5.0 Description of the Environment

This section provides a description of the historical and current environmental and socio-economic conditions against which the potential impacts from the hotel development project at Kilgwyn Bay can be assessed, and any future changes monitored. The baseline description is predicated on several primary and secondary data sources which presents an overview of the proposed hotel development site and its potential impact zonation defined by the limits of the EIA. Primary data sources include terrestrial water, sediment and benthic data, recent ecological surveys, recent nearshore environmental baseline surveys for benthic fauna, water chemistry, physical sediment characteristics and sediment chemistry surveys. Secondary data sources included the review of existing literature on any geology, geomorphology, natural hazards, environmental surveys and reports used to provide a socio-economic baseline. Stakeholder and public consultations were conducted in accordance with the Terms of Reference (TOR) as part of the socio-economic assessment. Consultations were conducted to identify the key stakeholders likely to be affected by the project and their concerns.

The proposed works will take the form of literature reviews and real time surveys of the Physical, Biological and Socio-cultural environment to effectively characterize the immediate study area and within a 2km and 5km impact zonation of the proposed hotel development project. In this instance the limits of the study area will be defined by the boundaries of the proposed land parcel and encompass the Backshore, Foreshore and Nearshore habitats of Kilgwyn Bay.

5.1 Physical Environment

5.1.1 Climate and Meteorology

Trinidad and Tobago is a twin island state located approximately 7km north off the coast of Venezuela and the South American mainland. It is the most southerly of the Lesser Antillean nations. Tobago is the smaller of the two land masses with and overall size of approximately 300 Km^2. The overall climate which influences the ecology of island is shaped by several interacting and counter-acting forces, but the geographical position of the islands is a predominant factor. The country is very close to the equator, and its location places it within the zones of influence of the Inter-Tropical Convergence Zone (ITCZ), the North Atlantic Sub-Tropical High-pressure cell (NASH) and the Tropical Atlantic Cyclone or Hurricane Belt which collectively contribute to the temperature, rainfall and wind regimes that are experienced.

Trinidad and Tobago's close proximity to the equator allows the country to have two climate types producing two opposing seasons. These seasons are differentiated as distinct dry and wet regimes. The dry season which occurs during January to May is symbolized by a tropical maritime climate that is characterized by moderate to strong low-level winds, warm days and cool nights, with rainfall mostly in the form of showers due to daytime convection. A modified moist equatorial climate characterized by low wind speeds, hot humid days and nights, a marked increase in rainfall which results mostly from migrating and latitudinal shifting equatorial weather systems, symbolizes the wet season during June to December. The periods late May and December are considered as transitional periods to the wet and dry seasons respectively (Meteorological Office, 2009 -2022).

Trinidad and Tobago's daily temperature cycle is more pronounced than its seasonal cycle. The long-term mean (1971 - 2000) annual maximum and minimum temperatures are 31.3 Celsius and 22.7 Celsius respectively with a mean daily temperature of 26.5 Celsius. Generally, the wet season temperatures are warmer than the dry season temperatures with September being the warmest wet season month and March the warmest in the dry season (Meteorological Office 2009-2022; Particip GmbhH, 2019).

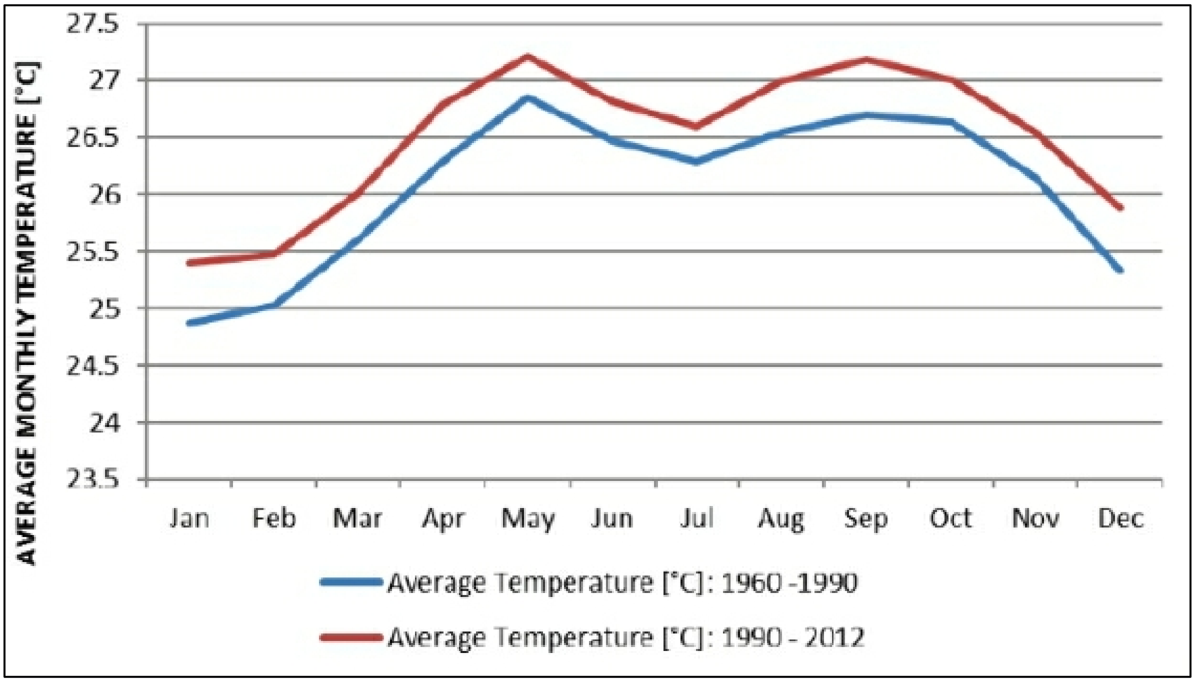

Figure 27 - 5.1: Mean Monthly Temperatures for Trinidad and Tobago for Two Periods: 1960-1990 and 1990-2012.
Source: Particip GmbH, 2019.

Wind speeds recorded at the Piarco station over the 1989 – 2009 period indicate a period average of 3.15 m/s, originating mainly from the east and east-north-east. The wind speed average varies by season, with a higher average during the dry season (3.35 m/s) compared to the wet season (2.61 m/s). During the dry season, there is a greater observed frequency of winds that exceed 4 m/s, whereas in the wet season, lower wind speeds have a higher frequency compared to the frequency recorded during the dry season. Marked diurnal variations are also exhibited, with peak wind speeds typically occurring at noon, and the lowest speeds during the night time (GORTT 2013).

Variations in the two climatic seasons between the islands of Trinidad and Tobago are primarily as a result of difference in land size, orography, elevation, orientation in terms of the trade winds and geographical location. Within the wet season is the hurricane season which runs from June to November, peaking between August and October. Trinidad's geographical location puts it on the southern periphery of the North Atlantic hurricane basin. As such, Trinidad is not affected directly by storms as frequent as Tobago; however, peripheral weather associated with the passage of tropical storm systems impacts Trinidad and Tobago similarly.

5.1.1.1 Winds Southwestern Tobago

Winds across Trinidad and Tobago are typically dominated by tropical Easterlies. Trinidad and Tobago is located within the north-east Trade-wind belt so the surface flow will have dominant wind directions being generally east southeast to east northeast. Meteorological Data collected from the A.N.R. Airport at crown point for the period 2011 to 2019 indicated that the wind direction at the southwestern end of Tobago and within the project study area was mostly easterly. The lack of northeastern data in this region is likely attributed to the location of the airport in the southwestern tip of Tobago and the elevated topography across the central and northeastern parts of the island (Main Ridge mountains). Elevation is generally below 20 metres across extremely flat parts of southwestern Tobago while elevation rises just west and northwest in the Scarborough area to 100 metres. This rise in topography increases northeast wards in the area of the Main Ridge to a height of 560 metres. Between 2011 and 2019 the recorded wind speed at Crown Point was 14.48 Kmph, the maximum wind speed was 72.27 Kmph and the minimum was 0 Kmph.

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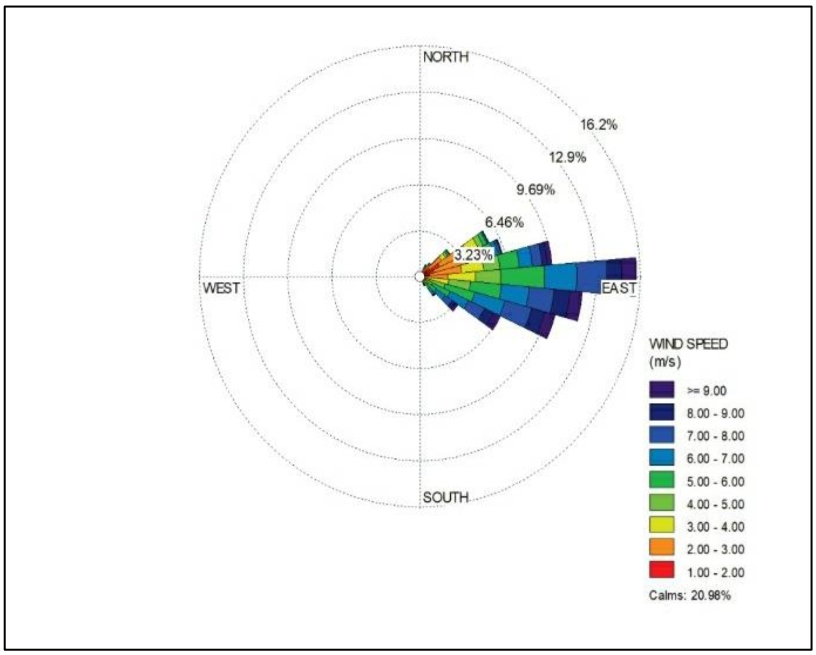


Figure 28 - 5.2: Wind Directions Observed at the Southwestern End of Tobago.
Source: Trinidad and Tobago Meteorological Office, 2018; A.N.R International Airport (TTPC) 2019.

5.1.1.2 Temperature Variations Southwestern Tobago

Baseline data from the Meteorological Office Crown Point measured daily from 2010 to 2018 ranged from 19.5°C to 33.9°C. During this period the average minimum was 24.4 and the average maximum was 30.9°C. There is no significant temperature change that occurs in the Twin islands the annual mean is approximately 27°C and there is a notable diurnal flux as cooler temperatures occur at night and warmer temperatures occur during the day.

5.1.1.3 Precipitation Southwestern Tobago

Precipitation in Tobago has two distinct Seasons; Dry from January to May and Wet which spans June to December. According to the Meteorological Office of Trinidad and Tobago the 2022 Wet Season began in the month of May. The Wet Season has bimodal characteristics with peaks in rainfall occurring in June and late November. Trinidad's primary rainfall mode occurs in June while Tobago's primary mode occurs in November. There is a brief dry spell locally referred to as the "petit careme" which occurs during the months of September and October. Different studies and research have provided statics on rainfall in Trinidad and Tobago and the findings are consistent.

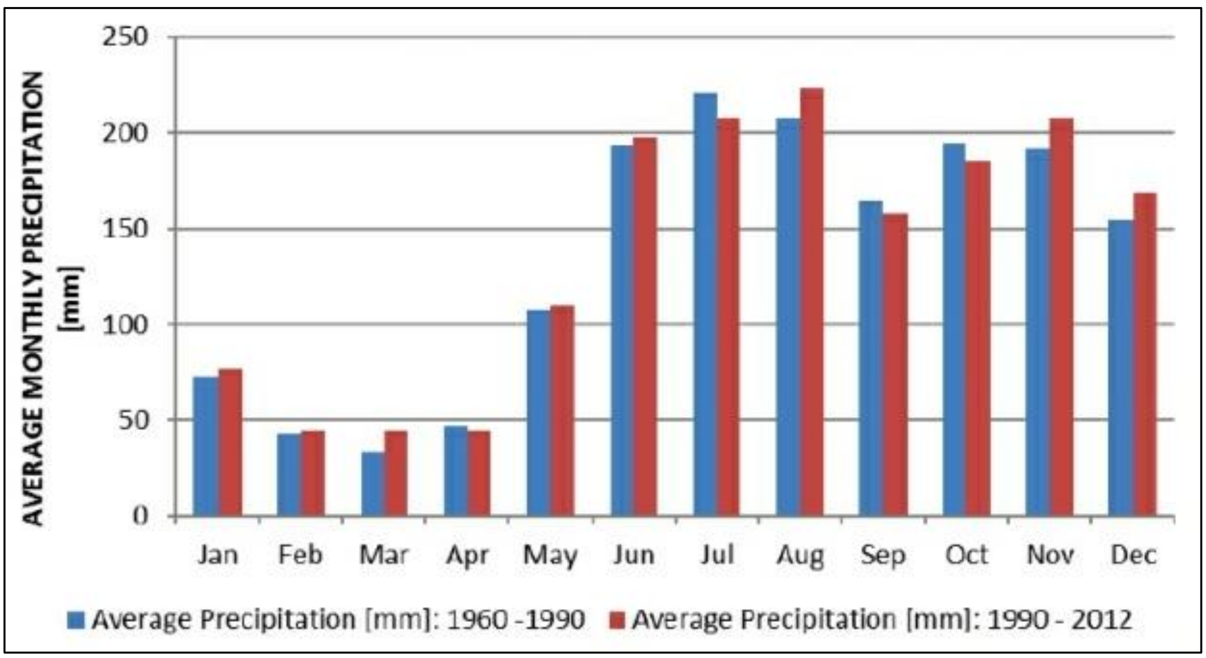


Figure 29 - 5.3: Mean Monthly Rainfall for Trinidad and Tobago for Two Periods 1960-1990 and 1990-2012.
Source: Particip GmbhH, 2019.

The Meteorological Office has published the distribution map below for annual precipitation rates on both islands. Annually and seasonally, Trinidad is wetter than Tobago. According to the ODPM 2014 and Particip GmbhH, 2019, the average annual rainfall in lowlands and Central areas of Tobago are 1,250 and 3800 mm respectively. Orographic rainfall continues the to the greatest amount of rain fall occurring over the main ridge in Central Tobago (ODPM 2014).

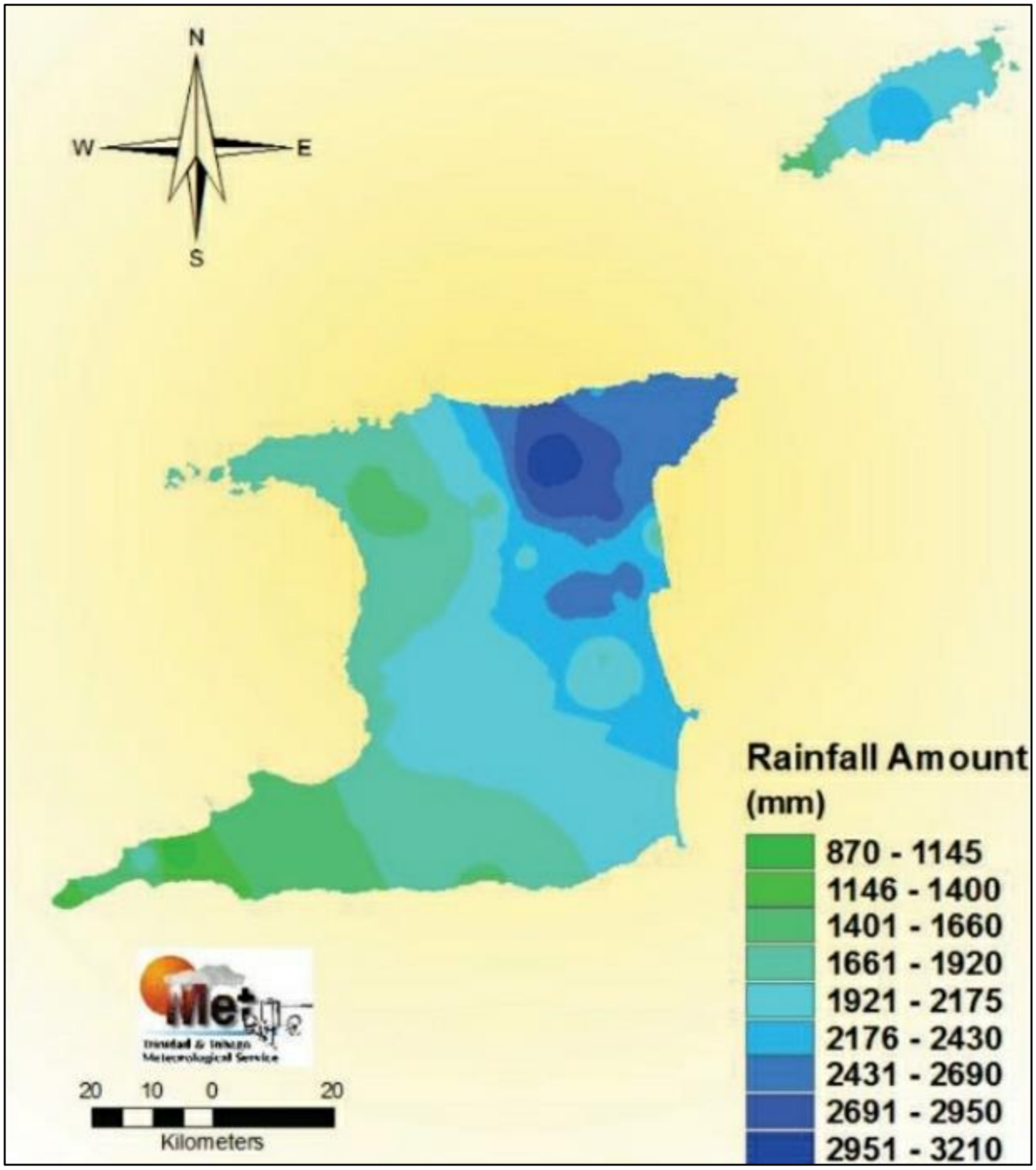


Figure 30 - 5.4: Mean Annual Rainfall of Trinidad and Tobago 2001-2010.

The seasonality of rainfall in Trinidad and Tobago directly influences the ecology and distribution of different habitats found on the two islands particularly swamps, marsh and lentic habitats which are significantly influenced and dependent on water availability. The main weather features that drive precipitation on the islands of Trinidad and Tobago include:

- Latitudinal position and the strength of the North Atlantic Sub-Tropical High-pressure cell (NASH)
- Meridional shift of the Inter-Tropical Convergence Zone (ITCZ)
- Westward propagating Tropical waves and cyclones (depressions, storms and hurricanes)
- Mid Atlantic Upper-level trough system
- Localized sea breezes effects
- Cloud clusters driven by large-scale low-level convergence
- Topography/Orography

The main drivers of the wet and dry season are the NASH and ITCZ. Generally, during the dry season the NASH pressure cell center migrates more southerly than during the wet season and expands equator-ward resulting in generally subsiding air, low level moisture evacuation and strong trade winds over Trinidad and Tobago, which result in a drier state of the atmosphere. Usually during May, the slow but sure shifting of the NASH pole-ward with winds on its southern flank converging more, allows rain bearing systems such as the ITCZ and Tropical waves to penetrate northward and eastward; resulting in the transition to and eventual onset of the wet season regime (Meteorological Office 2009-2022).

Most of the features which account for the variability of temperature and rainfall in Trinidad and Tobago originate in the tropics, but global features also impact the climatic variability. The El Niño-Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO) are two of the major drivers of climate variability in Trinidad and Tobago. It has also been shown that the interaction of the Madden-Julian Oscillation (MJO), the Saharan Air layer (SAL), tracks taken by tropical storms, migratory behaviour of the ITCZ and behaviour of the NASH also combine to influence local climatic changes (Meteorological Office 2009-2022).

Studies have shown that the El Nino phase of the ENSO modifies the annual cycle of rainfall over the Caribbean greatest, with varying results for different areas. The relationship between El Nino and the rainfall cycle starts with a drying trend during the latter half of the wet season which continues into the dry season and ends with a strong wet signal during the earliest period of the new wet season; this relationship was observed in Trinidad and Tobago during the 2009-2010 episode of the most recent El Nino event. With regards to La Nina, it has been found that the Southern Caribbean including Trinidad and Tobago exhibits wetter than normal late wet season and dry season; while the early wet season at the end of a La Nina event is drier than normal (Meteorological Office 2009-2022).

5.1.1.4 Overall Climate Trends Expected to Affect the Project Area (Kilgwyn Bay)

Several studies have found recent changes in the climate in Trinidad and Tobago, especially with respect to temperature trends (Meteorological Office 2009-2022). Temperatures in Trinidad and Tobago have been found to have increased steadily from 1946 to 1995. More recently, it has been shown that over the last three decades there has been an upward trend in temperatures that is statistically significant and which has been induced by a steady increase in daily minimum temperatures; this latter finding suggests that nights have become warmer. Other studies are also consistent with the warmer temperatures. Mc Sweeney et. al. 2010, using a Global Climate Model (GCM) found significant increases in the mean annual temperature in Trinidad and Tobago with an increase around 0.6 ^{o}C since 1960; an average of 0.13 ^{o}C per decade. The Trinidad and Tobago Meteorological Service (TTMS) also found that at Trinidad's, as well as, at Tobago's reference climatological stations, the annual mean air temperature has also warmed over the period 1981-2010 by 0.8 and 0.5 ^{o}C relative to 1961-1990 and 1971-1990, for Trinidad and Tobago respectively. The observed anomalous warming of 0.27 C per decade at the station in Trinidad and 0.17 ^{o}C per decade in Tobago are consistent with the IPCC (2007) observed 0.2 ^{o}C per decade in the Caribbean region.

Rainfall in Trinidad and Tobago has not shown as distinct a change as has been observed with temperatures. It appears that changes in rainfall differ across various parts of the country and over different time periods. During the 1960's to 80's it has been shown that Trinidad and Tobago annual rainfall totals increased, but subsequently decreased onward to the 1990's.

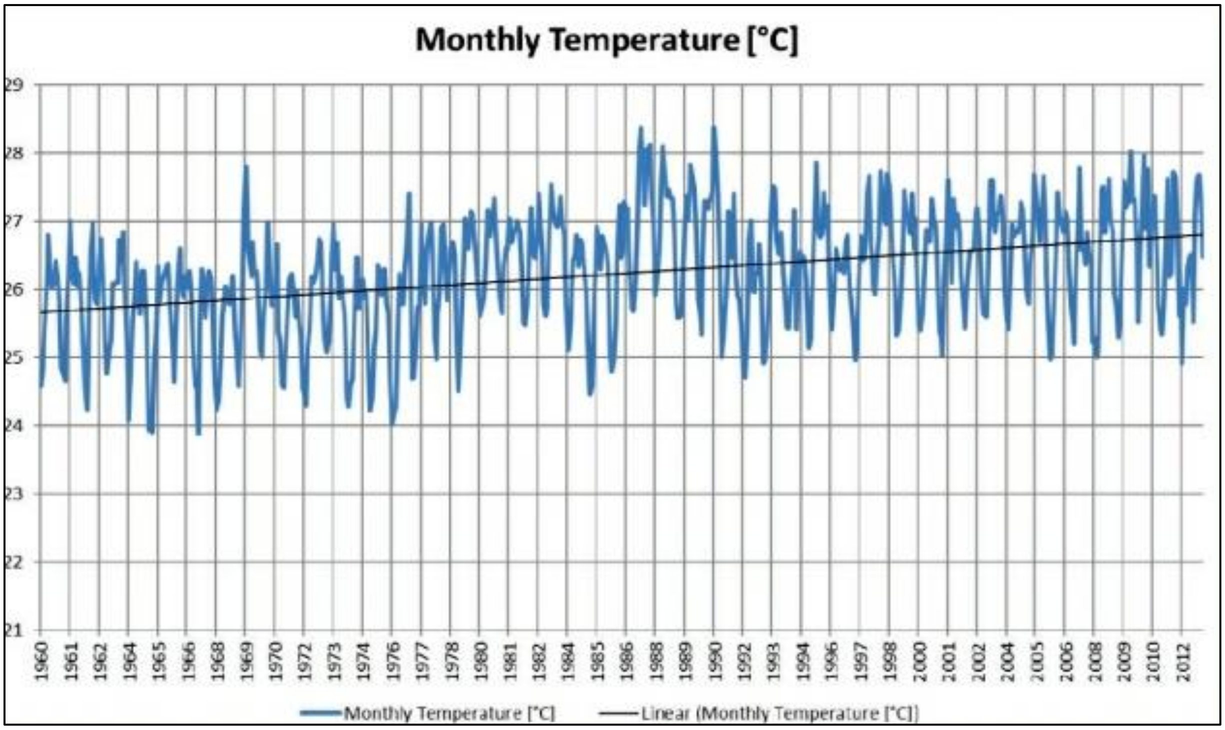


Figure 31 - 5.5: Historical Monthly Temperatures for Trinidad and Tobago for the Period 1960 -2012, With Regression Line.

More recently, rainfall in Penal in South Trinidad has showed a decreasing trend while at Piarco in the north, an increasing trend was observed. The Trinidad and Tobago Meteorological Service (TTMS) also found that there has not been any significant change in the annual mean rainfall totals in Trinidad over the period 1981 to 2010 compared to 1961-1990; however, there were larger changes in the annual mean rainfall totals over the latter period. These changes were driven by slight increases in the frequency of extreme dry and wet years, as well as, increases and decreases in extreme wet and dry years rainfall totals respectively.

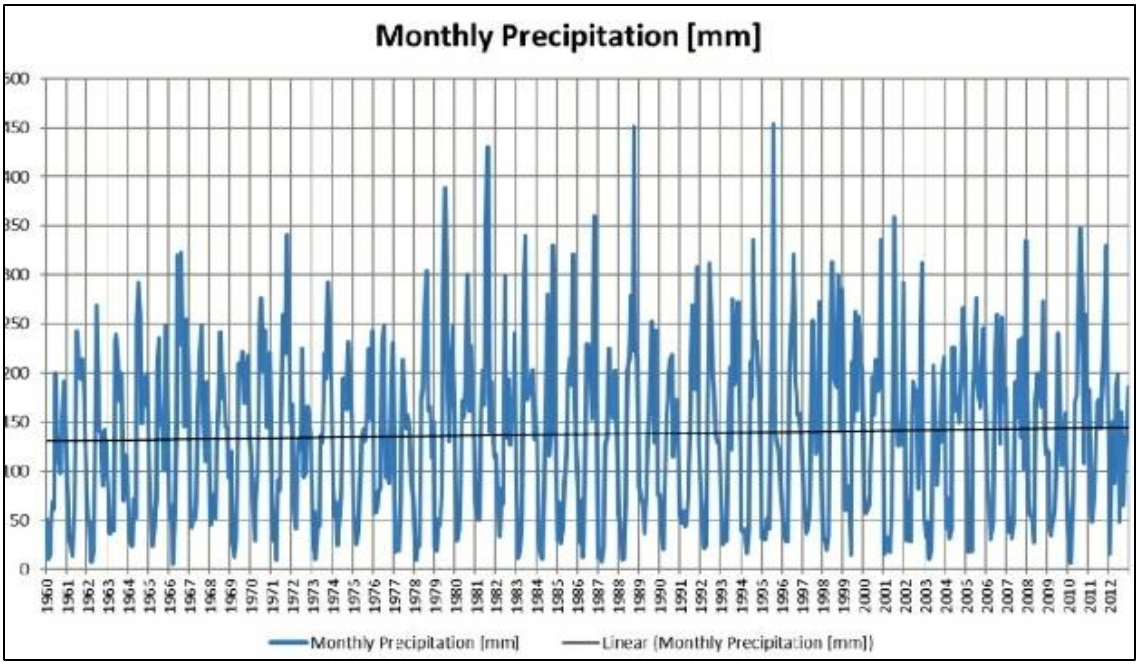


Figure 32 - 5.6: Historical Monthly Rainfall for Trinidad and Tobago for the Period 1960 -2012, With Regression Line.
Source: Particip GmbhH, 2019.

In Tobago however, the rainfall pattern has shown a different behaviour; Tobago's annual mean rainfall has decline by 36.4 mm per decade during the 1981-2010 period compared to the long-term average of the 1969 to 1990 period, this was driven primarily by a decrease in the number of years with near normal rainfall.

5.1.2 Topography

This section describes the terrestrial elevation from profiles and digital elevation model (DEM) data.

5.1.2.1 Method

A topographic survey of the mangrove and secondary forest area was conducted via theodolite survey. A GPS RTK GNSS Receiver was used to collect data of the ground elevation of sections of the bay. The data was limited to only areas where there was a clearing in the mangrove forest.

5.1.2.2 Results

Differential levelling surveys were conducted on the upper terrace and beach (**Figure 34 - 5.8**) using an automatic level (Leica NA730). At the upper terrace (northern end of L2), there is a steep slope of 56º (slope angle of 29°) spanning across a horizontal distance of 6 m towards the dirt road (**Figure 34 - 5.8**). There is a 36º slope (slope angle of 30 °) from the dirt road towards the mangrove (northern end of L1). At 6 m from the dirt road in a southern direction, there is a gentle slope (an average of 12º) towards the mangrove (Figure 9 and Table 3). Along the western end of the property, there is an average slope of 4º from the upper terrace to the start of the mangrove (L7) (**Figure 34 - 5.8**).

The total catchment area was delineated using the 1:5000 topographic map for the area and was found to be approximately 0.31km². The terrain of the site is generally undulating from the shoreline towards the Kilgwyn Bay Beach access road after which it rises with slopes varying between 10º - 18º towards the Kilgwyn Bay Extension Road. The Topography then plateaus towards Milford Road. Integrating planned hotel master designs with the landscape; approximate developed area (buildings, facilities, paved areas, pools) within this site was estimated to be 0.11km² or 35% of the total catchment area.

Figure 33 - 5.7: GPS Transect Line Mapping with over 600 GPS Points over the Kilgwyn Bay Property, SW Tobago.

The beach is a dynamic environment, very fine sediment can only accumulate under fairly calm hydrodynamic conditions, building fairly mild (1:1000 – 1:1500) and wide slopes with its deposits. Because of these mild and wide slopes, the tidal motion is largely perpendicular to the coastline and tidal velocities are low. Wind waves and swell are damped over the soft muddy bed, and refract towards the coastline. Coastal waters become fresher during the wet season from run-off and from

the tributaries around. Thus, a cross-shore salinity gradient is induced. These gradient drives a cross-shore gravitational circulation with an undertow towards the coast bringing sediments onshore together with the tidal motion. As a result, wave-induced long-shore sediment transport occurs, though generally low still allows the development of a distinctive 1m berm parallel to shoreline.

