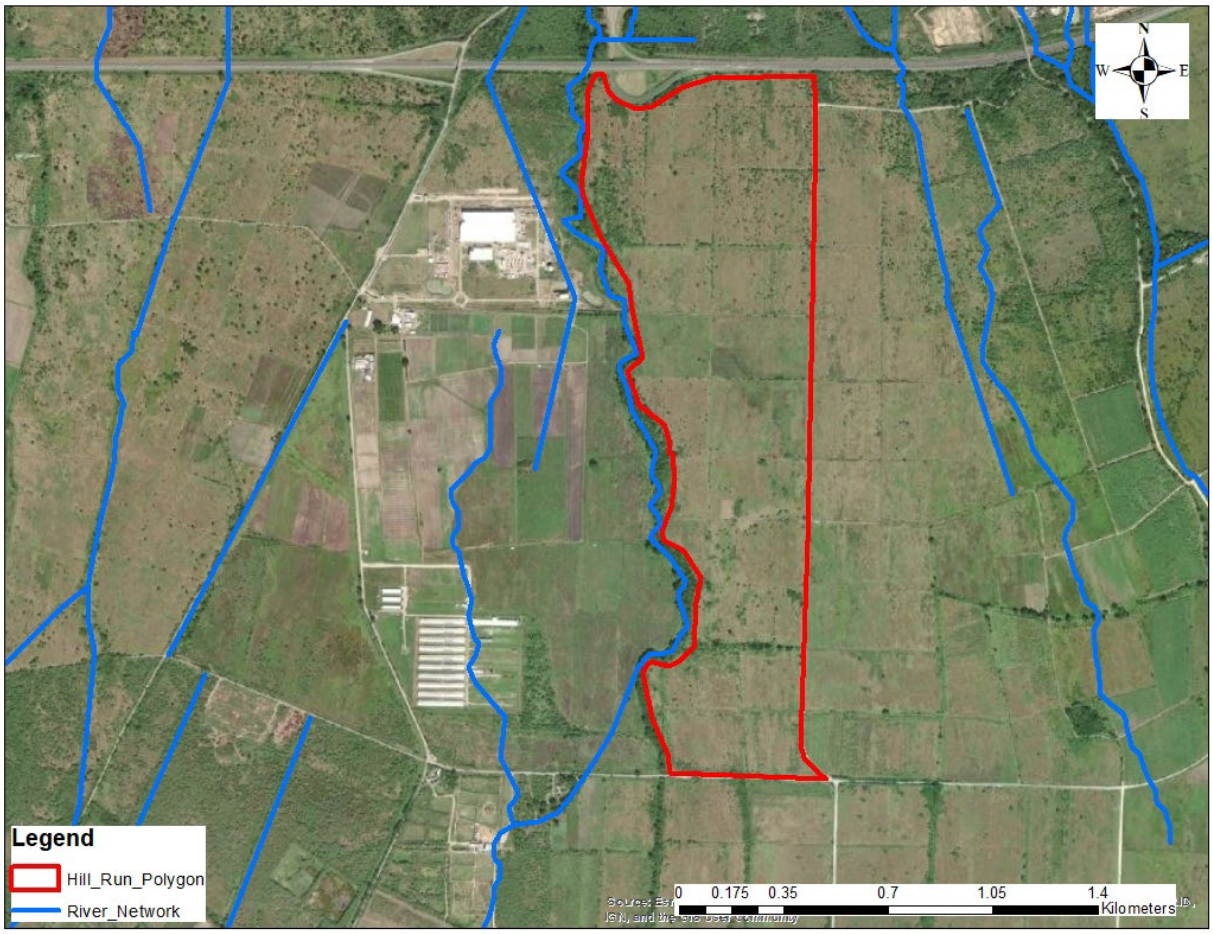


Figure 4-3 Showing existing drainage identified on the proposed Hill Run site

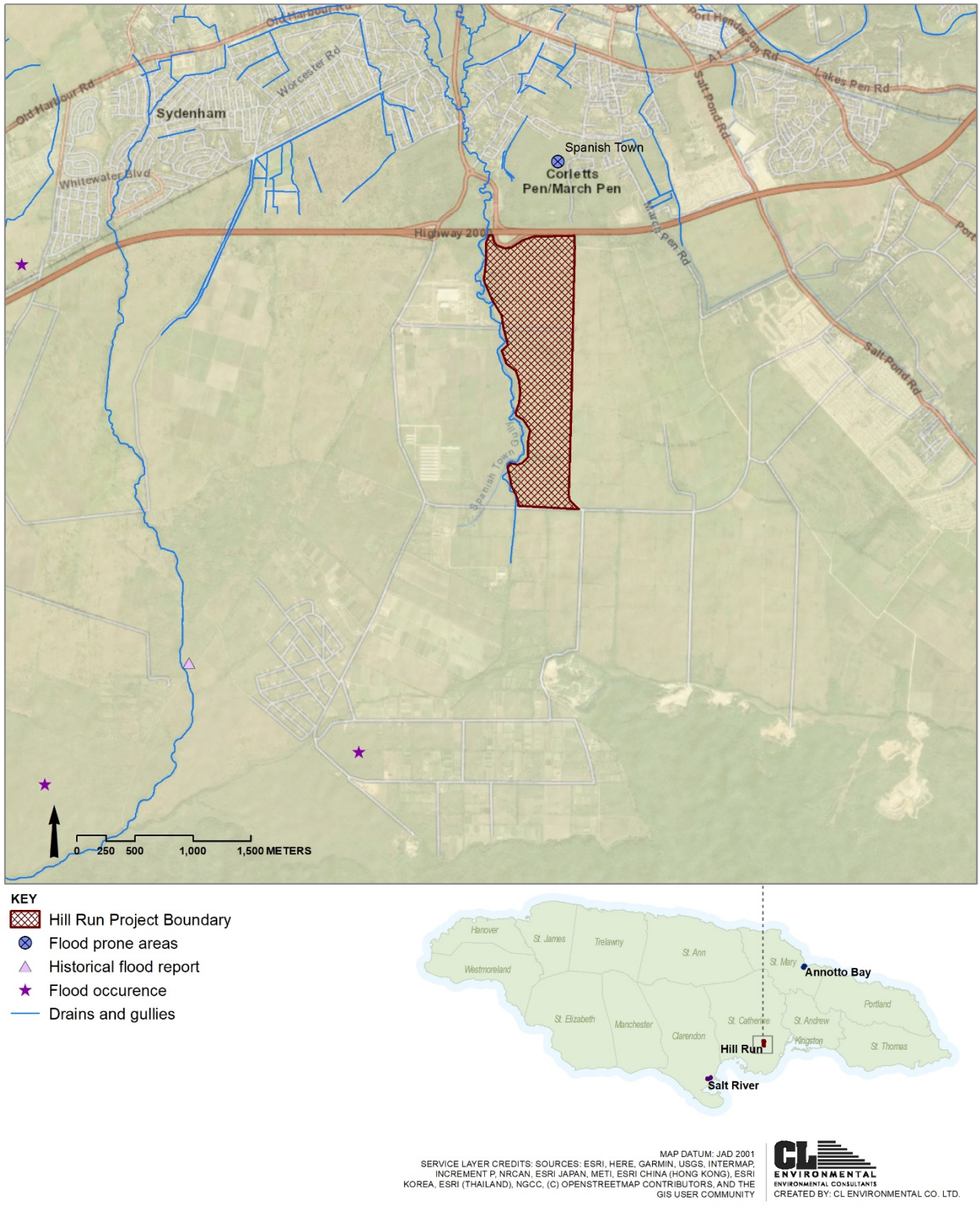


Figure 4-4 Hydrology and flooding, Hill Run, St. Catherine

4.1.3 Topography

Across the project site the elevation does not vary much and can be considered almost flat but with a very gentle downward slope towards the east and south (Figure 4-5 and Figure 4-6).

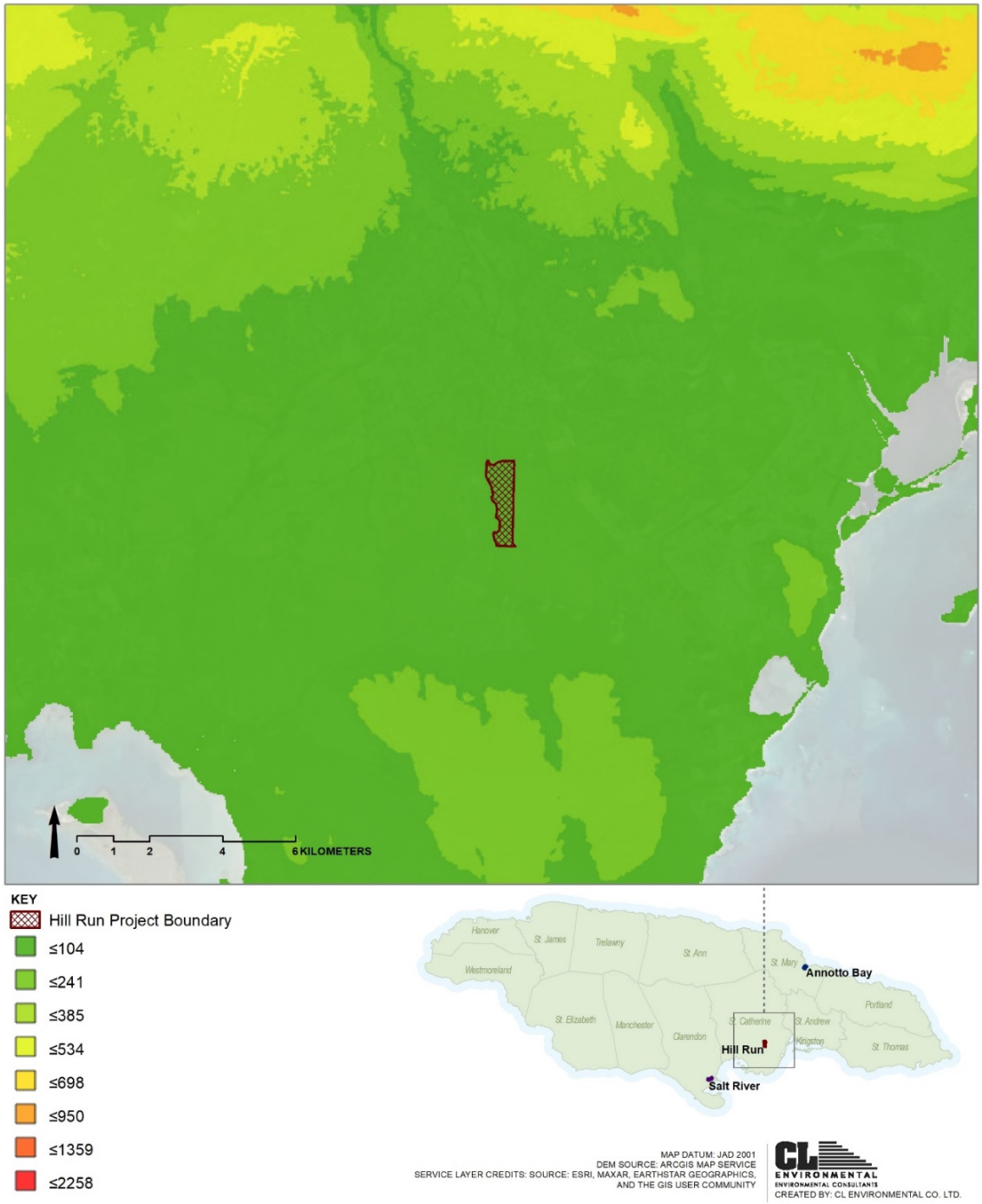


Figure 4-5 Topography Map of project site and surrounding area

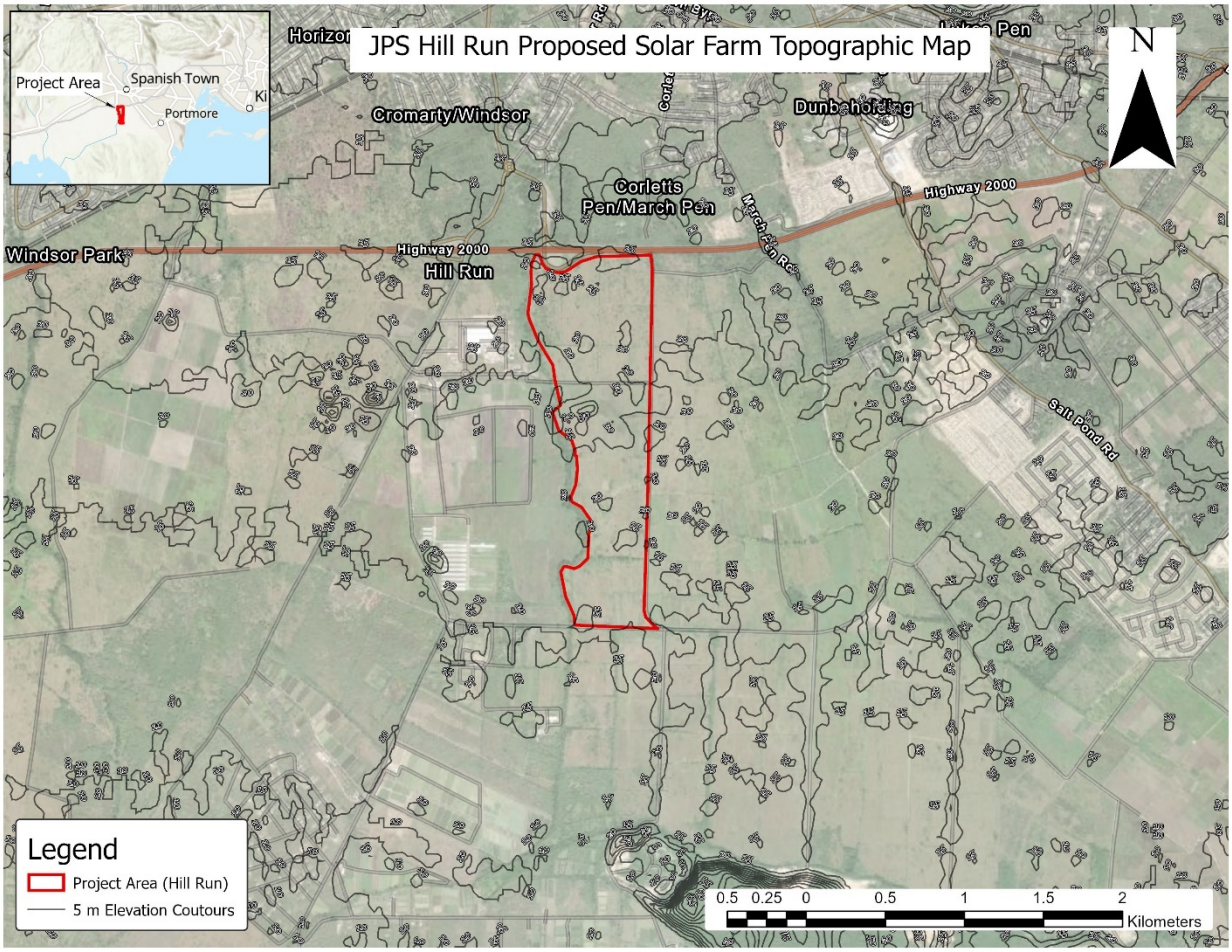


Figure 4-6 Topography Map of project site and surrounding area

4.1.4 Geology and Soils

The site is in an area geologically characterised by Alluvium and superficial deposits (Figure 4-7) and the dominant soil type is classified as Salt Island clay (Figure 4-8). No faults traverse the project site and the closest epicentres recorded were located about 1.5 km northwest and northeast of the site.

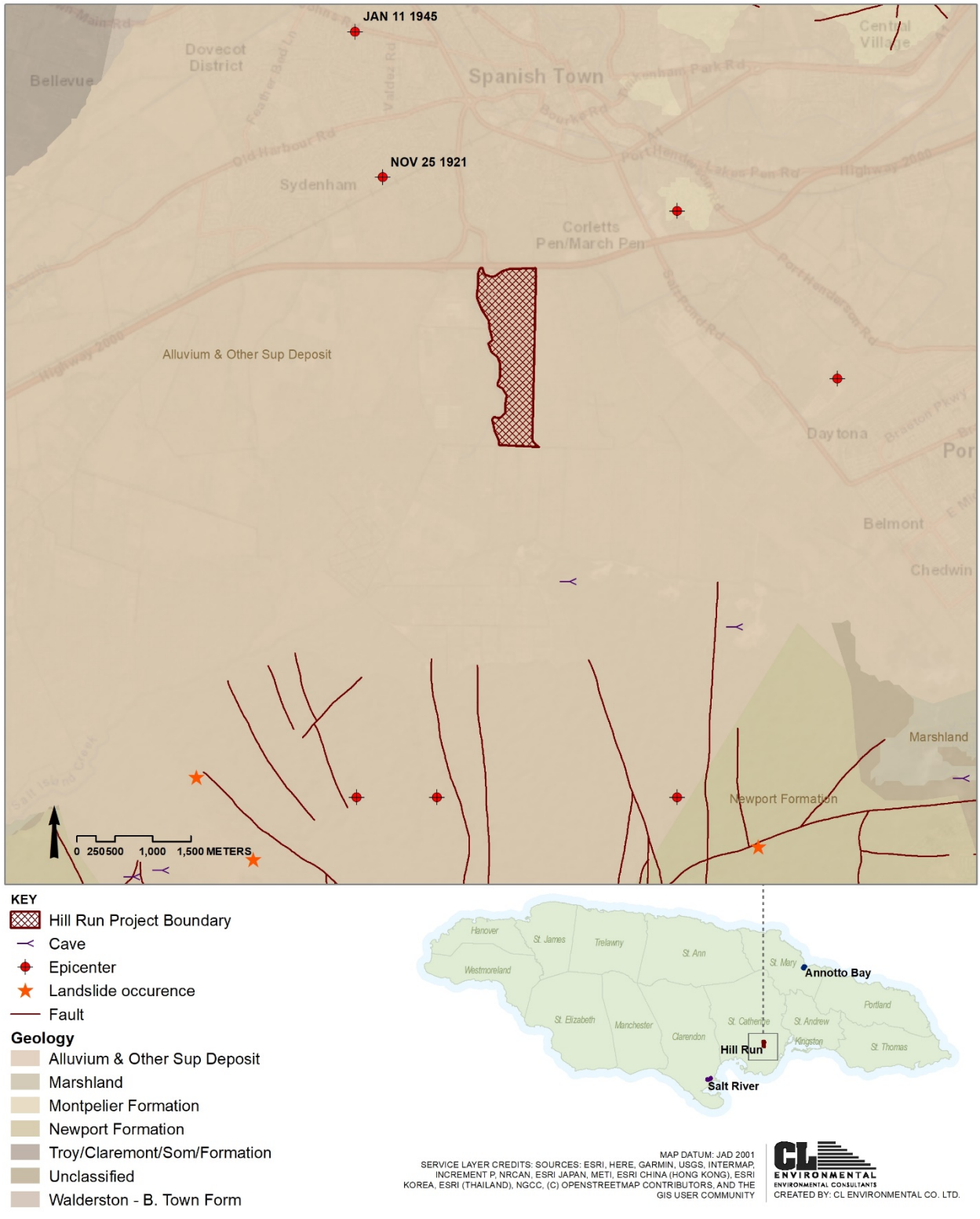


Figure 4-7 Geological formations, Hill Run, St. Catherine

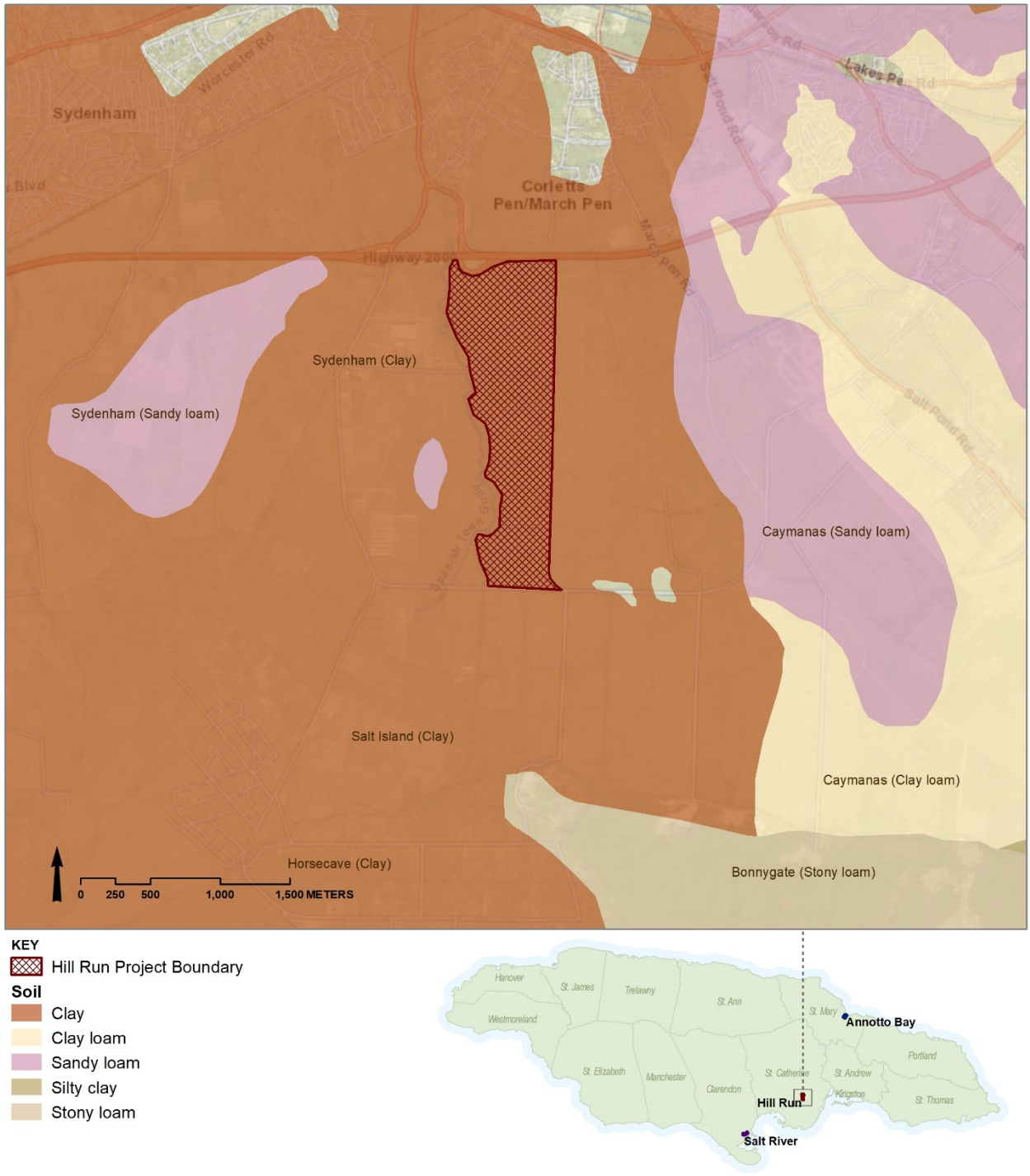


Figure 4-8 Soils, Hill Run, St. Catherine

4.1.5 Water Quality

4.1.5.1 Historical Water Quality

The following sections were taken from the Environmental Impact Assessment for Caribbean Broilers Hill Run Development" Hybrid Growth Centre "The Nest", prepared by Environmental Solutions Limited (Environmental Solutions Limited, 2018).