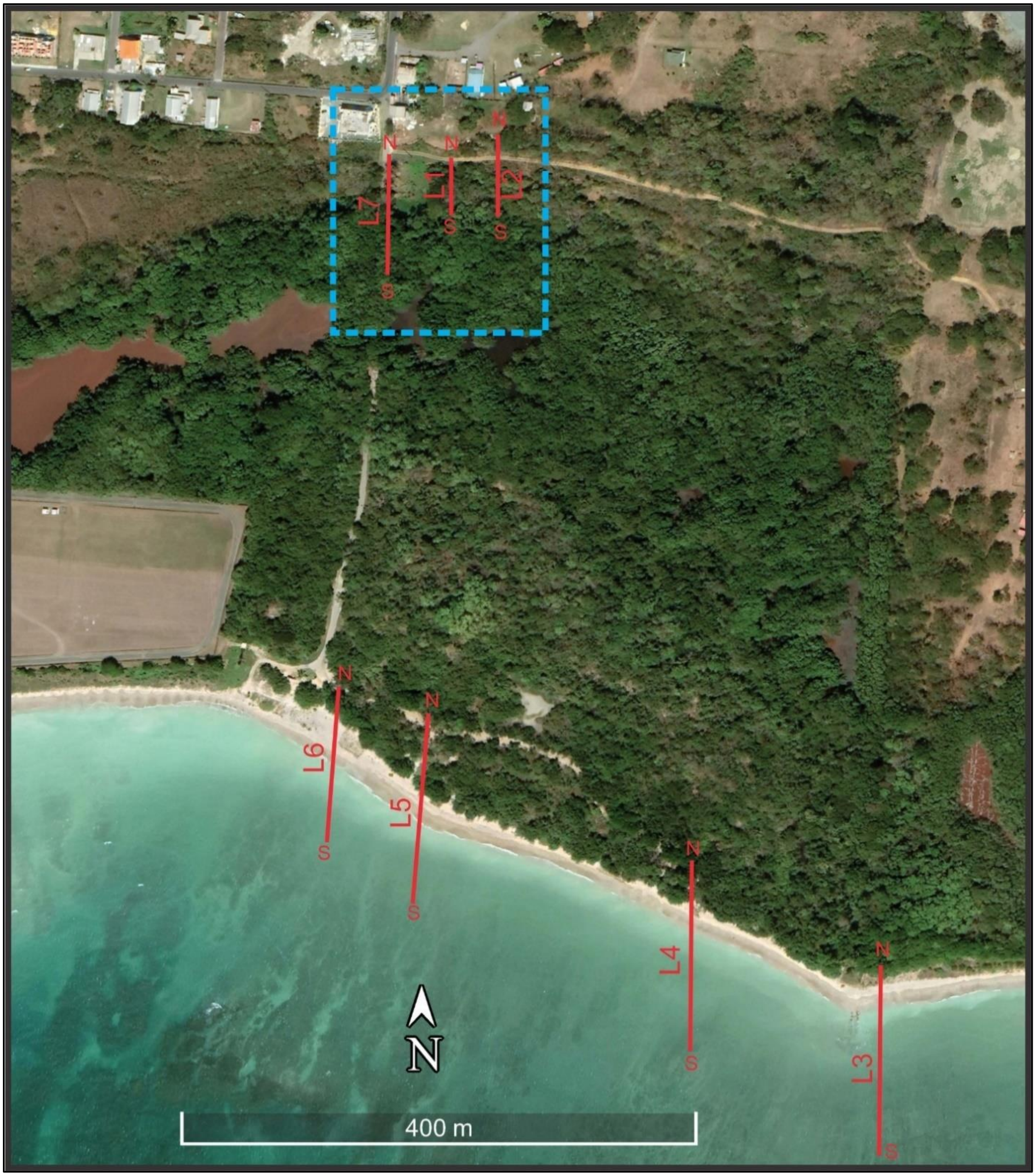


Figure 34 - 5.8: Map Showing Location of Differential Levelling Surveys.
N.B. The Upper Terrace surveys (L1, L2, and L7) are highlighted in the blue dashed rectangle box. L3-L6 are coastline surveys.

Figure 35 - 5.9: Google Earth Image integrated with Mapped Topography.

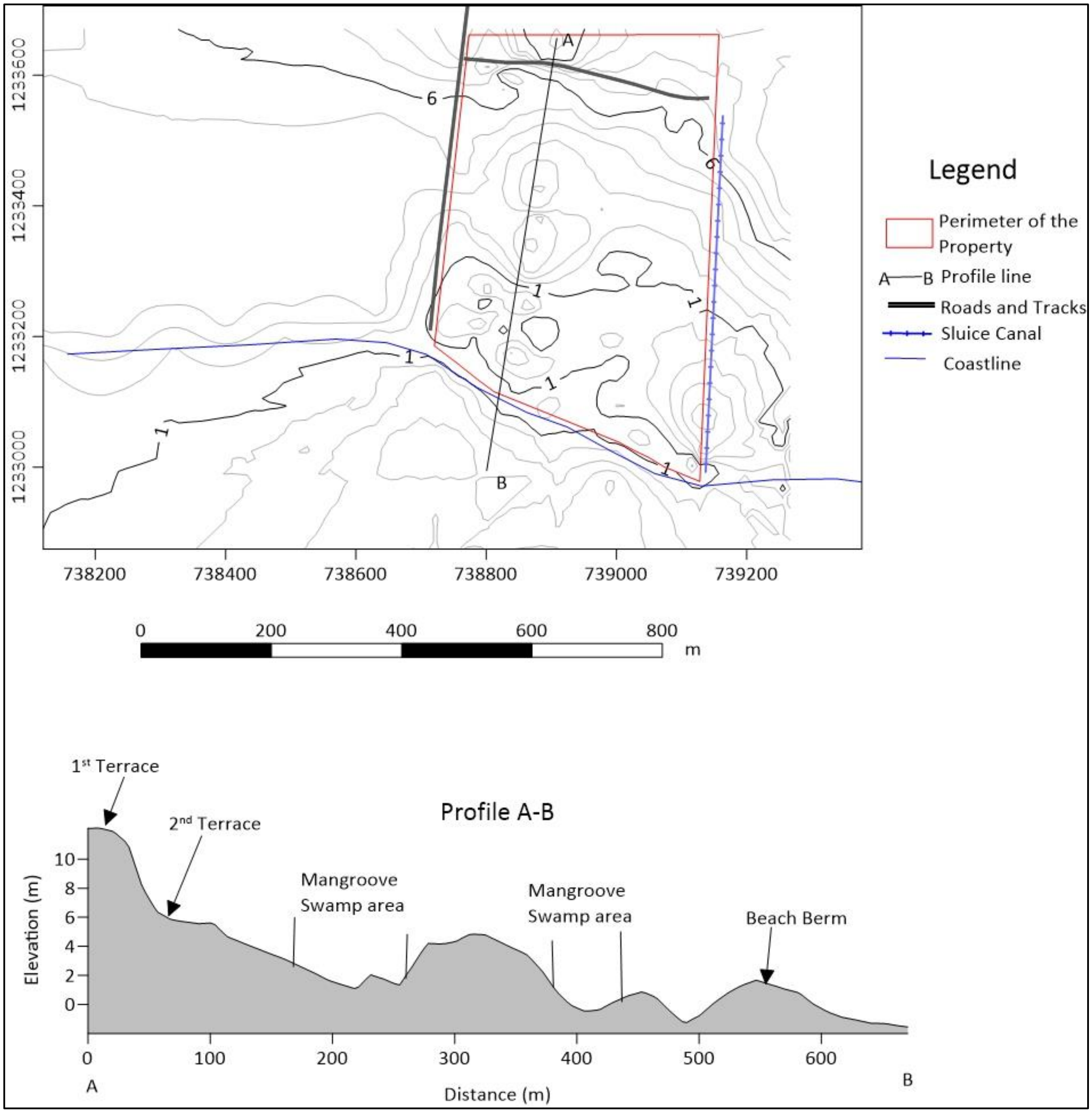


Figure 36 - 5.10: Generated Topographic Map and N-S Cross-section across the Kilgwyn Bay Proposed Hotel Development Property.

5.1.3 Geomorphology

Tobago is the second most southerly island of the Lesser Antilles. Tobago is 30 km (19 mi) northeast of Trinidad and is 41 km (25.5 mi) in length and 12 km (7.5 mi) at its greatest width. It is mountainous and dominated by the Main Ridge, which is 29 km (18 mi) long with elevations up to 640 m. There are deep valleys to the north and south of the Ridge.

The landscape at Kilgwyn Bay proposed hotel development site is located southwest of the Main Ridge and consists a terraced sloping landscape from the immediate Tyson Hall upper watershed toward the Kilgwyn Bay coastline. The landscape is occupied by mangroves, secondary forests and savannah grass lands, bordered on the seaward side by a low narrow coastal beach and on the landward side by an incised erosional plateau which rises gradually over a distance of 200m to a height of approximately 20 to 30 m above MSL.

The soils, colluvium and redistributed beach sediment of the Kilgwyn Bay area rests on the southwestern tip of the island's coral platform.

The coastal ridge/berm to the south within the property boundaries consists of coral rubble and calcareous sands. It has an average height of 0.75m and an average width of 20m. The berm reaches a maximum height of 1.5 m and a maximum width of 30m in the south-western half of the beach front and ends in the east towards Cove and Canoe Bay (**Figures 36 - 5.10** and **37 - 5.11**).

The beach is very shallow. It is about 1 to 1.4 metres deep and has a maximum depth of approximately 2m beyond the backreef areas. Analysis of 1m resolution satellite imagery by the IMA (1990's to 2001) compared with 2022 orthomosiacs imagery collected with a drone indicates that the coastline of the coastline has significantly been eroding. The southern edge of the cove toward Crown Point appears to have receded between 5 to 10m. Coastal erosion, to a lesser extent, is also taking place on the opposite side near Canoe Bay close to the eastern corner of the property.

The mangrove area behind the coastal berm is roughly at sea level. The mangrove canopy is closed and with minimal open water surfaces. Except for filled in access foot paths, secondary forest areas toward the coast and historical sand mining paths, the mangrove area to the north-central section of the site is completely waterlogged but the water in the mangrove appears to be very shallow (<1m-2m). The water depth in the areas that were accessible was in the order of 30 to 60cm.

Within the mangrove area there is one distinct drainage channel; a tidal creek with a visible surface water connection with the eastern sluice canal. A few channels have been cut through the mangroves in an attempt to provide drainage for the morass. One can be seen in the northern section of the property and is linked to a culvert at the northern boundary of the property and another one begins in near the edge of the open area in the southern section of the property and ends outside the property along Kilgwyn Bay Beach Road. None of these channels appear to be effective outside periods of heavy, persistent rainfall.

No continuous flowing streams are discharging into the morass during the dry season. Most of the flow comes from surface runoff during the wet season of the hinterland immediately above the surrounding road network, with flows either toward the northern swamp or to the low-lying areas along the Kilgwyn Bay Beach Road which discharges into western sluice canal long the boundary of the airport runway and western mangrove swamp. The boundary of that small drainage basin is shown in **Figure 38 - 5.12**.

Considering that there are no obvious channels or streams connecting the mangrove area to the sea at the time of this EIA study, it is expected that much of the runoff discharges as submarine seepage or offshore springs into the sea. A significant amount of the water is probably also released to the atmosphere through evapotranspiration processes in the wetland.

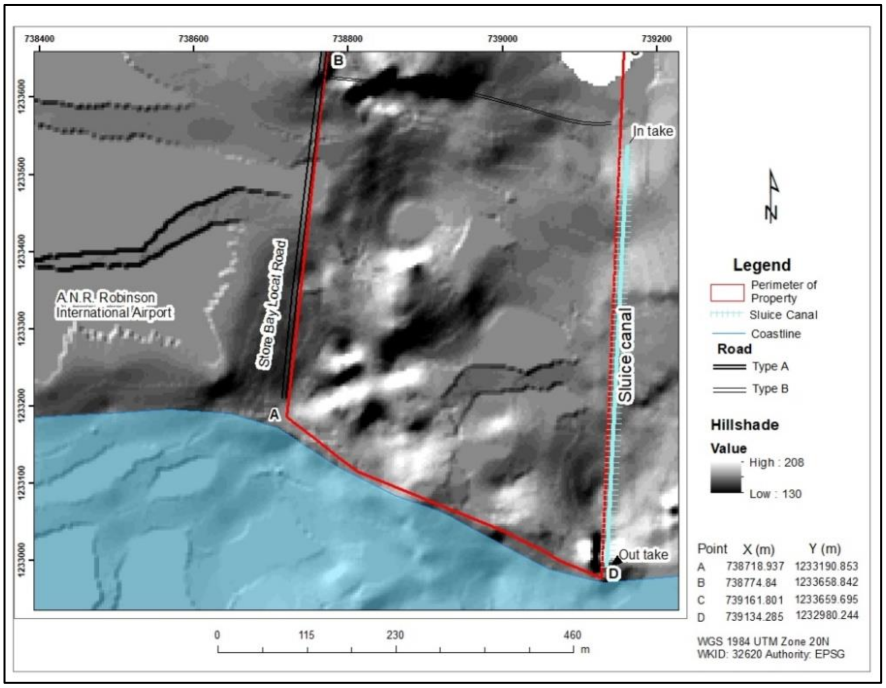


Figure 37 - 5.11: Digital Elevation Model (DEM).

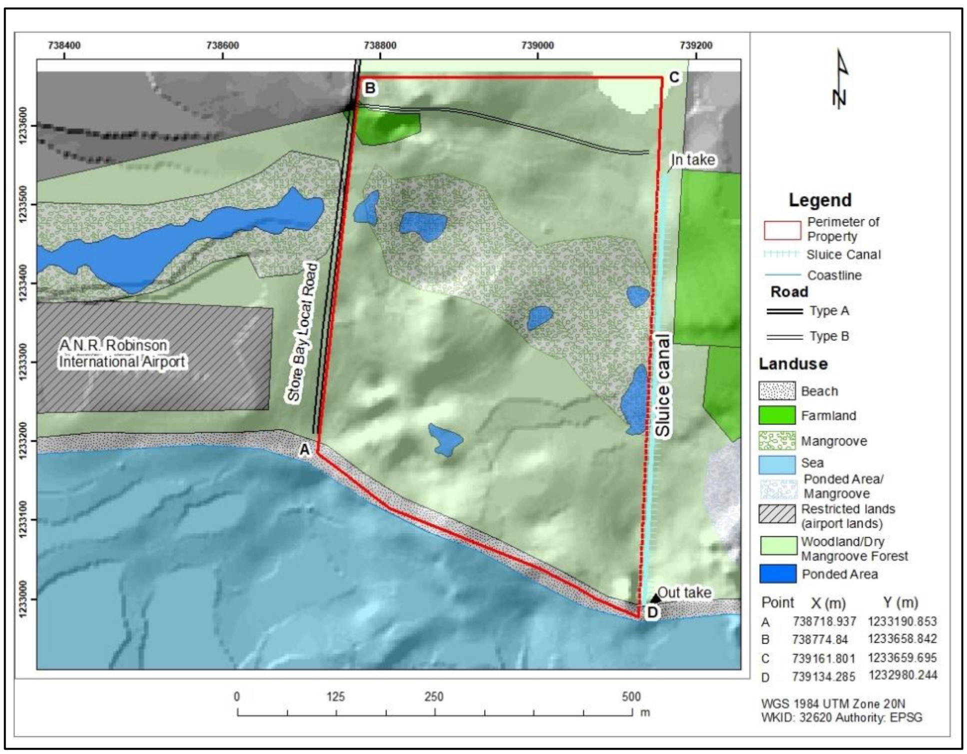


Figure 38 - 5.12: Land Use Spatial Analysis Integrated with DEM across the Property and Surrounding Areas, Kilgwyn Bay, Tobago.

5.1.4 Soils

The soils map in **Figure 39 - 5.13** is adapted from Ahmad, N.; Breckner, E. (1974).

5.1.4.1 Soils Classification

The soils retrieved from the site were in non-conformance to the classification and the lithology soils map data that exists in literature. The top soils were predominantly sandy soils (‘beach sand’) down to 0.5m and predominantly loamy and clayey soils from 0.5m-5m.
Soils are clayey, smectitic, isohyperthermic Lithic Haplustepts using the United State Department of Agriculture (USDA) Soil Taxonomy and the World Reference Base classification systems.

5.1.4.1 Soil Expansivity

According to the Soil Expansivity Index of USDA soil expansivity potential at the site is classified as none-expansive. Nevertheless, Fat Clays retrieved from BH1 and BH3 may have expansive/swelling characteristics. However, it was outside the scope of works for this project to conduct consolidation/swelling tests.
More details on soil characteristics will be discussed in the subsequent section on Bore Hole soil sampling.

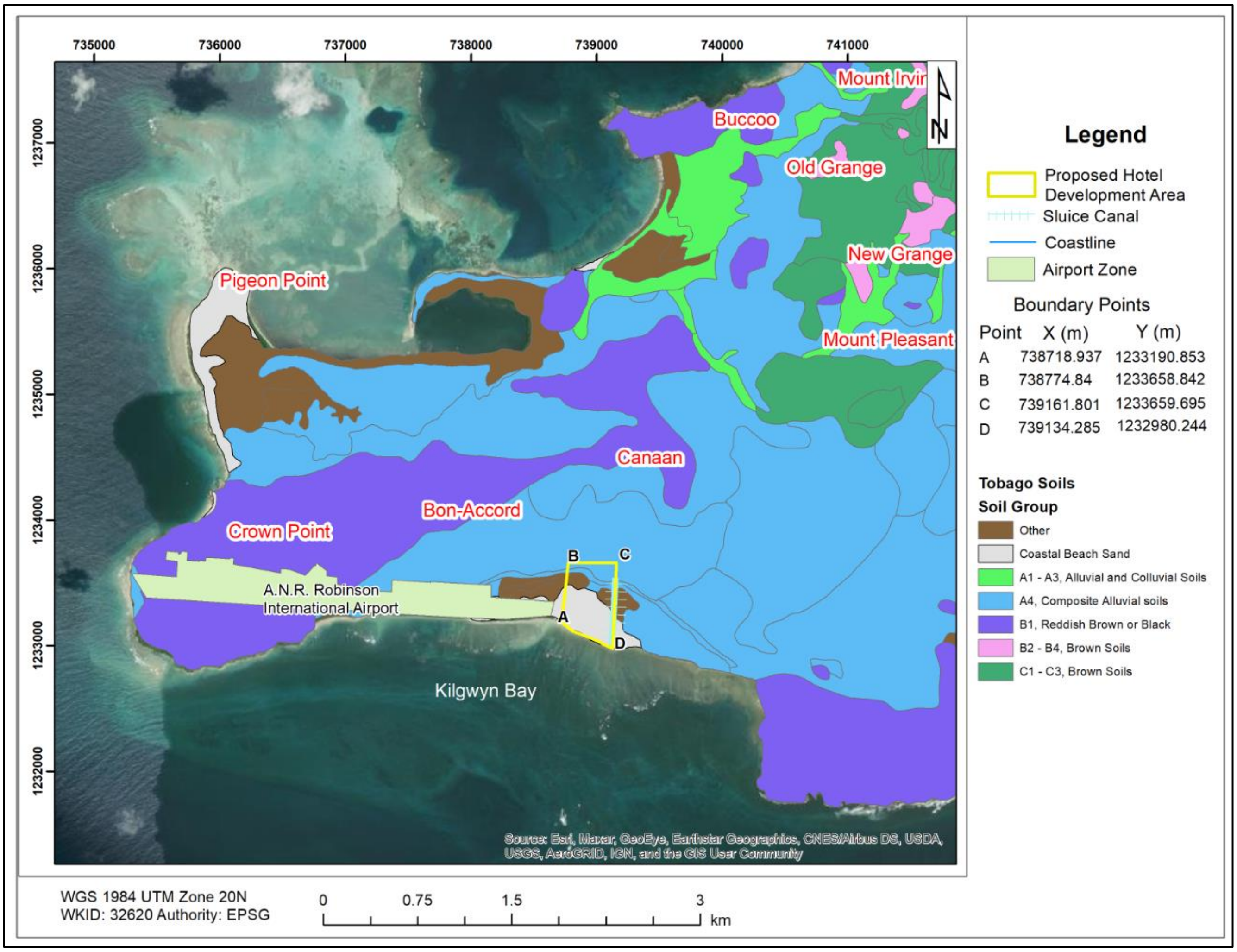


Figure 39 - 5.13: Soils Map.
(Adapted and modified from Ahmad, N.; Breckner, E. (1974).

5.1.5 Geology, Geophysical Surveys & Geotechnical Aspects

5.1.5.1 Geology

Research geologists from Universities (1938-present) and Maxwell (1948) mapped the geology of Tobago and provided the first detailed stratigraphy and tectonic framework. Stoke et al. (2001) revised the earlier version and presented a new geological map of Tobago (**Figure 40 - 5.14; top**). Subsequent to the latter Snoke in 2018 further revised the lithostratigraphy for the island and updated the geologic map (**Figure 40 - 5.14; bottom**).

Tobago is located in the tectonically active SE margin of the Caribbean Plate and is the eastern extension of the Caribbean Mountain System of northern South America. Geological succession of this island is broadly divided into three provinces: Cretaceous metavolcanics province in the northeast; un-metamorphosed Cretaceous volcanic and plutonic rocks in the center of the island; and a thin veneer of Plio-Pleistocene sedimentary sequence of terrigenous and carbonate rocks in the southwest (Donovan and Jackson, 2010). The stratigraphic distribution of these lithological units is shown in the geological map of Tobago (Snoke et al. 2001b; **Figure 40 - 5.14**). The main sedimentary stratigraphic unit is the Rockly Bay Formation. This formation comprises of well-bedded but friable sandstones and sandy mudrocks of Early to Early Middle Pliocene age based on foraminiferal evidence. The Pleistocene coralline limestone is a raised reef of the probable last interglacial age (Oxygen isotope age) outcrop that is in much of the southwestern part of the island (Donovan and Jackson, 2010).

The Kilgwyn Bay to Crown Point area is underlain by this Pleistocene coralline limestone of the Rockly Bay Formation.

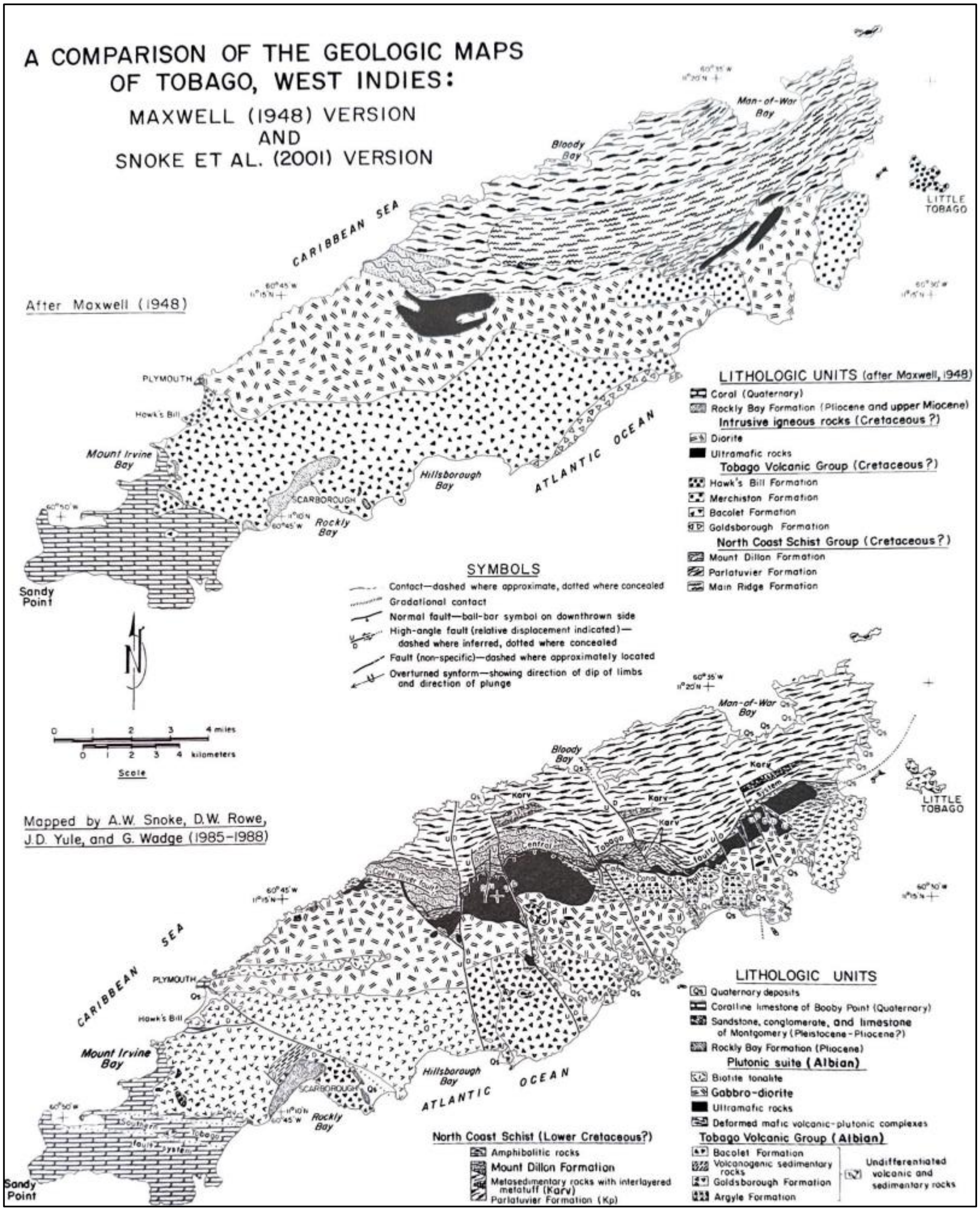


Figure 40 - 5.14: Comparison of Geology of Tobago, West Indies, from (top) Maxwell (1984) and (bottom) Snoke et al. (2001).

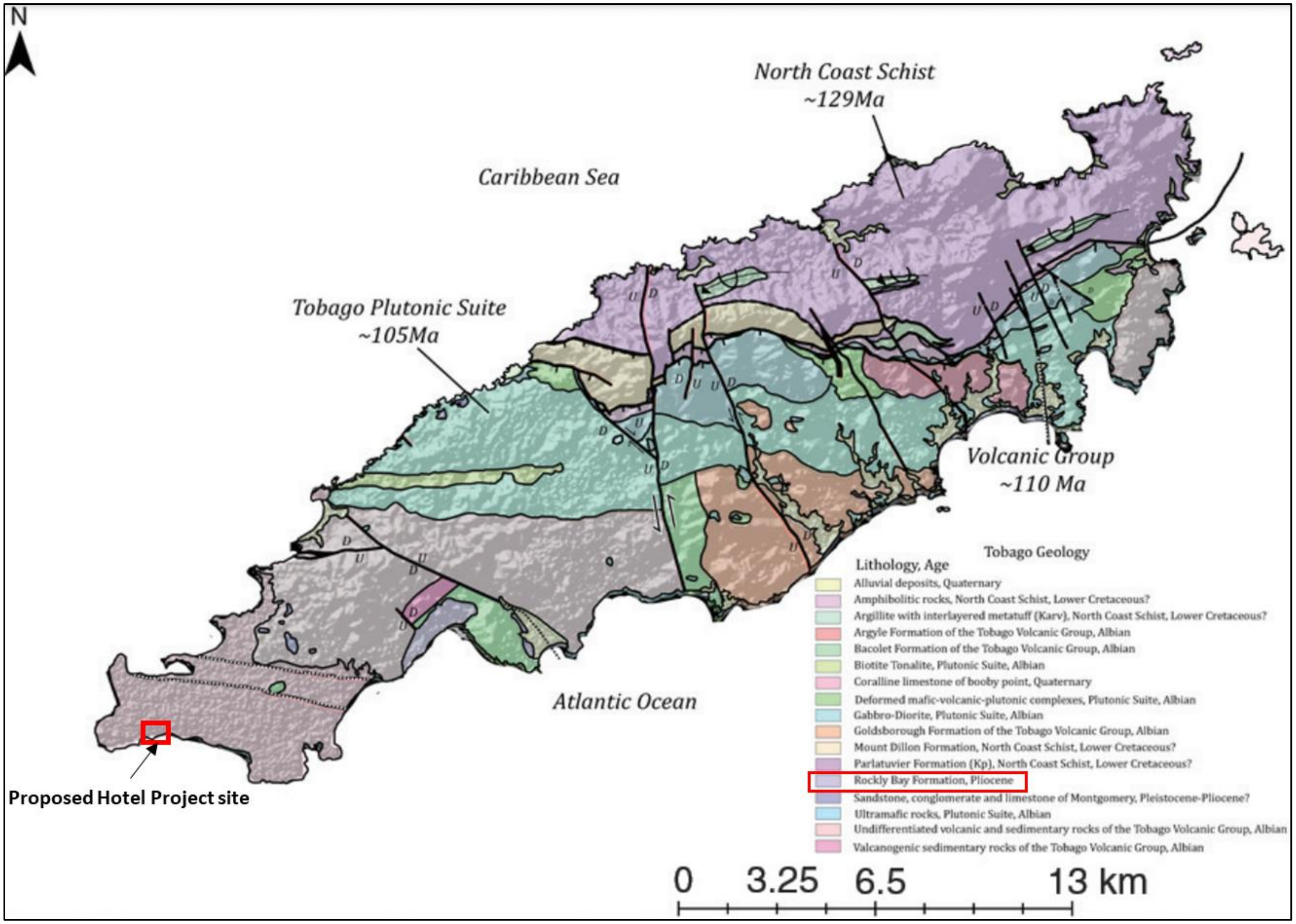


Figure 41 - 5.15: Geologic Map of Tobago Modified to Include Study Area Location (red polygon), from Snoke et al. (2001); Gomez et al. (2018).

5.1.5.2 Geophysical Surveys

Resistivity survey

A resistivity survey was employed to map a detailed tomography of the subsurface at four locations (R1, R2, R3, and R4) within the property (**Figure 42 - 5.16**).

Figure 42 - 5.16: Positions of the Resistivity Survey Lines. across the Property, Kilgwyn Bay, Tobago.

Resistivity Survey - Methodology

A single channel resistivity meter (Supersting R1IP from Advanced Geoscience Inc.) with passive multi-electrode cables and Switch Box system was used to acquire the resistivity data. A dipole-dipole electrode configuration array was utilized in the survey. The dipole-dipole provides excellent horizontal and vertical resolution, and penetrates a depth of approximately 40 m. Electrodes were placed at 3 m apart and a maximum of 56 electrodes were used. The total surface distance for the survey lines was 165 m. A handheld GPS (GPS map 64 from Garmin) was used to record the x, y, z positions of each electrode.

The measured apparent resistivity pseudosection (i.e. the acquired data) was processed using forward modeling to predict the apparent resistivity pseudosection (see top and middle images of **Figure 43 - 5.17**). The data was then inverted to give resistivity variations with depth (see bottom image in **Figure 43 - 5.17**). Statistical measures of l2-norm were used to monitor the inversion progress and convergence. The industry considered L2-norm less than 1 as acceptable measures for dipole-dipole array. If the statistical measures are outside the acceptable criteria, the inversion process is iterated until the criterion is met. If the inversion has not met the criterion after 8 iterations, then noisy data are carefully removed and the inversion process is repeated. This process is carefully repeated until the final inversion meets the criterion. Terrain corrections were not applied to the 2D electrical resistivity tomography as the elevations of each electrode was constant (flat surface).

Resistivity Survey - Results and Interpretation

Interpretations were made on the resistivity tomography using typical electrical resistivity values for rocks and fluid content (**Figure 44 - 5.18**), correlation between core description from the 1.5m boreholes (BH1, BH2, BH3, and BH4), and geological knowledge of the area. The upper terrace (resistivity line R1) is dominated by loamy soil which is highly saturated in the first approximately 10 m depth (**Figure 45 - 5.19**). The resistivity tomography of the middle and lower terraces (resistivity lines R2, R3, and R4) show that brine saturated sand with a thickness of approximately 10 m sits on top of loamy soil (**Figures 46 - 5.20, 47 - 5.21**, and

48 - 5.22). There is a lateral through flow of brine (sea water) within the sand layer, owing to the high permeability of the sand compared to the loamy soil.

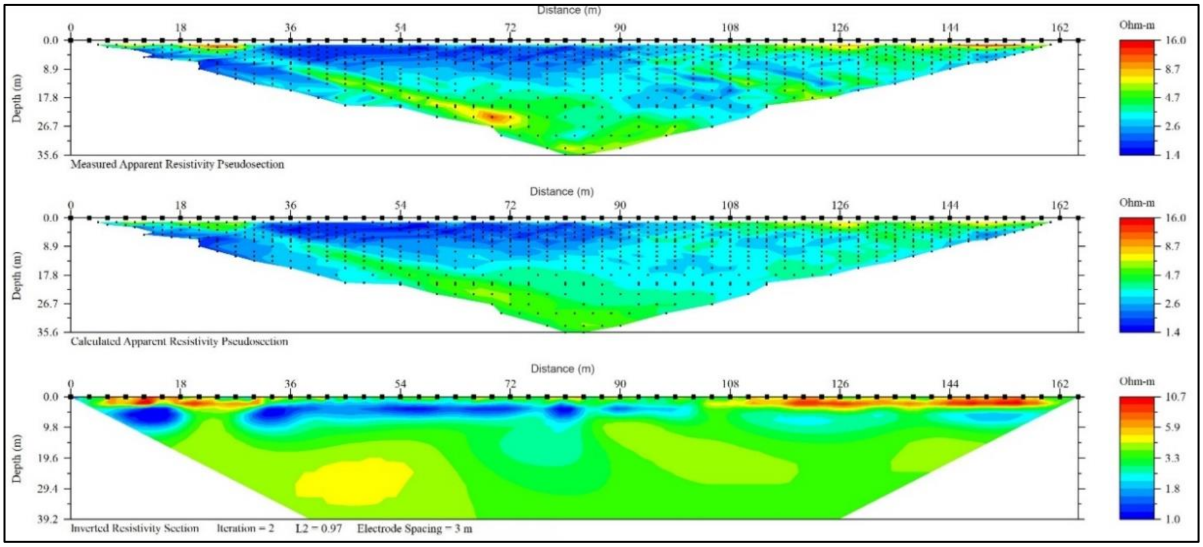


Figure 43 - 5.17: Measured Apparent Pseudosection (top), Calculated Pseudosection (middle), and Inverted Section (bottom), of Line R1 using the Dipole-dipole Array.

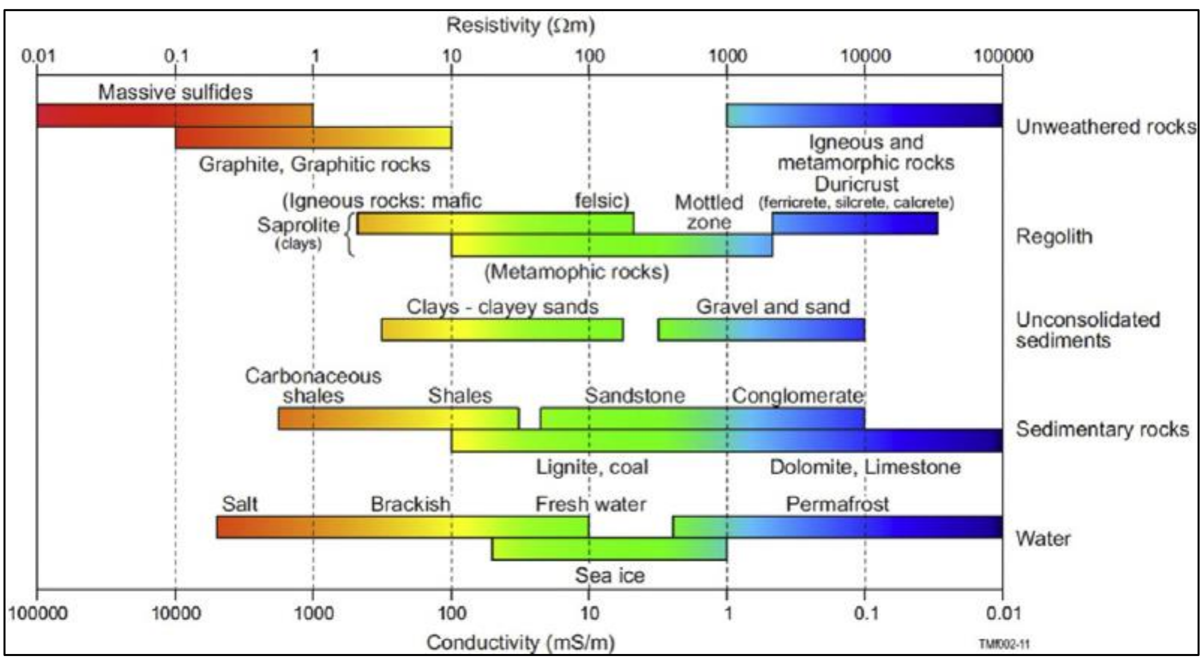


Figure 44 - 5.18: Index Electrical Resistivity and Conductivity Values of Various Rocks and Fluid Content.

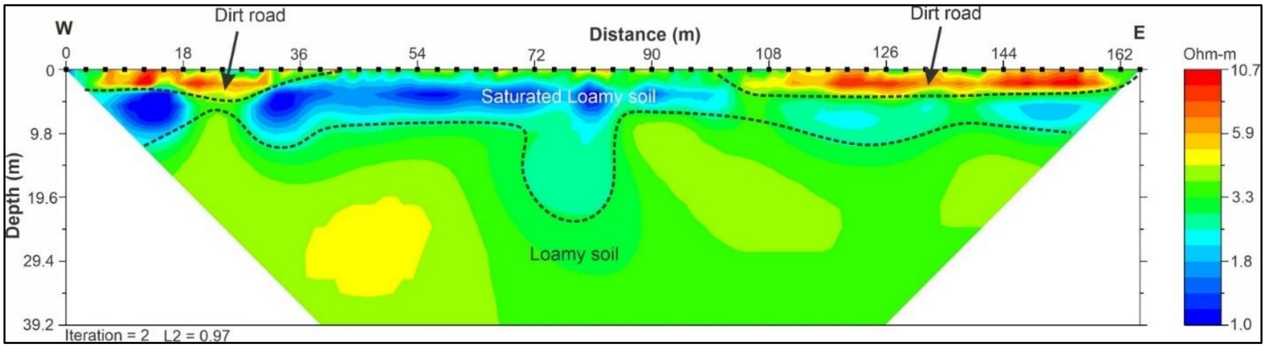


Figure 45 - 5.19: Inverted Resistivity Section of Resistivity Survey Line R1.

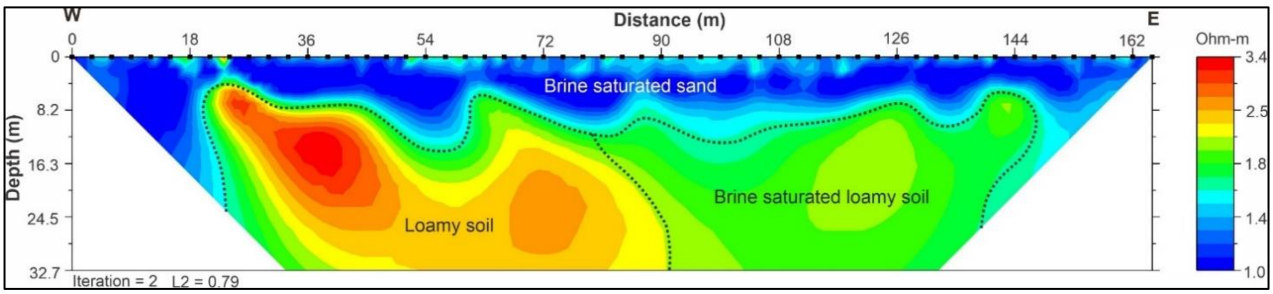


Figure 46 - 5.20: Inverted Resistivity Section of Resistivity Survey Line R2.

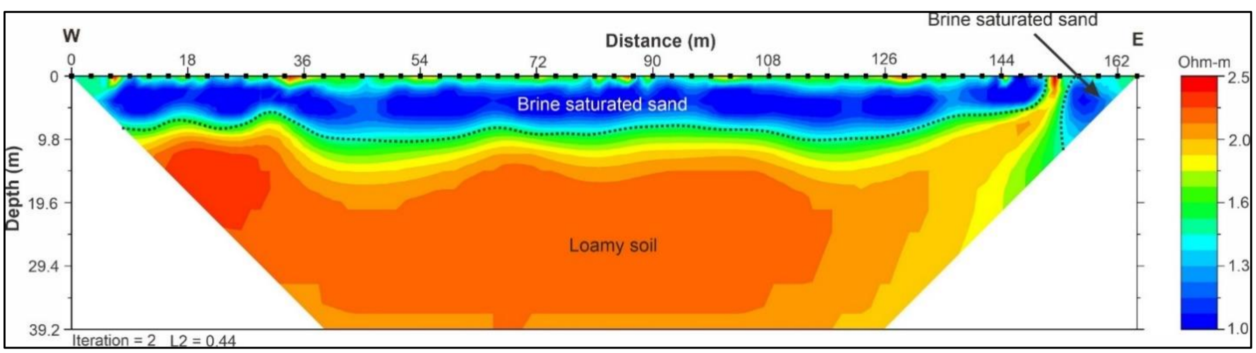


Figure 47 - 5.21: Inverted Resistivity Section of Resistivity Survey Line R3.

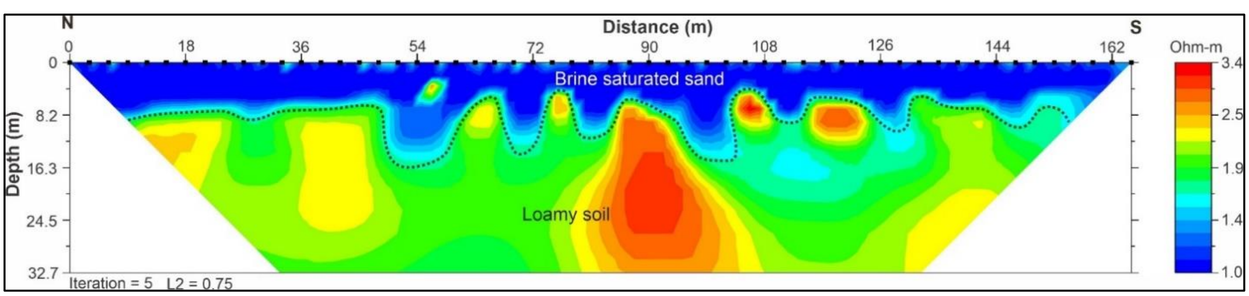


Figure 48 - 5.22: Inverted Resistivity Section of Resistivity Survey Line R4.

5.1.5.3 Shallow Borehole Survey-Field Investigation/Drilling

Four boreholes were drilled using the dry auger boring technique with a portable motorized auger and a standard 8inch drill bit. Drilling and sampling were carried out in accordance with the ASTM D 1586 and ASTM D 1587.

The four (4) boreholes were drilled to a depth of 1.5m. The required depth and location of the boreholes were guided by the results of the Soil Resistivity Surveys. The particulars (coordinates, depth and water level) of these boreholes are presented in **Table 5-1**. A site plan showing the location of the boreholes is presented in **Figure 49 - 5.23**. All data acquired in feet, a function of tools being calibrated accordingly in imperial system, were converted to metric-meters within the report for consistency.

Figure 49 - 5.23: Shallow Auger Borehole Localities (Blue dots - BH1 to BH4) and Borehole Drilling Locations (Red dots - BHKB-1 to BHKB-3).

Sampling

For all boreholes, samples were retrieved at 0.5m and 1. The soil between sampling intervals were washed (removed).

A total of six (6) disturbed samples were retrieved. Photographs of the retrieved soil samples are provided in ***Appendix E1 - Geology, Geophysical Surveys and Geotechnical Aspects.***

Each sample label contained information such as job name, sampling date, boring number, location, sample depth and water table data. The disturbed samples were placed and sealed in plastic bag and stored in a cooler. All samples were transported and stored in a cool enclosed environment to minimize moisture loss prior to the commencement of laboratory testing.

Table 13 - 5-1: Location of the Executed Boreholes (BH) and Borehole Soil Samples.

Borehole	GPS Location (WGS84)	Depth (m)	Water Table Depth (m)	Location Description
BH 1	E60.813236 N11.151521	1.5	-	Mid-point along dirt road upper terrace
BH 2	E60.813403 N11.147611	1.5	0.6-1	Mid-point along secondary road parallel to beach
BH 3	E60.813817 N11.149287	1.5	1-1.3	4m into Mangrove midway off the western boundary of the property
BH 4	E60.812706 N11.149445	1.5	0.2-0.8	100m into Mangrove midway off the western boundary of the property heading east

Soils Data-Borehole Characteristics

No detailed field borehole logs were undertaken as per the scope of this project; however, the location of the borehole presents information such as sample type, depth of, sample number, any ground water encountered and soil description. *(Refer to **Appendix E1 - Geology, Geophysical Surveys and Geotechnical Aspects**)*

The general practice of borehole water level measurements in the local industry are recorded at the end of drilling and 24-hours after. It is accepted that during this time, equilibrium water levels would be reinstated (Terzaghi, Peck and Mesri, 1995). The levels are meant to be a guide of the presence of water on the site. OptimalGESL has employed the ASTM standard D 4750 - 87 (Reapproved 2001) "Standard Test Method for Determining Subsurface Liquid Levels in a Borehole" during this project.

BH1

The first layer between 0.0 - 0.8m consisted of a medium stiff, dark brown, moist Loamy Sand with few to little clay. The second layer between 0.8m – 1.5m consisted of very stiff and hard, moist, light grey and light and dark brown LEAN CLAY with some red iron oxide staining. No 'apparent water table level' was encountered upon completion of the boring and after 24-hours after.

BH2

The entire 1.5m sample is classified as Slightly Gravelly SAND with a mean grain size

0.36 mm and median grain size of 0.37 mm. The sample consists of 0.53% Gravel (>2.0 mm), 99.37% Sand (0.0625 - 2.0 mm) and 0.10% Mud (<0.0625 mm). This 'beach sediment' is moderately sorted, Near Symmetrical and Mesokurtic. The 'apparent water table level', measured from the ground surface upon completion of the boring and after 24-hours was 1m and 0.6m respectively.

BH3

The first layer between 0.0 - 1m consisted of a moist, light and dark brown SILTY sand with organics and no clays. Between 1-1.5m sample is classified as Slightly Gravelly SAND with a mean grain size 0.34 mm and median grain size of 0.37 mm. The sample consists of 0.43% Gravel (>2.0 mm), 99.37% Sand (0.0625 - 2.0 mm) and 0.10% Mud (<0.0625 mm). This 'beach sediment' is moderately sorted, Near Symmetrical and Mesokurtic. The 'apparent water table level', measured from the ground surface upon completion of the boring and after 24-hours was 1.3m and 1m respectively.

BH4

The entire 1.5m borehole is classified as Slightly Gravelly SAND with a mean grain size of 0.31 mm and median grain size of 0.31 mm. The sample consists of 0.18% Gravel (>2.0 mm), 99.73% Sand (0.0625 - 2.0 mm) and 0.08% Mud. The 'apparent water table level', measured from the ground surface upon completion of the boring and after 24-hours was 0.8m and 0.2m respectively.

5.1.5.4 Geotechnical Analysis

Field Investigation

Boreholes were advanced using the wash boring technique with a portable Acker Tripod Drill Rig. Drilling and sampling were carried out in accordance with the ASTM D 1586 and ASTM D 1587. These boreholes were executed during the season to take advantage of favourable weather drilling conditions and reduce the risk to drilling in flooded and waterlogged conditions.

The field work consisted of drilling three (3) boreholes (**Table 15 - 5-3**). Borehole 1 was drilled to a depth of 34 ft. Borehole 2 was drilled to a depth of 22 ft. Borehole 3 was drilled to a depth of 34 ft. The particulars (coordinates, depth and water level) of these boreholes are presented in ***Appendix E1.1 - Geology, Geophysical Surveys and Geotechnical Aspects (Boreholes).*** A site plan showing the location of the boreholes is presented in **Figure 49 - 5.23** above. The boreholes were selected based on the location, design and planned hotel building foot print.

5.1.5.4.2 Sampling

For all boreholes (BHKB-1, BHKB-2 and BHKB-3) continuous disturbed soil samples were retrieved within the upper twelve (12) feet in two (2) feet increments. Thereafter, samples were recovered after 3 feet between 15ft - 17ft and at 5 feet increments thereafter for each of the boreholes. The soil between sampling intervals were washed (removed). Both disturbed (split-spoon) and undisturbed (Shelby tube) samples were retrieved. Samples were not recovered at Borehole 2 for SA 2 (2-4 ft) and SA 3(4 - 6 ft).

A total of twenty-seven (27) disturbed samples were retrieved. Photographs of the retrieved soil samples are provided in ***Appendix E1 - Geology, Geophysical Surveys and Geotechnical Aspects.***

Each sample label contained information such as job name, sampling date, boring number, location, sample depth and SPT data. The disturbed samples were placed and sealed in plastic bag and stored in a cooler. All samples were transported and stored in a cool enclosed environment to minimize moisture loss prior to the commencement of laboratory testing.

Standard Penetration Test (SPT)

The standard penetration test (SPT) is an indication of penetration resistance and measures the number of blows required by a 63.5kg (140lb) hammer, dropped freely over a distance of 760mm (30 in), to cause a standard 50.8 mm (2 in) outer diameter split barrel sampler to penetrate 300mm (12 in) into the undisturbed ground. The SPT also allows for the simultaneous collection of disturbed samples. Standard Penetration Test values are not derived for Shelby tube (undisturbed samples). Boreholes were progressed to the required depth or refusal, whichever came first. The SPT for the N_{60} value was corrected for field refusal conditions and are presented in ***Appendix E1.2 - Geology, Geophysical Surveys and Geotechnical Aspects (Field Borehole Logs).***

Laboratory Testing

All tests are carried out in accordance with the relevant American Society for Testing and Materials (ASTM) standard test method, unless stated otherwise. All laboratory test results are presented in ***Appendix E1.3 - Geology, Geophysical Surveys and Geotechnical Aspects (Laboratory Tests).***

Testing Schedule

Based on the Field Borehole Logs, the stratigraphy of the borehole profile will be used to determine and develop a testing schedule of the samples retrieved. **Table 14 - 5-2** states the laboratory tests that were performed during the works.

Table 14 - 5-2: Testing Schedule.

No.	Test	Field Testing	All Samples	Representative Samples
1	Visual/Lab description, grain size and lithology classification	✓	✓	
**2	Moisture Content		✓	
**3	Density (where applicable)			✓
4	Specify Gravity			✓
5	Atterberg Limits			✓
*6	Triaxial Strength/Direct Shear			✓
*7	UCS			✓
8	Standard Penetration Test	✓		

* Unconfined and Triaxial Strength test; To evaluate strength characteristics of the different rock types encountered. **Equipment**: Triaxial apparatus.

**Density and Moisture tests were carried out both in the Soils lab and by default within the Geomechanics lab by way of sample preparation procedures. Results are defined accordingly in the subsequent sections.

Natural Moisture Content - Soils Lab Testing

Measurements of the natural moisture content were done on selected retrieved samples and are shown in the Laboratory Summary. The moisture content of the samples varied from 14.8% to 45%. One (1) sample, BHKB3 SA7, had particularly high moisture content. The laboratory summary data also indicated that the natural moisture content was near the plastic limit for samples tested as being cohesive.

In-situ Density - Soils Lab Testing

Measurements of soil unit weights (γ_{wet}) were performed on selected disturbed samples pending their physical state. Due to the texture of the retrieved samples, it was only possible to test two (2) samples, BHKB 3 SA 8 and BHKB 3 SA 10. The bulk dry density unit weight of the samples generally varied between 14.8kN/m^3 and 23.8kN/m^3. The average unit weights are well within the expected ranges for the variety of soil types. Results are displayed in ***Appendix E1.4 - Geology, Geophysical Surveys and Geotechnical Aspects (Laboratory Tests' Results).***

Atterberg Limits- Soils Lab Testing

Atterberg limit tests were attempted on representative samples of the soil strata for each borehole. In general, the results showed that most of the underlying original soils were non-plastic and classified as Sands. Results are displayed in ***Appendix E1 - Geology, Geophysical Surveys and Geotechnical Aspects (Laboratory Tests' Results).***

At borehole BHKB-1, between 18.5 - 34 feet were determined to be cohesive and classified as an ELASTIC SILT (MH) having plasticity index of 29 for the representative sample tested. All other layers were classified to be SAND

At borehole 2, all samples were determined to be non-plastic. Fine grained samples, namely SILT, were classified between 0.0 - 6.0 feet and 13.5 - 22 feet.

At borehole 3, between 18.5- 32 feet samples were found to be cohesive consisting of LEAN CLAYS with plasticity indices between 21 to 22. All other layers were non-plastic and classified to be SAND.

Strength Measurements (Inclusive of Density and Moisture Content)

Core samples were retrieved from three borehole locations (BHKB-1, BHKB-2, and BHKB-3) at various depths. The standard practices for preserving and transporting the samples were followed according to ASTM D5079. Cylindrical specimens of 20 mm diameter were plugged from the cores. The specimens were cut so that their length-to-diameter ratios were in excess of 2 but less than 3 and precision ground to strict tolerances (±0.02 mm) as to the squareness of their ends in accordance with ASTM D4543 and ISRM (Suggested methods for determining the strength of rock materials in triaxial compression: Revised version) suggested methods. Results are displayed in ***Appendix E1.4 - Geology, Geophysical Surveys and Geotechnical Aspects (Laboratory Tests' Results).***

The density at in-situ saturated conditions were measured using a vernier caliper that has an accuracy of 0.01 mm to measure the volume, and a balance with a capacity to measure the weight to an accuracy of 0.01 %.

The strength tests confirm that at all stratigraphic levels the soils can be classified as weak in accordance to ISO 14689 standards. Ductile failure was observed with cataclastic flow failure mode for all specimens. The brittle-ductile transition that occurs in the soil samples is greatly influenced by changes in temperature, confining pressure, strain rate, and the presence of pore fluid; all factors to be considered in the engineering designs for both foundations and building structures. The poor compressive strength results also guide the effects of the inherent bearing capacity of the building spread footings and piles.

Table 15 - 5-3: Density of Tested Specimens at In-situ Conditions.

Borehole	Sample	Specimen	Density (kg/m3)	Average (kg/m3)	Standard deviation (kg/m3)
BHKB-1	SP8	SP8-1	1733	1698	26
		SP8-2	1691		
		SP8-3	1670		
	SP9	SP9-1	1692	1688	4
		SP9-2	1684		
	SP11	SP11-1	1732	1780	45
		SP11-2	1781		
		SP11-3	1741		
		SP11-4	1859		
		SP11-5	1789		
BHKB-2	SP1	SP1-1	1975	—	—
	SP7	SP7-1	1819	—	—
	SP8	SP8-1	1615	—	—
BHKB-3	SP8	SP8-1	2081	2097	13
		SP8-2	2087		
		SP8-3	2109		
		SP8-4	2110		
	SP9	SP9-1	1998	2055	41
		SP9-2	2095		
		SP9-3	2035		
		SP9-4	2092		

Table 16 - 5-4: Water Content of Tested Samples.

Borehole	Sample	Water (moisture) content (%)
BHKB-1	SP8	62
	SP9	59
	SP11	56
BHKB-2	SP1	30
	SP7	45
	SP8	35
BHKB-3	SP8	24
	SP9	26

Table 17 - 5-5: Summary of Strength Tests.

Borehole	Sample	Specimen	Length (mm)	Diameter (mm)	Length/diameter	σ_3 (MPa)	Strength (MPa)	σ_1 (MPa)	Failure behaviour	Failure mode	Internal friction angle (°)	Cohesion (MPa)
BHKB-1	SP8	SP8-1	37.40	19.15	2.0	0	0.35	0.35	Ductile	Cataclastic flow	6	0.22
		SP8-2	49.50	19.42	2.5	1	0.82	1.82	Ductile	Cataclastic flow		
		SP8-3	47.61	19.55	2.4	5	1.48	6.48	Ductile	Cataclastic flow		
	SP9	SP9-1	38.79	18.80	2.1	0	0.77	0.77	Ductile	Cataclastic flow	–	–
	SP11	SP11-2	39.95	18.74	2.1	0	0.85	0.85	Ductile	Cataclastic flow	–	–
		SP11-3	43.46	19.22	2.3	1	1.6	2.6	Ductile	Cataclastic flow		
		SP11-4	47.25	18.69	2.5	5	2.5	7.5	Ductile	Cataclastic flow		
		SP11-5	45.60	19.19	2.4	10	2.1	12.1	Ductile	Cataclastic flow		
BHKB-2	SP1	SP1-1	41.40	19.71	2.1	0	0.57	0.57	Ductile	Cataclastic flow	–	–
	SP7	SP7-1	51.00	18.65	2.7	0	3.25	3.25	Ductile	Cataclastic flow	–	–
	SP8	SP8-1	28.29	18.52	1.5	0	0.65	0.65	Ductile	Cataclastic flow	–	–
BHKB-3	SP8	SP8-1	45.43	20.00	2.3	0	1.2	1.2	Ductile	Cataclastic flow	3.5	0.6
		SP8-2	49.67	19.78	2.5	1	1.3	2.3	Ductile	Cataclastic flow		
		SP8-3	51.01	19.97	2.6	5	1.87	6.87	Ductile	Cataclastic flow		
		SP8-4	48.88	19.88	2.5	10	2.26	12.26	Ductile	Cataclastic flow		
	SP9	SP9-1	38.40	19.77	1.9	0	1.05	1.05	Ductile	Cataclastic flow	–	–
		SP9-2	41.00	19.86	2.1	1	2.5	3.5	Ductile	Cataclastic flow		
		SP9-3	45.10	19.75	2.3	5	1.5	6.5	Ductile	Cataclastic flow		
		SP9-4	45.57	19.71	2.3	10	2.6	12.6	Ductile	Cataclastic flow		

NB: A few specimens did not meet the ASTM and ISRM recommended length to diameter ratio of between 2 to 3. However, the strength values of these specimens are in a reasonable data range.

5.1.6 Drainage and Surface Hydrology

OptimalGESL conducted a detailed drainage assessment for the proposed project area. The following section presents some of the main findings from the associated report regarding existing drainage conditions.

5.1.6.1 Pre-development Flood Levels

The proposed project site gently slopes from elevations ranging from <0.5m at shoreline and mangrove to 10m above mean sea level (MSL) towards the northern upper terrace and plateau secondary forest tree line. This wetland is also located downstream of a wider Tyson Hall catchment area that drains into it. Hence, the mangrove forest acts as a natural retention system during low flows, storing runoff to nourish the flora within it. Pre-development site flood levels in the Kilgwyn Bay mangrove and surrounding areas are both flash floods and riverine flooding.

Climate variability (dry cycles to wet cycles) and land-use change play a significant role in the Kilgwyn Bay area, but there is a large amount of uncertainty around the flood quantile estimates (the value of discharge corresponding to the 100-year flood) mainly due to the lack of a long record of observed data at stream locations within the basin.

Table 18 - 5-6: Pre-development Flood Levels, SW Tobago (OptimalGESL, 2021).

Storm Event	Pre-Development Flood Levels (m MSL)
2 years	0.35
5 years	0.49
10 years	0.433
25 years	0.5200
50 years	0.647
100 years	0.721

5.1.6.2 Flow Paths

The average yearly precipitation and associated stream discharge of the Kilgwyn Bay area are 74-160mm/year and 950-1200mm/year respectively (Allen and Boutt, 2021).

Historically the mangrove swamps at Kilgwyn Bay are connected to the sea by two ephemeral sluice canals and the mangrove and secondary forest areas divided by the Kilgwyn Bay Beach Road. Mid-way along this beach access road a concrete culvert under the road connects the both mangrove areas. The Kilgwyn Swamp is estimated to be o.12km² and described as a permanent brackish lagoon with fringing mangrove swamps.

Runoff infiltration on the northern topographic highs is influenced by a combination of sloping geomorphology and clayey soils. Mangrove is clearly the defined receiving environment.

Recent anthropogenic activities; removal of mangroves and sand mining augmented by high natural erosion rates across the watershed has resulted in the mangrove forest and swamp within the proposed hotel development site an impounded basin. Consequently, a large area of mangrove die-off (IMA studies 2007 and 2008- Juman and Hassanali, 2013).

Overall, the extent of the wetland displays a complex hydrological regime with the eastern and western sections strongly influenced by tides, southern areas being primarily riverine and some mid-sections having mixed/estuarine properties. Water originating from the Kilgwyn Access Road and Kilgwyn Beach Access Road flows to the south toward the wetland via a northern culvert and western culvert of the Kilgwyn Beach Road (**Figure 51 - 5.25**), diverting to two main swamp areas; western and eastern tidal exchange points, and mixing with saltwater in some eastern and western sections of the forest.

Three (3) culverts were identified on the boundaries of the proposed hotel development site; along the Kilgwyn Bay Beach Road draining south towards the wetland (**Figure 51 - 5.25**). A very large and actively flowing culvert was observed at the northeastern extent of the dirt Friendship access road. This is the culvert which likely supplies the eastern area with fresh water and results in a heavy outflow through the service road culvert, towards the north eastern area of the mangrove (**Figure 51 - 5.25**).

The physical barriers created by the roadways in the wetland area are likely preventing more widespread mixing of fresh and saltwater in some segregated forest sections. Brackish waters were recorded in areas closer to the southeast and southwest tidal influence, but minimal saltwater influence was detected/recorded in the mid and northern sections of the mangrove.

Within the southern sections of the mangrove and secondary forest areas anomalous topographic high bifurcate the natural flow towards swamp. During periods of heavy rainfall during wet season, in the northern section of the property water erodes the landscape, streams form and channelize the surficial flow toward the mangrove swamp increasing turbidity conditions.

During anomalous rain fall periods (ref.; October-November 2022) spill over takes place across the Kilgwyn Bay Beach Road creating a less marine restricted mixing zone between neighbouring swamps (**Figure 51 - 5.25**; red arrows)

During Tropical Storm conditions coupled with high-tide marine spill over occurs on the south-west section of the property resulting in coastal flooding (most of the berm here removed due to sand mining) - (**Figure 51 - 5.25**; dark blue arrows)

Figure 52 - 5.26 shows hydrodynamic flow pathways across the property indicated by light blue arrows on this Paleo-drainage map.