Water quality was tested at six (6) locations within the project area on January 23, 2018 (Table 4-2). Five (5) of these sampling locations were in the Town Gully, which borders the east of the site and one (1) location in the National Irrigation Commission canal located at the western boundary of the site.

Table 4-2 Water quality sampling locations

WQ Station	Station Location	GPS coordinates (Degrees, minutes, seconds)	Description
WQ1	Town Gully – Bridge 50 meters away from roundabout after leaving toll plaza	17°58'38" N, 76°57'52" W	The environment was sunny with partly cloudy skies and light north-westerly winds. The water appeared slightly cloudy flowing in a south western direction with a depth of approximately 2ft. The sample collected was slightly cloudy with suspended and settled solids.
WQ2	Town Gully -1000 meters away from highway	17°58'17" N, 76°57'54" W	The environment was sunny with partly cloudy skies and light north-westerly winds. The gully was overgrown; domestic garbage was seen on the banks and in the water. The water was approximately 2ft deep. The sample collected was slightly cloudy with suspended and settled solids.
WQ3	Town Gully- close to project site	17°58'4" N, 76°57'52" W	The environment was sunny with partly cloudy skies. The water in the gully was flowing gently stream. The sample was collected in water which was between 0.5 and 1ft deep. Debris and domestic garbage inclusive of engine oil bottle was present in the stream. There was also domestic garbage deposited along the sides of the stream.
WQ4	Town Gully – boundary of Imagination farms-start	17°57'57" N, 76°57'50" W	The environment was sunny with partly cloudy skies and light winds. Slow moving stream with silt at bottom; tires and floating debris were present in the water. The stream was between 0.5 and 2ft deep. The sample was slightly green with no distinct odour.
WQ5	Town Gully – boundary of Imagination farms -end	17°58'7" N, 76°57'45" W	The environment was sunny with partly cloudy skies and moderate south-westerly winds. Water was flowing slowly in a south west direction. There was sand at the bottom of the gully and small aquatic animals living within. The water was between 0.5 and 1.5ft deep. The sample collected was slightly green with no distinct odour.
WQ6	NIC Canal-close o project site.	17°58'11" N, 76°57'13" W	The environment was sunny with partly cloudy skies and light winds. The canal was located between the main road and the project site. Water approximately 1 ft deep was flowing within the canal at the time of the sampling exercise. Dead leaves, grass and uprooted aquatic plants were also present in the flowing water. Small aquatic plants were observed growing on the concreted floor of the canal

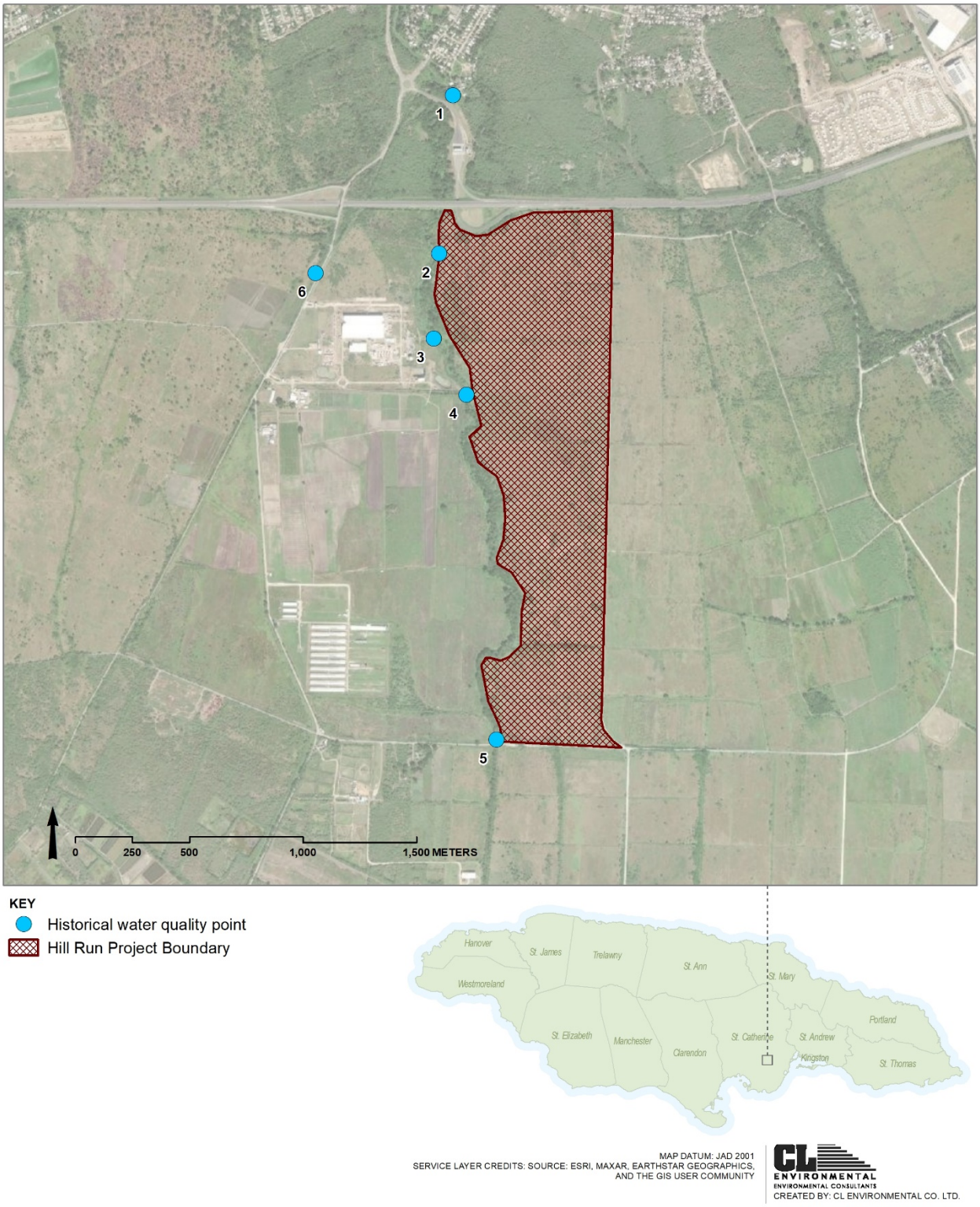


Figure 4-9 Historical Water Quality sampling locations (Environmental Solutions Limited, 2018)Parameters measured are shown in Table 4-3.

Table 4-3 Water quality parameters measured

- Biochemical Oxygen Demand (mg O_2/L)
- Chemical Oxygen Demand (mg O_2/L)
- Nitrates (mg NO_3^-/L)
- Ammonia (mg NH_3 /L)
- Phosphate (mg PO_4^{3-}/L)
- Total Nitrogen (mg N/L)
- Sulphate (mg SO_4^{2-}/L)
- Chloride (mg Cl^-/L)
- Salmonella (presence/Absence)
- Total Suspended Solids (mg/L)
- Nitrate as Nitrogen (mg N/L)
- Total Coliform (MPN/100ml)
- Faecal Coliform (MPN/100ml)
- *E. coli* (MPN/100ml)
- Fats Oils and Grease (mg/L)
- Alkalinity (mg/L)
- pH (pH Units)
- Salinity (ppt)
- Dissolved Oxygen (mg O_2/L)
- Turbidity (NTU)
- Calcium (mg Ca/L)
- Magnesium (mg Mg/L)
- Potassium (mg K/L)
- Sodium (mg Na/L)
- Arsenic (mg As/L)
- Chromium (mg Cr/L)
- Copper (mg Cu/L)
- Lead (mg Pb/L)
- Mercury (mg Hg/L)
- Iron (mg Fe/L)
- Zinc (mg Zn/L)
- Pesticide Screen (mg/L)

Water quality results are shown in Table 4-4.

The water quality data obtained from the present investigation indicates that both the Town Gully and NIC canal water quality are being affected by varied sources. The Town Gully is a major receptor for surface run-off from roads, industrial and commercial sites which could explain the elevated levels of phosphate, biochemical oxygen demand, sulphate, chloride, total dissolved solids, conductivity, potassium, and sodium at all sample points. It is suspected that the NIC canal is also influenced by industrial and/or commercial discharge.

The water quality in the NIC canal (WQ6) indicates evidence of possible trade effluent influences due to the further elevated pH, TDS, conductivity, and metal levels. The discharge is most likely from industrial activities upstream from the investigated area. There are also clear anthropogenic effects as solid waste was observed all along the banks of the Town Gully.

Table 4-4 Water quality results of January 23, 2018.

Parameter (units)	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6	NRCA Ambient (Fresh) Water Guideline
Nitrate (mg NO_3^-/L)	3.5	-	2.0	1.8	2.8	17.9	0.1 – 7.5
Salinity (ppt)	0.30	0.32	0.30	0.32	0.35	6.32	-
Temperature (°C)	30.5	28.0	28.0	27.5	28.6	29.5	-
Alkalinity (mg $CaCO_3$/L)	228.4	235.4	244.5	244.8	185.9	118.6	-
Phosphate mg PO_4^{3-}/L)	1.63	2.18	2.12	2.23	1.61	<0.02	0.01 – 0.8
Nitrate as Nitrogen (mg NO_3^--N/L)	0.8	<0.3	0.4	0.4	0.6	4.0	-
Ammonia (mg NH_3/L)	1.14	2.39	1.95	1.67	<0.02	<0.02	-
Total Nitrogen (mg N/L)	3.1	2.8	2.3	2.8	2.0	25.6	-
Biochemical Oxygen Demand (mg O_2/L)	2.3	2.8	2.5	2.8	2.0	1.6	0.8 – 1.7
Chemical Oxygen Demand (mg O_2/L)	<3	<3	<3	3	<3	52	-
Turbidity (NTU)	5.08	11.0	8.00	7.02	6.14	3.96	-
Sulphate (mg SO_4^{2-}/L)	23	29	26	27	31	68	3.0 – 10.0
Chloride (mg Cl^- /L)	21.4	48.8	34.4	38.4	132.2	3160.0	5.0 – 20.0
Salmonella (present/absent)	Present	Present	Absent	Present	Present	Present	-
Total Coliform (MPN/100ml)	>1600	>1600	>1600	>1600	>1600	>1600	-
E. coli (MPN/100ml)	>1600	>1600	79	350	350	920	-
Faecal Coliform (MPN/100ml)	>1600	>1600	240	540	350	>1600	-
Total Suspended Solids (mg/L)	5.6	11.4	6.8	6.1	4.2	9.0	-
pH (pH units)	8.00	7.71	7.71	7.88	8.09	8.91	7.00 – 8.40
Total Dissolved Solids (mg/L)	403.00	429.00	409.50	435.5	630.50	7254	120.0 – 300

Parameter (units)	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6	NRCA Ambient (Fresh) Water Guideline
Conductivity (mS/cm)	0.69	0.70	0.67	0.70	1.04	12.1	0.15– 0.6
Dissolved Oxygen (mg O_2/L)	5.77	2.40	2.78	2.84	4.75	15.87	-
Fats, Oil and Grease (mg/L)	<1	<1	2	<1	<1	<1	-
Calcium (mg Ca/L)	83.9	80.6	80.6	81.5	84.5	74.8	40.0 - 101.0
Magnesium (mg Mg/L)	12.9	12.6	12.5	12.8	13.9	14.9	3.6 – 27.0
Potassium (mg K/L)	5.05	6.66	6.58	6.95	8.83	7.93	0.74 – 5.0
Sodium (mg Na/L)	35.2	41.0	39.8	40.4	90.4	2510	4.5 – 12.0
Arsenic (µg As/L)	<10	<10	<10	<10	<10	<10	-
Chromium (µg Cr/L)	<20	<20	<20	<20	<20	<20	-
Copper (µg Cu/L)	<10	<10	<10	<10	<10	<10	-
Lead (µg Pb/L)	<20	<20	<20	<20	<20	<20	-
Mercury (µg Hg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-
Iron (µg Fe/ L)	163	185	171	67	22	22	-
Zinc (µg Zn/L)	15	11	14	19	21	29	-
Pesticide Screen (µg/L)	Not Detected	-	-	-	Not Detected	-	-

4.1.6 Noise

4.1.6.1 Methodology

Noise level readings were taken from 12:00am Thursday September 7th, 2023, to 12:00am Friday September 8th, 2023, by using Brüel & Kjaer noise analysers setup in outdoor monitoring kits. The octave band analysis was conducted concurrently with the noise level measurements. Measurements were taken in the third octave which provided thirty-three (33) octave bands from 12.5 Hz to 20 kHz (low, medium, and high frequency bands).

The noise meters were calibrated pre-and post-noise assessment by using a Brüel & Kjaer Type 4231 sound calibrator (Appendix 1). The meters were programmed 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 second.

Noise meters with outdoor monitoring kits were set up at six (6) noise monitoring stations (Table 4-5, Figure 4-10). These meters were left for the entire twenty-four (24) hour assessment period in an outdoor

measuring system and programmed to collect data every second. 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. There were no vertical reflecting surfaces within 3 m (10 feet) of the microphone. Noise statistics (L_{10} and L_{90}) were also calculated at each location.

Table 4-5 Noise and particulate monitoring location coordinates (JAD2001)

Station	X	Y
N1P1	754163.693	646990.624
N2P2	753887.897	646009.081
N3P3	754103.552	645315.866
N4P4	754240.756	644658.860
N5P5	754471.960	645755.5214
N6P6	753069.329	645278.358

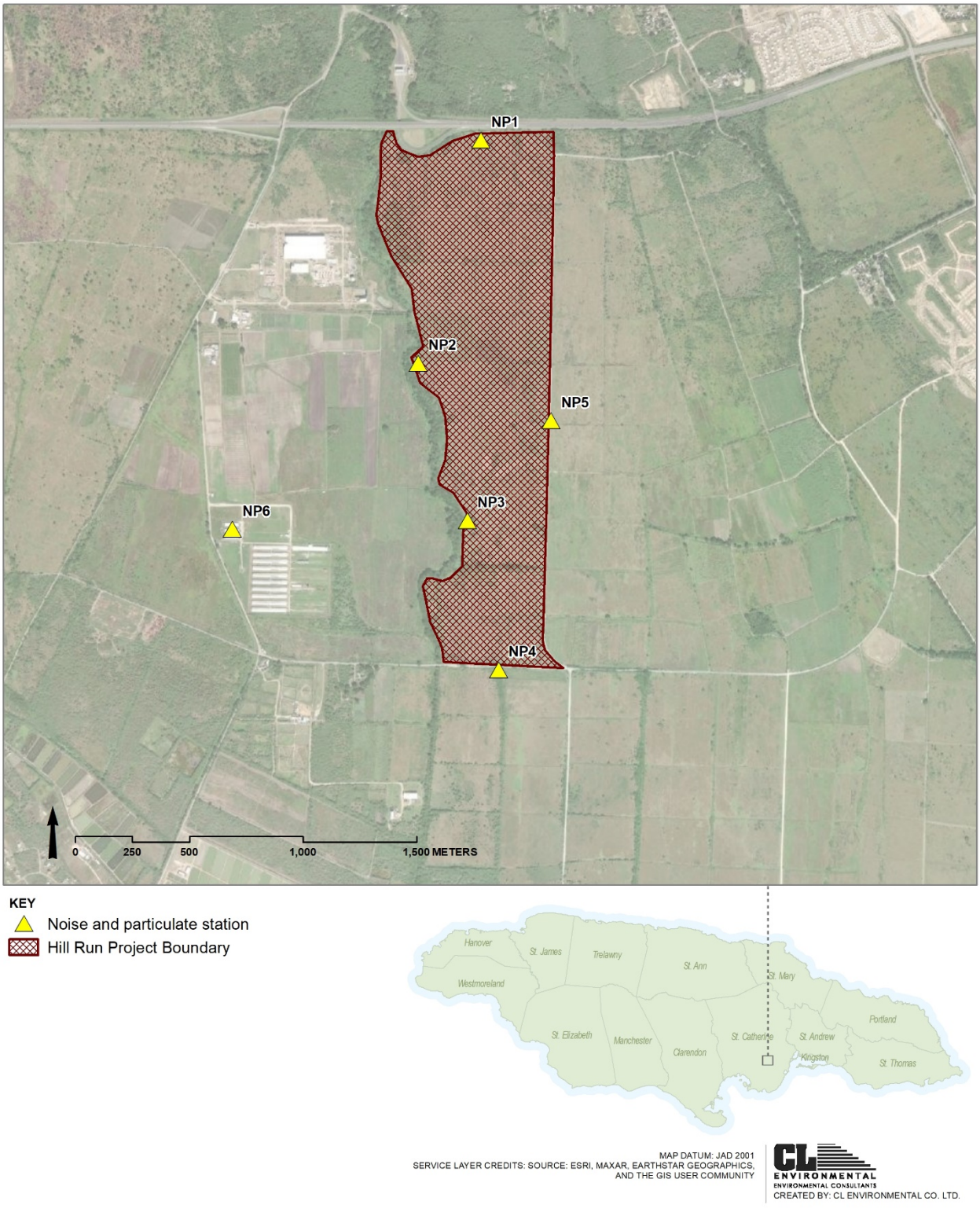


Figure 4-10 Location of noise and particulate monitoring stations at Hill Run

4.1.6.2 Results

Table 4-6 shows the minimum, maximum and average noise levels over the 24-hour assessment period, as well as the geometric mean centre frequencies obtained at each station.

Table 4-6 Ambient Noise data at all stations

Stn.#	Average Leq (24 hr)	Min (dBA)	Max (dBA)	Geometric Centre Frequency (Hz)	Octave Band Range (Hz)
N1	55.6	29.4	82.8	12.5	11-14
N2	50.9	26.1	98.6	12.5	11-14
N3	51.6	30.8	69.0	12500	11141 - 14025
N4	54.0	33.6	95.4	63	56-71
N5	48.3	32.3	78.8	63	56-71
N6	57.1	49.4	90.2	63	56-71

STATION 1

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 29.4 dBA to a high (Lmax) of 82.8 dBA. Average noise level for this period was 55.6 L_{Aeq} (24h). The fluctuation in noise levels over the 24-hour period is depicted in Figure 4-11.

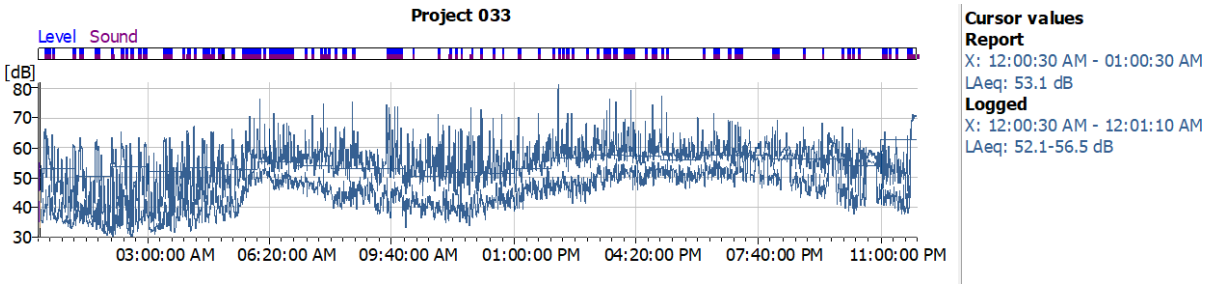


Figure 4-11 Noise fluctuation (Leq) over 24 hours at Station 1

OCTAVE BAND ANALYSIS AT STATION 1

The noise at this station during the 24-hour period was in the low frequency band with a dominant geometric mean frequency of 12.5 Hz. (Octave frequency range is 11 - 14 Hz) (Figure 4-12).

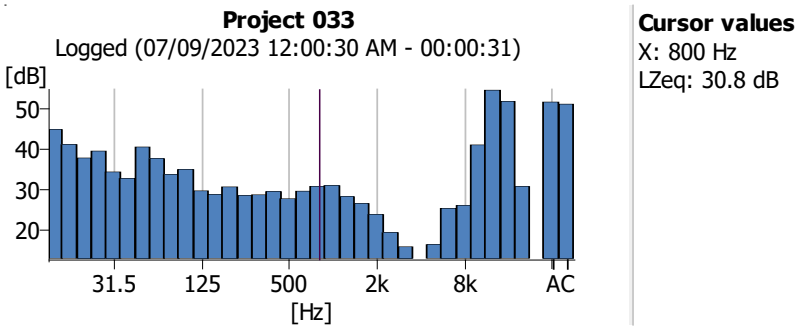


Figure 4-12 Octave band spectrum of noise at Station 1

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 overall L10 and L90 at this station for the time assessed were 58.2 dBA and 39.7 dBA respectively.

STATION 2

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 26.1 dBA to a high (Lmax) of 98.6 dBA. Average noise level for this period was 50.9 L_{Aeq} (24h). The fluctuation in noise levels over the 24-hour period is depicted in Figure 4-13.

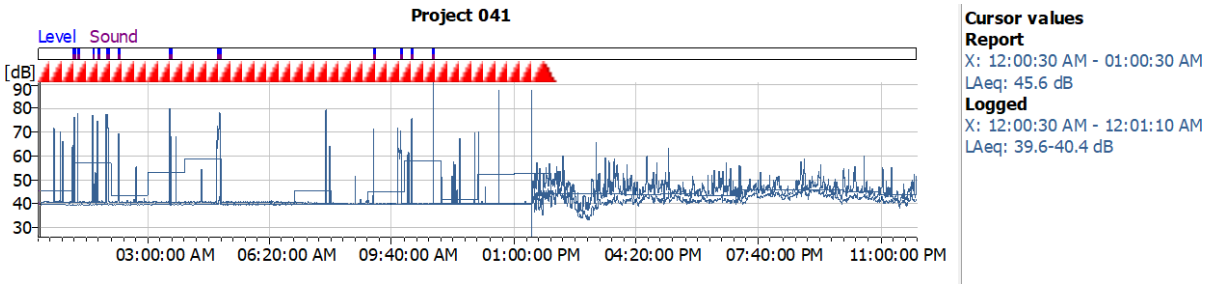


Figure 4-13 Noise fluctuation (Leq) over 24 hours at Station 2

OCTAVE BAND ANALYSIS AT STATION 2

The noise at this station during the 24-hour period was in the low frequency band with a dominant geometric mean frequency of 12.5 Hz. (Octave frequency range is 11 - 14 Hz) (Figure 4-14).

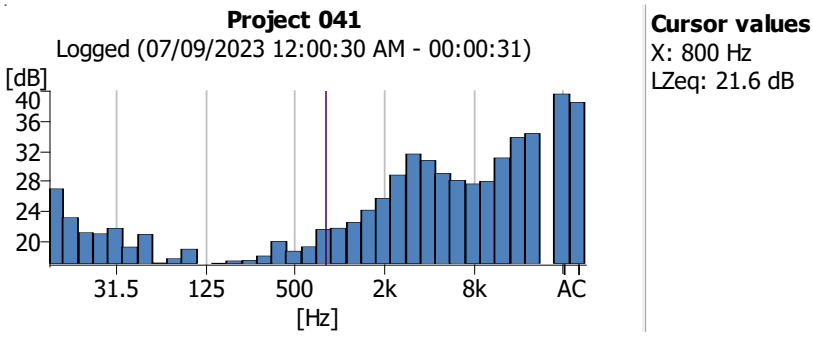


Figure 4-14 Octave band spectrum of noise at Station 2

L10 AND L90

The overall L10 and L 90 at this station for the time assessed were 45.2 dBA and 39.7 dBA respectively.

STATION 3

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 30.8 dBA to a high (Lmax) of 69.0 dBA. Average noise level for this period was 51.6 L_{Aeq} (72h). The fluctuation in noise levels over the 24-hour period is depicted in Figure 4-15.

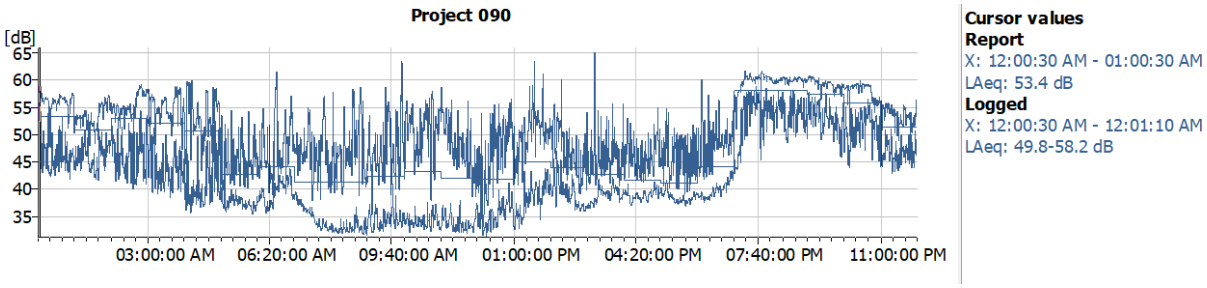


Figure 4-15 Noise fluctuation (Leq) over 24 hours at Station 3

OCTAVE BAND ANALYSIS AT STATION 3

The noise at this station during the 24-hour period was in the high frequency band centred around the geometric mean frequency of 12,500 Hz. (Octave frequency range is 11141 - 14025 Hz) (Figure 4-16).

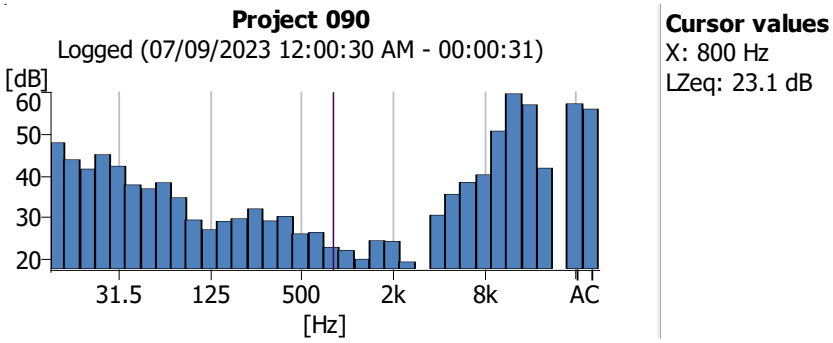


Figure 4-16 Octave band spectrum of noise at Station 3

L10 AND L90

L10 and L90 noise statistics were unavailable for this station.

STATION 4

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 33.6 dBA to a high (Lmax) of 95.4 dBA. Average noise level for this period was 54.0 L_{Aeq} (24h). The fluctuation in noise levels over the 24-hour period is depicted in Figure 4-17.

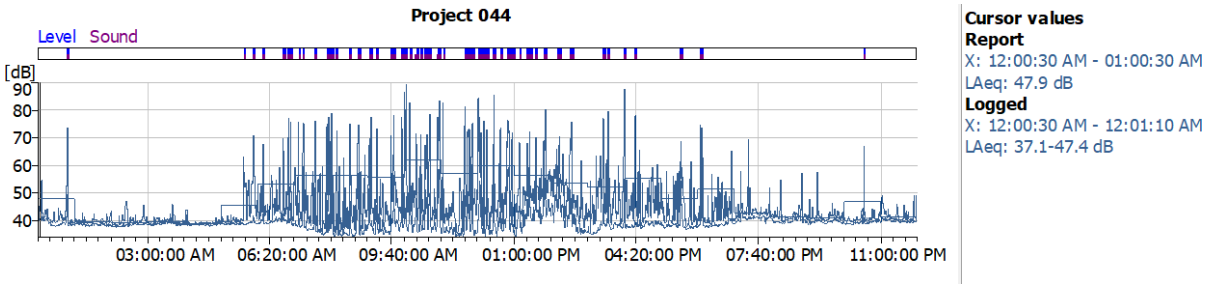


Figure 4-17 Noise fluctuation (Leq) over 24 hours at Station 4

OCTAVE BAND ANALYSIS AT STATION 4

The noise at this station during the 24-hour period was in the low frequency band with a dominant geometric mean frequency of 63 Hz. (Octave frequency range is 56 - 71 Hz) (Figure 4-18).

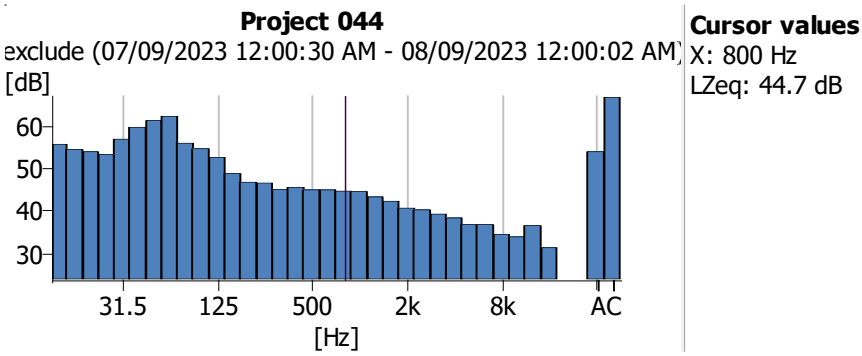


Figure 4-18 Octave band spectrum of noise at Station 4

L10 AND L90

The overall L10 and L 90 at this station for the time assessed were 47.7 dBA and 37.7 dBA respectively.

STATION 5

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 32.3 dBA to a high (Lmax) of 78.8 dBA. Average noise level for this period was 48.3 L_{Aeq} (24h). The fluctuation in noise levels over the 24-hour period is depicted in Figure 4-19.

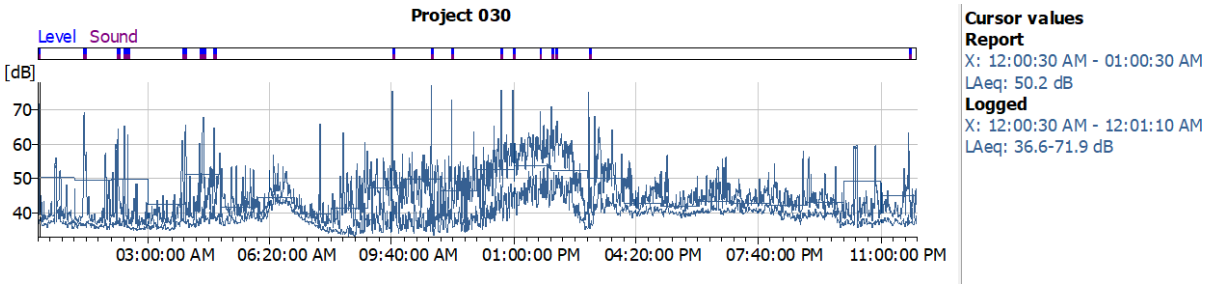


Figure 4-19 Noise fluctuation (Leq) over 24 hours at Station 5

OCTAVE BAND ANALYSIS AT STATION 5

The noise at this station during the 24-hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56 - 71 Hz) (Figure 4-20).

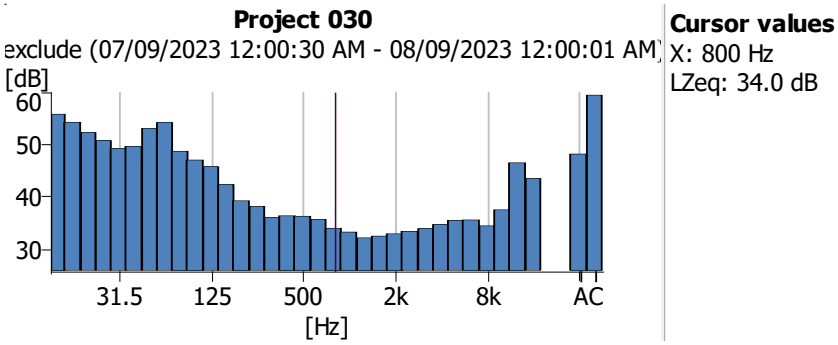


Figure 4-20 Octave band spectrum of noise at Station 5

L10 AND L90

The overall L10 and L90 at this station for the time assessed were 49.4 dBA and 36.6 dBA respectively.

STATION 6

During the 24-hour period, noise levels at this station ranged from a low (Lmin) of 49.4 dBA to a high (Lmax) of 90.2 dBA. Average noise level for this period was 57.1 L_{Aeq} (24h). The fluctuation in noise levels over the 24-hour period is depicted in Figure 4-21.

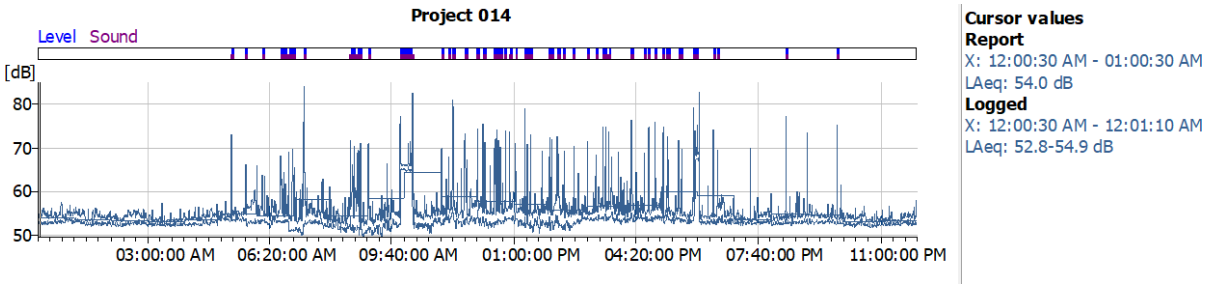


Figure 4-21 Noise fluctuation (Leq) over 24 hours at Station 6

OCTAVE BAND ANALYSIS AT STATION 6

The noise at this station during the 24-hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56 - 71 Hz) (Figure 4-22).

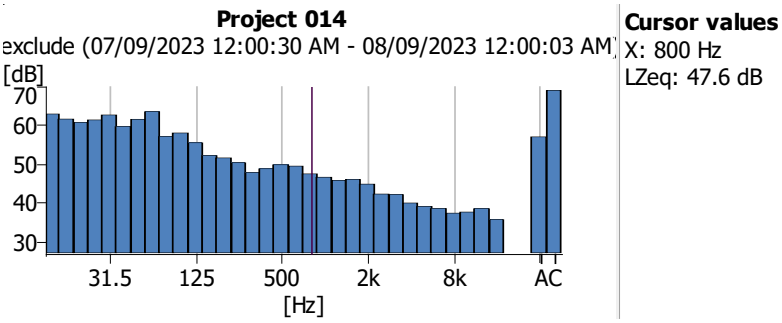


Figure 4-22 Octave band spectrum of noise at Station 6

L10 AND L90

The overall L10 and L90 at this station for the time assessed were 55.4 dBA and 52.7 dBA respectively.

Comparisons of Ambient Noise Levels with NRCA Daytime and Night-Time Guidelines

Comparison of the ambient noise levels in the study area with the Natural Resources and Conservation Agency (NRCA) Standards are shown in Table 4-7. During the daytime, noise levels at all Stations were compliant with respective NRCA daytime standards. During the night-time, noise levels at all Stations were compliant with respective NRCA night-time standards.

Table 4-7 Comparison of daytime and night-time noise levels at the stations with the NRCA guidelines

Stn.#	Zone	7 am. - 10 pm (dBA)	NRCA Standard (dBA)	10 pm. - 7 am (dBA)	NRCA Standard (dBA)
1	Commercial	54.7	*65*	54.1	*60*
2	Commercial	46.2	*65*	47.4	*60*
3	Commercial	45.6	*65*	50.5	*60*
4	Commercial	52.6	*65*	43.5	*60*
5	Commercial	45.9	*65*	47.1	*60*
6	Commercial	57.4	*65*	53.7	*60*

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

4.1.7 Air Quality (PM10 & PM2.5)

4.1.7.1 Definitions

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.

4.1.7.2 Methodology

PM10 and PM2.5 particulate sampling exercises were conducted simultaneously at the six (6) locations (where noise monitoring was conducted) for 24 hours each using Airmetrics Minivol Tactical Air Samplers. The locations are listed in Table 4-5 and illustrated in Figure 4-10. The PM10 and PM2.5 sampling exercises were conducted from 12:00am – 12:00am on September 7th, 2023.

4.1.7.3 Results

PM10

All locations had PM10 particulate concentrations which were moderately low and compliant with the 24-hour NRCA standard of 150 µg/m^3. Detailed PM10 results are shown in Table 4-8.

Table 4-8 Detailed PM10 Results

Sampling Date	STATION	Result [PM_{10}]/ugm^{-3}	NRCA PM10 24-hr Std [PM10]/ugm-3
September 7th, 2023	STN 1	**45.14**	150
	STN 2	**47.22**	
	STN 3	**48.89**	
	STN 4	**84.03**	
	STN 5	**49.03**	
	STN 6	**55.14**	

Values in red are non-compliant with NRCA standards.

PM2.5

All locations had particulate PM2.5 concentrations which were elevated but compliant with the 24-hour USEPA PM2.5 standard of 35µg/m^3. Detailed PM2.5 results are shown in Table 4-9.

Table 4-9 Detailed PM2.5 Results

Sampling Date	STATION	Result [PM2.5]/ugm^{-3}	USEPA PM2.5 24-hr Std [PM2.5]/ugm-3
September 7th, 2023	STN 1	**25.28**	35
	STN 2	**26.25**	
	STN 3	**27.50**	
	STN 4	**29.86**	
	STN 5	**26.11**	
	STN 6	**28.19**	

Values in red are non-compliant with NRCA standards.

4.1.8 Natural Hazards

4.1.8.1 Geotechnical and Seismic Hazards

Historical Seismic Activities

Seismic events have the capacity to be some of the most devastating and costly natural hazards. The level of damage or loss typically varies depending on the magnitude of an event, wherein effects can range from only being noticed via seismograph to significant loss of life and infrastructural damages. Despite having the tools for monitoring and recording these occurrences, earthquakes are unpredictable in nature.