As groundwater emerges to the surface through tidal ranges, it often forms a network of streams surficial streams even during dry season and proliferates flooding during the wet season. Therefore, there is a clear relationship between the growth and geometry of such seepage networks throughout the property.

Figure 50 - 5.24: Shallow Water Table (left); Debris Blocked and Structurally Damaged Sluice Canal.

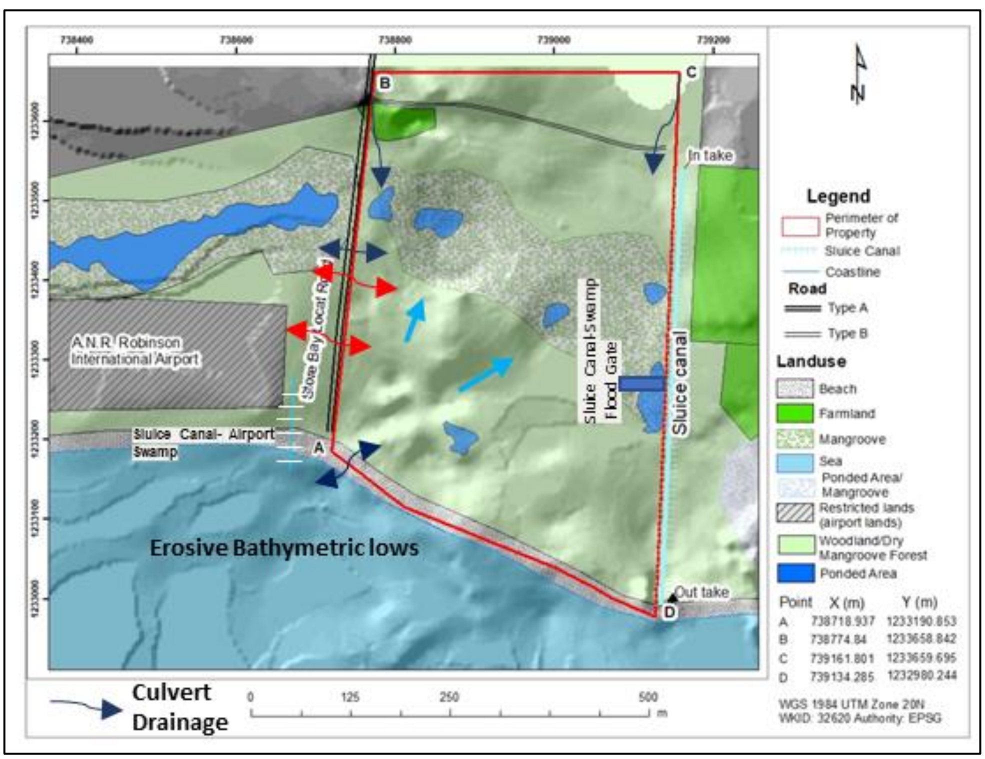


Figure 51 - 5.25: Plan View Schematic of Land Use Elements and Property Perimeter Sluice Canal.

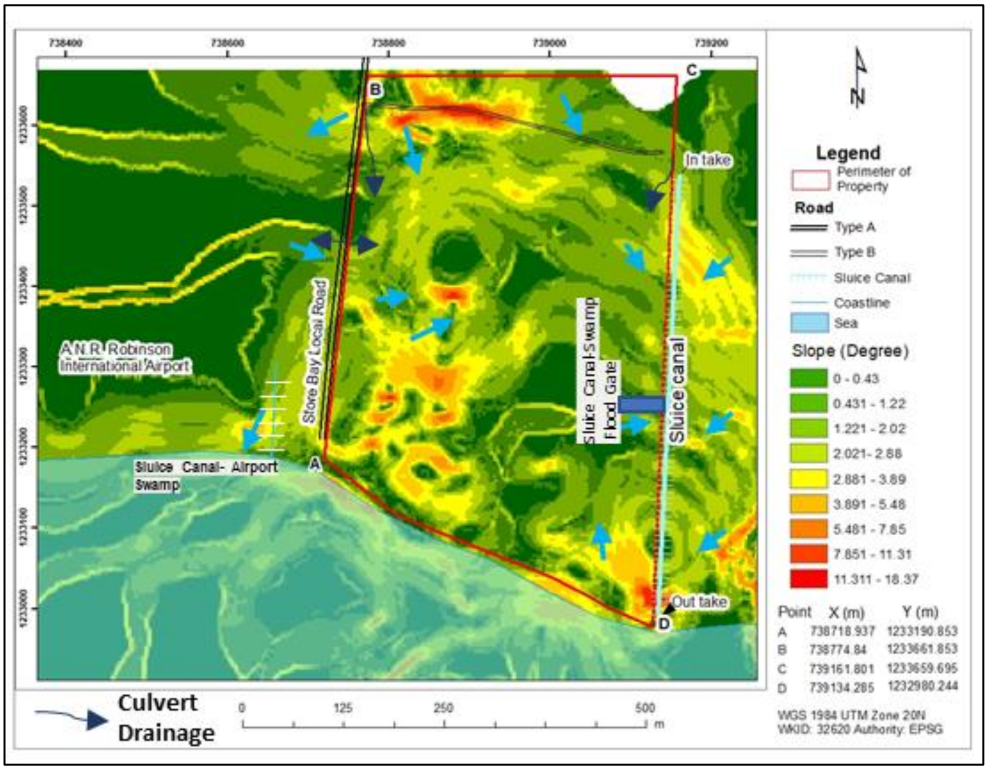


Figure 52 - 5.26: Observed Wetland Surface Hydrology Regime.

5.1.6.3 Ground Water

The island of Tobago contains a geologically complex aquifer system that is predominantly igneous and metamorphic rocks. There are small sedimentary deposits scattered throughout the island and a carbonate platform in the southern region which overlays basaltic basement rocks. (Snoke et al., 2001). The bedrock of Tobago also contains many fractures, faults and lineaments which are remnants of the active tectonic history of the region (Snoke et al., 2007). A recent hydrological assessment of the islands fractured rock aquifer system (Boutt et al., 2021) used an integrated approach which included isotopic analysis, annual recharge estimates and steady state groundwater modelling. They found that some groundwater catchments were over producing between 100 to 1000% of water compared to their local calculated recharge (Boutt et al., 2021). In the Kilgwyn Bay proposed project site there is no evidence of a premodern or modern groundwater sources (**Figure 53 - 5.27**).

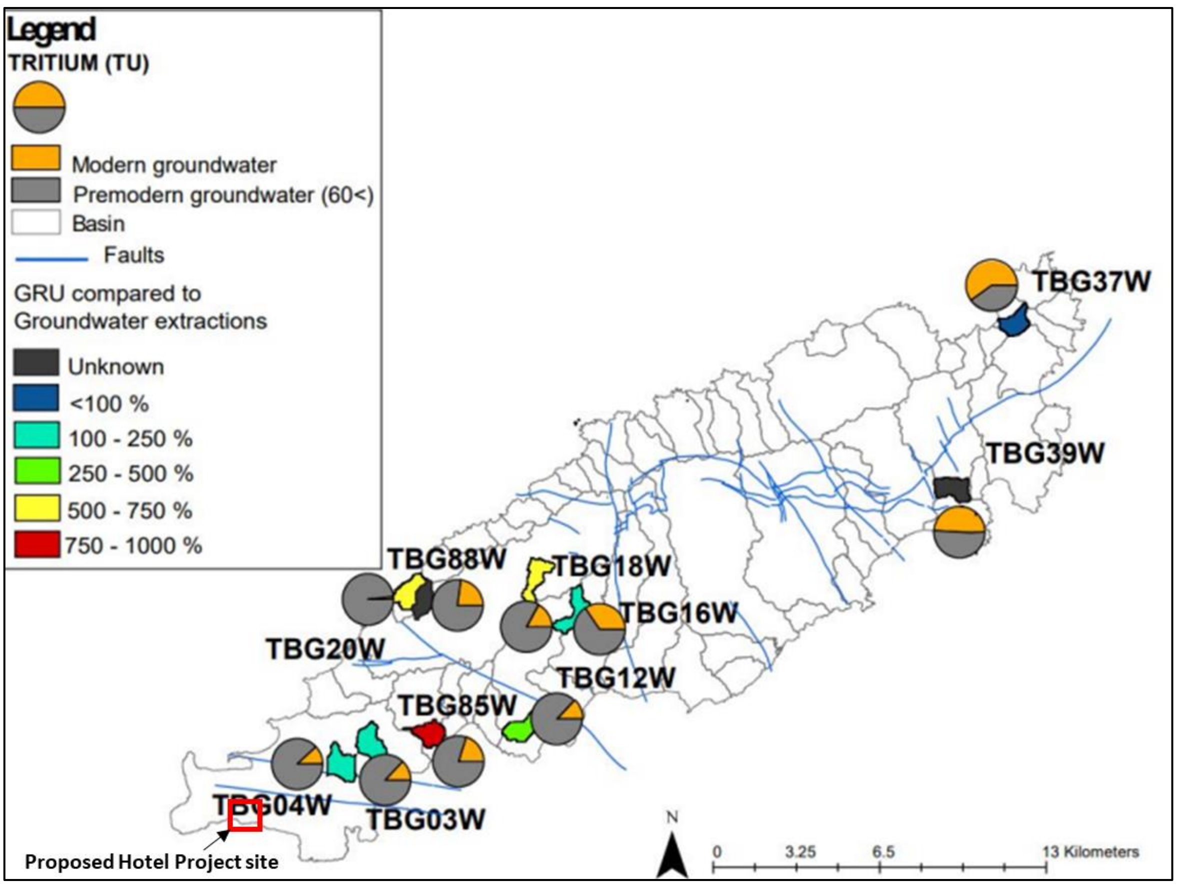


Figure 53 - 5.27: Premodern or Modern Groundwater Sources and Extraction across Tobago in Relation to Proposed Hotel Development Site-Kilgwyn Bay, SW Tobago.
Map Modified from Allen and Boutt, 2021.

Abstraction of fresh water occurs from the clastic sedimentary deposits in the southwestern part of the island where there is an especially high demand for potable water. Wells drilled into the limestone platform have encountered brackish water and are at present being used for observation purposes.

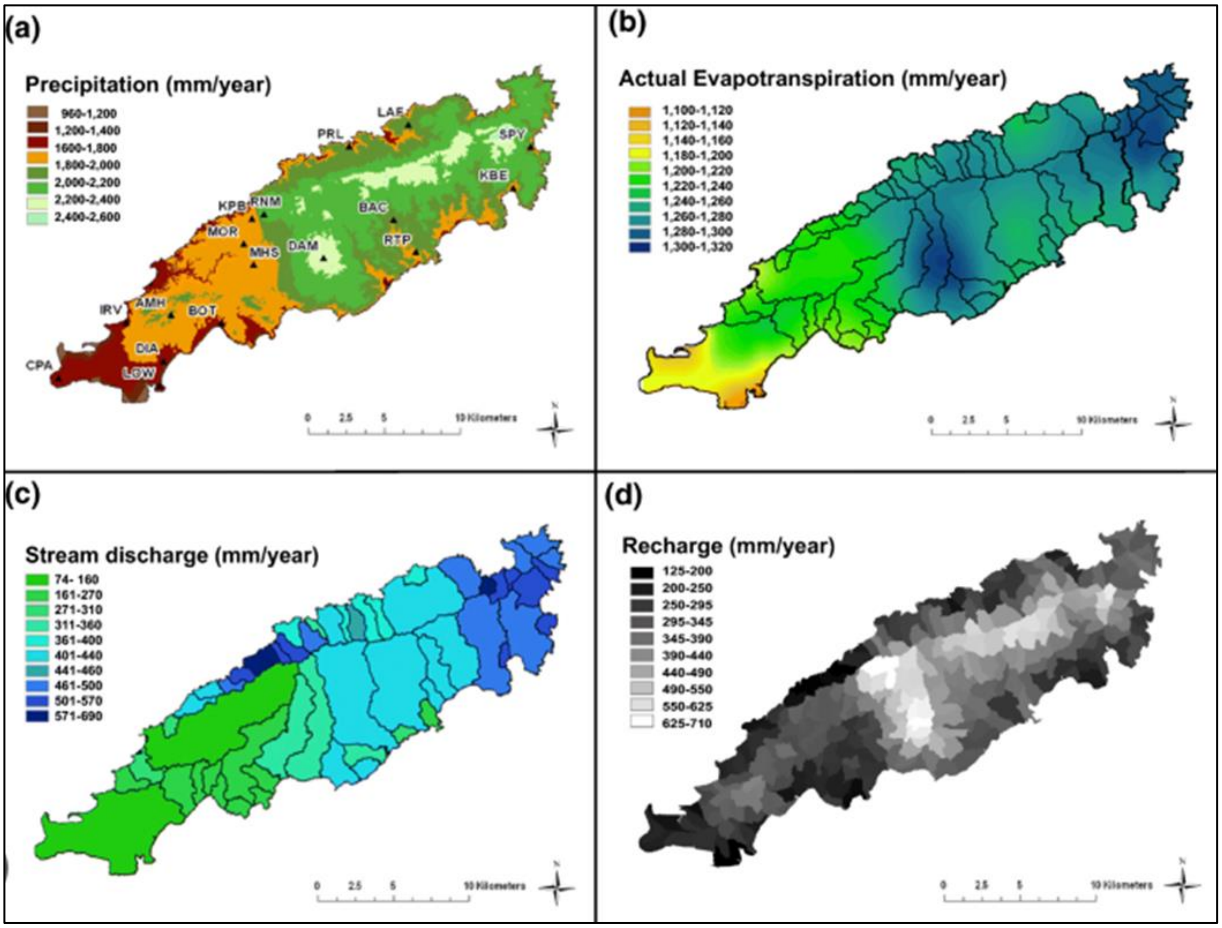


Figure 54 - 5.28: Yearly Average (Wet and Dry Season) Precipitation, Stream Discharge, Actual Evapotranspiration and Basin Recharge across Tobago.
Source: Boutt et al., 2021.

5.1.6.4 Soil and Sediment Erosion

Recent land use trends in Trinidad and Tobago have been dominated by a steady growth in urbanization and housing development, uncontrolled settlements, agricultural activities, such as slash and burn, water harvesting and deforestation. This is particularly valid for the southern foothills of the Northern Range in Trinidad, where it is evident that considerable expansion of urban areas is taking place at the expense of forests and agricultural lands. In Tobago, at least 15 % of the topsoil has been lost through inappropriate land use. Its topography is characterized by a high percentage of steep slopes with soils that are highly prone to erosion. The problem of soil erosion is manifested mainly in the south of the island as the northern areas which receive the most rainfall is still under original forest or permanent tree crops.

The coastal geomorphology of Kilgwyn Bay is constantly changing because of the dynamic destructive marine processes operating at this beach. This is due to freshwater outflow and tidal-inflow dynamics. At several points the beach berm/sand bar has also been eroded by freshwater outflow and sea-water inflow that has created areas where salt water is able to directly penetrate and alter the salinity in the nearshore areas (environmental Management Authority 2001 and IMA, 2000). Owing to the severe coastal erosion occurring at the shoreline of the client’s property, there are several main areas of concern that needed to be addressed that require longer term monitoring; high rates of shoreline erosion and saltwater throughflow and near surface water table. Further information and discussion on coastal erosion will be addressed in the following Section 5.1.7 - Coastal Processes.

5.1.7 Coastal Processes

5.1.7.1 Currents, Tides and Waves

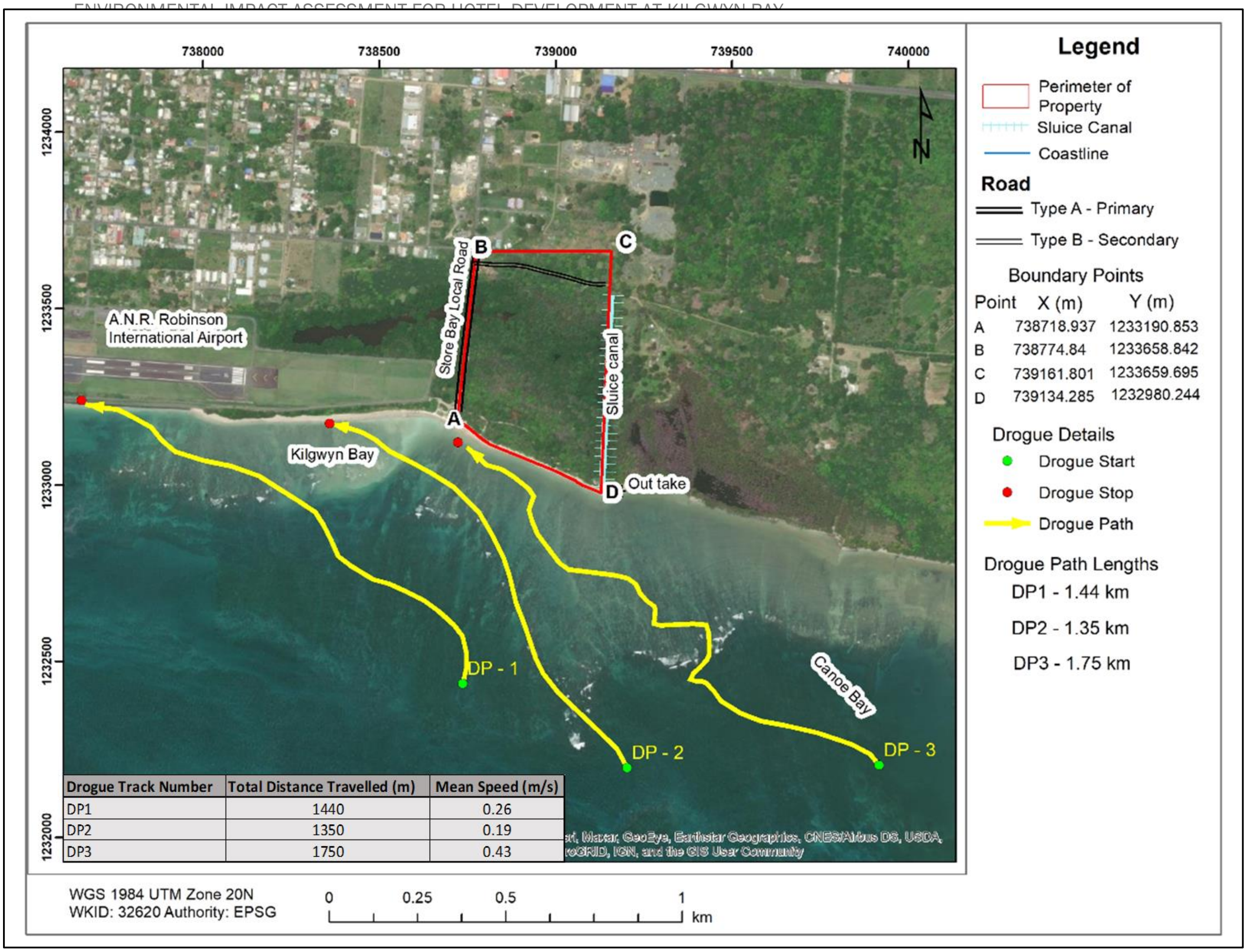
Methodology

Three (3) drogue tracks were done for the area. This involves placing a submerged floating device in the sea and tracking it with a GPS onboard a pirogue. This is a measurement of the surface currents in the area. The drogues were deployed at three different locations within Kilgwyn Bay and Cove Bay (**Figure 55 - 5.29**)

Results

All drogues moved toward the west as expected. All the drogues deployed inside the cove ran into the shoreline and stopped. This indicates that there is a tendency for any floating material to be brought into this area. This also implies that the current moves slowly and has contributed to the deposition of debris such as drift wood/vegetation, coral fragment and any plastic waste introduced from direct hinterland runoff or via canals.

In general, currents at the site flow from east to westerly direction. The currents are strongest in areas where waves break, i.e. along the rocky back reef fringes. The breaking of waves on the reef at the opening of the bays also causes these strong currents to pull water out of the bays and cause significant movement of any sediment in the area. Therefore, the shoreline of the proposed hotel development is erosive but also encourages progradation via longshore drift sediment deposition. A perched beach/berm in this area (as currently proposed) will create valuable sunbathing areas that would not be eroded by the strong currents. The beach in front of the prosed hotel development has slow-moving currents that will cause stagnation in the waves approaching from the southeast. Mean significant wave height is 0.13 m (+/-0.08 m) with a period of 5.23 (+/-3.04 s) while the breaker height is 0.15 m (+/-0.11 m)



Drogue Track Number	Total Distance Travelled (m)	Mean Speed (m/s)
DP1	1440	0.26
DP2	1350	0.19
DP3	1750	0.43

Figure 55 - 5.29: Drogue Tracking – Current Measurements.
Source: OptimalGESL, 2022.

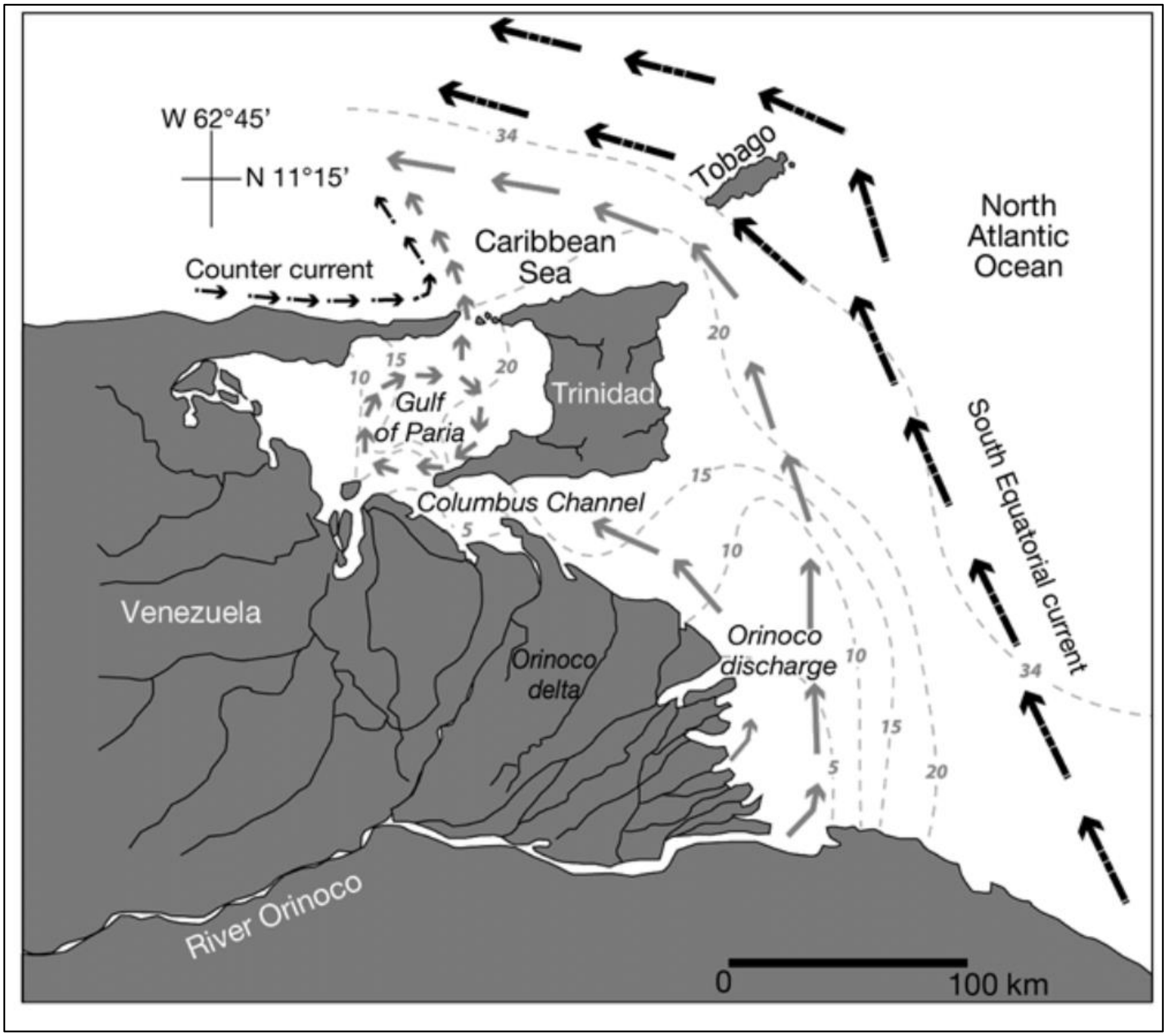


Figure 56 - 5.30: Location of Trinidad and Tobago Relative to the South American Mainland. Arrows indicate the principal currents distributing freshwater (and associated nutrients, organic matter and sediments) from the Orinoco River and Amazon River (via the South Equatorial Current) to the waters around Trinidad and Tobago. Dashed lines indicate surface salinity values.

Mean longshore flows in a predominantly westerly direction. Current averages 0.22 m/s (range 0.19 -0.43 m/s, +/-0.11 m/s) (**Figure 56 - 5.30)** above.

5.1.8 Beach/Shoreline Morphology

The Kilgwyn Bay shoreline show signs of dynamism, as it builds up during the summer months when the conditions are calmer and erode during the winter months when the wave conditions are stronger due to ocean swells. This section of the report presents shoreline trends (wet vs. dry season) along the project site. Historical shoreline morphology studies and results as part of this current EIA were used to illustrate and analyze trends for the area.

5.1.8.1 Historical Shoreline Analysis

The most well documented assessment of erosion and accretion trends across the southwest coast of Tobago with focus on Canoe Bay and La Guira (both bays <650m proximity to Kilgwyn Bay) was undertaken by the IMA between 2004-2008 (**Figure 58 - 5.32**). The shoreline monitoring component of the Coastal Conservation Project which commenced in 1988 provides valuable insights on the dynamics of the coastline. The scientific data are used by government and other agencies in formulating policies and plans for the coastline.

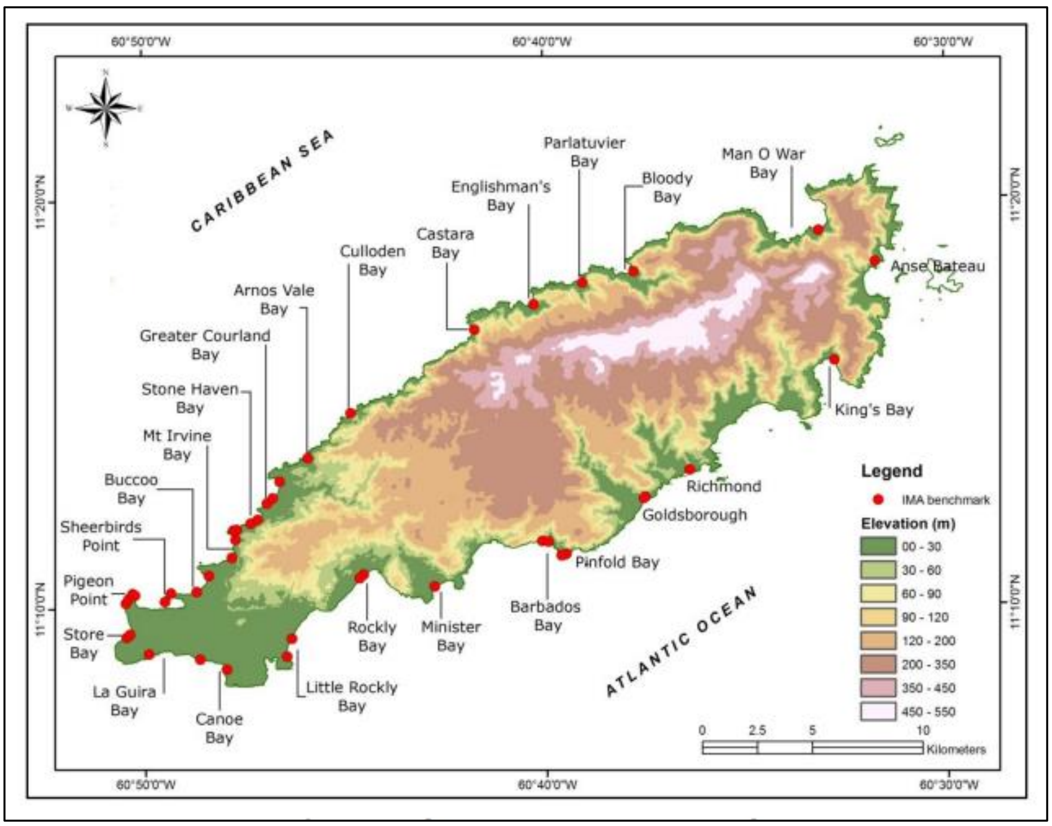


Figure 57 - 5.31: Location of IMA Beach Monitoring Stations in Tobago.
Source: Institute of Marine Affairs (2012).

The study methodology included an inspection of aerial images of the site over time and primary data collected include beach profiles, littoral processes and beach sediment grain size. Littoral processes data such as; wave approach, wave height, breaker height and near shore currents were collected at each profile location.

The IMA's La Guira Station 2A is located just to the SE corner of the proposed hotel development (**Figure 58 - 5.32**) and provides the best near proximity historical shoreline morphology and beach analysis.

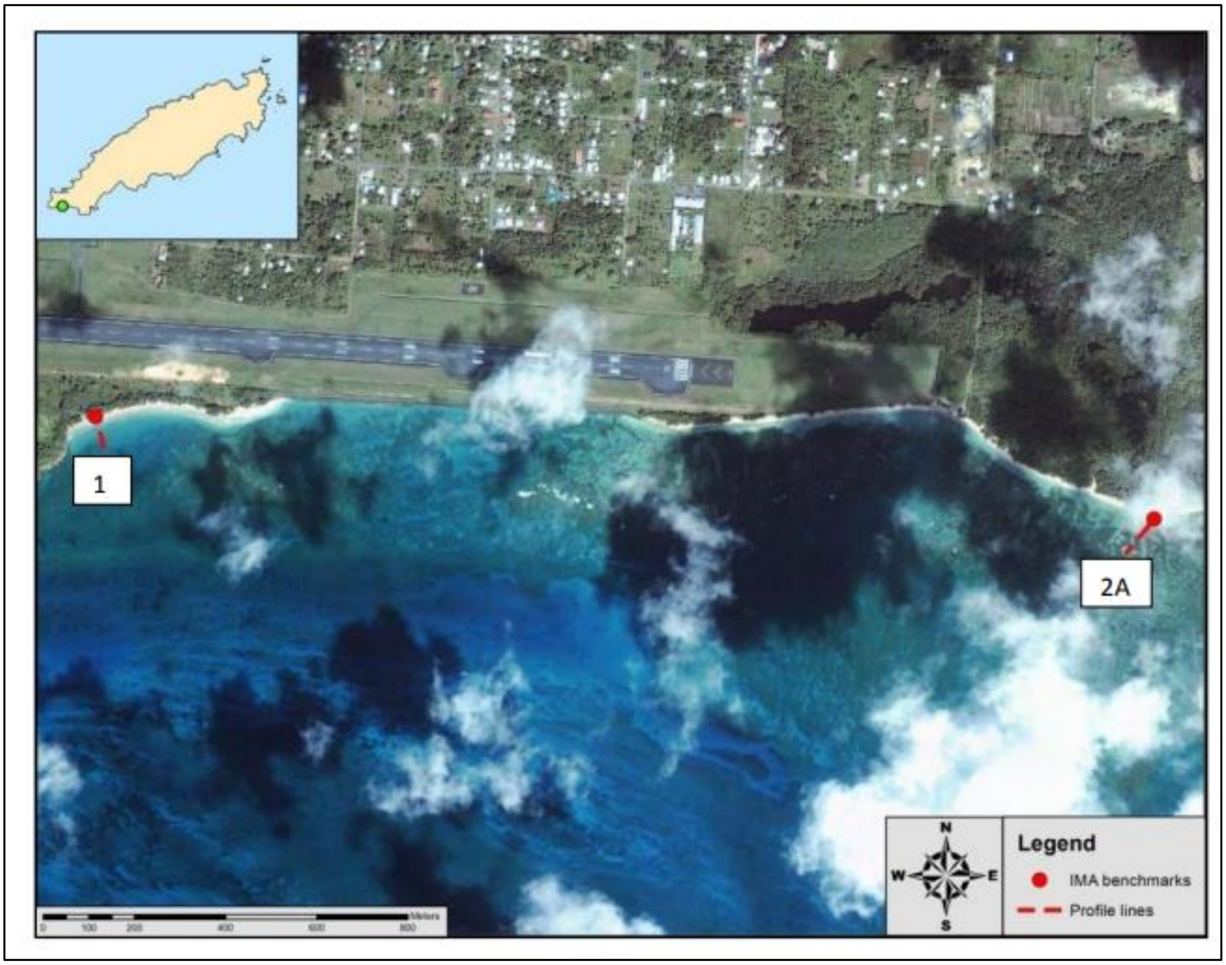


Figure 58 - 5.32: IKONOS Image of Canoe Bay Showing IMA Station Location (2007).