Jamaica straddles the boundary between Caribbean tectonic plate and Gonave micro-plate. The Walton and the Enriquillo Fault Zones, extending respectively to the west and the east of Jamaica, form the boundary between these two plates. The movement across these two fault zones are transmitted through the Jamaican Fault system and are the source of significant earthquake activity in the island. The closest active faults near the project site are the Duanvale Fault zone and the Montpelier-New-Market Fault zone which intersects near Montego Bay and has respectively an E-W and NNW- SSE orientation (C. DeMets, 2007).

Jamaica has had a notable earthquake history with significant events such as the 1692 Port Royal earthquake, the 1907 Kingston earthquake, the 1957 March 1st earthquake, which impacted the western end of the island and the 1993 January 13th earthquake. These events were the cause of significant losses for Jamaican citizens but only represent a small portion of the seismic activity occurring on the island; more recently, between 2011 and 2020 there were over 1000 recorded earthquakes with local epicentres, of which approximately 94 were actually felt (Figure 4-23). Although none were catastrophic, it highlights the significant levels of seismic activity across Jamaica.

Observance of these historical events along with the other smaller recorded occurrences sets the precedence of the importance of seismic consideration in the codes and practices used to develop infrastructure and ensuring they are operationally safe. This assessment focuses on PV solar farms which are generally more critical infrastructures expected to remain operational even in hazardous scenarios.

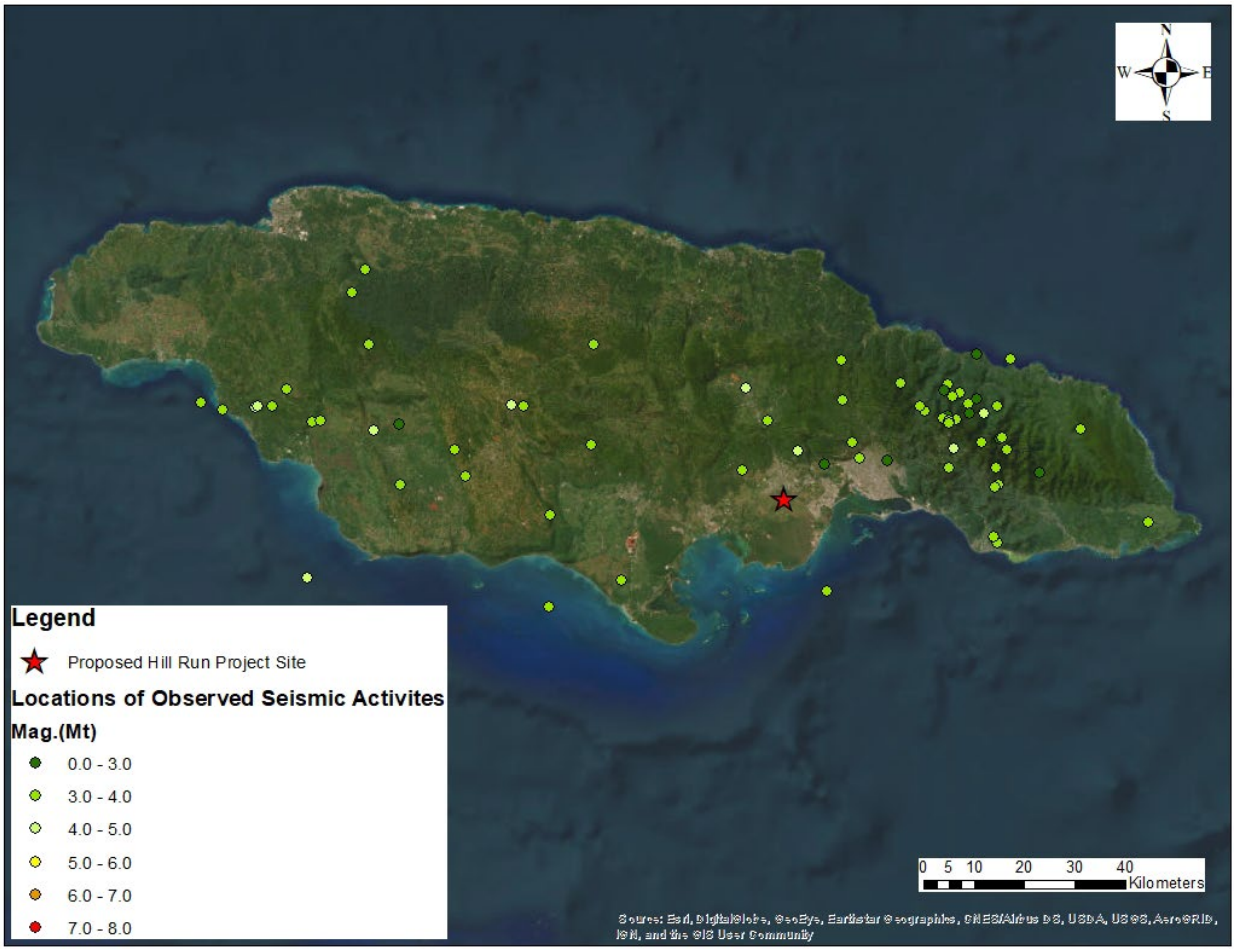


Figure 4-23 Earthquakes observed (felt) in Jamaica 2011-2020 (Source: Earthquake Unit, University of the West Indies, Mona Campus)

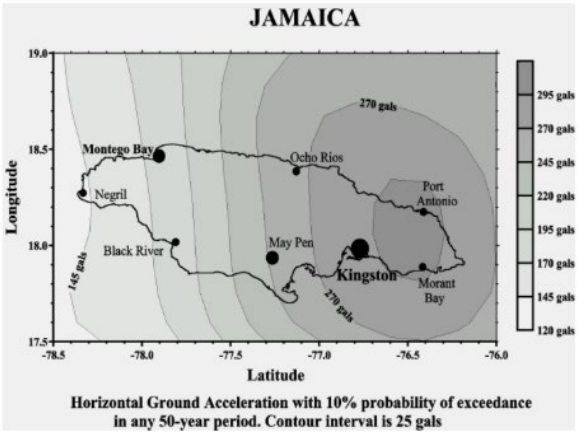
Horizontal Ground Acceleration

The Peak Ground Acceleration for the project area were extrapolated for the project area from the seismic hazard maps for Jamaica generated under the Caribbean Disaster Mitigation Project (CDMP, 1998). The seismic risk maps indicate that for the proposed Hill Run facility, there is a 10% probability of exceedance in any 50- year period of the following:

i. Horizontal Ground Acceleration: 270 gals with 10% probability of exceedance in any 50-year period
ii. Horizontal Ground Velocity: 18cm/sec with a 10% probability of exceedance in any 50- year period
iii. Modified Maximum Mercalli Intensity: Zone VII with 10% probability of exceedance in any 50-year period.

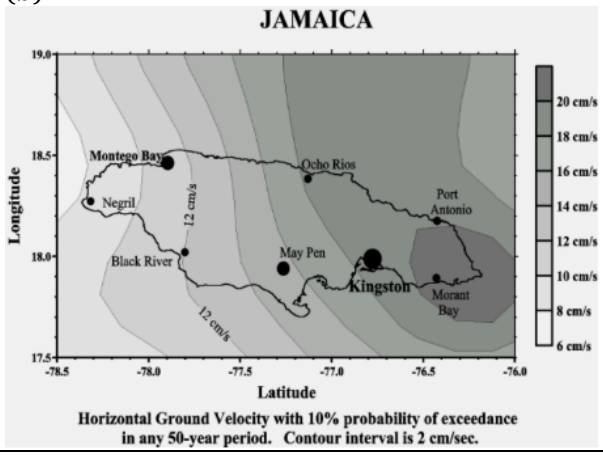
Table 4-10 Seismic Hazard Maps for Jamaica (Source: CDMP, 1998): (a) Horizontal Ground Acceleration; (b) Horizontal Ground Velocity; (c) Modified Maximum Mercalli Intensity

(a)



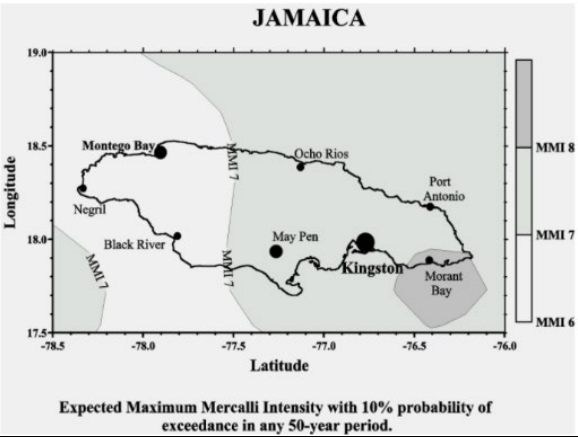
Horizontal Ground Acceleration with 10% probability of exceedance in any 50-year period. Contour interval is 25 gals

(b)



Horizontal Ground Velocity with 10% probability of exceedance in any 50-year period. Contour interval is 2 cm/sec.

(c)



Expected Maximum Mercalli Intensity with 10% probability of exceedance in any 50-year period.

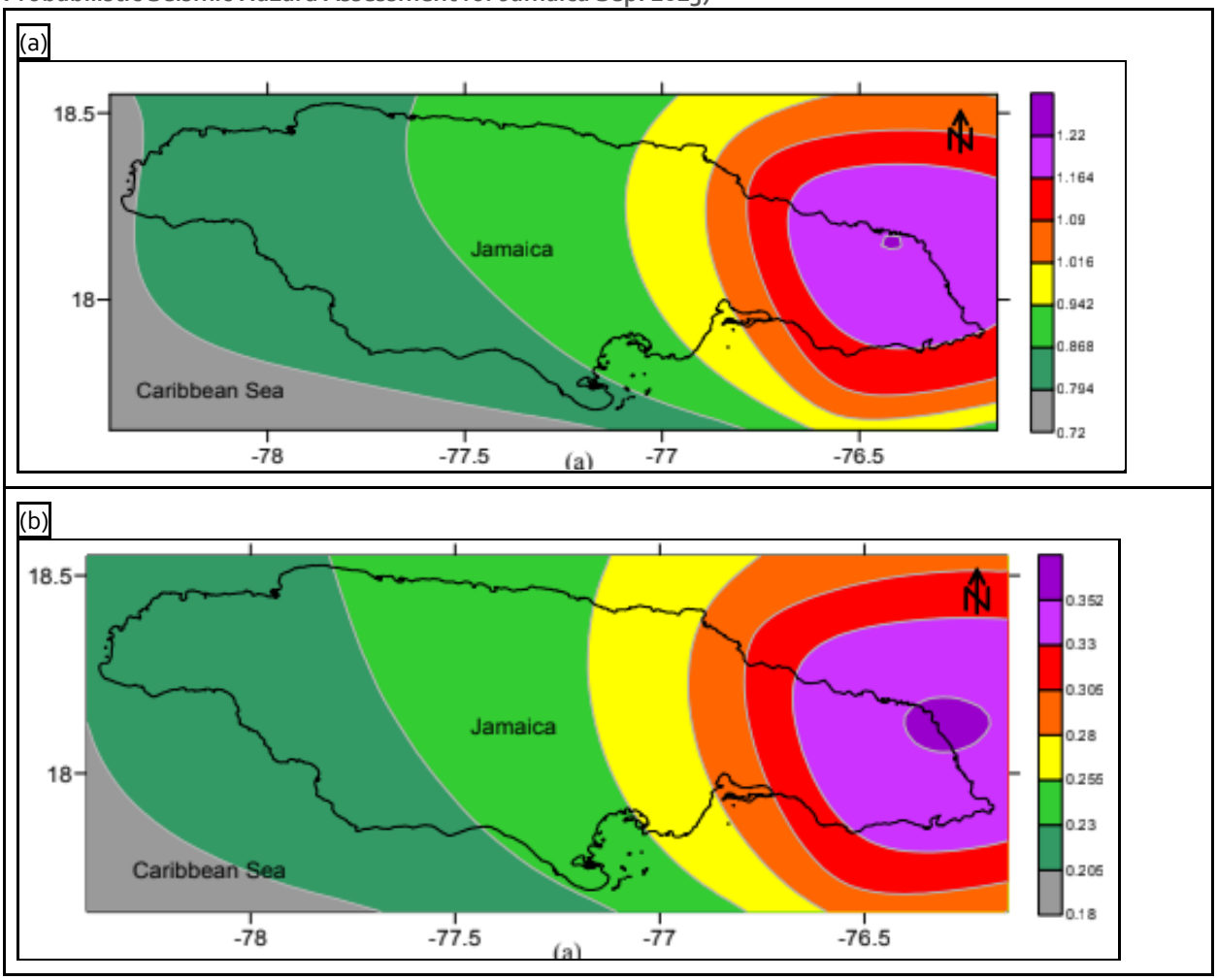
Spectral Acceleration

The Spectral Acceleration (SA) is the preferred Seismic Hazard intensity parameter used in most modern building codes. This is a measure of maximum acceleration observed from a specific oscillatory period (similar to that of natural building oscillation) caused by a sustained shaking during an Earthquake. This acceleration varies based on location and as result means that the level of ground shaking also varies based on location.

Determining the short and long period spectral accelerations associated with varying regions can be a useful indicator of the level of seismicity and consequently the possibility of more pronounced ground motions in one area versus the other. The spectral acceleration periods observed were 0.2 seconds which is representative of short buildings (a few floors tall) and 1.0 second which is geared towards representing the oscillations of taller structures (greater than 7 floors). The Spectral Accelerations for the project area

were extrapolated for the project area from the seismic hazard maps recommended in the IBC Code adopted for Jamaica (Table 4-11).

Table 4-11 Site Spectral Response map for 0.2s short period (a) and 1.0s long period (b) (Source: Probabilistic Seismic Hazard Assessment for Jamaica Sep. 2013)



4.1.8.2 Hydrology and Flood Plain Mapping

A flood plain model was developed to investigate the likelihood and depths of inundation within the project area. Hydrologic Engineering Centre's River Analysis System (HEC-RAS) was the tool of choice. The United States army corps of engineers created this software to perform one and two-dimensional hydraulic calculations for a complete network of natural and constructed channels. Due to the complex nature of the hydrodynamics within the project area, a 2-D model was used to generate flood depth to predict flooding to determine its impact on the surrounding infrastructure. To fully understand its extent, it was necessary to analyse the project area using a general approach, taking into account the dynamic nature of the environment and the existing drainage channels. The assessment was developed using a flood modelling framework that consists of three components:

1. Hydrological model simulates and transforms 24-hour rainfall depths into runoff time series with peak flows.
2. Hydraulic Model simulates the time series, including the peak flow and translates runoff into river flow and inundation over floodplain areas. A 2-D flow area model framework was used.
3. Flood analysis calculates the extent of flooding, water depth, and potential impact.

Key features used to do the assessment are as follows:

1. Topographic data (JAXA 30m Topographic Geotiff)
2. Rainfall data (From rainfall stations provided by the Meteorological Office of Jamaica)
3. Rivers, streams, and stormwater infrastructure

For this assessment, pre and post-construction scenarios for the 25-year, 50-year, and 100-year present and future rainfall events were modelled to determine the extent of the impact with varying intensity. In addition, the key access to the project area was also assessed to determine the potential impact.

Hydrological Analysis

The HEC-RAS hydrological data analysis was used to model how the water is conveyed over the flood plain to the downstream outflow points. The input parameters of this model were made up of 2 main components: (i) the geometry (terrain data); and (ii) the hydrological data. Within the scope of this project, present and future rainfall were used as the driving factor to model flooding in the project area.

Present Rainfall conditions are outlined in Section 4.1.1.1

FUTURE CLIMATE CONSIDERATIONS

Future climate extreme rainfall was estimated based on the findings and recommendations of IPCC (2018)[2]. This estimation is based on the probability ratio of heavy precipitation as a function of global warming and event probability. Climate change factors for the 10-yr, 25-yr, 50-yr and 100-yr were determined to be 1.2 to 1.45 for the 2°C above pre-industrial levels. Change factors (CCF) were applied to the present climate 24-hour rainfall depth extremes to determine the estimated future climate rainfall extremes as depicted in Table 4.2 Present climate (IPCC 2018) and estimated future climate 24-hour rainfall depths at 2°C.

RAINFALL HYETOGRAPH

A hyetograph is the distribution of rainfall intensity over time. For example, in the 24-hour rainfall distributions developed by the Soil Conservation Service, rainfall intensity progressively increases until it reaches a maximum then gradually decreases. The Type III rainfall distribution curve was used for this assessment as it most accurately reflects the 24-hour rainfall distribution experienced by the island. Rainfall Hyetographs were generated using the present and future climate conditions extreme rainfall and used to model the respective return periods.

[2] Masson-Delmotte, Valérie, Panmao Zhai, Hans-Otto Pörtner, Debra Roberts, Jim Skea, Priyadarshi R. Shukla, Anna Pirani et al. "Global warming of 1.5 C." An IPCC Special Report on the impacts of global warming of 1 (2018).

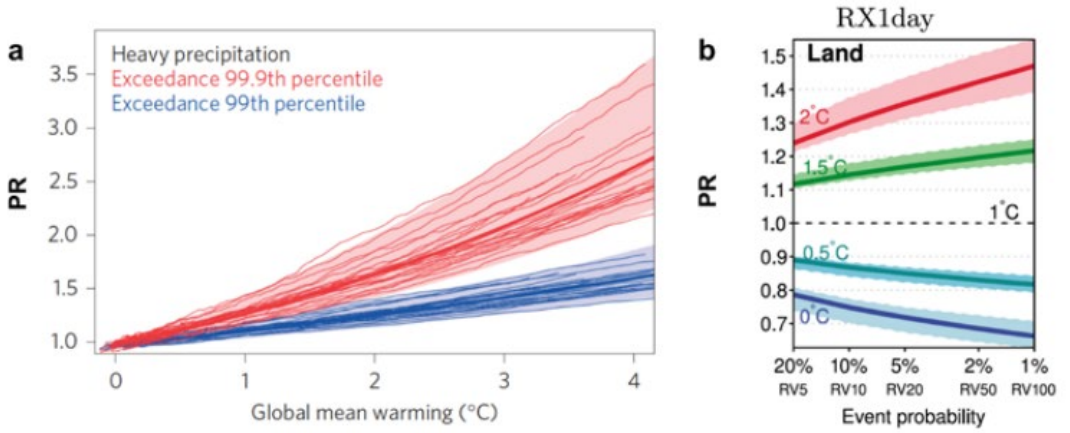


Figure 3.10 | Probability ratio (PR) of exceeding (heavy precipitation) thresholds. (a) PR of exceeding the 99th (blue) and 99.9th (red) percentile of pre-industrial daily precipitation at a given warming level, averaged across land (from Fischer and Knutti, 2015). (b) PR for precipitation extremes (RX1day) for different event probabilities (with RV indicating return values) in the current climate (1°C of global warming). Shading shows the interquartile (25–75%) range (from Kharin et al., 2018).

Figure 4-24 Probability ratio of heavy precipitation as a function of global warming and event probability (IPCC 2018)

Topography

The terrain data was derived from a combination of submitted site specific topographic data, in combination with available JAXA (Japanese Aerospace Exploration Agency) Digital Elevation Map (DEM) of the island, captured using advanced satellite imagery. The DEM serves as the base of the 2D model, using a finite element mesh to calculate the water volumes and thus the flood plains throughout the model.

Assumptions of Model

Due to the scale of the model, some limitations were identified, and assumptions were made as follows:

1. Simulation cell size used was 5m x 5m, and output rasters were resampled at 30m x 30m cells.
2. Evapotranspiration was assumed constant at 5mm/hr.
3. No blockage due to debris or otherwise was considered for the channels.

Flood Plain Analysis

ODPEM FLOOD PRONE AREAS

The comparison of the ODPEM Flood Prone Areas was used as the secondary validation method for the model. The ODPEM data presented two-hundred and ninety-three (293) flood-prone areas and allowed for confirmation of known flood-prone areas, however, no depths were recorded in the dataset. This validation involved probing whether or not the flood plain generated was within a 500m radius of the flood-prone areas as presented by the ODPEM. The OPDEM Flood Prone Areas map has identified Spanish Town as an area prone to flooding.

MODEL RESULTS

The model scenarios that were simulated consisted of the 10-yr, 50-yr, and 100-yr return periods under future climate conditions. The results of the hydraulic model for the present 10-yr, 50-yr and 100-yr RP

highlighted areas scattered on the property exposed to minor pluvial (floods occurring independent of overflowing water body) flooding. There are sections of the property to the south and west in which isolated ponding occurs, with depths up to 3.4m (see Table 4-12). These isolated areas could potentially be caused by small depressions on the land.

Table 4-12 Summary of maximum inundation depths determined on the proposed site.

Return period	Maximum Inundation Depth (m)
10-Year	3.20
25-Year	3.25
50-Year	3.30
100-Year	3.40

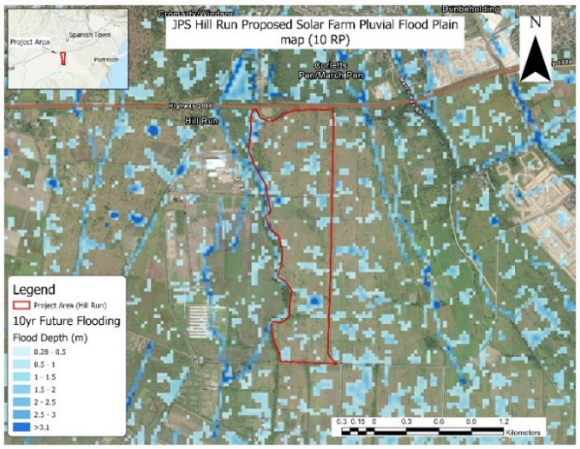


Plate 4-1. Floodplain map for a 10-yr return period

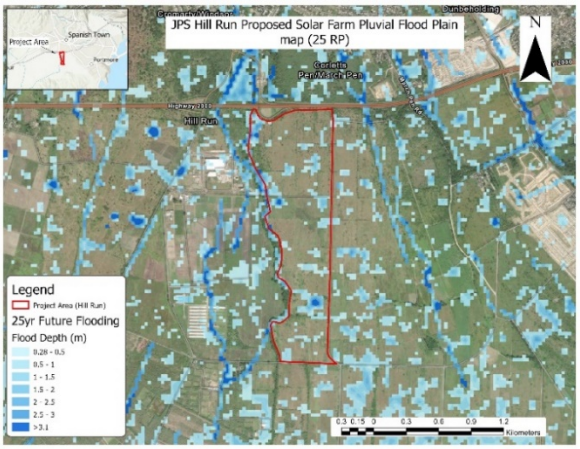


Plate 4-2. Floodplain map for a 25-yr return period

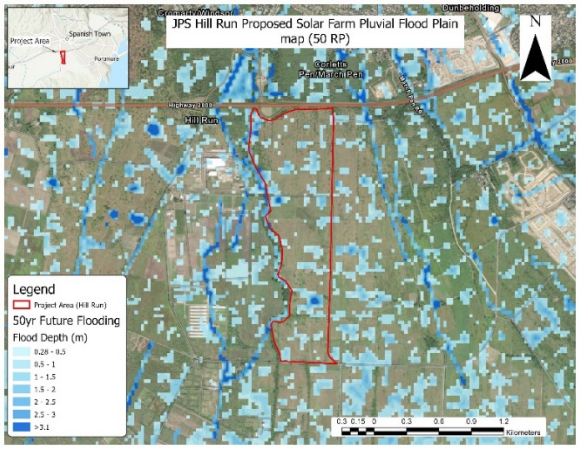


Plate 4-3. Floodplain map for a 50-yr return period

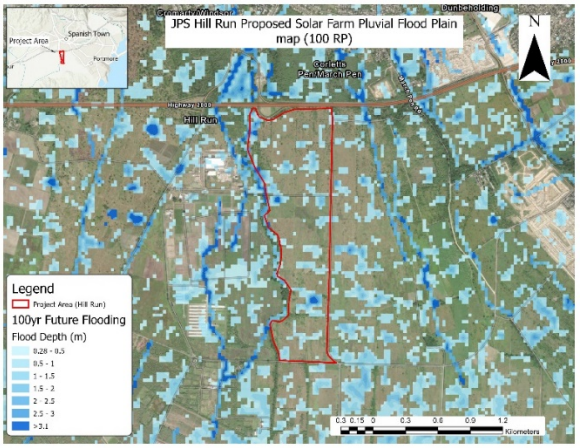


Plate 4-4. Floodplain map for a 100-yr return period

4.1.8.3 Storm Surge Hazard

A storm surge analysis was not undertaken for the proposed Hill Run site due to its geographical location. The closest point of vulnerability, where storm surge potentially will originate from, is approximately

10km to the east. It was determined that the proposed site is not exposed or vulnerable to storm surge inundation.

4.2 BIOLOGICAL

4.2.1 Flora

The proposed project site consists of highly modified agricultural lands, including areas that have been used for sugarcane farming. As such the floral community is extremely limited and only primary, fast-growing species were observed. The area can be classified as highly modified, with an extremely limited floral community, with extremely low species diversity and abundance.

The proposed project area also had a few irrigation canals (dry) and access roads. The lack of habitat and diversity, industrial and agricultural activities in and around the proposed project area, result in an extremely limited biological community. The proposed project may have a minimal and temporary impact on the biological community, temporarily displacing species. This is expected to be similar to the regular maintenance. Landscaping (planting a variety of shrubs trees and flowers) options may improve the floristic diversity available to insects and possibly birds over time.

The table below gives a species list of Flora observed (Table 4-13). Examples of vegetation on site are given in Plate 4-5 and Plate 4-6.

Table 4-13 Flora species list

Common name	Scientific Name	Conservation Status
Bastard Cedar	*Guazuma ulmifolia*	None
Beach Grass	*Ammophila spp*	None
Guinea Grass	*Panicum maximum*	None
Lead Tree	*Leucaena leucocephala*	Can become invasive
Pangola Grass	*Digitaria eriantha*	None
Guango	*Cordia alliodora*	None
Acacia	*Acacia sp.*	None

Plate 4-5 Example of vegetation seen on site

Plate 4-6 Example of vegetation seen on site

Plate 4-7 dense grass section of the property

Plate 4-8 Pathway with limited tree cover on the property

Plate 4-9 **Grasses, shrubs and trees which dominate the project area**

Plate 4-10 **Leucaena leucocephala – Lead Tree**

4.2.2 Fauna

Agriculture and anthropogenic influences have had a profound impact on fauna species diversity and abundance. Intensive agriculture practices, including deforestation, pesticide use, and habitat conversion, can led to the loss of natural habitats and disruption of ecosystems. It may also result in habitat fragmentation and a decline in many wildlife species as their habitats shrink or disappear.

The faunal community seen in the proposed project area is also a reflection of a highly modified habitat with extremely limited diversity and abundance. The surrounding agricultural lands (monoculture) also limit the surrounding faunal community. Monoculture reduces diversity of both the flora and faunal community, creating large areas of habitat which is only suitable to a few species, unlike naturally occurring forested areas. A few insects were seen in the project area; butterflies, dragonflies and several birds were observed in around the project area, including cattle egrets, turkey vultures, nightingales, and several doves. The most dominate species seen was the cattle egret. Mongoose were also observed on site.

Additionally, pollution from agricultural runoff, industrial activities, and urban development may contaminated water bodies, affecting aquatic species and disrupting food chains.

4.3 HUMAN/ SOCIAL

4.3.1 Socioeconomic Profile

4.3.1.1 Approach

To assess the socioeconomic elements of the proposed project, a Social Impact Area (SIA) was established. A SIA may be described as the estimated spatial extent of the proposed project's effect on the surrounding communities; for the purposes of this study, it was delineated using a two (2) kilometre buffer around the proposed project area. The SIA comprises 26 km^2 of land to the south of Spanish Town, the capital of the parish of St. Catherine. The project area is in the community of Cromarty, and this community, in addition to 3 neighbouring communities are either wholly or partially located in the 2km SIA (Figure 4-25, Table 4-14).

Table 4-14 Communities located within the Hill Run SIA, sorted from largest to smallest in area of coverage within the SIA

Community name	Parish	Land area with the SA (km^2)
Cromarty	St. Catherine	13.66
Hellshire	St. Catherine	8.36
Spanish Town Central	St. Catherine	3.49
Willowdene	St. Catherine	0.51
Total		**26.03**

Population data were extracted from the Statistical Institute of Jamaica (STATIN) 2011 Population Census database for the extent of the SIA by enumeration district (ED) and processed relative to the ED's

percentage coverage within the SIA using Geographic Information Systems (GIS) methodologies. The following computations were made:

- ***Population growth***: **[$P_n = P_o (1 + r)^t$]**
  Where P_o is the population at the beginning of a period, t is the period of time in years, r is the annual rate of increase, and P_n is the population at the end of the period (United Nations, 1952).
- ***Dependency ratio***: **[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:*** **[male population / female population X 100]**
  This in effect denotes the number of males there are to every 100 females and is useful for determining the predominant gender in a particular area.
- ***Domestic water consumption***
  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***
  Calculated at 4.11 kg/household/day (National Solid Waste Management Authority).

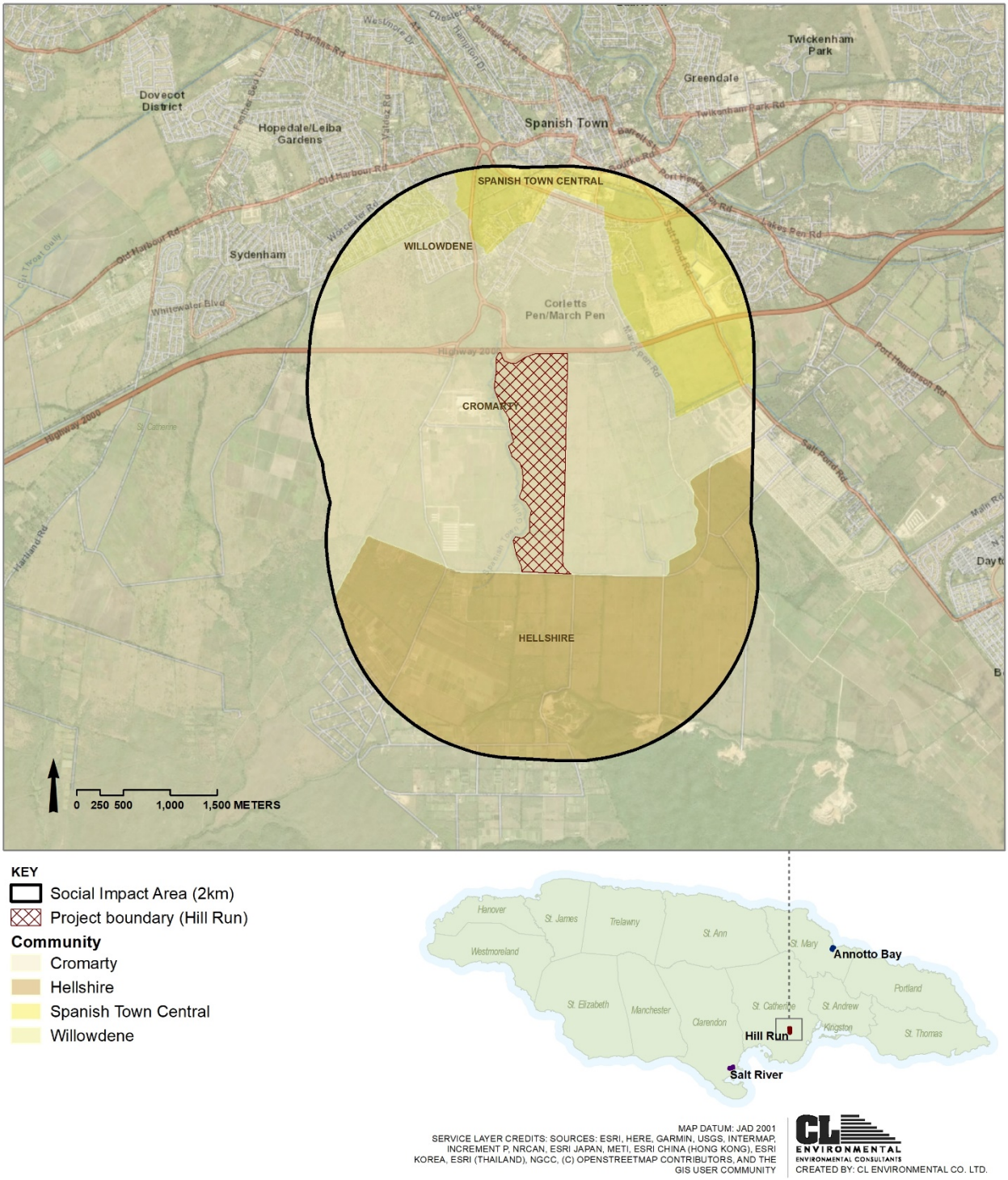


Figure 4-25 Communities within the Social Impact Area (SIA) for the proposed Hill Run project site

4.3.1.2 Demographics

The total population within the SIA in 2011 was approximately 13,520 persons (STATIN 2011 Population Census). With a total land area within the SIA of approximately 26 km^2, the overall population density for the SIA was calculated to be 519 persons/km^2 (Table 4-15). However, as shown in Figure 4-26, a far greater number of persons live closer to Spanish Town than in the more rural areas of the southern SIA.

Overall sex ratio within the SIA was calculated to be 88.5 males per one hundred females; however, this ratio varies across the SIA by ED (Figure 4-26).

Table 4-15 Comparison of ED population densities for the year 2011 within the Hill Run SIA

Source: STATIN Population Census 2011

Category	Jamaica	St. Catherine	SIA
Total ED area (km2)	10,991.0	1,190.6	26.0
ED Population	2,697,983	516,218	13,520
ED Population density	245	434	519

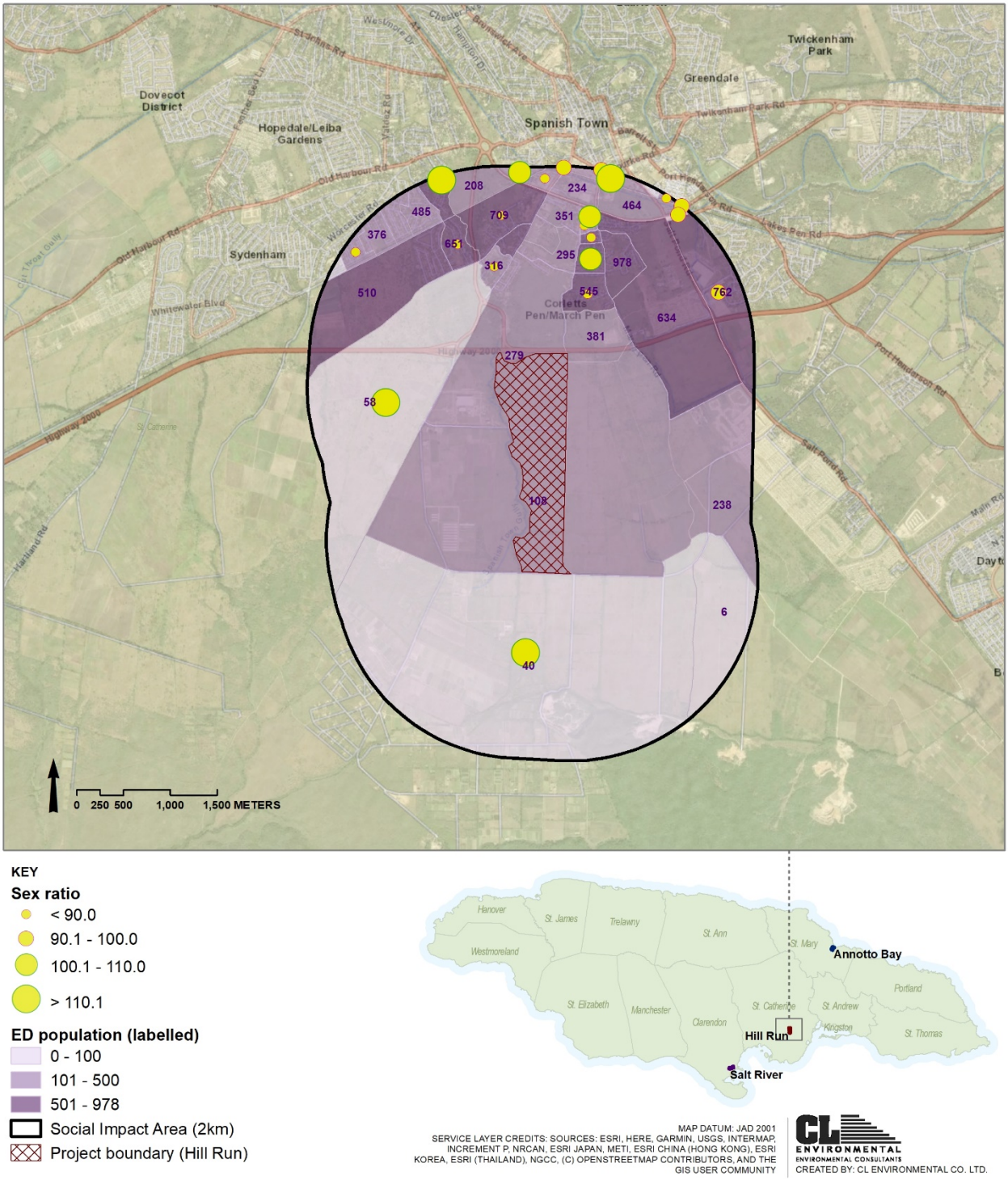
In 2001, there were approximately 14,169 persons living in the SIA. The overall growth within the SIA between 2001 and 2011 was approximately -0.47% per annum; based on this growth rate, at the time of this study (2023), the population is approximately 12,780 persons and is expected to decrease to 11,366 persons over the next twenty-five years if the current SIA population growth rate remains the same. The annual growth rate between 2001 and 2011 for the parish of St. Catherine is 0.72%; using this regional rate, the population in 2023 is estimated to be 14,735 persons, and in 2048, 17,630 persons.

Within the SIA, the 15-64 years' age category accounted for 65.9% and can therefore be considered a working age population (Table 4-16). The segment of a population that is considered more vulnerable are the young (children less than five years old) and the elderly (65 years and over); in the SIA population, 8.1% comprised the vulnerable young category and 6.8% comprised the elderly.

Table 4-16 Age categories as percentage of the population for the year 2011 within the Hill Run SIA

Source: STATIN Population Census 2011

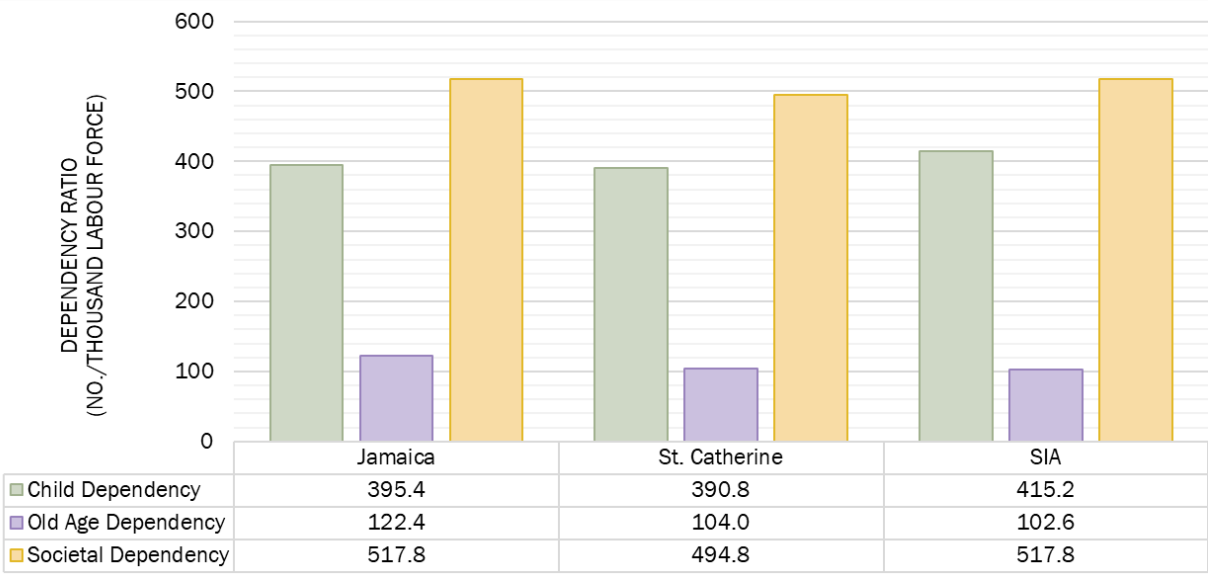
Age Categories	Jamaica	St. Catherine	SIA
0-14	26.1%	26.1%	27.4%
15 - 64	65.9%	66.9%	65.9%
65 & Over	8.1%	7.0%	6.8%



Source data: STATIN Population Census 2011

Figure 4-26 Sex ratio and population by ED within the Hill Run SIA

The child dependency ratio for the SIA in 2011 was 415.2 per 1000 persons of labour force age; old age dependency ratio stood at 102.6 per 1000 persons of labour force age; and societal dependency ratio of 517.8 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 (Figure 4-27).