At Station 2 A, the beach profile shows some seasonal cyclicity and a berm (January 2004) which was eroded by October 2008. Beach profile indicates lateral erosion of approximately 4 m over the 5-year study period (**Figure 59 - 5.33**).

Waves approach from the southeast. Mean significant wave height is 0.11 m (+/-0.08 m) with a period of 5.01 (+/-3.02 s) while the breaker height is 0.15 m (+/-0.11 m). Mean longshore current averages 11.91 cm/s (range 1.93-43.52 cm/s, +/-11.12 cm/s) and flows in a predominantly westerly direction (IMA, 2012).

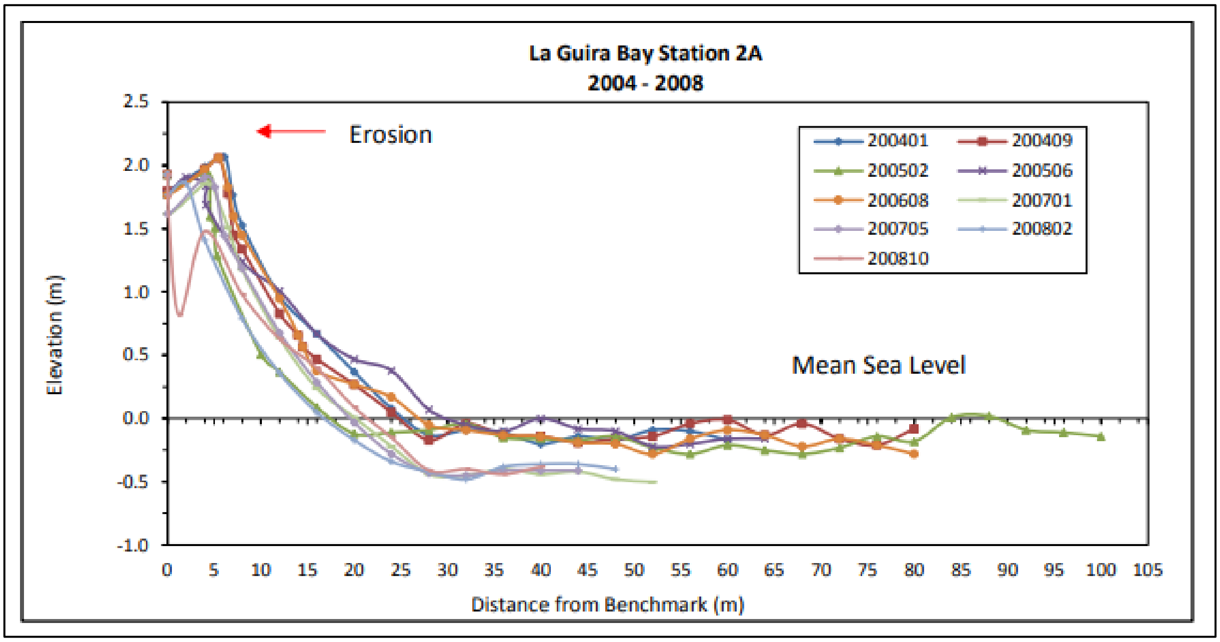


Figure 59 - 5.33: Profiles for La Guira Bay Station 2A during the Period 2004 – 2008. Source: IMA, 2012.

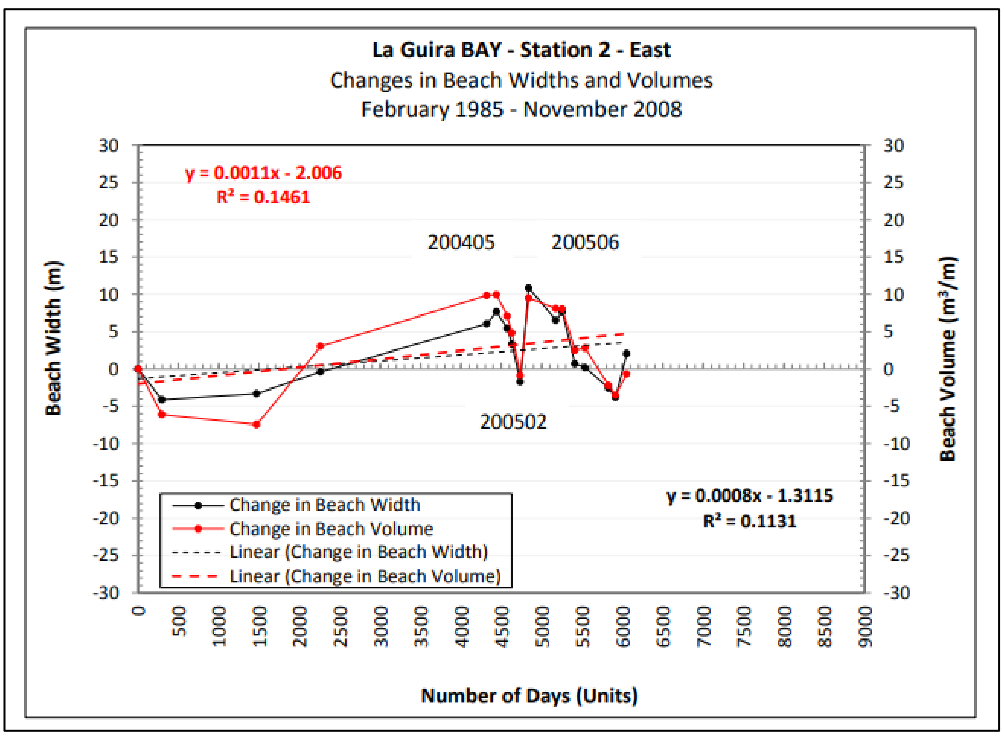


Figure 60 - 5.34: Plot of Beach Width and Volume vs Number of Days for La Guira Bay, Station 2, for the Period February 1985 – November 2008.
Source: IMA, 2012.

At Station 2 the upper beach sediment sampled by the IMA is classified as Slightly Gravelly SAND with a mean grain size of 0.31 mm and median grain size of 0.31 mm. The sample consists of 0.18% Gravel (>2.0 mm), 99.73% Sand (0.0625 - 2.0 mm) and 0.08% Mud (2.0 mm), 99.37% Sand (0.0625 - 2.0 mm) and 0.10% Mud (2.0 mm), 92.97%

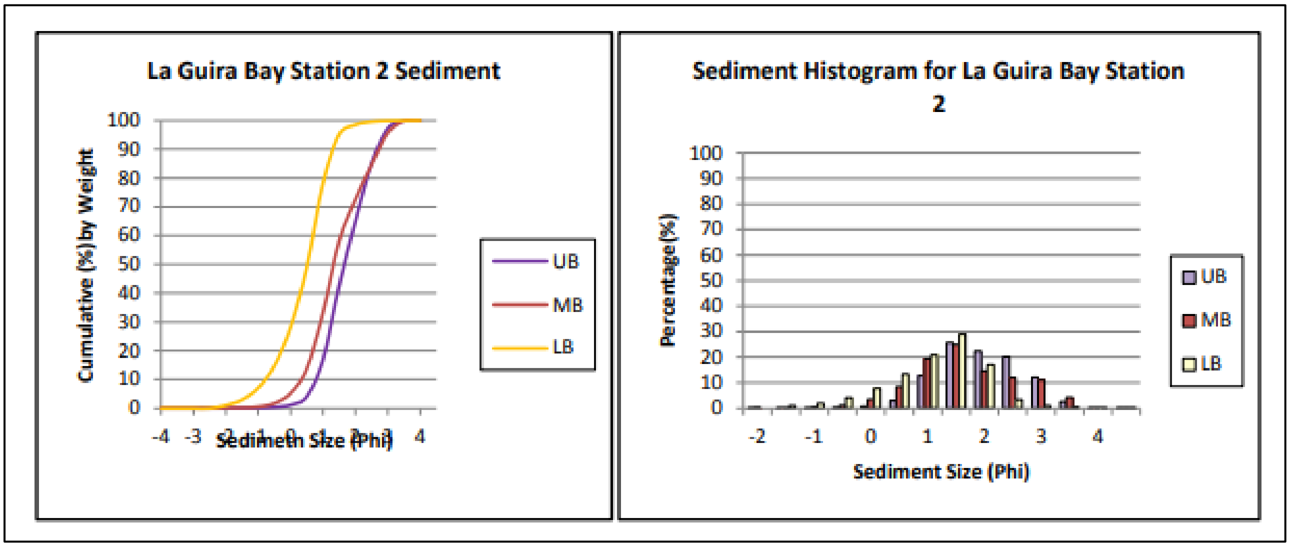


Figure 61 - 5.35: Sediment Grain-size Distributions for La Guira Bay Station 2A.

Overall, the beach profile at Station 2 showed some seasonal cyclicity and a berm (January 2004) which was eroded by October 2008. Beach profile indicates lateral erosion of approximately 4 m over the 5-year study period (**Figure 59 - 5.33**).

5.1.8.2 2022 EIA Coastline Study

Four (4) coastline profiles were undertaken for this EIA study (L3, L4, L5 and L6). primary data collected include beach profiles, littoral processes and beach sediment grain size.

The beach profile at location L3 shows that there is a slope of 4º in the backshore region (**Figure 63 - 5.37** and **Table 19 - 5-7**). A slope of 20º was measured between the top and base of the berm across a horizontal distance of 2.4 m. An average slope of 8º exist between the base of the berm and the mean sea level. The mean sea level for the beach profile was taken at low tide level. The terrain is relatively flat in the nearshore region. The backshore region at location L4 is similar to that of location L3 (**Figure 63 - 5.37** and **Table 19 - 5-7**). At location L4, an average slope of 10º was measured between the crest of the berm towards the mean sea level. A slope of 11º exist in the nearshore region. The backshore region at location L5 is relatively flat *(Refer to* ***Appendix E2 - Beach/Shoreline Morphology****.* An average slope of 12º was measured between the crest of the berm towards the mean sea level. The nearshore region is relatively flat, which is similar to location L3. At location L6, the backshore region has a slope of 5º and the foreshore has an average slope of 17º *(Refer to* ***Appendix E2 - Beach/Shoreline Morphology.***

A comparison with similar proximity IMA 2004-2008 data at Station 2 and the recent 2022 EIA data at L3 showed that significant erosion of some 10.3m occurred within the Kilgwyn Bay coastline over an 18-year period. This provides an idea of the amount of fluctuation in beach width over the years. Although the rate of erosion is significant, within the bay the rate slowed compare to the 5-year period 2004-2008, suggesting a tendency to equilibrium or stability.

A comparison of profiles during wet and dry seasons in 2022 does show significant accretion of some 2-4m across the profile (**Figures 63 - 5.37** and **64 - 5.38**). Therefore, for the Kilgwyn Bay beach there is some level of dynamism (erosion and accretion), but the overall longer-term trend is one of erosion.

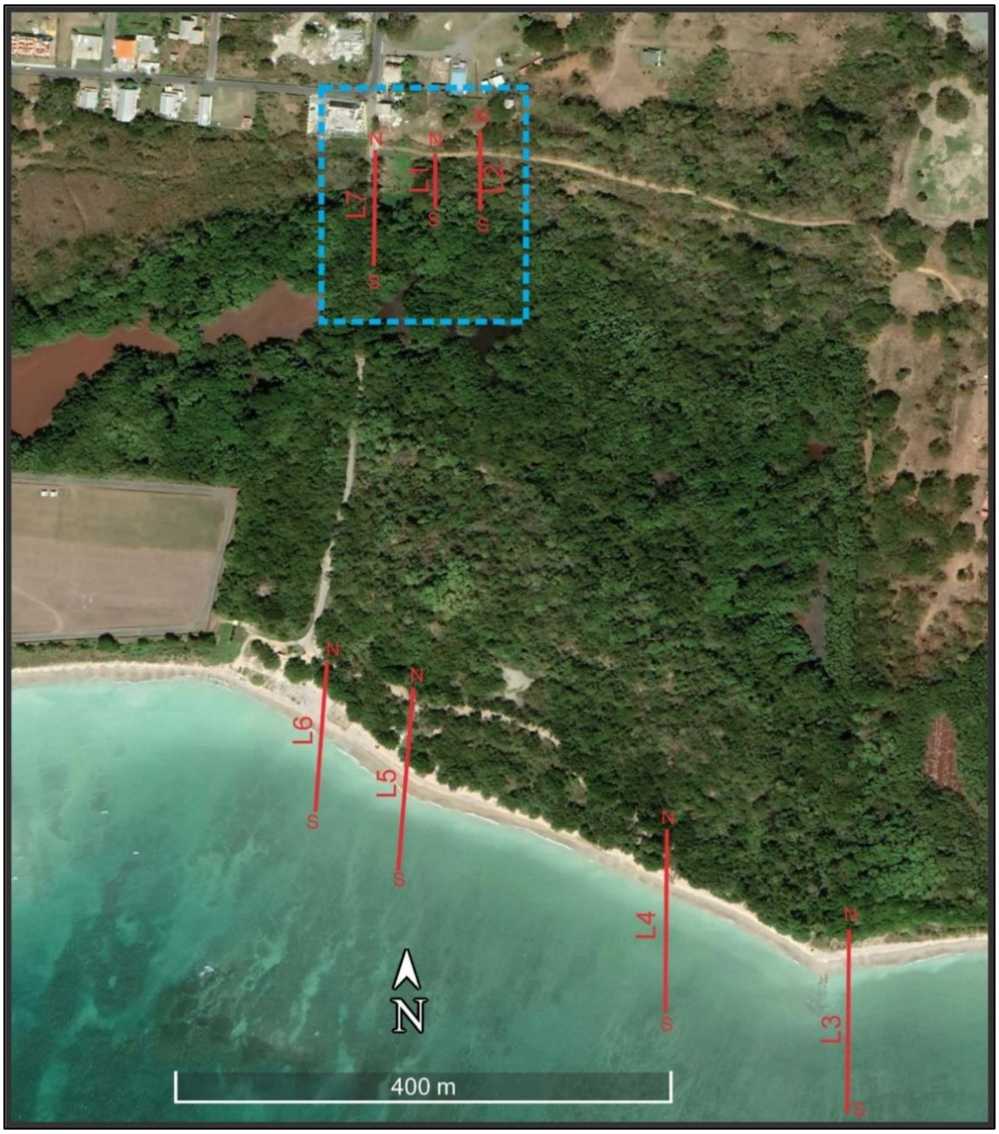


Figure 62 - 5.36: Map Showing Location of Shoreline Profiles Undertaken for the EIA. Coastline profiles are L3, L4, L5 And L6. Stippled blue box indicates those profiles undertaking onshore.

5.1.8.3 Dry Season Shoreline Analysis

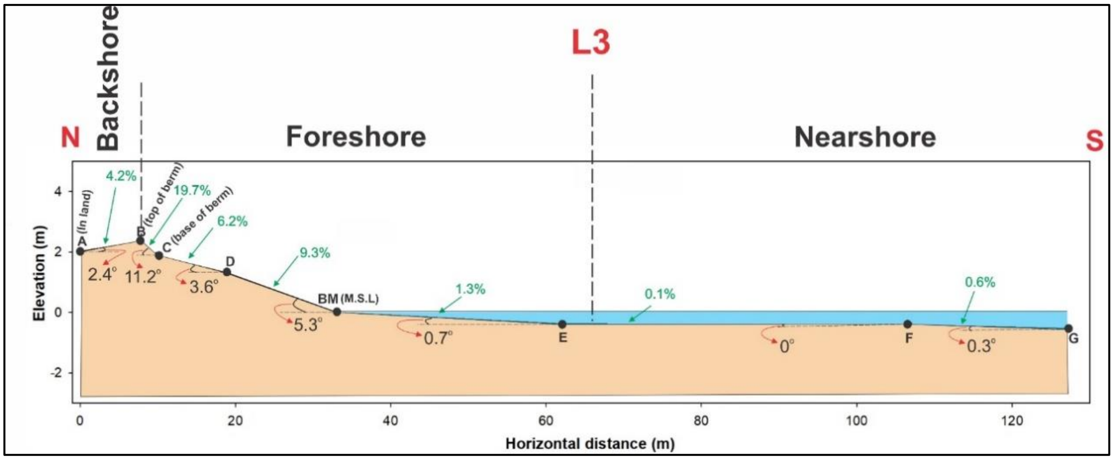


Figure 63 - 5.37: Beach Profile at Location L3 as an Example of Profiles Undertaken.

(For all profiles, refer to ***Appendix E2 - Beach/Shoreline Morphology)***

Table 19 - 5-7: Distance, Height and Slope Data Gathered as an Example at Location L3.

Point	Horizontal distance between points (m)	Relative height from each point (m)	Slope - rise/run (%)	Slope angle (°)
A				
	7.7	0.3	4.2	2.4
B				
	2.4	0.5	19.7	11.2
C				
	9.0	0.6	6.2	3.6
D				
	14.2	14.2	1.3	9.3
BM				
	29.0	29.0	0.4	1.3
E				
	44.6	0.0	0.1	0.0
F				
	20.7	0.1	0.6	0.3
G				

(For all data, refer to ***Appendix E2 - Beach/Shoreline Morphology)***

5.1.8.4 Wet Season Shoreline Analysis

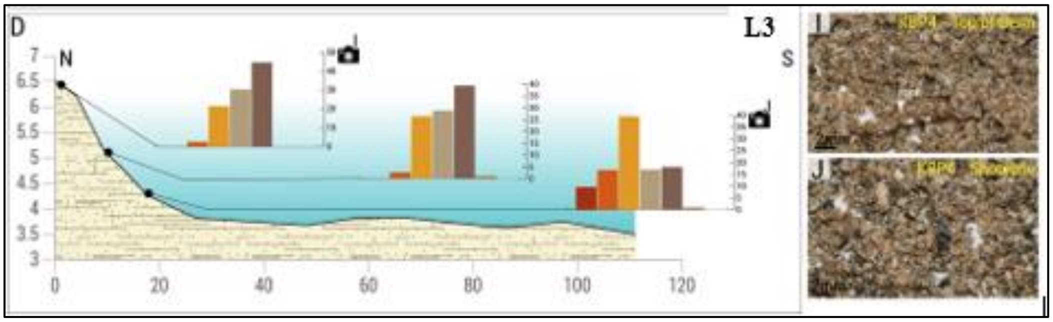


Figure 64 - 5.38: Kilgwyn Beach Wet Season Profiles, Sediment Grainsize Distribution Histograms and Sample Photographs.

(For all data and profiles, refer to ***Appendix E2 - Beach/Shoreline Morphology)***

Note that black dots along the beach profiles show the approximate location of where samples were taken and their associated grainsize distribution histograms.

5.1.8.5 Sedimentology - Beach and Nearshore Sieve Analysis

Three (3) sand samples were collected from the beach and sieve analysis conducted on each sample for both wet and dry seasons. All samples were light brown coralline sand indicating high calcium content.

The sediment distributed across the shoreline, berm slope, and top of berm of the Kilgwyn Beach, Tobago, is predominantly medium- to coarse-grained sands, with decreasing fractions of fine sand, very coarse sand, very fine sand, and little to no mud respectively. The samples are moderately-sorted, platykurtic to very platykurtic bioclastic sediments. The bioclasts vary in size across the beach with very-fine gravel-sized clasts observed at the top of the berm along profile L6. However, a majority of the bioclasts, made up of mainly limestone fragments and lesser organisms shells and shell fragments (bivalves and gastropods), fall within the sand grainsize range.

The profiles show a general increase in coarse-grained sand towards the shorline with the exception of the L6 Top of Berm sample. Sample L6 – Top of Berm is generally coarser-grained than the other samples across the beach, described as polymodal and very platykurtic with large fractions of very-fine gravel, and coarse- and medium sand. Profiles KBP2 and KBP3 show increases in the coarse-grained sand fraction towards the shoreline, however, profile KBP3 is generally coarser grained, and has sees a subtle increase in the coarse sand fraction. Profile KBP4 sees an overall increase in fine-grained sediment at the top of the berm relative to other top of berm samples across the beach, which decreases slightly across the slope, and becomes much coarser at the shoreline. Sample KBP4 – Shoreline described as polymodal, very-fine gravelly coarse-sand, that is poorly sorted, and leptokurtic.

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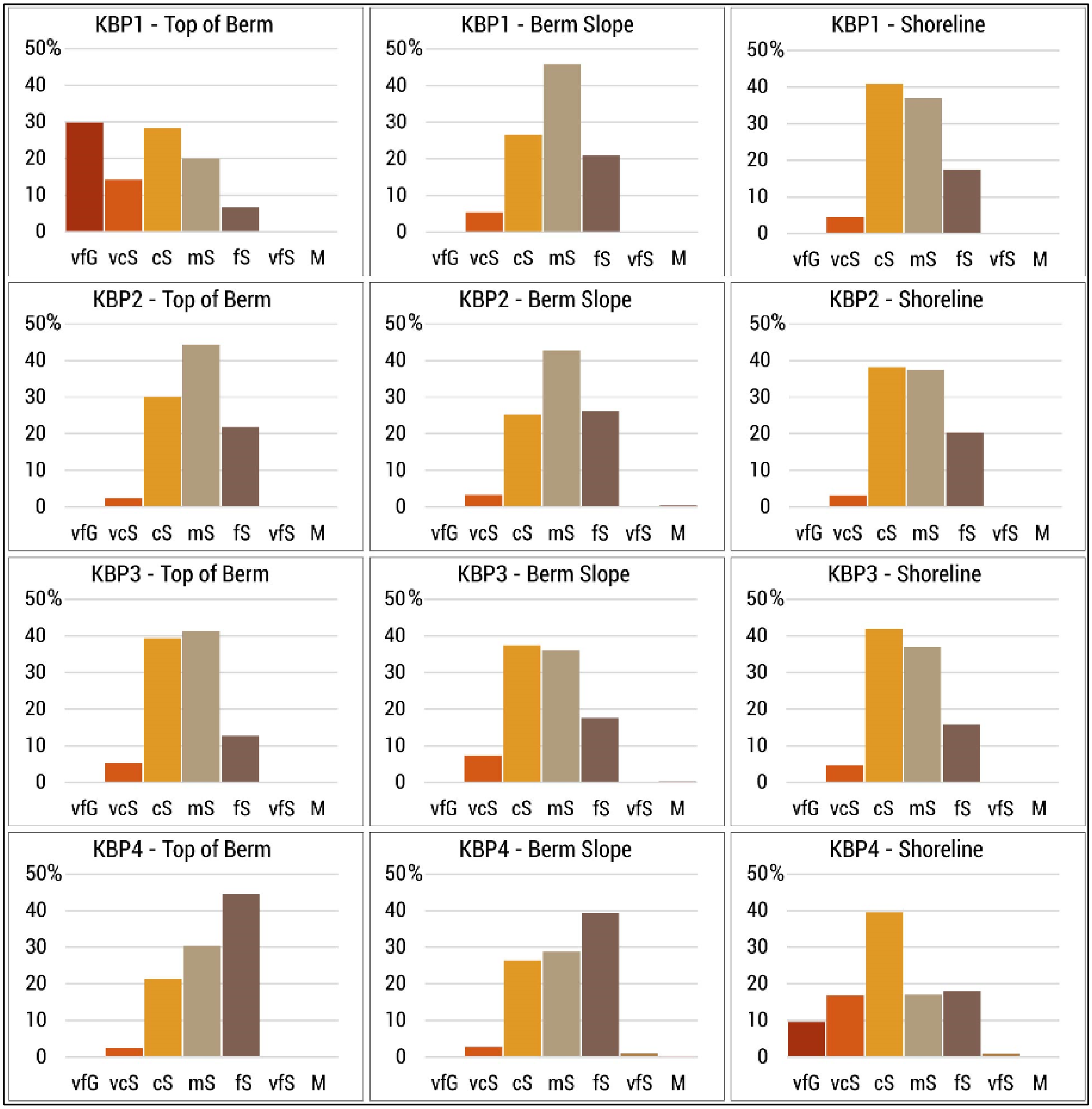

Figure 65 - 5.39: Sieve Analysis Results for Beach Sediments Collected.

5.1.8.6 Beach Classification

Masselink and Short (1993) put forth the most widely used beach classification scheme based on the relative tidal range (RTR) and the dimensionless sediment fall velocity (S). The relative tidal range is calculated as the ratio of tidal range to wave height. Kilgywn Beach, along Tobago's southwestern leeward coastline sees wave hights of approximately 1.5 m and a mean tidal range of ~ 1 m. This results in a RTR of 0.667. Based on Masselink and Short (1993) classification, Kilgwyn Beach can be classified as reflective, barred, or barred-dissipative. Qualitatively, by comparison to the Masselink and Short (1993) classification, Kilgwyn Beach can be classified as barred having a steep beach face and distinct but sometimes subdued bars across the shoreface.

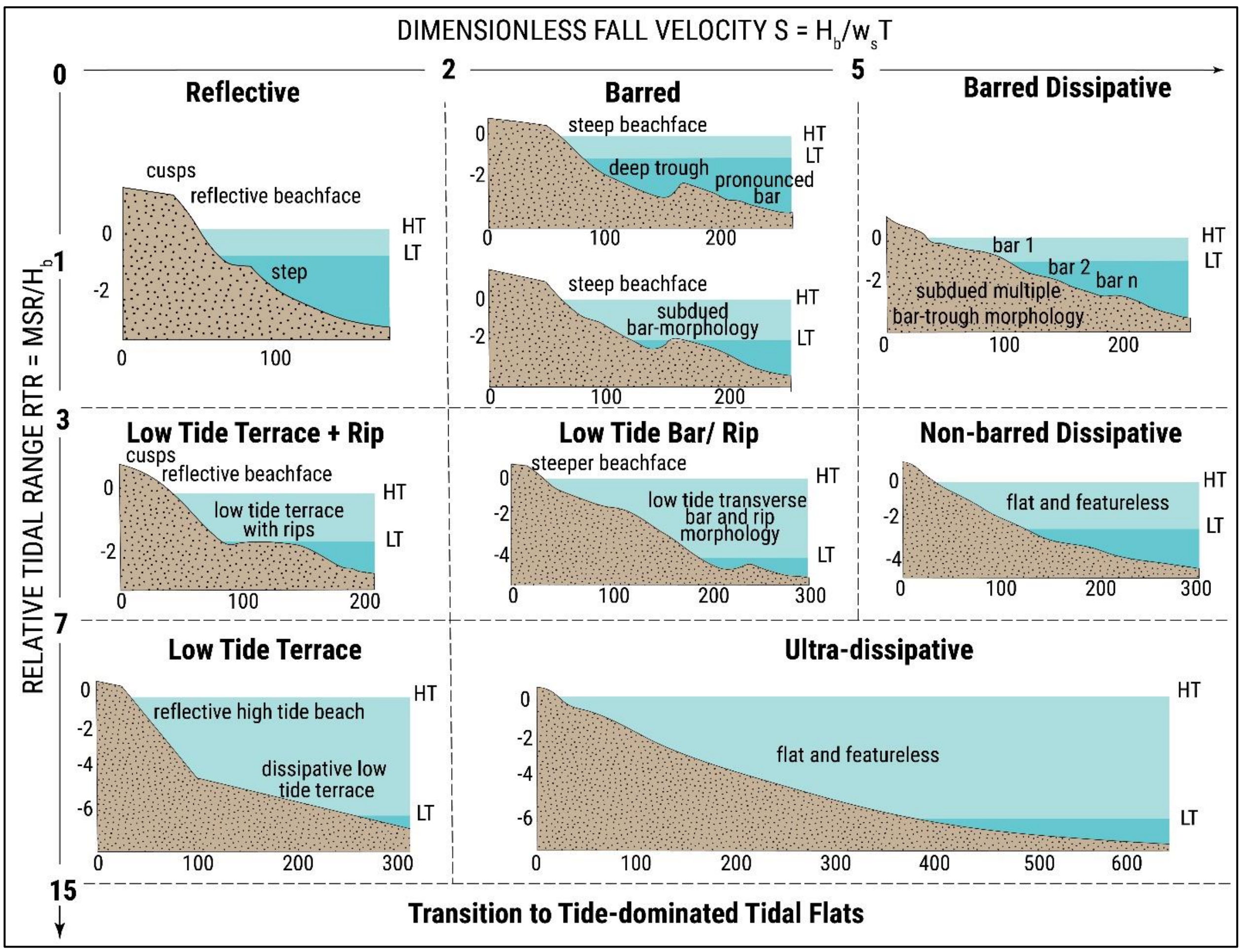

Figure 66 - 5.40: Beach Classification Scheme.
Source: Masselink and Short (1993).

5.1.9 Ambient Air and Noise Quality

Terrestrial - Nearshore

An understanding of the existing air and noise quality in the Kilgwyn Bay area is useful when assessing the potential future impact upon air quality from the proposed hotel construction and operations and the existing state of the air environment in the adjacent community. However, data on air quality in the proposed site is limited due to an absence of onshore air quality monitoring stations. For representative ambient air quality of the current area for the proposed activities a mobile platform without any structures that emit emissions was erected to setup air monitoring equipment upon for both wet and dry season. The recorded levels were used to record and demonstrate the pre-construction and predicted post-construction impacts associated with construction and subsequent operations, but not for the levels currently without any operations, i.e. ambient air quality. With respect to the latter, no ambient air or nor noise monitoring data was collected in the nearshore environment.