Source: STATIN Population Census 2011

Figure 4-27 Comparison of dependency ratios for the year 2011 within the Hill Run SIA

4.3.1.3 Education

Two schools are located towards the northern section of the demarcated SIA (Figure 4-28), namely Homestead Primary and Horizon Park Primary & Jnr. High. There is a propensity towards the attainment of primary and secondary education as the highest level of education, with 48.9% of the SIA population having attained secondary school education as the highest level, followed by 34.4% attaining primary education. Tertiary education attainment (combined university and other) as the highest level of education is 5.8% in the SIA, lower than the national level of 4.8% (Table 4-17).

Table 4-17 Percentage SIA population 3 years old and over by highest level of educational attainment for the Hill Run SIA

Source: STATIN Population Census 2011

	Jamaica	St. Catherine	SIA
No Schooling	0.7%	0.6%	0.7%
Pre Primary	4.8%	4.9%	5.5%
Primary	34.4%	32.0%	34.4%
Secondary	45.7%	44.7%	48.9%
University	4.7%	5.9%	2.0%
Other Tertiary	5.2%	6.8%	3.8%
Other	0.5%	0.7%	0.5%
Not Stated	4.0%	4.4%	4.2%

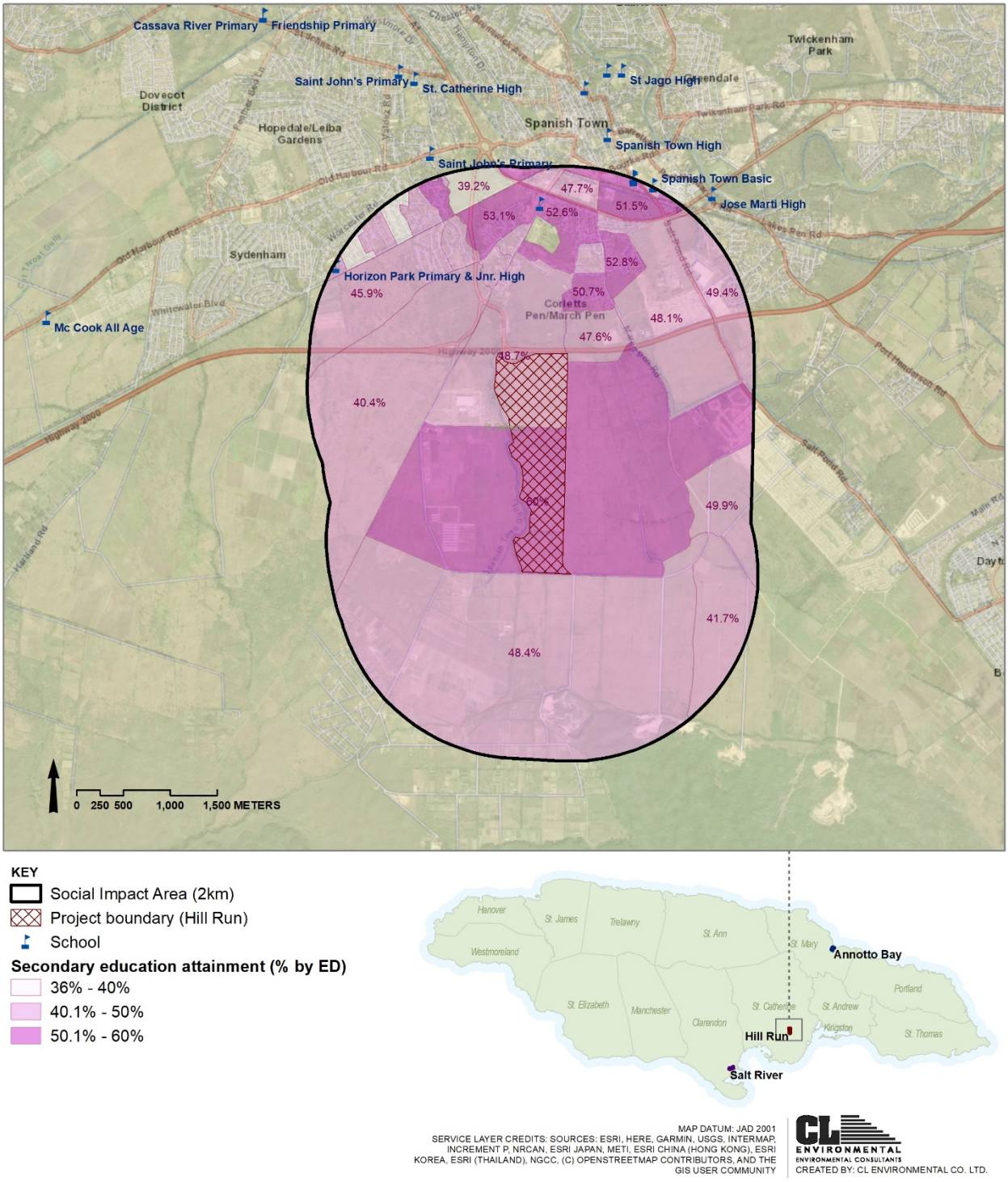


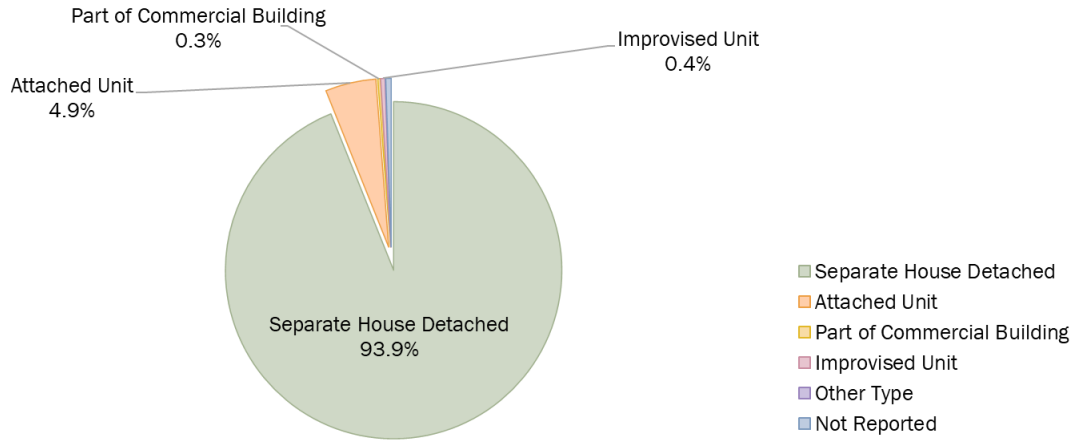
Figure 4-28 Secondary education attainment by ED and schools within the Hill Run SIA

4.3.1.4 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. The SIA population has poverty levels between 6.38 and 18.03% of persons living in poverty (Figure 4-30).

4.3.1.5 Housing

There were 3,822 housing units[3] (93.9% of which were separate detached houses, Figure 4-29), 4,475 dwellings[4] and 4,650 households within the SIA in 2011. The average number of dwellings in each housing unit was 1.2 and the average household to each dwelling was 1.0. The average household size in the SIA was 2.9 persons/ household. Comparisons of the SIA with national and regional ratios indicate that the SIA had comparable household/dwelling, average household size and dwelling/ housing unit ratios (Table 4-18).



Source: STATIN Population Census 2011

Figure 4-29 Percentage of housing units by type within the Hill Run SIA

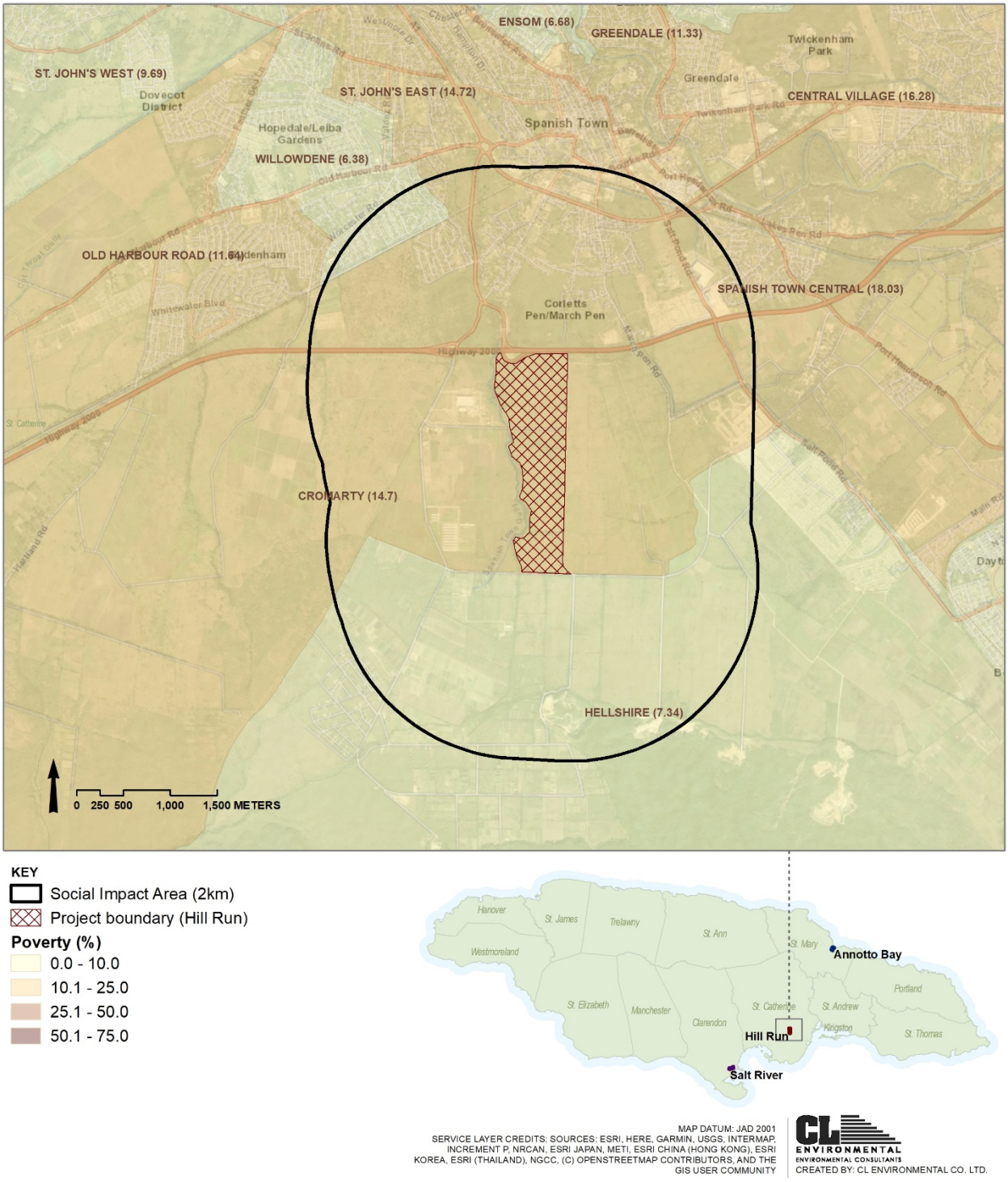
Table 4-18 Comparison of national, regional and SIA housing ratios for 2011 within the Hill Run SIA

Source: STATIN Population Census 2011

	Jamaica	St. Catherine	SA
Dwelling/Housing Unit	1.2	1.2	1.2
Household/Dwelling	1.0	1.0	1.0
Average Household Size	3.1	3.2	2.9

[3] Housing unit - building or buildings used for living purposes at the time of the census.

[4] Dwelling - 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. 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.



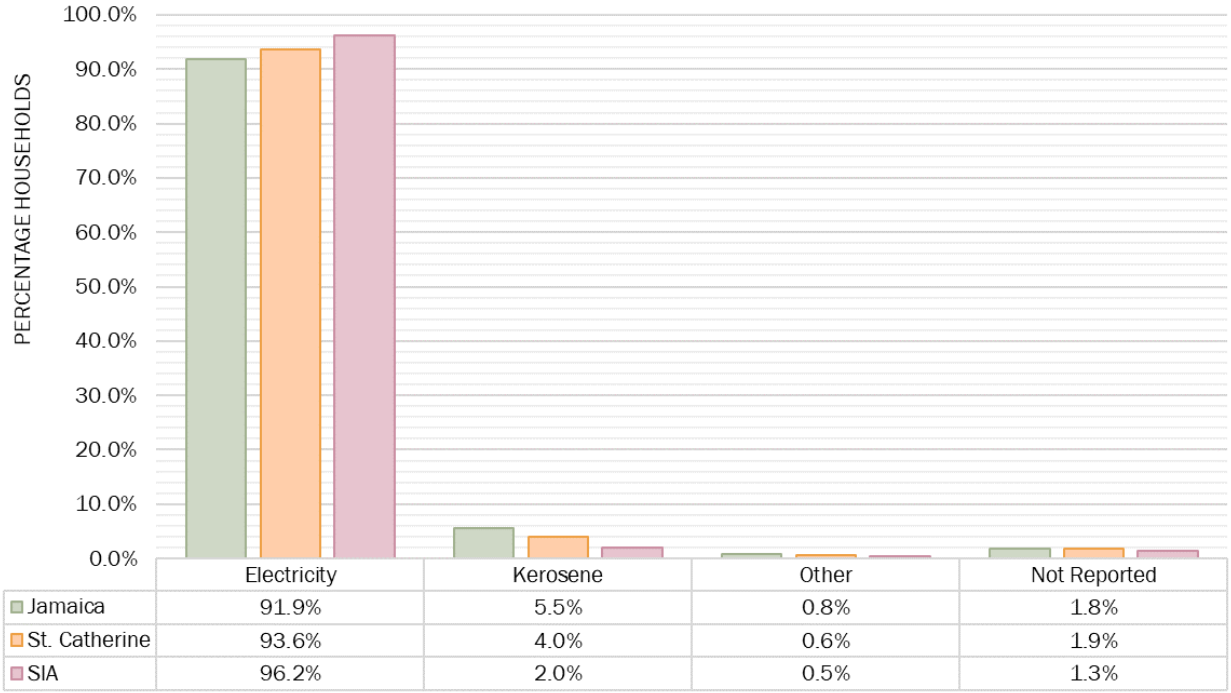
Data source: PIOJ (with contributions from STATIN, SDC and the University of Technology

Figure 4-30 Proportion of persons in poverty in each community within the Hill Run SIA

4.3.2 Utilities

4.3.2.1 Lighting

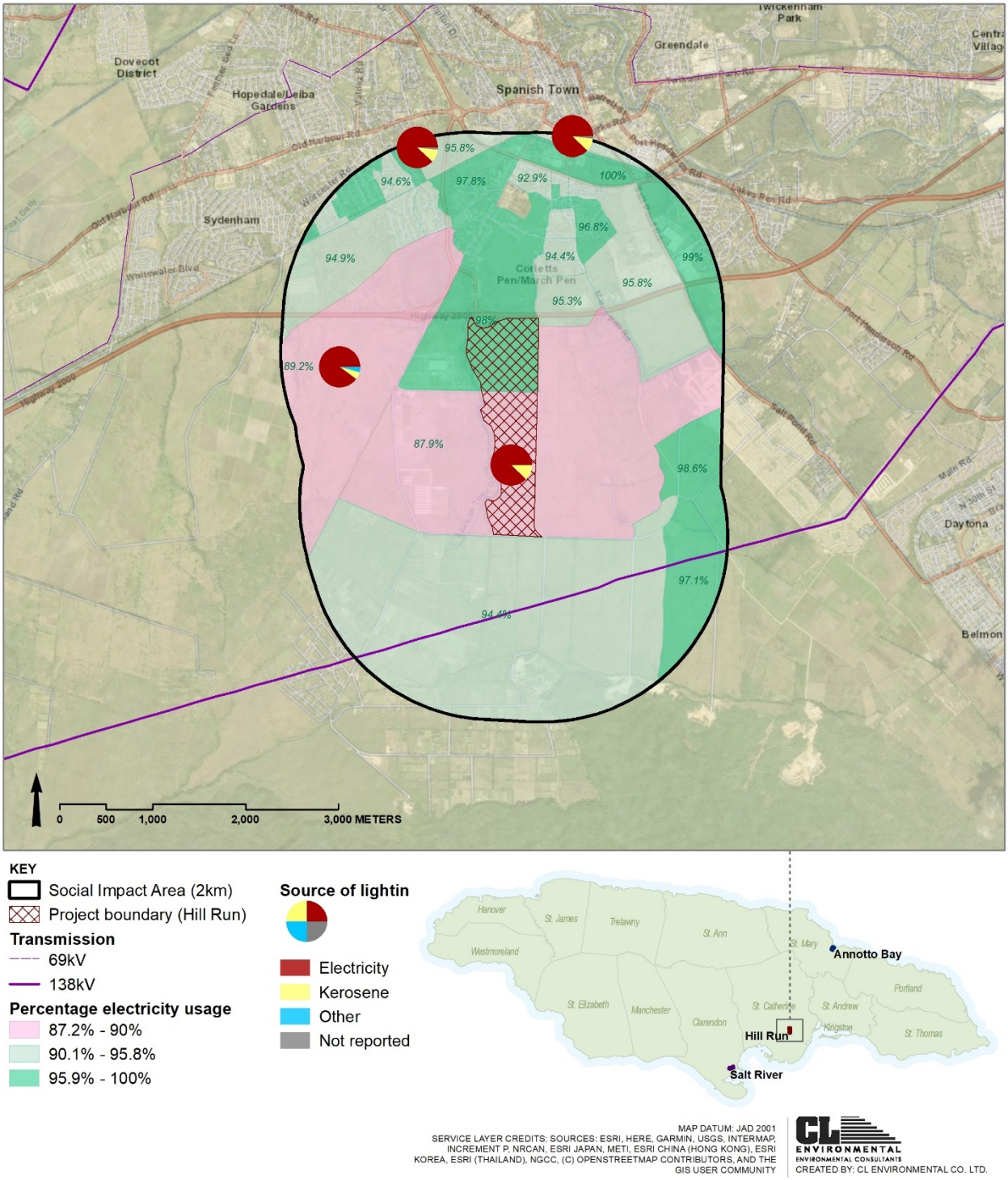
Electricity is provided by Jamaica Public Service Company Ltd.; infrastructure within the project area is depicted in Figure 4-32. Most SIA households utilise electricity as their main source of lighting (96.2%), with kerosene being the secondary source of lighting.



	Electricity	Kerosene	Other	Not Reported
Jamaica	91.9%	5.5%	0.8%	1.8%
St. Catherine	93.6%	4.0%	0.6%	1.9%
SIA	96.2%	2.0%	0.5%	1.3%

Source: STATIN Population Census 2011

Figure 4-31 Percentage households by source of lighting for the Hill Run SIA



Source: STATIN Population Census 2011

Figure 4-32 Percentage electricity usage for the year 2011 and location of transmission lines within the Hill Run SIA

4.3.2.2 Water Supply

The National Water Commission (NWC) is the public agency responsible for providing Jamaica's domestic water supply. Sources of water, such as rivers, wells and springs within the project boundary are depicted in Figure 4-33. Within the 2 km SIA, there are 24 wells belonging to the Rio Cobre Hydrologic Basin (Table 4-19, Figure 4-33); Fellowship Hall #2 well is located about 8m south of the proposed project boundary.

Table 4-19 Wells found within the SIA for the proposed Hill Run site

Name	Owner	State	Use	Monitoring
Fellowship Hall #2	Bernard Lodge Sugar Factory	Non Pumping	Public/Domestic Supply	Monitoring
March Pen 2	Bernard Lodge Sugar Factory	Pumping	Irrigation	Monitoring
Phoenix Park 4 (FMLC)	Frome Monymusk Land Co.	Pumping	Irrigation	
Hill Run Monitoring Well 5 (Piezo. #2)	Water Resources Authority	Pumping	Irrigation	Monitoring
March Pen CH 3	Water Resources Authority			
Phoenix Park 3 (FMLC)	Frome Monymusk Land Co.	Pumping	Irrigation	
Blair Pen	Frome Monymusk Land Co.	Pumping	Public/Domestic Supply	
Woodland 2	National Irrigation Commission	Non Pumping	Irrigation	
Woodland 1	Frome Monymusk Land Co.			Monitoring
Little Windsor Expl. I	Bernard Lodge Sugar Factory	Non Pumping		Monitoring
Craigallachie 2	Sugar Company of Jamaica	Pumping	Public/Domestic Supply	
Craigallachie 3	Sugar Company of Jamaica	Pumping	Irrigation	
Spanish Town (Windsor Road)	Industrial Chemical Co	Pumping	Industrial	
Spanish Town (Corletts Road)	Carib Pipe Company			
Bagasse Board 1	Standard Building Prod	Pumping	Industrial	
Bagasse Board 2	Standard Building Prod	Pumping	Industrial	
Fellowship Hall 1	R. McPherson			Monitoring
La Caridad	Frome Monymusk Land Co.			
Little Windsor (Fellowship)	United Fruit (Ja.) Co.			
March Pen 1	Frome Monymusk Land Co.			
Sydenham (Abd.)				
Tennants	Frome Monymusk Land Co.			Monitoring
Woodlands Expl. 1	Water Resources Authority			Monitoring
Woodland Dug		Abandoned		

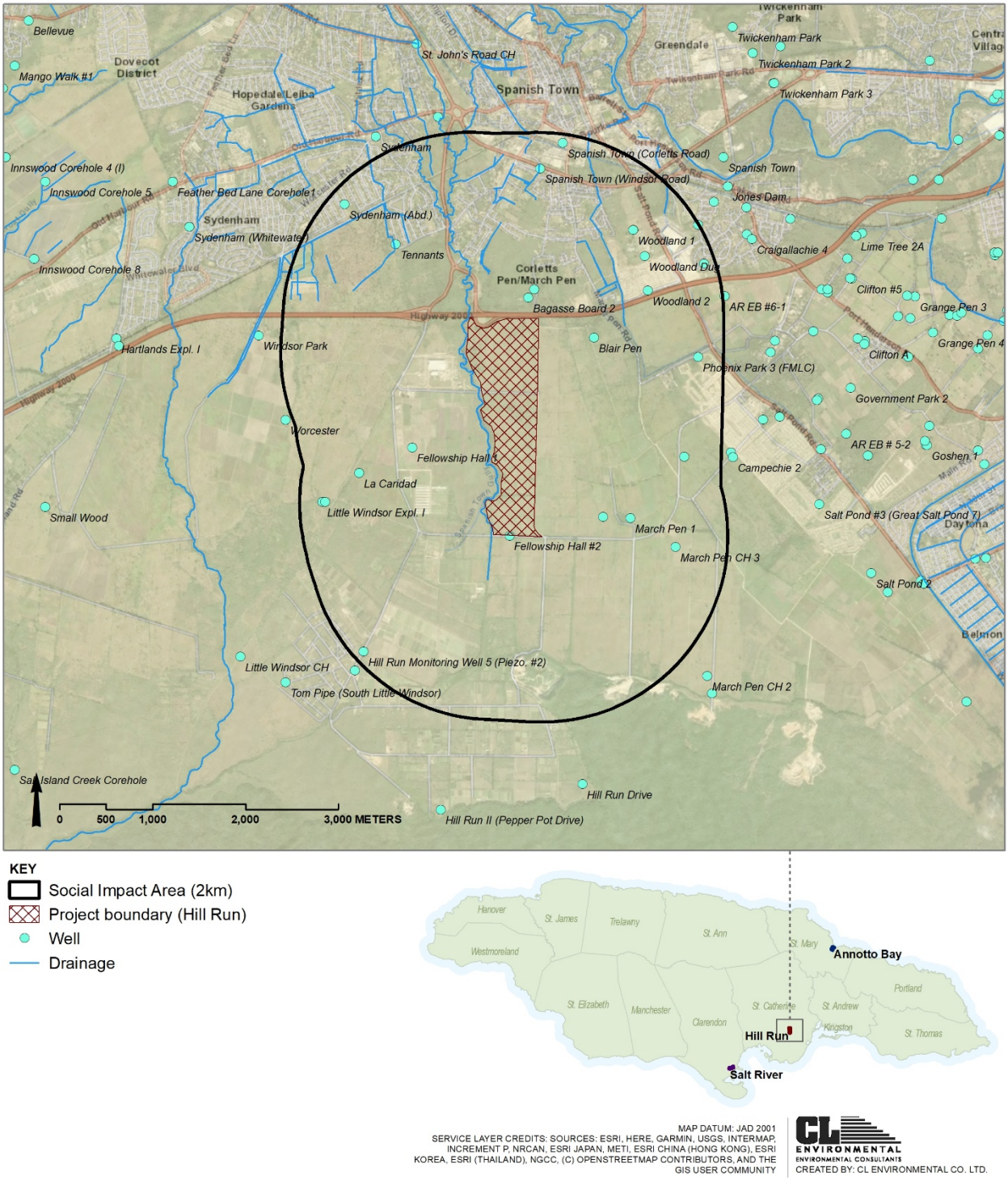


Figure 4-33 Sources of water supply within the Hill Run SIA

Most households within the SIA (93.9%) received their domestic water supply from NWC, whilst 3.9% from a private source (Table 4-20). Water demand for the SIA in 2023 is estimated to be 2,916,167.10

litres/day (≈770,369.99 gals/day) and is expected to decrease to 2,593,470.10 litres/day (≈685,122.44 gals/day) over the next twenty-five years based on population growth rates calculated previously.

Table 4-20 Percentage of households by water supply for the year 2011 within the Hill Run SIA

Source: STATIN Population Census 2011

	Category	Jamaica	St. Catherine	SA
Public Source	Piped in Dwelling	49.7%	63.5%	52.7%
	Piped in Yard	16.5%	16.1%	39.0%
	Stand Pipe	7.1%	1.8%	1.9%
	Catchment	2.2%	0.9%	0.3%
Private Source	Into Dwelling	6.4%	4.4%	2.7%
	Catchment	9.8%	3.6%	1.1%
	Spring/ River	3.0%	3.1%	0.0%
	Trucked Water/Water Truck	2.1%	3.7%	0.2%
	Other	1.8%	1.6%	0.8%
	Not Reported	1.3%	1.2%	1.2%

4.3.2.3 Wastewater Generation and Disposal

It is estimated that approximately 2,332,933.68 litres/day (≈616,295.99 gals/day) of wastewater is generated within the study area (for 2023) and is expected to decrease to 2,074,776.08 litres/day (≈548,097.95 gals/day) over the next twenty-five years based on calculated growth rates.

4.3.2.4 Solid Waste Generation and Disposal

It is estimated that at the time of this study (2023), approximately 18,150.82 kg/day (≈18.15 tonnes/day) of solid waste was being generated. This is expected to decrease to 16,142.29 kg (≈16.14 tonnes) over the next twenty-five years based on calculated growth rates.

The National Solid Waste Management Authority (NSWMA) is responsible for domestic solid waste collection within the study area. In residential areas, garbage is collected once per week. This service is provided free (partial covered by property taxes) for the households within the area.

4.3.2.5 Telecommunication

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

4.3.3 Land Cover and Zoning

4.3.3.1 Land Use and Services

The proposed site currently ruinate with what appears to be some subsistence farming to the south of the property and also informal dumping of solid waste. The PJ Paterson Highway and its connection to Highway 2000 traverses the northern boundary of the project site (Figure 4-34). To the west of the site, the Nest (Caribbean Broilers) which processes chickens, has a feed mill and wholesale farming which produces onions, pepper, and sweet corn. It also has a natural gas power plant that supplies its energy needs.

Within the wider 2km SIA, land cover is predominantly fields, with a high density of buildings and other infrastructure located north of the site within the Spanish Town environs (Figure 4-35). Within Spanish Town, various emergency services exist, which would likely respond to emergencies at the proposed site (Figure 4-34).

Spanish Town is the capital of the parish of St. Catherine. Land use in Spanish Town is diverse with institutional, residential, commercial light industrial, light industrial, heavy industry, utility-sewage, institutional office, office commercial, Government purposes and statutory undertakings, cemetery, and transportation centre. Spanish Town is considered an historic town holding several archaeological and historical sites and monuments. This great number of sites have ultimately led to the Jamaica National Heritage Trust declaring a section of Spanish Town national protected heritage in December of 1994 (Jamaica National Heritage Trust, 2021).

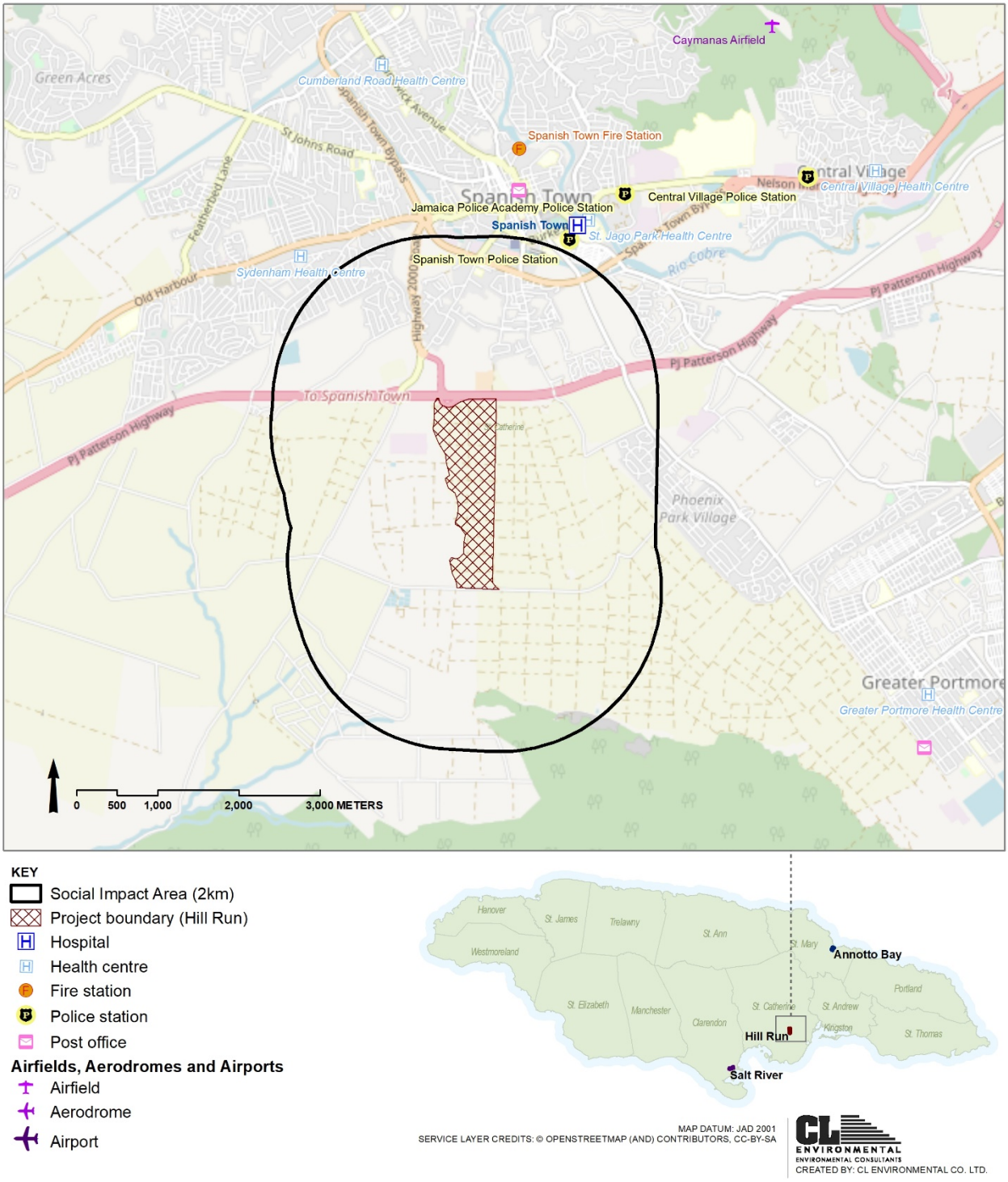
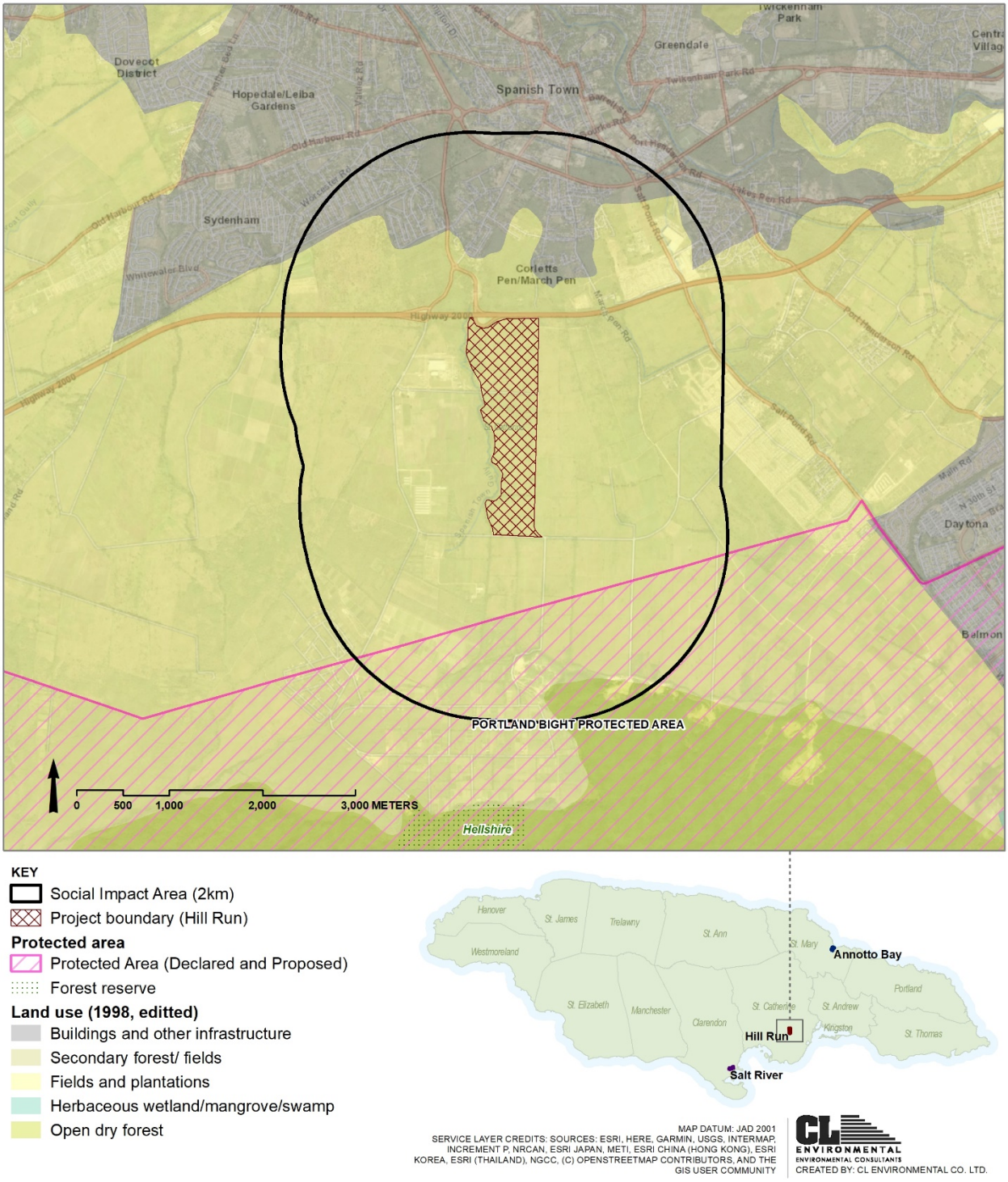


Figure 4-34 Road network and services located in the Hill Run SIA



Data sources: Land use (edited based on Forestry Department, 1998), forest estates (Forestry Department) and protected areas (NEPA and MGI)

Figure 4-35 Land use, protected areas, and forest estates within the Hill Run SIA

Table 4-21 Historical Google Earth imagery at Hill Run site (March 2001 – March 2022)

4.3.3.2 Protected Areas

Protected areas examined here include all areas of land or water protected by various laws in Jamaica, as well as international agreements, that fall within or in proximity to the project area; these include fish sanctuaries or Special Fishery Conservation Areas (SFCAs), protected areas (declared and proposed), national parks, forest reserves, marine parks, game reserves and national heritage and monuments. The project site does not directly fall within any area designated as a protected area or marine park under the Natural Resources Conservation Authority Act; however, the Portland Bight Protected Area is located ≈800 m south of the proposed site.

The Portland Bight Protected area was declared April 22, 1999, under Natural Resources Conservation Authority (NRCA) Act. It is co-managed by the Caribbean Coastal Area Management Foundation (CCAM) and the National Environment and Planning Agency (NEPA). The PBPA is the largest protected area in Jamaica enclosing 1,876 km2 of coastal land and sea between Portland Ridge and Hellshire Hills and including nearby cays such as Little Goat Island. More than half of the land area of the PBPA exists in its natural state and includes dry limestone forests (210.3 km2) and wetlands (82.0 km2). The remainder of land is used for the cultivation of sugar cane or human settlement (Caribbean Coastal Area Management (C-CAM) Foundation, 2007). Regionally important examples of dry forest and nationally important areas of coral reef, mangrove wetland and seagrass occur within this area, which also provides habitat for at least 20 globally threatened species.

4.3.3.3 Zoning

The project site falls within the boundaries of the Town and Country Planning (Saint Catherine Parish) Provisional Development Order, 2017, which was confirmed with modifications in 2019 by way of the Town and Country Planning (Saint Catherine Parish) Provisional Development Order, 2017 (Confirmation) Notification, 2019. As seen in Figure 4-36, the project site falls within areas zoned for agriculture, and within the wider SIA for local planning (Spanish Town, Figure 4-37), other development orders and areas and the Portland Bight Protected Area. Within the Spanish Town Local Planning Area Land Use Proposals (Inset No.1), the buildings and infrastructure located within Spanish Town have varying uses including but not limited to residential, government purposes, institutional, industrial, commercial, and open space (Figure 4-36).

4.4 HERITAGE AND CULTURAL

According to the Jamaica National Heritage Trust website *(http://www.jnht.com/st_catherine.php),* there is one (1) national heritage site found within approximately 1 km of the proposed project site, which is the Highway 2000 corridor located at the northern boundary of the project property.