Onshore - Terrestrial Environment

Ambient Air

The construction and operation of the hotel will potentially result in reduced air quality in the project area and environs. OptimalGESL in conjunction with Equilibrium Environmental Solutions Ltd conducted an ambient air survey at the hotel site to determine the air quality prior to works, in the event that during construction and operations air monitoring is requested by the EMA.

This section documents the results of the ambient air monitoring to adequately characterize the proposed development area and environs, likely to be impacted by any future resort development activity. The Dry Season study took place from 16th to 17th May 2022, while the Wet Season study took place from 6th to 7th October 2022.

OptimalGESL conducted an Ambient Air Quality Survey for one event at two locations; upwind and downwind of the proposed hotel site. The following ambient air parameters was measured at each site; Total Suspended Solids (TSP), Particulate Matter 2.5 (PM2.5), Particulate Matter 10 (PM10), Volatile Organic Carbon (VOCs), Nitrogen Dioxide (NO2), Sulphur Dioxide (SO2), Carbon Monoxide (CO), using USEPA and ISO recommended methods.

Methodology

The Ambient Air Survey conducted for one event for 24 hours at each site. The 24-hour periods included night-time hours; therefore, each air survey event occurred over two calendar days.

Meteorological measurements were recorded by HOBO U30/NRC Remote Monitoring System, located in the immediate vicinity. All points were marked via GPS and illustrated on a map of the area. **Table 20 - 5-8** and ***Appendix E3.1 - Ambient Air and Noise Quality*** provide details of the methodology adopted for Ambient Air Survey.

Table 20 - 5-8: Summary of Methodology Adopted for Ambient Air Survey.

PARAMTER	METHOD
Ozone (O_3)	PTC SOP - 00197 Monitoring O_3 in the Atmosphere by using BV Labs All-Season Passive Samplers [H. Tang and T. Lau "A New All-Season Passive Sampling System for Monitoring Ozone in Air", Environmental Monitoring and Assessment, 65 (1-2) 129-137, 2000.] Ozone – 8hr as indicated in literature review (appendices)
Carbon Monoxide (CO)	Thermo Electron Model 48, Non-Dispersive Infra-Red Analyzer; US EPA Designation RFCA-0981-054 (Grab sample collection then subsequent off-site analysis)
Particulate Matter of diameters ≤10µm & ≤2.5µm (PM_{10} / $PM_{2.5}$); Total Suspended Particulate (TSP)	Near Federal Reference Low Volume Air Sample Pump capable of achieving 16.7 litres per minute (lpm) flow rate with subsequent gravimetric analysis; Saturation Monitoring as per US EPA 40 CFR part 58; ARA Instruments N-FRM
Meteorological	Onset HOBO U30 Remote Monitoring Station: Relative Humidity, Temperature, Wind Speed, Wind Direction, Rainfall, Atmospheric Pressure

Results and Analysis *(Refer to full report in **Appendix E3.1 - Ambient Air and Noise Quality)***

Meteorological Summary

General wind direction from the dry season to the wet season was east to east-south-east. Predominant trade winds move across the island from a generally easterly direction and the data is in accordance with the general pattern of wind distribution. Sample collection was not impaired by significant adverse weather patterns or large-scale cyclonic events.

Atmospheric Particulates

Across all size fractions (total, ≤10 μm, ≤2.5 μm) particulate contributions to the atmosphere from fugitive and point source releases are comparatively appreciably low across wet and dry seasons.

Gaseous Parameters

Carbon monoxide, primarily emitted as a component of fossil fuel engines (road and non-road) had comparatively low concentrations for the sample period across dry and wet seasons. Low level ozone concentrations, the result of atmospheric interactions of VOCs, with oxides of nitrogen and sunlight, also had comparatively low concentrations for the sample period across dry and wet seasons.

Table 21 - 5-9: Summary of Dry Season Ambient Air Monitoring Data.

	Upwind Tyson Hall	Downwind Old Store	Downwind Crown Point	APR 2014 Short-Term Maximum Permissible	
	µg/m³	µg/m³	µg/m³	µg/m³	averaging time
TSP	20.63	20.74	20.94	150	24 hours
PM_{10}	12.31	12.27	15.43	75	24 hours
$PM_{2.5}$	4.05	4.10	4.01	65	24 hours
Carbon Monoxide (CO)	1718	1718	1718	100,000	15 minutes
Ozone (O_3)	20	24	26	120	8 hours

Table 22 - 5-10: Summary of Wet Season Ambient Air Monitoring Data.

	Upwind Tyson Hall	Downwind Old Store	Downwind Crown Point	APR 2014 Short-Term Maximum Permissible	
	µg/m³	µg/m³	µg/m³	µg/m³	averaging time
TSP	12.38	16.59	16.76	150	24 hours
PM_{10}	12.31	12.27	11.57	75	24 hours
$PM_{2.5}$	4.10	3.94	3.86	65	24 hours
Carbon Monoxide (CO)	1718	1718	1718	100,000	15 minutes
Ozone (O_3)	19	24	22	120	8 hours

Conclusion

The sample sites selected upwind and downwind of the proposed project sites current usage/utilization serve to define baseline conditions pre-construction and pre-operation.

Proposed activities throughout the construction and operational phases of the proposed development should be assessed against the Air Pollution Rules, 2014 to determine impact to community receptors.

Ambient Noise

This section documents the results of the base line noise monitoring to adequately characterize the proposed development area and environs, likely to be impacted by any future resort development activity. Scope of the ambient noise sampling survey;

1. To perform baseline noise monitoring in the vicinity of the proposed study area, in accordance with the Environmental Management Act (EMA) Noise Pollution Control Rules (NPCR), 2001
2. Frequency: Wet Season (weekday + weekend sampling); Dry Season (weekday + weekend sampling)
3. Parameters: Equivalent Continuous Sound Pressure Level (Leq); Instantaneous Unweighted, Peak Sound Pressure Level (Lpeak); Minimum Sound Pressure Level (Lmin); Maximum Sound Pressure Level (Lmax)
4. Follow all measurement protocols stipulated in the Second Schedule of the EMA NPCR, 2001
5. Measurement Interval – 24 hours per sample location
6. Prepare a Report in accordance with the Third Schedule of the EMA NPR 2001

Meteorological measurements were recorded by HOBO U30/NRC Remote Monitoring System, located in the immediate vicinity.

Methodology

A Quest Technologies Model Sound Pro DL: Type 1/2 integrating – averaging sound level meter was deployed. Its measurement range (20 – 140 dB) was adjusted after powering on to suit ambient noise conditions. This instrument conforms to the requirements as stipulated in the ANSI S1.4-1983, IEC 651-1979, IEC 804-1985 standards. It can determine unweighted sound pressure levels (linear response) or “LEQs” as well as peak time weighted characteristic or “LPEAK” as specified in IEC 651-1979.

Field calibration took place prior to measurement via the use of a Quest Technologies AC-300 single frequency acoustic calibrator, specifically designed for the calibration of type 2 meters.

The instrument was set at an exchange rate of 3 dB; on a “Fast” response and “A-weighted” frequency response for measuring the equivalent sound level; on the “PEAK” response and “Linear” frequency (unweighted) characteristic to determine the peak sound pressure level.

The instrument was shielded from rain within the confines of a specifically designed environmental enclosure and fitted with a manufacturer-supplied windscreen. The microphone was oriented towards the noise source at a height of 1.5 m above the ground away from any building or facade.

The period of measurement will be 24 hours per location. Three locations were selected;

1. Upwind – Tyson Hall
2. Downwind – Store Bay Local Road
3. Downwind – Crown Point

Site selection justification is further discussed in ***Appendix E3 - Ambient Air and Noise Quality)***

Results and Analysis (*Refer to full report in* ***Appendix E3.2 - Ambient Air and Noise Quality)***

Baseline LEQ ranges were as follows:

- Tyson Hall – 44.0db(A) to 54.8dB(A)
- Old Store Bay Road – 56.8 dB(A) to 60.6 dB(A)
- Crown Point – 44.9 dB(A) to 53.9 dB(A)

Baseline LPEAK ranges were as follows:

- Tyson Hall – 95.6 dB to 109.6 Db
- Old Store Bay Road – 99.6 dB to 118.9 dB
- Crown Point – 94.8 dB to 111.6 dB

Baseline LMAX ranges were as follows:

- Tyson Hall – 72.8 db(A) to 99.4 dB(A)
- Old Store Bay Road – 77.7 dB(A) to 106.0 dB(A)
- Crown Point – 72.7 dB(A) to 93.7 dB(A)

Baseline LMIN ranges were as follows:

- Tyson Hall – 33.9 db(A) to 44.7 dB(A)
- Old Store Bay Road – 44.7 dB(A) to 45.2 dB(A)
- Crown Point – 41.3 dB(A) to 44.7 dB(A)

Conclusion

Proposed activities throughout the construction and operational phases of the proposed development should be assessed against the Noise Pollution Control Rules, 2001 Zone 3 General Areas limits (*Refer to* ***Appendix E3 - Ambient Air and Noise Quality*** for disturbance to community receptors.

Sample Locations

Refer to **Table 23 - 5-11** and **Figure 67 - 5.41** below.

Table 23 - 5-11: Air and Noise Monitoring Locations.

Sample Location	UTM Coordinates	
1	739299	Upwind – Tyson Hall
	1233460	
2	738063	Downwind – Old Store Road
	1233750	
3	737359	Downwind – Crown Point
	1233514	

Figure 67 - 5.41: Southwest Tobago Depicting Study Area (Blue) in Relation to Air and Noise Monitoring/Sample Locations Upwind and Downwind of Proposed Kilgwyn Bay Hotel Site.

Figure 68 - 5.42: Air Monitoring Sample Stations; Old Store Bay Road Sample Point (Left image), Tyson Hall Sample Point (Center image) and Crown Point Sample Point (Right-image).

Figure 69 - 5.43: Noise Monitoring Sample Stations; Old Store Bay Road Sample Point (Left image), Crown Point Sample Point (Center image) and Tyson Hall Sample Point (Right-image).

5.1.10 Surface Water and Sediment Quality

5.1.10.1 Marine Water and Sediment Quality

OptimalGESL conducted the proposed water and sediment surveys during the dry season (March/April 2022) and wet season (September/October 2022) sampling events.

Marine Sediment Survey

The seabed survey conducted by sampling surficial sediment at each of the chosen environmental stations. Four sediment grabs were taken at each station. For each sediment grab an open 0.19 m^2 van Veen Sediment grab was lowered to the seabed using the vessel's winch. The grab was triggered by contact with the seabed and sampled the surface sediment in its claws. The grab was then winched back on board the survey vessel. The grab was opened from the top and sediment scooped out.

One of the sediment grab samples taken was analysed for sediment quality. The sediment was placed in sterile storage jars onsite and stored on ice until delivery to BV Laboratories who are sub-contracted to conduct the chemical analysis on the sediment samples (Refer to Attachment 3 for Company Profile). The following analyses were be done on the samples:

- Total and Bioavailable: aluminum, arsenic, barium, cadmium, chromium, copper, iron, mercury, nickel, lead, vanadium, zinc. Two sub-samples (500 g) will be taken for Bioavailable Metals analysis to be undertaken by Kaizen Laboratories, Calgary, Canada
- Organics: Total petroleum hydrocarbons and polycyclic aromatic hydrocarbons.

A second sediment grab was taken for the benthic analysis. These were analysed by Biosphere Limited. The sediment was placed in plastic bags and delivered to the Biosphere Laboratory. The chain of custody forms were completed. Three grabs provided three samples to be washed through a 0.5 mm^2 sieve bucket and all benthic organisms retained were preserved in a 10% formalin buffered seawater solution. Additionally, the organisms were stained using a proteinaceous dye (Rose Bengal) and securely stored in plastic containers for transport to the laboratory.

Marine Water Quality Survey

OptimalGESL collected water samples at the proposed stations using 10L Nisken Water Samplers deployed over the side of the survey vessel while on station. The samplers were attached to the deployment line and triggered when they are at the appropriate depths using trigger messengers sent down the deployment line from the ship. Water samples were taken at two depths: Surface (1 m below surface) and Bottom (1.5 m above seabed). The samples were chemically fixed and stored at 4°C in coolers on board until delivery to BV Laboratories who will be sub-contracted to conduct the chemical analysis on the samples. The following water quality analyses were conducted on each sample:

- Total Suspended Solids (TSS), COD, Total Nitrogen, Total Phosphorus;
- Total Petroleum Hydrocarbons, BTEX, PAHs;
- Total Metals (Barium, Cadmium, Chromium, Copper, Mercury, Nickel, Lead, Vanadium and Zinc)

At the water sampling stations, a Conductivity, Temperature, and Density (CTD) probe, MIDAS CTD+, will be lowered over the side of the vessel.

Storage of samples

During the survey the sediment samples were stored in bags and jars within coolers. The coolers were strapped down on the vessel. The bottles chosen for each parameter met the test method requirements to ensure the validity of the samples. All sample containers were properly labeled with a waterproof marker prior to sampling and accompanied by all the appropriate chain-of-custody documentation. Containers were labeled on their sides in addition to or instead of labeling the lids. Each label included, at a minimum, the study title, station location and/or sample identification, date and time of collection, sample type, and name of collector.

Table 24 - 5-12: Bottle Requirement for The Various Parameters.

Parameters	Container Type
pH	125 mL plastic
Total Oil & Grease	250mL Glass, amber with Teflon lined cap
Total Petroleum Hydrocarbons	
Benzene, Toluene, Ethylbenzene and Xylenes (BTEX)	125 mL Glass with septum lid
Polycyclic Aromatic Hydrocarbons (PAHs)	250 mL Glass with Teflon-lined lid
Total and Bioavailable Metals	250 mL Glass with Teflon-lined lid
Mercury	

The water samples were stored at 4˚C using ice and coolers. After all samples were collected, the samples were preserved observing USEPA guidelines (**Table 25 - 5-13**).

Table 25 - 5-13: USEPA Storage Guidelines.

Parameters	Min. Sample Volume	Container Type	Handling, Storage Conditions, and/or Preservation Method	Holding Time
Chemical Oxygen Demand	500 mL	Glass/plastic	Cool, ≤6° C18, H_2SO_4 to pH<2	28 days
Total Oil & Grease Total Petroleum Hydrocarbons	1 L	Glass, amber with Teflon lined caps	H_2SO_4 to pH<2, refrigeration	28 days
Benzene, Toluene, Ethylbenzene, and Xylene	50 mL	Amber glass vial, with septum cap, Teflon lined	Refrigerate to <6˚C but not <1˚C (no headspace)	7 days
Polycyclic Aromatic Hydrocarbons	1 L	Glass, amber with Teflon lined caps	H_2SO_4 to pH<2, refrigeration	7 days
Total Metals	250 mL	Glass, amber with Teflon lined caps	Acidify to <2 pH with HNO_3	6 months
			Cool, 4°C, H_2SO_4 to pH<2	
Mercury				28 days
Total nitrogen			Cool, 4°C, H_2SO_4 to pH<2	28 days
Total phosphorus				
E. Coli	250 mL	Glass with Teflon lined caps	Cool, 4°C	6 hours

5.1.10.2 Onshore Water Quality Survey

The onshore water quality survey was conducted within the mangrove and bounding drainage areas using seven stations. At each station, water samples were retrieved utilizing a peristaltic pump, as some of the pooling water were shallow (less than one meter during the dry season). The terrestrial sampling was done on the first day.

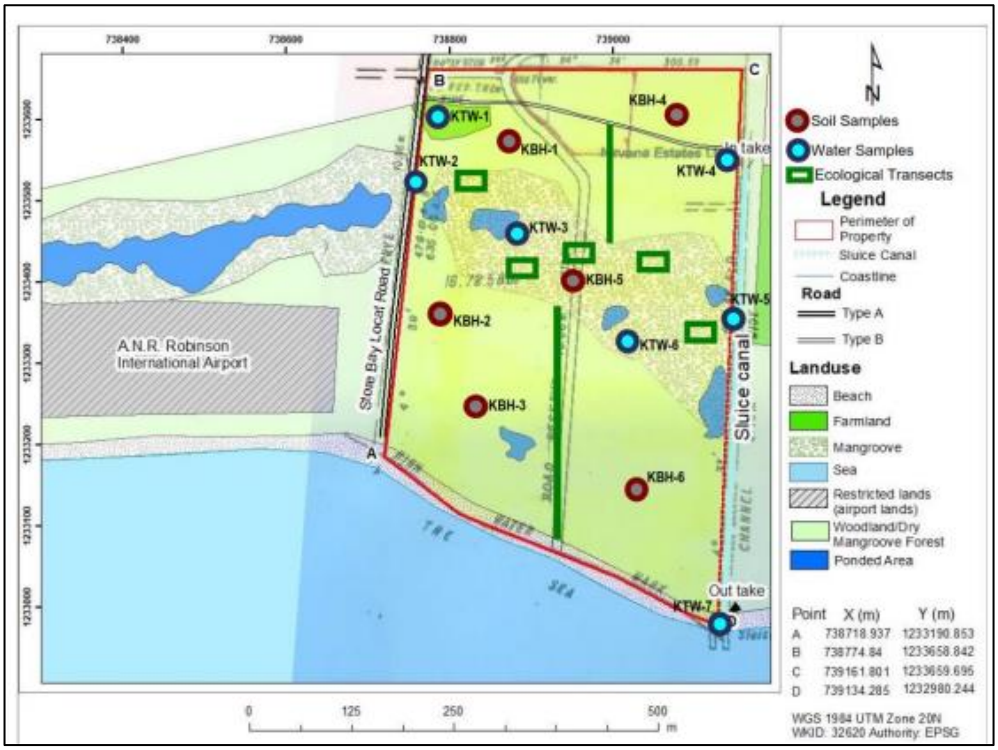

Figure 70 - 5.44: Terrestrial Sample Stations in Blue (N=7).

Physical Water Quality

YSI EXO W multiparameter sonde was submerged at each sample location and left for 1 minute to acclimatize, then three readings were taken. The average of these values was then calculated. The following parameters were measured: pH, temperature, salinity, TDS and dissolved oxygen.

Chemical Water Quality

Samples were collected using a geometric pump. Each sample bottle was filled, then preserved using to pH <2.0. These samples were kept on ice until delivery to BV Laboratories for analyses. The following parameters will be analysed:

Organics: TSS, COD, TPH, LC50 (toxicity), total nitrogen, total phosphorus, BTEX and PAHs

Total and bioavailable metals: arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel and zinc.

Figure 71 - 5.45: YSI Probe Used to Determine Ambient Water Quality.

5.1.10.3 Onshore Sediment/Soil Quality Survey

The onshore soil/sediment quality survey occurred within the mangrove and bounding drainage areas at six stations (upstream and downstream, after a reconnaissance OptimalGESL determined if less/more stations were required. Soil samples were taken using a motorised Auger. One of the samples was taken at 1-foot depth and another at 3 feet depth and will be analysed for sediment quality. The sediment was placed in sterile storage jars onsite and stored on ice until delivery to BV Laboratories who were sub-contracted to conduct the chemical analysis on the sediment samples (Refer to Attachment 3 for Company Profile). The following analyses will be done on the samples:

- Total and Bioavailable): aluminum, arsenic, barium, cadmium, chromium, copper, iron, mercury, nickel, lead, vanadium, zinc. Two sub-samples (500 g) will be taken for Bioavailable Metals analysis to be undertaken by Kaizen Laboratories, Calgary, Canada
- Organics: Total petroleum hydrocarbons and polycyclic aromatic hydrocarbons.

5.1.10.4 Ambient Water Quality

This section will examine the sources, fate and potential effects of the existing ambient environment and activities in the Kilgwyn Bay and surrounding areas. There are two main systems: 1) terrestrial and 2) coastal and marine.

The terrestrial system

The terrestrial portion of the study area comprises a unique mixture of mangrove forest, upland basin forest, and disturbed estuarine environment. The basin forest is approximately 0.12 km^2 (Juman and Hassanali, 2013). The mangrove forest forms part of the wider study area. It is found behind a beach berm approximately 7-m wide and it is dominated by *L. racemosa*, with fewer *A. germinans* and *R. mangle* found along the berm. Most of this wetland is not flooded by tides, as inland water within the basin is impounded. There are no functional channels/outlets to the sea and there is minimal groundwater saltwater intrusion.

The sampling plan comprised of: 7 surface water samples (KTW) and 6 soil samples (KBH). These samples were all collected between March 27th and March 29th, 2022.

Tables 26 - 5-14 to **30 - 5-18** illustrate the results obtained for samples collected on March 27th, 2022. A combination of the Environmental Management Authority Water Pollution Rules, 2019 (WPR, 2019) and Florida Departmental of Environmental Protection (FDEP) surface water criteria (where no guidelines from WPR, 2019) were utilized in determining the current state of the environment.

Nutrients

Chemical Oxygen Demand (COD) gives a baseline indication if there is organic nutrient loading, as bio-chemical oxygen demand (BOD) is usually between one-third and two-thirds the amount of oxygen required in an aerobic system to fully oxidize biologically available carbon to carbon dioxide and water. During the dry season, sites KTW-1 through KTW-3 met the COD WPR, 2019 guideline for coastal areas; However, the terrestrial sites (KTW-4 – KTW-7) exceeded the WPR, 2019 guideline for coastal areas of 250.0 mg/ L (**Table 26 - 5-14**). The sampling sites of concern are all on the eastern side of the property, along the unmanaged sluice gate and south of the residential and agricultural areas outside the study area.

The COD results for all terrestrial sampling stations met regulatory guidelines during the wet season (<250.0 mg/ L) and were very statistically significantly less than the dry season ($p < 0.01, t = 3.39, df = 12$).

Nitrogen and phosphorus are the macronutrients that facilitate algal and plant growth. In high amounts (>5.0 mg/L), it contributes to a high eutrophication potential. The total nitrogen measure comprises all the species of nitrogen (ammonia, nitrites, nitrates) and gives a good indication of present bioavailable nitrogen and potential nutrient loading, as some nitrogen may be only available after biological decomposition. Nitrogen also increases the oxygen demand as microorganism utilize nitrogen sources as carbonaceous BOD is preferentially utilized. All terrestrial water sites were below the FDEP regulatory freshwater surface water guidelines (<5.0 mg/L) and were at quantities that did not warrant immediate concern. There were no significant differences between the dry and wet seasons.

Enterococci is used as the most common reference species to indicate fecal contamination of water sources. It also facilities environmental scientists the ability to discern sources of organic nutrient pollution and determine if there the area has high amounts of untreated wastewater in the study area. As outlined above, the sites KTW-4 – KTW-7 exceeded regulatory limits. The WPR, 2019 guidelines for COD. This coupled with high *Enterococci* colony counts at all sites (>35 colonies/ 100 mL) especially at sites KTW-3 through KTW-5 suggest that there is untreated municipal wastewater entering the site and increasing the COD along the eastern property boundary sluice gate.

With reference to **Tables 26 – 5-14** to **52 – 5-40** presented below, the values highlighted in red have surpassed permissible limits whereas the values highlighted in green are within said limits.

Table 26 - 5-14: Nutrients at Water Sampling Locations.

		UNITS	FDEP Regulatory guideline (mg/L)	**KTW-1 mean**	**KTW-2 mean**	**KTW-3 mean**	**KTW-4 mean**	**KTW-5 mean**	**KTW-6 mean**	**KTW-7 mean**
Dry season	Chemical Oxygen Demand	mg/L	250.0	50	206	231.5	374.5	607	267.5	262.5
	Total Phosphorus (P)	mg/L	5.0	1.485	<0.15	<0.15	0.515	0.25	0.26	0.15
	Total Nitrogen (N)	mg/L	5.0	2.27	2.31	2.75	4.80	4.94	4.12	3.39
Wet season	Chemical Oxygen Demand	mg/L	250.0	37	67	87	50	67	87	54
	Total Phosphorus (P)	mg/L	5.0	0.41	-	0.15	0.20	0.23	0.24	-
	Total Nitrogen (N)	mg/L	5.0	1.34	-	1.57	1.61	1.73	1.56	-

Table 27 - 5-15: *Enterococci* Colonies from Water Sampling Locations.

Season	UNITS	WPR Regulatory guideline (cfu/ mL)	**KTW-1 mean**	**KTW-2 mean**	**KTW-3 mean**	**KTW-4 mean**	**KTW-5 mean**	**KTW-6 mean**	**KTW-7 mean**
Dry	colonies	< 35 enterococci/100 mL	400	1100	3000	11200	100	4100	1000
Wet			4	5	0	7	0	0	0

5.1.10.5 Hydrocarbons and Polyaromatic Hydrocarbons in Surface Water of the Terrestrial Environment

The total oil and grease parameter comprises dissolved and dispersed liquid hydrocarbons and organic compounds. It gives a good indication of domestic and industrial sources of pollution that may enter a receiving waterbody. All of the terrestrial sites were below the WPR nearshore regulatory limit (15.0 mg/L) for both the wet and dry seasons. The highest PAHs (7.1 mg/ L) were found at KTW-2. These results coupled with moderately low PAH values suggest that most of the COD amount is bioavailable and non-petroleum in nature.

The total PAH exceeded FDEP surface waters guidelines at most terrestrial sites (KTW-1, KTW-2, KTW-4, KTW-6 and KTW-7). KTW-3 and KTW-5 were below the minimum detection limit, and it cannot be deduced if the PAH levels are below the FDEP surface water guideline. Conversely, all sites met regulatory guidelines for Total PAHs.

At site KTW-1, 28% of the tested polycyclic aromatics did not meet Alberta 1 surface water guidelines. These included: Acenaphthylene, Phenanthrene, Fluoranthene, Pyrene and Benzo(a)anthracene. This sampling location was approximately 300 meters from Crown Point Airport runway and would be highly influenced by the storage and combustion of fuel in proximity. This was the only site that had several polycyclic aromatics not meeting regulatory standards.

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Table 28 - 5-16: Polyaromatic Hydrocarbons (PAH) at the Water Sampling Stations.

		UNITS	FDEP freshwater surface regulatory guideline (µg/L)	**KTW-1 mean**	**KTW-2 mean**	**KTW-3 mean**	**KTW-4 mean**	**KTW-5 mean**	**KTW-6 mean**	**KTW-7 mean**
Dry Season	Low MW PAH`s	µg/L	NQ	6.25	0.24	<0.10	0.495	<0.10	2.15	2.75
	High MW PAH`s	µg/L	NQ	0.27	<0.05	<0.050	<0.050	<0.050	0.16	<0.05
	Total PAH	µg/L	0.031	6.275	0.24	<0.10	0.45	<0.10	2.3	2.75
Wet Season	Low MW PAH`s	µg/L	NQ	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	High MW PAH`s	µg/L	NQ	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Total PAH	µg/L	0.031	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

MW- molecular weight

Table 29 - 5-17: Total Oil and Grease at Water Sampling Locations.

	UNITS	**Regulatory guideline (mg/L)**	**KTW-1 mean**	**KTW-2 mean**	**KTW-3 mean**	**KTW-4 mean**	**KTW-5 mean**	**KTW-6 mean**	**KTW-7 mean**
Wet season	mg/L	15.0	<1.0	7.1	-	1.05	1.05	<1.0	<1.0
Dry season			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table 30 - 5-18: Polycyclic Aromatics Noted in the Water Samples During the Dry Season.

	Polycyclic Aromatics	UNITS	Alberta I / FDEP surface water guidelines	KTW-1 mean	KTW-2 mean	KTW-3 mean	KTW-4 mean	KTW-5 mean	KTW-6 mean	KTW-7
Dry season	Quinoline	ug/L	3.4	<0.85	0.057	<0.020	0.342	0.06	0.09	0.16
	Naphthalene	ug/L	1.0	0.47	<0.10	<0.10	0.18	<0.10	0.36	0.45
	1-Methylnaphthalene	ug/L	95.0	3.8	0.084	<0.050	0.16	<0.050	0.65	0.81
	2-Methylnaphthalene	ug/L	30.0	3.2	0.1	<0.10	0.21	<0.10	0.80	1.15
	Acenaphthylene	ug/L	0.03	0.079	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthene	ug/L	3.00	0.26	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene	ug/L	30.00	1.7	<0.050	<0.050	<0.050	<0.050	0.13	0.115
	Phenanthrene	ug/L	0.4	2.00	<0.050	<0.050	<0.050	<0.050	0.31	0.0925
	Anthracene	ug/L	0.012	0.064	<0.010	<0.010	<0.010	<0.010	0.01	<0.010
	Acridine	ug/L	4.4	0.14	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene	ug/L	0.04	0.073	<0.020	<0.020	<0.020	<0.020	0.03	<0.020
	Pyrene	ug/L	0.03	0.15	<0.020	<0.020	<0.020	<0.020	0.05	<0.020
	Benzo(a)anthracene	ug/L	0.02	0.031	<0.010	<0.010	<0.010	<0.010	0.07	<0.010
	Chrysene	ug/L	NQ	0.21	<0.020	<0.020	<0.020	<0.020	0.07	<0.020
	Benzo(b&j)fluoranthene	ug/L	0.04	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
	Benzo(k)fluoranthene	ug/L	NQ	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene	ug/L	0.03	0.021	<0.0050	<0.0050	<0.0050	<0.0050	0.01	<0.0050
	Indeno(1,2,3-cd)pyrene	ug/L	62-302**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene	ug/L	62-302**	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
	Benzo(g,h,i)perylene	ug/L	62-302**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Table 31 - 5-19: Polycyclic Aromatics Noted in the Water Samples During the Wet Season.

	Polycyclic Aromatics	UNITS	Alberta I surface water guidelines	KTW-1 mean	KTW-2 mean	KTW-3 mean	KTW-4 mean	KTW-5 mean	KTW-6 mean	KTW-7
Wet season	Quinoline	ug/L	3.4	<0.020	0.024	0.022	<0.020	<0.020	<0.020	<0.020
	Naphthalene	ug/L	1.0	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	1-Methylnaphthalene	ug/L	95.0	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene	ug/L	30.0	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	Acenaphthylene	ug/L	0.03	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthene	ug/L	3.00	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene	ug/L	30.00	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene	ug/L	0.4	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene	ug/L	0.012	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Acridine	ug/L	4.4	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene	ug/L	0.04	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
	Pyrene	ug/L	0.03	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
	Benzo(a)anthracene	ug/L	0.02	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Chrysene	ug/L	NQ	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
	Benzo(b&j)fluoranthene	ug/L	0.04	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
	Benzo(k)fluoranthene	ug/L	NQ	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene	ug/L	0.03	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Indeno(1,2,3-cd)pyrene	ug/L	62-302**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene	ug/L	62-302**	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
	Benzo(g,h,i)perylene	ug/L	62-302**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

5.1.10.6 Total Metals in the Terrestrial Surface Water Samples

Most heavy metals occur naturally in the ambient physical environment. However, through human activities, these can be mobilized and become more bioavailable and cause deleterious effects to human and ecological effects, as it is a neurotoxin. **Table 5-21** results show that all of the total metals were all below the regulatory limits of WPR, 2019 for both the wet and dry seasons and there was no significant difference between the seasons.

Table 32 - 5-20: Total Mercury in Terrestrial Sampling Locations.