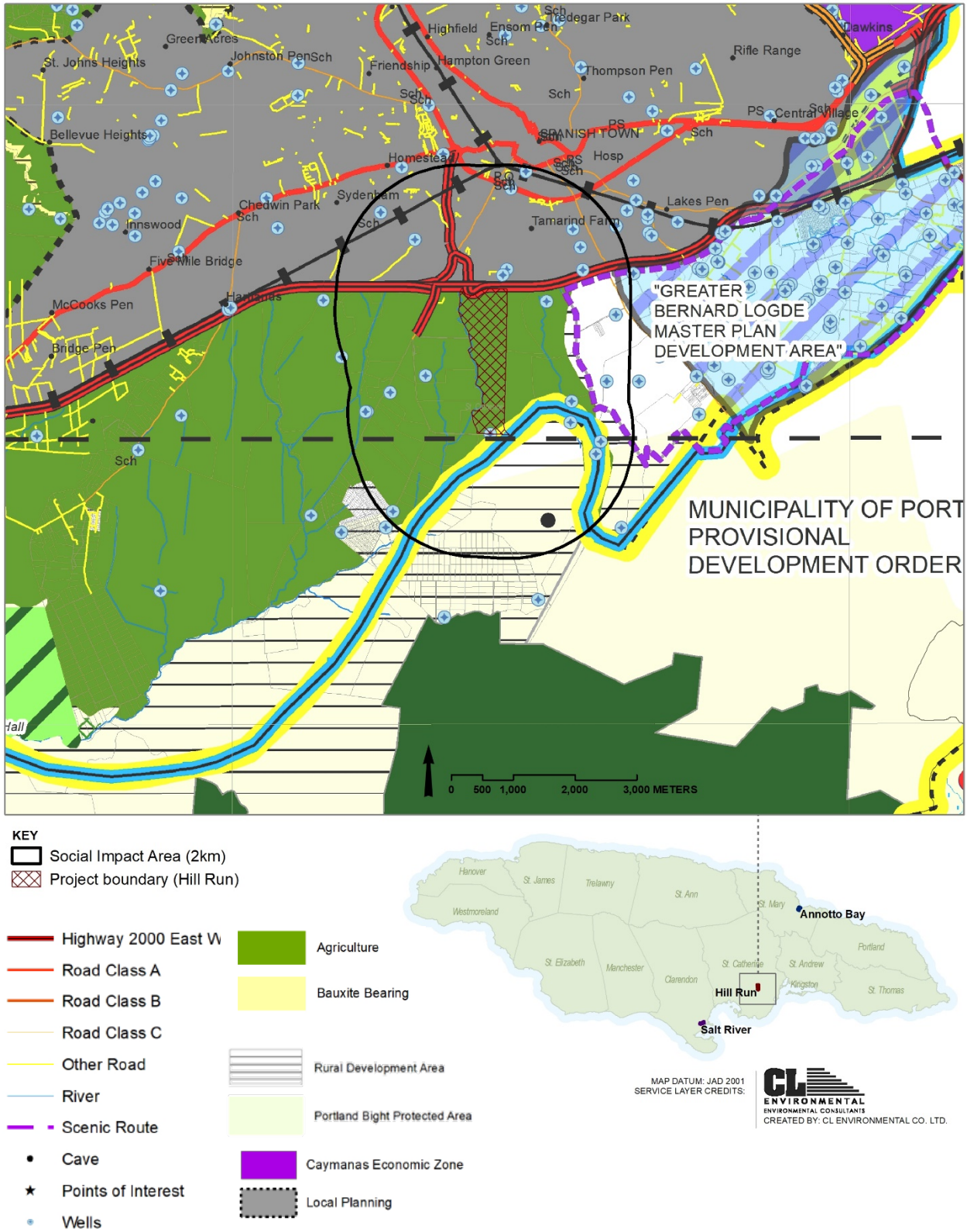


Figure 4-36 Zoning proposed within the Town and Country Planning (Saint Catherine Parish) Provisional Development Order, 2017 (Confirmation) Notification, 2019, in relation to the Hill Run SIA

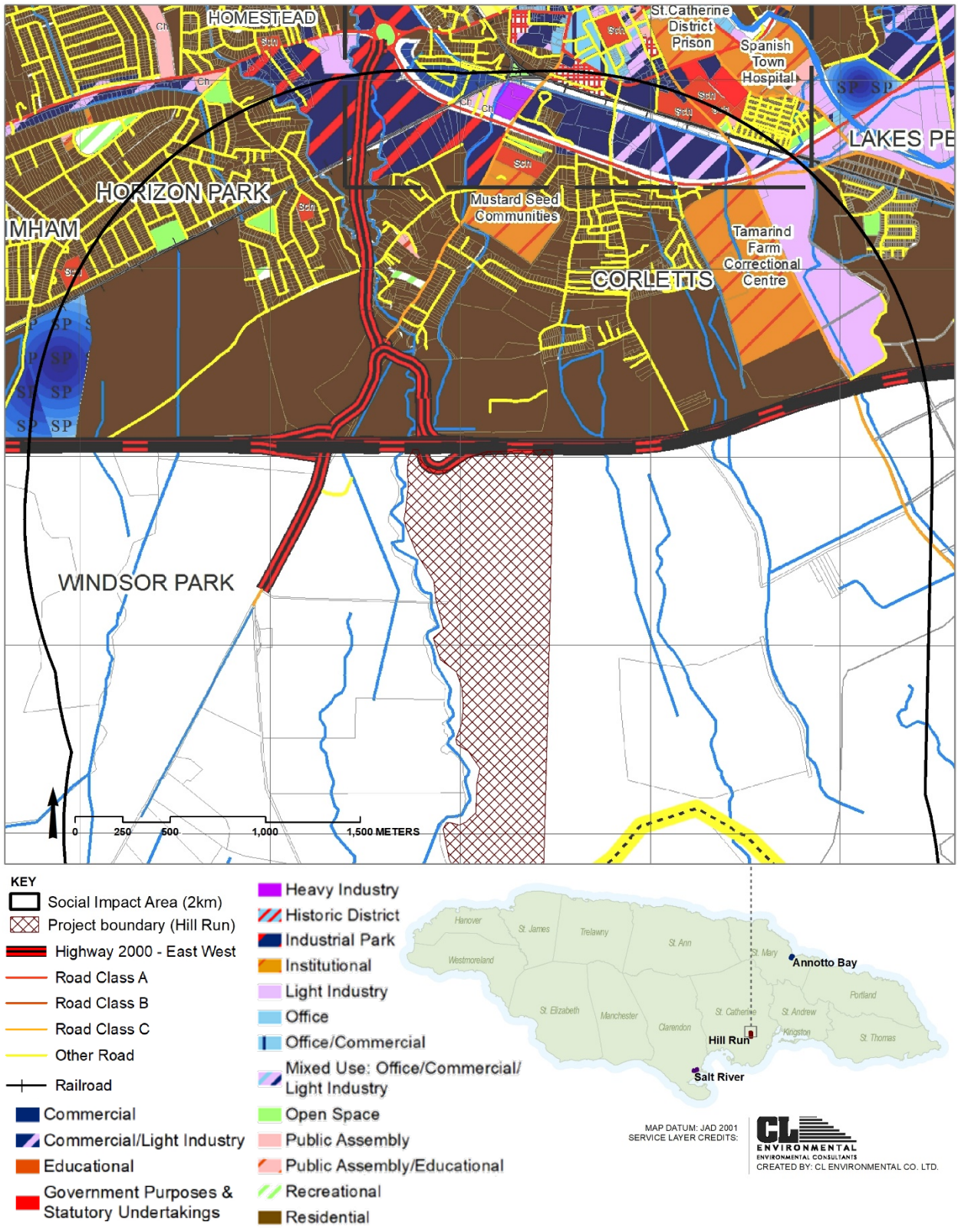


Figure 4-37 Spanish Town Local Planning Area Land Use Proposals in relation to the Hill Run project site

5.0 IDENTIFICATION OF POTENTIAL IMPACTS AND RECOMMENDED MITIGATION

5.1 PHYSICAL

5.1.1 Geotechnical and Seismic Hazard

Impact

The proposed site was determined to be in a moderately high seismicity zone based on the level of spectral acceleration or oscillatory movement associated with a 2,475-year return period earthquake. This indicates that it is paramount that seismic provisions provided in codes such as the UBC, IBC and other local codes be followed.

Recommended Mitigation

1. Conduct a thorough geotechnical investigation to understand the soil and geological conditions, as these can significantly impact the response of the solar farm to seismic forces.
2. This outcome poses a recommendation for a detailed structural analyses and designs of the sites to confirm an elevated probability of collapse or structural failure:
    a. Incorporate seismic bracing and anchoring systems for both the solar panels and supporting structures.
    b. Design foundations with flexibility to dissipate seismic energy and reduce the risk of overturning or settlement.
    c. Consider the use of seismic dampers, base isolators, or energy dissipation devices to absorb and dissipate seismic energy.

5.1.2 Hydrology and Flood Plain Mapping

Impact

After assessment of the proposed Hill Run site, it was concluded that there are a few isolated sections of the property that experiences ponding, however, generally the site is not exposed to a high vulnerability of flooding during extreme storm events.

Recommended Mitigative Measures

1. A detailed floodplain study should be undertaken consisting of a refined topography and appropriately scaled model domain. It is imperative that the Spanish Town gully to the west of the proposed site be included in the simulation.
2. Critical infrastructure should be placed at a minimum elevation of +29.4m AMSL with the use of stilts for the PV panels and plinths.

3. Proposed drainage system implementation should be considered and implemented with the guidelines outlined by the NWA in their Drainage Guideline documentations.
4. To maintain efficient runoff from the facility, proposed drains must be maintained properly. This includes frequent cleaning and rehabilitation where necessary.

5.1.3 Air Quality

Impact

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

Operationally, solar power generation does not produce air pollutants, contributing to improved air quality and public health.

Recommended Mitigation

i. Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.
ii. Minimize cleared areas to those that are needed to be used.
iii. Cover or wet construction materials such as marl to prevent a dust nuisance.
iv. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.
v. Ensure material stockpiles and construction debris are stored away from the roadway
vi. Consultation with Stakeholders to inform them of the work schedule and activities and to get their feedback.
vii. Use of properly serviced and maintained equipment to reduce air emissions.

5.1.4 Noise

Impact

Any site clearance, filling or grading for the proposed project necessitates the use of heavy equipment to carry out the job. Equipment to be used include bulldozers, backhoes etc. They possess the potential to have a direct negative impact on the noise climate. Construction noise can result in short-term impacts of varying duration and magnitude. The construction noise levels are a function of the scale of the project, the phase of the construction, the condition of the equipment and its operating cycles and the number of pieces of construction equipment operating concurrently.

Operationally, solar power generation only emit low-level noise via Inverters and other equipment.

Recommended Mitigation

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

5.1.5 Vibration

Impact

Construction activities often generate vibration complaints. This may be as a result of interfering with persons normal routines/activities. This can become more acute if the community has no understanding of the extent and duration of the construction. This can lead to misunderstandings if the contractor is considered to be insensitive by the communities although he may believe he is in compliance with the required conditions/ordinances. Construction activities may result in various degrees of ground vibration, dependent on the type of equipment used and the methodologies employed.

Recommended Mitigation

i. Sequence of operations:
    - Phase earth-moving and ground-impacting operations so as not to occur in the same time period. Unlike noise, the total vibration level produced could be significantly less when each vibration source operates separately.
    - Avoid night-time activities. People are more aware of vibration during the night-time hours.
ii. Avoid impact pile driving where possible in vibration-sensitive areas. Drilled piles or vibratory pile driving causes lower vibration.
iii. Have regular meetings or devise a communication strategy to inform the surrounding residents and businesses of construction activities.

5.1.6 Water Quality

Impact

There may be the potential for coarse and fine material, whether from excavation or material storage on site, to drain into the gully located at the western boundary of the project site, resulting in excessive siltation. Stored fuels, lubricants, hazardous substances and the repair and usage of construction equipment have the potential to leak hydraulic fuels, oils, etc and thereby have the potential to compromise the water quality as well.

Recommended Mitigative Measures

i. The project site will put in sediment control measures such as silt fences around the active work area to prevent the runoff of sediments and contaminants into the gully.
ii. A central area will be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of chemicals into the sediment.
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 and equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff.
v. Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage.

5.2 BIOLOGICAL

5.2.1 Flora and Fauna

Impact

There may be a temporary and minimal impact on both habitat and species diversity. Both the flora and fauna community are very limited and shaped by the agricultural practises within the proposed project area.

Collision Risk: Birds can collide with solar panels, support structures, or other equipment, especially during periods of low visibility, such as fog or heavy rain.

Heat Island Effects: Solar panels can create localized heating effects, which may deter some bird species from foraging or roosting in the area. No recommended mitigation.

Glare from solar panel may be a disturbance/deterrent to birds, but this is expected to be minimal. No recommended mitigation.

Recommended Mitigative Measures

i. Planting of grasses and shrubs around suitable areas. This will encourage and support insects in and around the project area.
ii. Avian-Friendly Design: Solar farms can be designed with avian safety in mind. For example, using materials that reduce reflection and making panels more visible to birds can help prevent collisions.

5.3 HUMAN/ SOCIAL

5.3.1 Employment

Impact

There is the potential for increased employment during the site preparation and construction phases. In addition, it is anticipated that indirect and induced jobs are expected to be created during the site clearance and construction phases respectively; thus, further benefitting the community. This represents a significant level of employment within the study area and has the potential to be a significant positive impact.

Recommended Mitigation

None Required

5.3.2 Energy Generation

The proposed project supports the national energy policy to reduce the dependence on imported fossil fuels and reduce greenhouse gas emissions.

Recommended Mitigation

None Required

5.3.3 Health and Safety

Impact

Construction activities have the potential for accidental injury, whether major or minor. This may also include fire safety, safe access routes, clearly defined pedestrian pathways, electrical hazards, eye hazards and radiation hazards. In addition, disasters such as earthquakes, floods and hurricanes are real possibilities.

Recommended Mitigation

i. Ensure that there is an ambulance and requisite staff onsite for any eventualities.
ii. Ensuring that workers wear personal protective equipment (hard hats, reflective vests, safety shoes, eye protection etc.)
iii. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.
iv. 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.
v. There should be onsite first aid kits and arrangement for a local nurse and/or doctor to be on call for the construction site.
vi. Make prior arrangements with staff at the nearest hospital and/or health centre to accommodate any eventualities. There is a doctor's office in proximity to the site which could also be explored.

vii. Make prior arrangements with the nearest police and fire stations to accommodate any eventualities.
viii. Material Safety Data Sheets (MSDS) should be stored onsite.
ix. A lead person should be identified and appointed to be responsible for emergencies occurring on the site. This person should be clearly identified to the construction workers.
x. Trench Excavation
    - A trench 1.2m or more in depth must have a means of egress (ladders/ stairways/ramps) and should be located at 8m intervals.
    - Excavated materials must be stored 0.6m or more from the open trench (not to be measured from the crown of the spoil).
    - Spoil should be placed so that the channels rainwater and other runoff water away from the excavation.
    - Take precautions regarding Tension Cracks
        - Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench.
        - Sliding or sloughing may occur as a result of tension cracks. [5]
xi. Designing and implementing an Emergency Response Plan (ERP) in the event of any emergency.

5.3.4 Aesthetics

Impact

Construction activities may decrease the aesthetic appeal of the area; however, this will be for a short-term period during construction. In particular, trucks leaving the construction site have the potential to deposit marl and mud onto the main road, making the main road aesthetically unappealing and in the process, affecting the conditions of other vehicles traversing the main road.

Operationally, solar farms can be visually intrusive, especially if not well-integrated into the landscape.

Recommended Mitigation

- Good housekeeping activities and adherence to other mitigative measures.
- An area of gravel should be placed on site (just before exiting onto the main road) to help remove mud/marl from truck wheels.
- A wheel wash area on site (just before exiting onto the main road) should be implemented to rid wheels of as much mud/marl as possible.

[5] Worker Health and Safety Guidelines as per OSHA #510 Construction Industry Standard 29 CFR Part 1926.

5.3.5 Grievance Mechanisms

Impact

Construction activities often causes inconveniences, health risks and can be a source of nuisance to stakeholders (both internal and external) on site and in the general area. Incidences of Gender Based Violence (GBV), Sexual Exploitation and Abuse (SEA) and Sexual Orientation Discrimination may also occur.

Recommended Mitigation

With the aim of establishing and maintaining a harmonious relationship between the stakeholders (both internal and external) and the Project, a Claims and Complaints Absolution Program will be implemented, whose general objective is to create a system that allows timely response to complaints from residents who are perceived to be affected or harmed by any aspect of the Project. A Grievance Redress Mechanism (GRM) to include reports of allegations of Gender Based Violence (GBV), Sexual Exploitation and Abuse (SEA) and Sexual Orientation Discrimination will be formulated.

6.0 SITE SUITABILITY

The site under consideration proves to be highly suitable for the establishment of a solar farm. This suitability stems from several key factors, including the site's prior land use, which had minimal environmental impact, facilitating a smoother transition to renewable energy generation. The topography of the site is also gently sloping which facilitates solar farm construction. It is situated immediately off the PJ Patterson Highway which will facilitate easier transportation of equipment from the wharf for both construction and maintenance of the facility. Additionally, the area boasts favourable irradiation factors, ensuring optimal sunlight exposure for solar panels, which translates to efficient energy production. These combined attributes make the site an excellent choice for a solar farm, aligning with the GOJ's commitment to sustainable and environmentally responsible energy generation practices.

7.0 REFERENCES

Environmental Solutions Limited, 2018. *Environmental Impact Assessment for Caribbean Broilers Hill Run Development " Hybrid Growth Centre "The Nest"*, s.l.: s.n.

National Environment and Planning Agency, n.d. *Protected Areas System Master Plan: Jamaica 2013 – 2017, Final Submission to the Protected Areas Committee*, s.l.: s.n.

8.0 APPENDICES

Appendix 1 Noise Calibration Certificate

HBK HOTTINGER BRÜEL & KJÆR
The Hottinger Brüel & Kjær Inc. Calibration Laboratory
3079 Premiere Parkway Suite 120
Duluth, GA 30097
Telephone: 770-209-6907
Fax: 770-447-4033
Web site address: http://www.hbkworld.com

A2LA ACCREDITED
Calibration Certificate # 1568.01

CERTIFICATE OF CALIBRATION No.: CAS-655130-C4L2B9-401 Page 1 of 2

CALIBRATION OF:

Calibrator:	Brüel & Kjær	Type	4231	Serial No.:	3018640
		IEC Class:	1		

CUSTOMER:

CL Environmental
20 Windsor Avenue
5 Kingston, Jamaica

CALIBRATION CONDITIONS:

Environment conditions:	Air temperature:	23	°C
	Air pressure:	97.505	kPa
	Relative Humidity:	54.2	%RH

SPECIFICATIONS:

This document certifies that the acoustic calibrator as listed under "Type" has been calibrated and unless otherwise indicated under "Final Data", meets acceptance criteria as prescribed by the referenced Procedure. Statements of compliance, where applicable, are based on calibration results falling within specified criteria with no reduction by the uncertainty of the measurements. The calibration of the listed transducer was accomplished using a test system which conforms to the requirements of ISO/IEC 17025, ANSI/NCSL Z540-1, and guidelines of ISO 10012-1. For "as received" and "final" data, see the attached page(s). Items marked with one asterisk (*) are not covered by the scope of the current A2LA accreditation. This Certificate and attached data pages shall not be reproduced, except in full, without written approval of the Hottinger Brüel & Kjær Inc. Calibration Laboratory-Duluth, GA. Results relate only to the items tested. The transducer has been calibrated using Measurement Standards with values traceable to the National Institute of Standards and Technology, National Measurement Institutes or derived from natural physical constants. The acoustic calibrator has been calibrated in accordance with the requirements as specified in IEC60942.

PROCEDURE:

The measurements have been performed with the assistance of Hottinger Brüel & Kjær Inc. acoustic calibrator calibration application
Software version 2.3.4 Type 7794 using calibration procedure 4231 Complete

RESULTS:

☒ "As Received" Data: Within Acceptance Criteria ☐ "As Received" Data: Outside Acceptance Criteria
☒ "Final" Data : Within Acceptance Criteria ☐ "Final" Data : Outside Acceptance Criteria

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA-4/02from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the calibrator under calibration.

Date of Calibration: August 29, 2023 Certificate issued: August 29, 2023

Meshaun Hobbs
Calibration Technician

William Shipman
Quality Representative

CERTIFICATE OF CALIBRATION

No.: CAS-655130-C4L2B9-401

Type: 4231 Serial No.: 3018640

Sound Pressure Levels

All stated values are valid at environmental reference conditions

Nominal Level [dB]	Accept Limit Lower [dB]	Accept Limit Upper [dB]	Measured Level [dB]	Measurement Uncertainty [dB]
94	93.80	94.20	94.00	0.12
114	113.80	114.20	113.99	0.12

Frequency

Nominal Frequency [Hz]	Accept Limit Lower [Hz]	Accept Limit Upper [Hz]	Measured Frequency [Hz]	Measurement Uncertainty [Hz]
1000	999.00	1001.00	999.97	0.10

Total Distortion*

Distortion mode: [X] TD* [ ] THD*

Calibration Level [dB]*	Accept Limit [%]*	Measured Distortion [%]*	Measurement Uncertainty [%]*
94	1.00	0.44	0.13
114	1.00	0.58	0.13

Environmental Reference Conditions:

Pressure: 101.3 kPa, Temperature: 23 °C, Relative Humidity: 50%

Instrument List

Type	Description	Serial no	Cal. date	Due date	Calibrated by	Trace number
3560	PULSE Analyzer	2723320	2022-10-04	2023-10-31	GK	CAS-602587-G9F5L4-801
9545	Transfer Microphone	3	2022-10-06	2023-10-31	MH	CAS-602587-G9F5L4-403
4228	Reference Sound Source	1618502	2023-04-19	2025-04-30	WS	CAS-632564-L2S0L9-708

During the calibration the calibrator has been loaded by the load volume of the Transfer Microphone. The load volumes for a number of different types of Transfer Microphones are listed in the table below.
For Brüel & Kjær Pistonphones types 4220 and 4228 the result of the SPL calibration has been corrected to be valid for a load volume of 1333 mm^3 . For all other types the result is valid with the actual load volume.

Transfer Microphone Type	Fulfils standard IEC 61094-1 LS	Fulfils standard IEC 61094-4 WS	Load Volume 1" (1/2" mic including DP-0776)	Load Volume 1/2"
4180	yes	yes	1126 mm^3	43 mm^3
4192	-	yes	1273 mm^3	190 mm^3
9545	-	-	1333 mm^3	-

Condition "As Received":

Comments