	UNITS	FDEP 2005 criteria	KTW-1 mean	KTW-2 mean	KTW-3 mean	KTW-4 mean	KTW-5 mean	KTW-6 MEAN	KTW-7-MEAN
Total Mercury (Hg) Dry	ug/L	0.18	0.0040	0.0118	0.0053	0.0042	<0.019	0.0023	0.0036
Total Mercury (Hg) Wet	ug/L	0.18	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019

Table 33 - 5-21: Total Metals in Terrestrial Sampling Locations for Both Dry and Wet Seasons.

Season		UNITS	WPR 2019 Schedule II (µg/L)	KTW-1 mean	KTW-2 mean	KTW-3 mean	KTW-4 mean	KTW-5 mean	KTW-6 mean	KTW-7 mean
Dry season	Total Arsenic (As)	ug/L	100	3.105	2.42	1.92	5.585	3.495	1.97	1.96
	Total Barium (Ba)	ug/L	NQ	35.6		31.65	106.5	153	32.3	49.9
	Total Cadmium (Cd)	ug/L	100	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
	Total Chromium (Cr)	ug/L	500	1.325	<0.050	0.7	2.785	2.82	<0.50	0.675
	Total Copper (Cu)	ug/L	500	4.38	1.32	0.61	1.125	0.89	0.675	6.84
	Total Iron (Fe)	ug/L	3500	818	56	28	462.5	342	42.5	35.5
	Total Lead (Pb)	ug/L	100	1.3	0.155	0.16	0.33	0.17	0.14	0.225
	Total Vanadium (V)	ug/L	NQ	<10	<10	<10	<10	<10	<10	<10
	Total Zinc (Zn)	ug/L	2000	12.4	<5.0	<5.0	5.35	<5.0	5	5.6
Wet Season	Total Arsenic (As)	ug/L	100	3.35	1.495	1.20	3.44	2.24	1.37	2.09

	Total Barium (Ba)	**ug/L**	**NQ**	**26.80**	**10.65**	**10.05**	**43.1**	**22.00**	**7.60**	**17.90**
	Total Cadmium (Cd)	**ug/L**	**100**	**<0.050**	**<0.050**	**<0.050**	**<0.050**	**<0.050**	**<0.050**	**<0.050**
	Total Chromium (Cr)	**ug/L**	**500**	**<0.50**	**0.63**	**1.02**	**0.56**	**<0.050**	**<0.50**	**<0.50**
	Total Copper (Cu)	**ug/L**	**500**	**1.56**	**0.76**	**0.65**	**0.855**	**<0.050**	**<0.55**	**0.58**
	Total Iron (Fe)	**ug/L**	**3500**	**268.50**	**248**	**80.50**	**577.5**	**399.50**	**76.00**	**274.50**
	Total Lead (Pb)	**ug/L**	**100**	**0.23**	**0.135**	**0.15**	**0.17**	**0.12**	**0.16**	**0.14**
	Total Vanadium (V)	**ug/L**	**NQ**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**
	Total Zinc (Zn)	**ug/L**	**2000**	**9.00**	**<5.0**	**<5.0**	**11**	**6.20**	**8.90**	**<5.0**

5.1.10.7 Characterization of Terrestrial Soils

Geology and Geomorphology

The pH of the soils at all sites were alkaline and varied between 8.31 and 8.95. These levels should not present any immediate short- or long-term problems. The natural, underground clastic and carbonate sedimentary rock was responsible for the alkaline soils.

COD in soils is governed by several factors including soil types, vegetation, drainage, and land use. Wetlands facilitate the accumulation of water and organics. The COD was high for all sites (>250mg/ kg). This is not very surprising as much of the area is vegetated with secondary forested cover with some area being continuously inundated with water. The soils are rich in organic matter. This also positively influences the amount of moisture. Sites moisture content ranged between 9.8- and 32%. Despite having high COD values, the system remain oligotrophic as total phosphorus levels are between 0.0 mg/ kg and 0.1 mg/ kg and total nitrogen levels for all sites are less than 1.0 mg/kg. The total oil and grease were highly variable and varied between <100 µg/ g and 900 µg/ g (KBH-5). Total oil and grease were more variable (<100 and 900 µg/g) in the dry season than in the wet season (<100 and 160 µg/g). The total organic carbon was slightly higher at some sites than others. These differences were not significantly different (t= 2.0106, df=10, p-value = 0.0721).

Table 34 - 5-22: PH Values of Terrestrial Samples.

Physical Properties	**Acceptable range**	**KBH-1**	**KBH-2**	**KBH-3**	**KBH-4**	**KBH-5**	**KBH-6**
Soluble (2:1) pH	6.0 - 9.0	8.31	8.89	8.78	8.71	8.67	8.95

5.1.10.8 Hydrocarbons and Polyaromatics in Terrestrial Soils

Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that occur naturally in coal and petroleum-based products such as crude oil, and gasoline. PAH soil levels were highest at KBH-1 and KBH-4, the northern sample points of the property and is consistent with the points high in total metals. Airport emissions and illegal solid waste disposal are likely to be the chief sources. Most of the total PAH at sample point KBH-4 comprised of low PAHs and serves as a pollutant sink as the adjacent drains enter this mangrove and herbaceous system.

Table 35 - 5-23: Total Oil and Grease at Terrestrial Sampling Locations.

	GUIDELINES	UNITS	Season	KBH-1	KBH-2	KBH-3	KBH-4	KBH-5	KBH-6
Total Oil and grease	NQ	ug/g	Dry	<100	<100	120	<100	900	<100
			Wet	160	100	<100	<100	<100	<100

Table 36 - 5-24: TOC (%) at Terrestrial Soil Sample Sites.

Season	EPA screening guideline	KBH-1	KBH-2	KBH-3	KBH-4	KBH-5	KBH-6
Dry	NQ	0.91	0.210	0.050	0.280	0.62	0.49
Wet		1.15	2.34	2.25	<0.04	1.24	0.40

5.1.10.9 Metals in Terrestrial Soils

The northwestern edge of the property (KBH-1) soil has the highest levels of total metals. The levels of arsenic, chromium, cadmium, copper and lead all exceeded USEPA screening guidelines. This sampling location is approximately 303.6 meters from the airport. The airport will be a source of metals as these are used in flame retardants and combustion emissions from jet fuel. In addition, illegal dumping of electrical items and car batteries by adjacent communities may also contribute to the observed levels. Although the total metals quantities are of concern for the ambient environment, it is reassuring that the observed bioavailable metals were all below the screening levels (**Table 37 - 5-25**).

As previously mentioned, heavy metals care naturally occurring. However, high levels in the ambient environment can cause deleterious effects. Total cadmium and mercury were all under the USEPA screening guidelines and therefore cause no immediate cause for concern. Although, Chromium is considered a nutritional element and therefore in limited quantities, there will be health and environmental benefits of chromium present. The levels observed throughput the study site exceeded the suggested USEPA guidelines. This suggests that there is reason for concern and caution should be observed.

25 of the regulated total metals did not meet USEPA screening regulatory guidelines during the dry season, whilst 39% of the regulated total metals did not meet USEPA screening regulatory guidelines during the wet season (**Table 38 - 5-26**).

Table 37 - 5-25: Total Metals in Terrestrial Soil Samples.

Season	Metal	UNITS	EPA screening limit	KBH-1	KBH-2	KBH-3	KBH-4	KBH-5	KBH-6
Dry	Total Arsenic (As)	mg/kg	7.24	14.5	3.68	2.69	9.49	3.35	3.56
	Total Barium (Ba)	mg/kg	NQ	37.6	5.24	15.1	38.6	7.98	6.24
	Total Cadmium (Cd)	mg/kg	0.68	0.253	0.090	0.080	0.184	0.237	0.099
	Total Chromium (Cr)	mg/kg	0.0083	29.0	5.30	6.05	28.6	7.67	6.86
	Total Copper (Cu)	mg/kg	18.7	46.8	<0.50	2.78	8.51	1.09	0.57
	Total Iron (Fe)	mg/kg	NQ	34400	2030	2280	24000	1790	1690
	Total Lead (Pb)	mg/kg	30.2	129	1.22	1.93	7.18	4.44	1.73
	Total Mercury (Hg)	mg/kg	0.13	0.083	<0.050	<0.050	<0.050	<0.050	<0.050
	Total Vanadium (V)	mg/kg	NQ	57.1	6.2	7.4	41.3	4.4	4.0
	Total Zinc (Zn)	mg/kg	NQ	84.2	2.6	4.5	42.5	3.6	4.0
Wet	Total Arsenic (As)	mg/kg	7.24	10.0	14.9	2.12	6.53	15.0	2.20
	Total Barium (Ba)	mg/kg	NQ	49.0	210	6.91	33.8	40.9	6.55
	Total Cadmium (Cd)	mg/kg	0.68	0.304	0.254	0.120	0.138	0.353	0.091
	Total Chromium (Cr)	mg/kg	0.0083	27.8	58.9	7.64	25.5	48.7	4.81
	Total Copper (Cu)	mg/kg	18.7	231	99.5	2.85	7.92	39.8	0.74
	Total Iron (Fe)	mg/kg	NQ	20900	42900	2910	13900	24600	1390
	Total Lead (Pb)	mg/kg	30.2	284	50.9	3.28	5.06	14.0	1.64
	Total Mercury (Hg)	mg/kg	0.13	0.060	0.075	<0.050	<0.050	<0.050	<0.050
	Total Vanadium (V)	mg/kg	NQ	46.4	164	8.9	29.9	58.2	3.2
	Total Zinc (Zn)	mg/kg	NQ	88.3	92.6	7.9	23.8	67.8	3.0

Table 38 - 5-26: Dry and Wet Season Total Metals in Terrestrial Soil Samples.

		UNITS	EPA screening guideline	KBH-1	KBH-2	KBH-3	KBH-4	KBH-5	KBH-6
Dry season									
	Bioavailable Arsenic (As)	mg/kg	7.24	0.015	0.210	0.050	0.009	0.019	0.030
	Bioavailable Barium (Ba)	mg/kg	NQ	1.502	0.018	0.023	1.740	1.720	1.430
	Bioavailable Cadmium (Cd)	mg/kg	0.68	0.009	0.083	<0.003	0.559	<0.003	<0.003
	Bioavailable Chromium (Cr)	mg/kg	0.0083	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Bioavailable Copper (Cu)	mg/kg	18.7	-	-	-	-	-	-
	Bioavailable Iron (Fe)	mg/kg	NQ	12.52	5.88	9.82	2.10	3.48	27.40
	Bioavailable Lead (Pb)	mg/kg	30.2	9.007	0.071	0.049	0.051	0.206	0.171
	Bioavailable Mercury (Hg)	mg/kg	0.13	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Bioavailable Vanadium (V)	mg/kg	NQ	<0.01	0.075	0.123	<0.01	0.0238	0.12
	Bioavailable Zinc (Zn)	mg/kg	NQ	<0.700	<0.700	<0.700	<0.700	<0.700	<0.700
Wet season									
	Bioavailable Arsenic (As)	mg/kg	7.24	0.01582	0.01794	0.02314	<0.004	0.01158	0.01944
	Bioavailable Barium (Ba)	mg/kg	NQ	0.2526	0.4826	0.3252	0.3358	0.3210	0.3220
	Bioavailable Cadmium (Cd)	mg/kg	0.68	0.00656	0.0097	<0.00300	<0.00300	0.01332	<0.00300
	Bioavailable Chromium (Cr)	mg/kg	0.0083	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500
	Bioavailable Copper (Cu)	mg/kg	18.7	7.648	1.0254	0.2316	<0.0600	0.9538	<0.0600
	Bioavailable Iron (Fe)	mg/kg	NQ	7.20	3.68	110.80	<0.400	3.78	39.6
	Bioavailable Lead (Pb)	mg/kg	30.2	9.4136	7.6628	0.93600	0.8428	0.3536	0.18202
	Bioavailable Mercury (Hg)	mg/kg	0.13	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
	Bioavailable Vanadium (V)	mg/kg	NQ	0.3090	0.1712	0.3490	<0.0100	0.1506	0.1540
	Bioavailable Zinc (Zn)	mg/kg	NQ	<0.700	<0.700	<0.700	<0.700	2.38	<0.700

Table 39 - 5-27: Moisture % in Terrestrial Soil Samples.

	UNITS	KBH-1	KBH-2	KBH-3	KBH-4	KBH-5	KBH-6
Moisture	%	28	32	24	9.8	33	25

Table 40 - 5-28: Calculated Parameters in Terrestrial Soil Samples.

	UNITS	EPA Sediment benchmark	KBH-1	KBH-2	KBH-3	KBH-4	KBH-5	KBH-6
Calculated Parameters								
Low Molecular Weight PAH`s	mg/kg	0.31	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
High Molecular Weight PAH`s	mg/kg	0.66	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total PAH	mg/kg	2.90	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Polycyclic Aromatics								
Quinoline	mg/kg	NQ	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Naphthalene	mg/kg	0.03	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
1-Methylnaphthalene	mg/kg	NQ	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	mg/kg	0.02	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Acenaphthylene	mg/kg	0.01	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Acenaphthene	mg/kg	0.01	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Fluorene	mg/kg	0.02	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Phenanthrene	mg/kg	0.09	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Anthracene	mg/kg	0.05	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Fluoranthene	mg/kg	0.11	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Pyrene	mg/kg	0.15	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)anthracene	mg/kg	0.07	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	mg/kg	0.11	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(b&j)fluoranthene	mg/kg	NQ	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(b)fluoranthene	mg/kg	NQ	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	mg/kg	NQ	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	mg/kg	NQ	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Indeno(1,2,3-cd)pyrene	mg/kg	NQ	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenz(a,h)anthracene	mg/kg	0.01	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(g,h,i)perylene	mg/kg	NQ	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

5.1.10.10 Physical and Chemical Characterization of Marine Offshore Water

Although, the COD for all marine water sites were high and ranged between 1035.5 and 1295.0 mg/kg (**Table 41 - 5-29**), total nitrogen and total phosphorus were low (<1.0 mg/kg). This coupled with the low *Enterococci coli* colonies at all marine sites suggest that the pollutants are non-biodegradable, hydrocarbons and not from biodegradable organic sources such as domestic sewage and agricultural waste (**Table 43 - 5-31**).

The total oil and grease concentrations were low at all sites (<15.0 mg/ L). However, the low and high PAH are high at KBMS-1 and exceeded the USEPA guidelines. The likely sources include fuel storage and airport activities to the west of the property. KBMS-4 low PAHs are high (7.55 mg/ kg) and contributed to the total PAHs and exceeded the USEPA guidelines (**Table 44 - 5-32**). Similarly, both sites, KBMS-1 and KBMS-4 exceeded the Alberta-1 surface water guidelines for Polyaromatics: Phenanthrene and Anthracene. Fluoranthene, Pyrene and Benzo(a)anthracene exceeded KBMS-1

All the total metals in marine water samples were all in the acceptable range with respect to WPR, 2019 standards and should not be any immediate concern to human health and the environment (**Table 48 - 5-36**).

Table 41 - 5-29: COD (Mg/L) of Marine Water at Marine Sampling Sites.

Parameter	WPR, 2019	KBMS-1 mean	KBMS-2 mean	KBMS-3 mean	KBMS-4 mean	KBMS-5 mean
Demand Parameters						
Chemical Oxygen Demand	250.0	1035.5	1275.0	1145.0	1240.0	1295.0

Table 42 - 5-30: Nutrients in Marine Water at Marine Sampling Sites.

Parameter	WPR, 2019	KBMS-1 mean	KBMS-2 mean	KBMS-3 mean	KBMS-4 mean	KBMS-5 mean
ANIONS						
Nitrite (N)	NQ	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrate (N)	10.0	<0.020	<0.020	<0.020	<0.020	<0.020
Nitrate plus Nitrite (N)	10.0	<0.020	<0.020	<0.020	<0.020	<0.020
Total Nitrogen (N)	3.0mg/L ** FDEP Permit stds	0.11	0.12	0.11	0.13	0.11
Orthophosphate (P)	NA	0.00	0.00	<0.0030	0.00	<0.0030
Total Phosphorus (P)	5.0	0.01	0.00	0.00	0.00	0.00

Table 43 - 5-31: Enterococci in Marine Water at Marine Sampling Sites.

Parameter	UNITS	WPR Regulatory guideline (cfu/ mL)	**KBMS-1 mean**	**KBMS-2 mean**	**KBMS-3 mean**	**KBMS-4 mean**	**KBMS-5 mean**
Enterococci	colonies	< 35 enterococci/100 mL	0	0	1	0	0

Table 44 - 5-32: Total Oil and Grease in Marine Water at Marine Sampling Sites.

	WPR, 2019 Schedule II	**KBMS-1 mean**	**KBMS-2 mean**	**KBMS-3 mean**	**KBMS-4 mean**	**KBMS-5 mean**
Total Oil and grease (mg/ kg)	15.0 mg/ L	<1.0	<1.0	<1.0	<1.0	<1.0

Table 45 - 5-33: PAH In Marine Water at Marine Sampling Sites.

Parameter	**EPA sediment benchmark**	**KBMS-1**	**KBMS-2**	**KBMS-3**	**KBMS-4**	**KBMS-5**
Low Molecular Weight PAH`s	0.076	1.85	<0.10	<0.10	7.55	<0.10
High Molecular Weight PAH`s	0.19	0.45	<0.050	<0.050	0.08	<0.050
Total PAH	1.61	2.25	<0.10	<0.10	8.00	<0.10

Table 46 - 5-34: Polycyclic Aromatics Noted in the Marine Water Samples.

	UNITS	Alberta I surface water guidelines	KBMS-1 DUPLICATE	KBMS-2 mean	KBMS-3 mean	KBMS-4 mean	KBMS-5 mean
Polycyclic Aromatics							
Quinoline	ug/L	3.40	<0.022	<0.020	<0.020	0.15	<0.020
Naphthalene	ug/L	1.00	0.15	<0.10	<0.10	0.33	<0.10
1-Methylnaphthalene	ug/L	NQ	0.21	<0.050	<0.050	2.9	<0.050
2-Methylnaphthalene	ug/L	NQ	0.26	<0.10	<0.10	3.1	<0.10
Acenaphthylene	ug/L	NQ	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthene	ug/L	5.80	<0.050	<0.050	<0.050	0.10	<0.050
Fluorene	ug/L	3.00	0.35	<0.050	<0.050	0.47	<0.050
Phenanthrene	ug/L	0.40	0.975	<0.050	<0.050	0.6	<0.050
Anthracene	ug/L	0.012	0.051	<0.010	<0.010	0.017	<0.010
Acridine	ug/L	4.40	<0.050	<0.050	<0.050	<0.050	<0.050
Fluoranthene	ug/L	0.04	0.08	<0.020	<0.020	<0.021	<0.020
Pyrene	ug/L	0.03	0.13	<0.020	<0.020	0.027	<0.020
Benzo(a)anthracene	ug/L	0.02	0.041	<0.010	<0.010	<0.01	<0.010
Chrysene	ug/L	NQ	0.18	<0.020	<0.020	0.033	<0.020
Benzo(b&j)fluoranthene	ug/L	0.04	0.038	<0.030	<0.030	<0.030	<0.030
Benzo(k)fluoranthene	ug/L	NQ	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(a)pyrene	ug/L	0.03	0.012	<0.0050	<0.0050	<0.0050	<0.0050
Indeno(1,2,3-cd)pyrene	ug/L	NQ	<0.050	<0.050	<0.050	<0.050	<0.050
Dibenz(a,h)anthracene	ug/L	NQ	0.0043	<0.0030	<0.0030	<0.0030	<0.0030
Benzo(g,h,i)perylene	ug/L	NQ	<0.050	<0.050	<0.050	<0.050	<0.050

Table 47 - 5-35: Total Mercury for Marine Nearshore Water Samples.

Season	UNITS	USEPA screening guideline	KBMS-1 mean	KBMS-2 mean	KBMS-3 mean	KBMS-4 mean	KBMS-5 mean
Dry	ug/L	10	0.0024	0.0042	0.0279	0.0027	0.0028
Wet			<0.0019	<0.0019	<0.0019	0.0026	0.0033

Table 48 - 5-36: Total Metals for Marine Nearshore Water Samples.

	UNITS	WPR, 2019	KBMS-1 mean	KBMS-2 mean	KBMS-3 mean	KBMS-4 mean	KBMS-5 mean
Total Metals by ICPMS							
Total Arsenic (As)	ug/L	100	2.09	2.13	1.89	2.05	2.105
Total Barium (Ba)	ug/L	NQ	7.30	7.20	7.05	7.40	7.15
Total Cadmium (Cd)	ug/L	100	<0.050	<0.050	<0.050	<0.050	<0.050
Total Chromium (Cr)	ug/L	500	1.20	0.93	1.27	1.39	1.45
Total Copper (Cu)	ug/L	2000	0.57	0.51	1.20	1.11	0.61
Total Iron (Fe)	ug/L	3500	110.50	45.00	28.00	52.50	24
Total Lead (Pb)	ug/L	100	0.29	0.22	0.18	0.36	0.155
Total Vanadium (V)	ug/L	NQ	<10	<10	<10	<10	<10

5.1.10.11 Physical and Chemical Characterization of Marine Sediment

Oil and Grease

All sediment samples in the marine environment had low levels of total oil and grease [TOG] (<130 ug/g) and does not pose any immediate threat to the marine environment (**Table 49 - 5-37**). The underlying sediment is of carbonaceous is not a contributing factor to the TOG observed at KBMS-3. This is probably associated with runoff from land-based sources.

Table 49 - 5-37: Total Oil and Grease in Sediment Samples.

	UNITS	KBMS-1	KBMS-2	KBMS-3	KBMS-4
Total Oil and grease	ug/g	<100	100	130	<100

pH

The pH of all marine sediments is alkaline and was between 8.57 and 8.76 (Table XX). This is typical for a marine environment with an underlying fringing reef.

Table 50 - 5-38: pH in Sediment Samples.

	UNITS	KBMS-1	KBMS-2	KBMS-3	KBMS-4
pH	pH	8.57	8.68	8.64	8.76

5.1.10.12 Hydrocarbons and Polyaromatic Hydrocarbons in Marine Sediments

The polyaromatic hydrocarbons in the marine sediments met all the USEPA screening guidelines for marine sediments and pose no immediate threat to the environment or human health (**Table 51 - 5-39**).

Table 51 - 5-39: Total Metal in Marine Sediments.

	UNITS	USEPA guidelines (mg/kg)	KBMS-1	KBMS-2	KBMS-3	KBMS-4
Total Metals by ICPMS						
Total Arsenic (As)	mg/kg	7.24	3.13	3.41	4.88	5.31
Total Barium (Ba)	mg/kg	NQ	5.53	6.3	5.89	4
Total Cadmium (Cd)	mg/kg	0.68	0.204	0.067	0.085	0.098
Total Chromium (Cr)	mg/kg	52.3	5.42	5.09	6.54	4.75
Total Copper (Cu)	mg/kg	18.7	0.75	<0.50	0.55	0.51
Total Iron (Fe)	mg/kg	NQ	1010	1070	1550	1530
Total Lead (Pb)	mg/kg	30.2	1.46	0.98	1.37	1.34
Total Mercury (Hg)	mg/kg	0.13	<0.050	<0.050	<0.050	<0.050
Total Vanadium (V)	mg/kg	NQ	3.9	3.9	5.4	4.5
Total Zinc (Zn)	mg/kg	124	2.3	1.8	2.5	2.3

Table 52 - 5-40: Calculated Parameters in Marine Samples.

	UNITS		KBMS-1	KBMS-2	KBMS-3	KBMS-4
Calculated Parameters						
Index of Additive Cancer Risk(IACR)	N/A		<0.10	<0.10	<0.10	<0.10
Low Molecular Weight PAH`s	mg/kg	0.312	0.0010	0.0011	<0.0010	<0.0010
High Molecular Weight PAH`s	mg/kg	0.655	<0.0010	<0.0010	<0.0010	<0.0010
Total PAH	mg/kg	2.9	0.0010	0.0011	<0.0010	<0.0010
Polycyclic Aromatics						
Naphthalene	mg/kg	0.0346	<0.0010	<0.0010	<0.0010	<0.0010
2-Methylnaphthalene	mg/kg	0.0202	<0.0010	<0.0010	<0.0010	<0.0010
Acenaphthylene	mg/kg	0.0059	<0.0005	<0.0005	<0.0005	<0.0005
Acenaphthene	mg/kg	0.0067	<0.0005	<0.0005	<0.0005	<0.0005
Fluorene	mg/kg	0.0212	<0.0010	<0.0010	<0.0010	<0.0010
Phenanthrene	mg/kg	0.0867	0.0010	0.0011	<0.0010	<0.0010
Anthracene	mg/kg	0.0469	<0.0010	<0.0010	<0.0010	<0.0010
Fluoranthene	mg/kg	0.113	<0.0010	<0.0010	<0.0010	<0.0010
Pyrene	mg/kg	0.153	<0.0010	<0.0010	<0.0010	<0.0010
Benzo(a)anthracene	mg/kg	0.0748	<0.0010	<0.0010	<0.0010	<0.0010
Chrysene	mg/kg	0.108	<0.0010	<0.0010	<0.0010	<0.0010
Benzo(b&j)fluoranthene	mg/kg	NQ	<0.0010	<0.0010	<0.0010	<0.0010
Benzo(b)fluoranthene	mg/kg	NQ	<0.0010	<0.0010	<0.0010	<0.0010
Benzo(k)fluoranthene	mg/kg	NQ	<0.0010	<0.0010	<0.0010	<0.0010
Benzo(a)pyrene	mg/kg	0.0888	<0.0010	<0.0010	<0.0010	<0.0010
Indeno(1,2,3-cd)pyrene	mg/kg	NQ	<0.0020	<0.0020	<0.0020	<0.0020
Dibenz(a,h)anthracene	mg/kg	NQ	<0.0005	<0.0005	<0.0005	<0.0005
Benzo(g,h,i)perylene	mg/kg	NQ	<0.0020	<0.0020	<0.0020	<0.0020

5.1.10.13 Concluding Statements

Most of this wetland is not flooded by tides, as inland water within the basin is impounded. Sites KTW-4 – KTW-7 exceeded regulatory limits the WPR, 2019 guidelines for COD. This coupled with high Enterococci colony counts at all terrestrial sites (>35 colonies/ 100 mL) especially at sites KTW-3 through KTW-5 suggest that there is untreated municipal wastewater entering the site and increasing the COD along the sluice gate. As there are no functional channels/outlets to the sea and there is minimal groundwater saltwater intrusion or current impact on the marine system. The COD for all marine water sites were high, whilst total nitrogen and total phosphorus were low. This coupled with the low Enterococci coli colonies at all marine sites suggest that the pollutants are non-biodegradable, hydrocarbons. Low and high PAH are high at KBMS-1 and exceeded the USEPA guidelines in marine water and stems from existing land-based activities. Total PAH remain low in all marine sediments.

5.1.10.14 Alternative Waste Treatment Strategies

With any development, waste streams will be generated. In this case, the development has two phases. The first phase proposes 300 rooms, while the second room proposes 200 hundred rooms and affiliated entertainment areas. This section considers the waste generated and the options for waste treatment and management. It is important to create programs and systems to ensure there is minimal disruption to human health and the environment.

Waste Generated

The following considers the main waste streams associated with operation of Secrets and Dreams resort:

1. Domestic sewage
2. Stormwater from vehicles and paved areas
3. Solid waste

Domestic Sewage

The domestic wastewater generated is approximately 932 m^3/ day. Wastewater will comprise biodegradable organics, nutrients, and pathogens. It is therefore crucial that that the different scenarios be considered:

A. On-site wastewater treatment plant with a sequencing batch reactor.

There are some conceptual differences if this is being operated as a plug flow or a series of completely mixed reactors. This option may offer more efficient treatment of biochemical oxygen demand (BOD substances. However, the activated sludge generated from the this needs to be considered. There needs to be sufficient staff dedicated and properly trained in sludge solids handling for this. In addition, the wastewater effluent should be treated with a disinfection step to ensure pathogen inactivation. If this method is chosen, the sluice gate surface water should be tested as part of the mitigation and EMP. A total of four sites should be tested. In the sampling plan.one sample site prior to the outfall, one site at the outfall and at least two sites after the outfall should be monitored twice a year.

B. External wastewater treatment plant (WWTP).

The domestic wastewater treatment plants in the vicinity have capacities of 9,090 m3/day and 5,455 m3/day. The wastewater generated is approximately 10-20% of the capacity. The current operational loading rates need to be considered prior to construction and routing wastewater to these wastewater treatment plants. Most treatment plants in Trinidad and Tobago have primary and limited secondary treatment. If this development brings the WWTP close or surpasses the capacity, the WWTPs effluent may not follow the Water Pollution Rules 2019 (WRP, 2019) regulatory requirements.

With this option, Secret and Dreams will not be responsible for sludge handling and offers that advantage.

Stormwater from Vehicles and Paved Areas

The development is expected to be approximately 20,500 m^2 or 11% of the total site area with 200 parking spaces and 4 main impacted areas. The runoff from impervious surfaces will produce stormwater. It is therefore crucial that the stormwater be treated as this will include hydrocarbons, particulate matter, metals and nitrogenous compounds. It is therefore crucial that that the different scenarios be considered:

A. Use of bioswales

The use of bioswales is the most appropriate treatment given the location of the parking lots, main accommodation and entertainment areas, minimization of impacts on the mangrove areas. The proposed development features four bioswales will filter the stormwater. These bioswales should have endemic, hydrophytes or wetland species that can tolerate inundated flooded conditions. Four species that can be used for these bioswales and landscaping include: *Cyprus giganteas*, *Acrostichum aureum*, *Dodonea viscosa* and *Conocarpus erectus*.

Figure 72 - 5.46: Species that can be used for Bioswales and Landscaping.

B. Use of water retention systems

Water retention systems are very similar to bioswales, as they too are retrofitted with endemic, hydrophytes, but usually take up more aerial coverage. In this regard, it may result in greater disturbances to the surrounding mangrove systems and important areas of conservation.

Solid Waste

Solid waste generation is more difficult to predict than wastewater and stormwater generation, as there are many variables that influence solid waste generation. Key contributing factors include income, education, and occupancy. There will be differences in solid waste generation between peak and non-peak seasons.

Trinbagonian citizens-generates an average 1.4 kg of waste daily (Dhalai, 2018). A 2009 solid waste characterization study assessed four of the country's landfills (Singh et al. 2009). The study revealed that of the 700,000 tons of solid waste that was recorded at the landfills in Trinidad; Approximately 84.0% of all items were recyclable or compostable. It would increase cooperate responsibility if Dreams and Secrets work with SWMCOL to develop a solid waste management plan that encourages onsite recycling and upcycling and composting of food waste and biodegradable organic waste.

5.1.11 Biological Environment

5.1.11.1 Existing Ecosystems

- Forest
- Coastal Littoral Woodland

The flora on the immediate study area earmarked for development contains a mix of coastal littoral woodland typical of Tobago's coasts, mangrove swamp and disturbed agricultural scrub lands. Along the coast is a clearly defined Littoral Woodland with a (*Coccoloba uvifera* and *Hippomane mancinella*) association. This original sea-shore vegetation association persists on cliffs, rocks, sandbanks, and small islets off the coast of Tobago (Beard, 1944). In this case the Littoral Woodland extends some 100m to less than 50m from the high tide mark into the emergent Kilgwyn swamp (**Figure 74 - 5.48**). The pervasiveness of this floral association inland seems to be limited by the hydrology of the area. At points where waterlogged drains, channels or shallow ponds occur there is a swift transition from woodland to mangrove trees or marsh flora (i.e. sedges or Mangrove Fern (*Acrostichum aureum*)). Based on local observation, resident (Mr. Othniel Ramsey; Kilgwyn Bay fisherman and farmer) has indicated that the extent of the wetland system has expanded seaward in the aftermath of unregulated sand mining and extraction activities. It was estimated that these activities took place in the late 1990s and created ponds as well as shallow drains which were colonized by sedges.

Kilgwyn Bay is defined by a sandbar which separates the mangrove swamp from the marine environment. The littoral zone of the beach is littered with broken coral pieces and encrusting algal forms, marine algae (e.g. *Gracilaria* sp. commercially important sea moss) and *Sargassum* sp. The beach is terraced on the eastern and western extremities but has a more gently sloping profile toward the east and the collapsed groyne. The beach berm and backshore area support some strand vegetation of grasses, shrubs and vines i.e. *Wedelia tribolata*, *Sporobolus* sp., *Paspalum* spp., *Panicum* spp., *Ipomoea pes-capre* and *Canavalia rosea*. This pioneer colony merges into a well-defined coastal Littoral Woodland. Structurally this Woodland formation exhibited dwarfed and distorted windswept crowns and gnarled branches which pointed away from the wind caused by the strong sea breezes on the windward coast. Some tree leaves held crystallized salt from sea spray deposits. The majority of trees had fleshy and thick cutinized leaves to limit water loss and several tree species had thorns (e.g. Black Jessie (*Pithecellobium unguis-cati*)) to limit herbivore. According to exposure the stature of the Littoral woodland varies from shrubs to taller growth 5 to 10 m (**Figures 73 - 5.47** and **75 - 5.49**). This Littoral Woodland had a unique understory (1-2m) in most areas which consisted primarily of Noni trees (*Morinda citrifolia*)[1]. The density of this species observed is quite uncommon for costal littoral forests in Tobago (Beard, 1944) and as such the observed population in Kilgwyn may be the result of human influence and possible seed dispersal by fauna.

The Littoral Woodland was dissected on its most southern boundary by an access trail. Within the proximity of this access trail, several species of primary trees typical of disturbed pasture/farmlands and scrub forest were observed e.g., Quick stick (*Gliricidia sepium*), Wild tamarind (*Leucadia leucocephela*) and other typical roadside pioneer shrubs (i.e. Indian root (*Asclepias curassavica*), Vervain (*Stachytarpheta jamaicensis*), Christmas bush (*Eupatorium odoratum*), Blackwell sage (*Cordia curassavica*), *Sida acuta*. It should be noted that tropical dry forests are threatened by degradation particularly from edge effects which arise as a result of perturbations such as the creation and maintenance of roads and other clearings. Research has shown that the interactive effect of understory species (exotic or native) and road width on tree death can be significant, with highest tree death occurring near wide roads bordered by exotic or human influenced understory. Conversely, tree community composition (dominant floral association) was influenced by road width and understory type, but not by proximity to roads. Creation and maintenance of roads has serious implications for tree communities in tropical dry forests (Prasad 2009), and it is likely this access trail has significantly influenced the status and composition of floral species found within the Littoral Woodland.

[1] Although listed as present in coastal environments in Caribbean (Carrington, 1998) it is native to Asia and Australia.

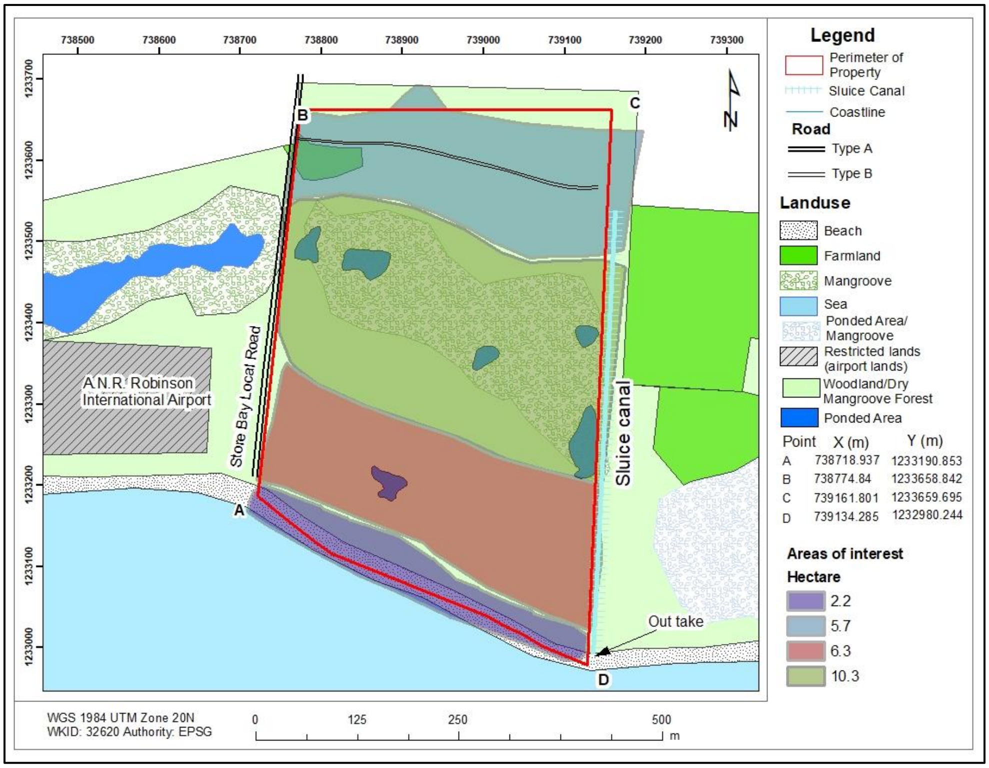


Figure 73 - 5.47: Floral Map of the Kilgwyn Study Area, Southwest Tobago.

a) **Beach strand Vegetation**

d) Noni trees (*Morinda citrifolia*)

b) *Coccoloba uvifera* and *Hippomane mancinella* Association

e) Indian root (*Asclepias curassavica*)

c) Black Jessie (*Pithecellobium unguis-cati)*

f) Quick stick (*Gliricidia sepium*), Wild tamarind (*Leucadia leucocephela*)

Figure 74 - 5.48: Coastal Littoral Woodland, Kilgwyn Bay, Tobago.

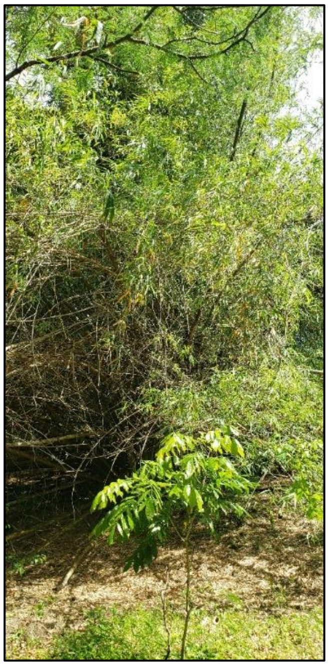
Common tree species observed in the Littoral Woodland are listed in **Table 75 - 5-41** below.

Figure 75 - 5-41: Coastal Littoral Tree Species Recorded, Southwest Tobago.

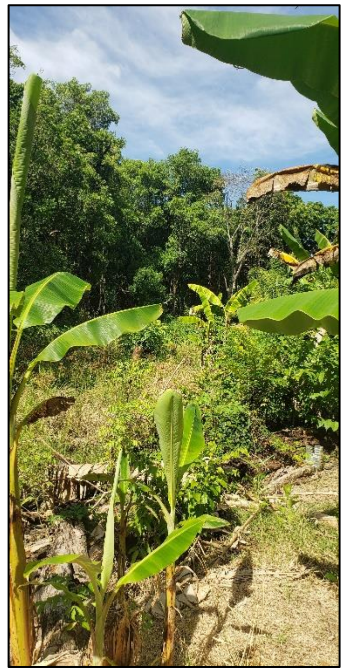
Common Name	Scientific Name
Sea grape	*Coccoloba uvifera*
Manchineel	*Hippomane mancinella*
Fiddlewood	*Citharexylum spinosum*
Naked Indian	*Bursera simarubs*
Black Jessie	*Pithecellobium unguis-cati*
Almond	*Terminalia catappa*
Seaside Mahoe	*Thespesia populnea*
Button Mangrove	*Conocarpus erectus*
-	*Randia aculeata*
-	*Bumelia* sp.
-	*Trichilia trifolia*

5.1.11.2 Dry Seasonal Forest and Disturbed Agricultural/Scrub Vegetation

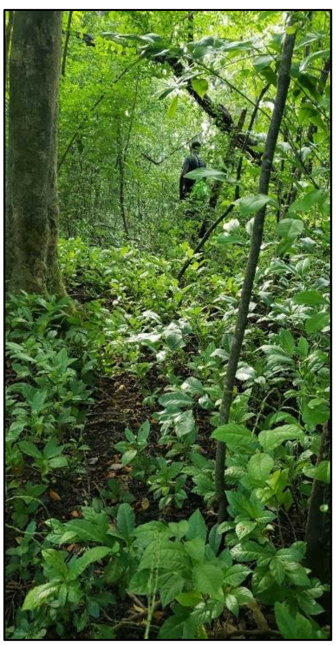
Nearly all the lower land in Tobago which was formerly seasonal forest has long since been taken up for agriculture or housing and it is now only possible to reconstruct a conjectural picture of the original vegetation from a few relics (Beard, 1944). At the northern extremities of the Kilgwyn Swamp and the proposed property is a disturbed dry forest area. It is dissected by an access trail used for an existing farmstead and the area has been previously cleared for agriculture and the dumping of solid waste (**Figures 76 - 5.50** and **95 - 5.69**). The vegetation in this area consists of trees typically observed in a Seasonal Dry Forest canopies e.g. C*itharexylum spinosum, Pithecellobium unguis-cati*, *Bursera simarubs*, *Spondias* *mombin* and *Tamarindus indica***.** Also present were a few stands/patches of Bamboo. At present, the Caribbean and West Indies is known to have 4 genera and 36 species of native woody bamboo. These plants naturally occur in the tropics and subtropics however dense clumps of these trees as observed in the northern sector of the proposed study area are typical descriptors of forest degradation and land clearance for agriculture. Bamboo is a fast growing, colonizing plant and can quickly occupy cleared areas. Its vertical growth and rhizome root system can in turn prevent the reforestation by other natural tree species thus permanently modifying the ecology of an area.



a) Bamboo Patch Agricultural Area



b) Agricultural Plot (Secondary Forest Trees and Crops)



c) Understory of Disturbed Seasonal Forest

d) Secondary Vegetation Along Access Road to Farmstead

Figure 76 - 5.49: Dry Forest and Agriculture/Scrub Vegetation.

5.1.11.3 Rapid Assessment of Forest Habitats (2022)

The intent of the ecological surveys for this Environmental Assessment is to identify the status biological resources within the project area, the quality of the environment in which they exist and the potential and or cumulative impacts/threats which may result from the proposed development. An accurate description of the biological resources present at Kilgwyn and the ecosystem services provided by the floral communities allowed practitioners to develop suitable mitigation measures to abate or reduce project impacts. The results of the ecological studies thus informed the mitigation and monitoring requirements proposed to ensure the preservation of the native species and sensitive biological resources found.

The objectives of the real time forest floral study were;

- To assess the health and diversity of flora which exists within the transition zones of the Scrub Mangrove and the disturbed agricultural lands.
- To determine the extent and influence of the disturbed seasonal deciduous forest.
- To identify species of major importance due to their influence on the local ecology, commercial value or sensitivity (i.e. endangered, rare, threatened, endemic).

Surveys were done to capture two (2) seasons of data as requested by the Environmental Management Authority of Trinidad and Tobago. The Dry Season data was collected over the period March 27th and March 29th, 2022. The Wet Season surveys were carried out between 18th September and 19th June 2022. These studies ensured that all reasonable consideration was given to identify changes which occurred within habitats as a result of rainfall/climactic conditions. The emphasis of biological surveys was directed at searching for rare, endangered, threatened, or otherwise sensitive resources. Statements explaining the theoretical physical and biological basis for any lack of expected species (based on historical literature for Kilgwyn) were included in study discussions.

During each survey event a 50 m transect was laid using a measuring tape and at 5 m intervals on the line data on floral species, forest characteristics, relative coverage, canopy cover, seedling density and observed health (i.e. signs of diseases) were recorded. Counts began at one end of the line and plants which were within 1 m of the line at the identified intervals and plants whose foliage overlaid the transect were included in the interval counts. The measurement of intercept length was used to estimate coverage. Intercept length was interpreted as the portion of the transect length intercepted by a plant measured at or near the base of the plant, by a perpendicular projection of its foliage intercepted by the line or at diameter at breast height for trees. The line transect was deemed the most appropriate sampling technique for transition zones on the property since these areas consisted of different habitat types and floral communities (i.e. beach strand, marsh, xerophytic forest) with different ground cover structures (i.e. grassed clumps, trees, shrubs). Three heights were estimated using a laser ranger finder.

For each plant counted the intercept length was recorded and the Raw Data sheets are presented in ***Appendix E4.1 - Biological Environment (Raw Data Sheets)***. Parameters such as linear density index, relative density of species, linear coverage of species, relative coverage of species frequency of species and importance value were calculated. There would be some sample bias introduced since the location for transects were based on accessibility and observed forest structure (with the aim to capture data for locations with the most diversity of flora) additionally given the strategic and rapid nature of the survey only two (2) transects were established in the transition zones to assess the general characteristics of the communities.

Based on the results the deciduous seasonal forest expressed a marked deciduous period coincidental with the dry season. The forest had two strata of which the upper is open and the lower closed. A large number of seedlings were observed, particularly in areas where tree fall and incidental light penetration to the forest floor was significant. The lower story ranges from 3 to 6 m in height and the upper story between 10 and 12 m. The large trees branched low down and had large spreading crowns, and many shrubs of the lower story grew in clumps. *Lianes* and *epiphytes* were rare. The ground vegetation was extraordinarily sparse closer to the mangrove forest and grasses only existed in well-lit areas along cleared pathways, access trails and areas used for the grazing far animals. The upper story consisted of species such as *Bursera simarubs*, *Spondias mombin* and *Tamarindus indica.* No trees developed a buttressing normally. The majority of the lower story trees had thorns or spines common species observed in this story included *Chlorophora tinctoria*, *Pithecellobium uingais-cati*, *Trichilia trifolia*, *Cordia collococca* and *Citharexylum spinosum*.

Because the species making up the floral faciation were primarily deciduous, leaf fall appeared to be intense during the dry season and dense leaf litter was observed in March. New leaves develop at the onset of the rains and the crown of understory trees appeared to be thicker during the rainy season (September). Leaf litter in many areas was washed away during the rainy season particularly on the terraced faces of the property and where the local surface hydrology allowed for flooding (i.e. near the mangrove wetland). Beard (1944) identified that the degree of deciduousness varies in such seasonal communities based on the intensity of the drought and in wetter years no marked leaf fall may take place. This disturbed forest community did support a diverse avifaunal population as well as reptiles, mammals and insects (ants and termites).

Wetlands

According to the Ramsar Convention (1971) a wetland is considered any area of marsh, fen, peatland or water whether natural or artificial permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water the depth of which at low tide does not exceed 6 metres. Based on these criteria Kilgwyn Bay has a contiguous system of interconnected wetland habitats consisting of mangroves, marshes, ponds, sea-grass beds and a reef system within the bay.

Emergent Wetlands

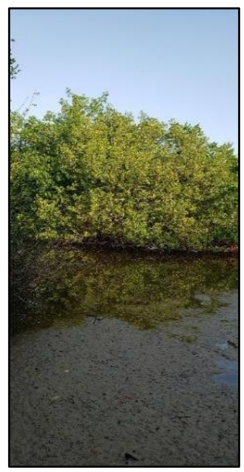
When an emergent wetland is dominated by trees it is referred to as swamp. When it is dominated by grasses it is referred to as marsh. Kilgwyn Bay is dominated by a mix of both swamp and marsh. Within Kilgwyn Bay there are two mangrove areas: -Kilgwyn Swamp and the western extremities of Friendship Swamp. Kilgwyn Swamp is a basin mangrove forest surrounding a shallow lagoon fed behind a beach sand barrier. The mangrove forest including the lagoon is estimated at 0.34 km^2 and was reported to be dominated by White Mangrove (*Lagucularia racemosa*) (Juman and Hassanali, 2013). Red Mangrove (*Rhizophora mangle*) and Black Mangrove (*Avicennia germinans*) form a narrow fringe along the periphery of the lagoon while *L. racemosa* appears to be more abundant and widely distributed within the more disturbed areas of the basin system where the hydrology has been modified by illegal sand mining and solid waste disposal (Juman and Hassanali, 2013). Disturbed locations have a hummock topography resulting from bunds and shallow ponds created from human activities. The drier locations supported the *L. racemosa* species which is less tolerant of inundation but can survive in sediments with highly saline interstitial water (Florida Museum of Natural History, 2018).

The main lagoon was once connected to the sea by an ephemeral canal which has now become cut off from the sea by sand deposits at the mouth (**Figure 77 - 5.50 a)**), and the mangrove forest and lagoon have been dissected into two sections by a road leading to the beach. A concrete culvert under the road connects the two sections (**Figures 77 - 5.50 b) and 77 - 5.50c)**). In 1986, Kilgwyn Swamp was estimated to be 0.12 km^2 (described as a permanent brackish lagoon with fringing mangrove swamps, separated from the sea by a sand bar (Scott and Carbonell, 1986)). The increase in mangrove area from 1986 to present, suggest there has been recent improvements to the wetland system.

The Friendship mangrove forest is east of Kilgwyn and is a basin system estimated at 0.12 km^2 (Juman and Hassanali, 2013). This mangrove forest forms part of the wider study area. Found behind a beach berm approximately 7 m wide, it is dominated by *L. racemosa*, with fewer *A. germinans* and *R. mangle* found along the berm. Like Kilgwyn Swamp, the Friendship wetland is not flooded by tides. The water within the basin is impounded. However, unlike the Kilgwyn Swamp, there are no channels/outlets to the sea at Friendship. The Kilgwyn and Friendship mangrove areas were one hydrologically connected and may have been a contiguous system that was impacted by the construction of a channel and sand mining activities. Attempts were made to drain the eastern part of the swamp, as there was evidence of channels traversing this area and an old pump station on the coast (IMA 1990).

This mangrove forest type is probably common to all the shores of the Caribbean. The mangrove (*Rhizophora-Avecinia-Laguncularia*) association has an even wider range and occupies the entire intertropical Atlantic seaboard of Africa and the Americas. Nearly all the coastal swamps in Tobago have been drained or reclaimed and cultivated but certain relatively small areas remain where the necessary combination of tidal mudflats and brackish water permits the establishment of mangrove vegetation (Beard, 1944). The mangrove woodland of Kilgwyn exhibits no unusual features and appears to have no diseased trees.

a) Sluice Drain a temporal channel connecting the Kilgwyn Mangrove to the Sea	**b) Road Dissecting tar Kilgwyn Mangrove System**



c) Culvert connecting the two segments of Kilgwyn Mangrove	**d) Pond formed in mined out location**

Figure 77 - 5.50: Emergent Wetland Features at Kilgwyn.

Rapid Assessment of Emergent Wetland (2022)

The intent of the wetland surveys for this Environmental Assessment were to identify the health of the wetland, the quality of the environment within which they exist and the potential and or cumulative impacts/threats which may result from the proposed development. Like the dry forest an accurate description of the wetland and the ecosystem services provided by the mangroves allowed practitioners to develop suitable mitigation measures to abate or reduce project impacts. The results of the ecological studies informed the mitigation and monitoring requirements proposed to ensure the preservation of the habitats and sensitive biological resources.

The objectives of the real time mangrove study were;

- To assess the health and diversity of flora which exists within the mangrove swamp.
- To identify species of major importance due to their influence on the local ecology.

Surveys were done to capture two (2) seasons of data as requested by the Environmental Management Authority of Trinidad and Tobago. The Dry Season data was collected over the period March 27th and March 29th, 2022. The Wet Season surveys were carried out between 18th September and 19th June 2022. These studies ensured that all reasonable consideration was given to identify changes which occurred within habitats as a result of rainfall. Statements explaining the theoretical physical and biological basis for any lack of expected zonation patterns (based on historical literature for Kilgwyn) were included in study discussions.

During each survey event five (5) sample plots with dimension of 10m x 10m (0.01 ha) were established (**Figure 78 – 5.51**). The number and location of these plots are provided in **Figure 78 – 5.51** below. The methods applied for the wetland survey were referenced from; Cintron and Novelli, 1984 (UNESCO 1984); Brower *et al* (1985); ASEAN (1997) and CARICOMP (2000).

The following data was collected during each monitoring event:

1. Structural measurements of the trees in each plot
    - Tree species type: Species will be positively identified using diagnostic physiognomic criteria for mangrove (Snedaker & Snedaker, 1984)
    - Diameter at breast height (DBH) of all trees with a trunk having a circumference > 2.5cm within each sample plot.
    - Approximate tree height (in meters)
    - Density of each species in each plot (number of trees per species per 0.01 hectare)

2. Physical characteristics of the plots
    - Degree of consolidation of the substrate
    - Influence of the tidal regime
    - Presence, depth and stage of decay of leaf litter
    - Soil colour
    - Texture
    - Presence of noxious odors
    - Percentage of infiltration of sunlight through the upper canopy
    - Presence, type and amount of garbage
    - Sources of effluent
    - Hydrologic conditions (i.e. depth of surface water, surface water movement, ability of a standard depth hole to fill with water)
    - Presence of living organisms

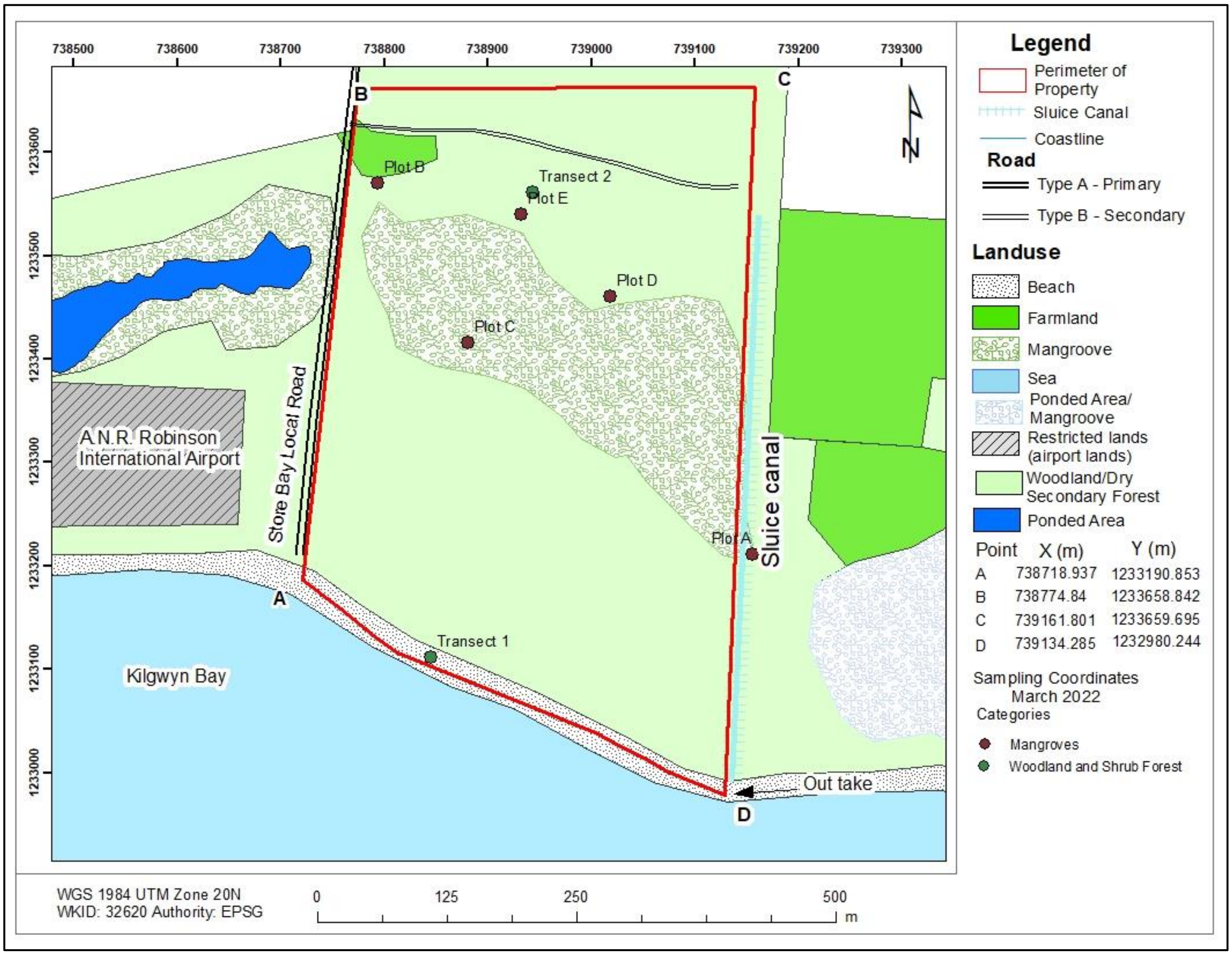


Figure 78 - 5.51: Map of Wetland Sample Plot Locations.

Based on the recent surveys the most dominant species observed within the mangrove wetland were *L. racemosa*, and *A. germinans*. These two species were more abundant (i.e. based on numbers, density and basal area coverage) in areas of the mangrove where disturbances and changes in hydrology had taken place (*Refer to* ***Appendix E4 - Biological Environment***. *Rhizophora mangle* trees occupied areas near the lagoon and habitats which were permanently inundated with water. It was clear based on reconnaissance walks through the mangrove that areas where the surface hydrology has been modified the health of the mangrove forest has been affected. Sections along the northeast boundary of the swamp, along the sluice drain embankment had die back sites where many trees had collapsed, or their growth appeared to be stunted. It is likely that the change in drainage as a result of the malfunctioning sluice drain may have impacted tree growth in these areas. Generally, the mangrove canopy was quite dense within the *Rhizophora mangle* habitat *(Refer to **Appendix E4 - Biological Environment*** intercepting a maximum of 70-80% of incident light. Within the disturbed mangrove area to the south and northeast of the proposed development site, the mangrove canopy was a bit more open and allowed for the infiltration of 40 to 60 % of the incidental sunlight. Replacement seedlings were abundant at these locations and accounted for approximately 20 to 30% of the forest floor cover.

There was a distinct transition in the surface water levels between the wet season and the dry season. During the month of March 2022 the only locations where the plots were inundated with water were at location A and B (i.e. <0.3 m). During the month of September all study plots were inundated with water and location B and C were inaccessible (water level was greater than 1m).

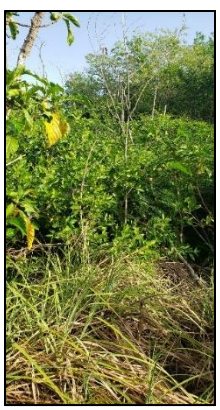
It should be noted that the southern extremities of the wetland system where intensive sand mining had occurred (particularly near the coast) have developed small areas of marsh near residual ponds and channels in mined out depressions (**Figure 79 - 5.52 d)**). These areas are colonized by sedges such as (*Eleocharis* spp, *Cyperus* spp, and *Fimbristylis* spp). The fern *Acrostichum aureum* is the only other component observed within the marsh areas. Button Mangrove (*Conocarpus erectus*) is somewhat abundant at the landward or sand bar fringes, occasionally with *Dodonea viscosa* (particularly within the transition zone between swamp/marsh and Coastal Littoral Forest) (**Figures 79 - 5.52 e)** and **79 - 5.52 f)**).

a) Plot A showing Red Mangrove Tree

b) Plot E Showing White and Black Mangroves trees and pneumatophore root systems

c) Die-back area at eastern extremities of the Kilgwyn Wetland

d) Wet season flooding of Plot E



e) Sedges in Transition herbaceous swamp

f) Mangrove Fern in Transition herbaceous swamp

Figure 79 - 5.52: Different Locations in and around Kilgwyn Bay and Their Associated Species Observed.

Submerged Wetlands

The immediate study area for the marine environment was defined as Kilgwyn Bay which is approximately 2.47 km long. It is a back reef habitat fronted by a fore reef approximately 150-200m from the low water mark. Kilgwyn Bay is located on the Windward Coast of South-western Tobago, nestled between La Guria Bay to the west, and Canoe Bay to the east (Juman and Hassanali, 2013) (**Figure 80 - 5.53**).

The substrate of Kilgwyn Bay is composed of fine sand, rubble and rubble reef flat. The sandy areas once supported dense seagrass beds interspersed with several species of algae. Cheong (1990) reported that fine sands fringed the shoreline at Kilgwyn in bands which varied from 10 to 20 m and seaward of these sands a broader band of seagrass beds interspersed with channels of rubble once existed. These seagrass and algal communities have now become patchy and quite sparce. Recent dive surveys conducted by Khan in 2021 identified that the nearshore area east of Kilgwyn Bay consisted of mainly coral rubble (approximately 66.5% of the substrate) and sand (approximately 15.9%), with the remainder of the benthos consisting of coral stone (4.5%), dead coral boulders (7.8%) and dead coral formations (5.4%) *(Refer to **Appendix E4 - Biological Environment**)*

Figure 80 - 5.53: Map of Wetland Sample Plot Locations Highlighting Rough and Backreef Study Areas.

Seagrass Beds and Algal Mats

An extensive continuous seagrass community was once supported on the windward side of Tobago extending from La Guira Bay (in line with the airport runway) to the east-northeast at Canoe Bay, (Juman, 2010; IMA, 2016). The beds included Kilgwyn and Friendship Bays and abuted the flying reef system. In La Guira Bay, Kilgwyn and off Friendship, Turtles Grass (*Talassia testidinum*) was the most dominant grass species. The Institute of Marine Affairs reported in 2002 that Kilgwyn Bay had one of the most productive seagrass communities in Tobago (Institute of Marine Affairs, 2016). Studies by Juman in 2005 identified that the Turtle Grass (*Thalassia testudinum*) from Kilgwyn Bay, had an estimated biomass of 964 g dry wt. m^2 (Juman, 2005). A more detailed study describing the seagrass communities at Kilgwyn Bay conducted by Juman and Alexander in 2006, identified that the seagrass beds were found 10 - 20 m from the high tide mark in the backreef area of Flying Reef and stretched more than 300 metres seaward in areas. These beds were densest in La Guira Bay and in front of the Kilgwyn wetland system, (Juman, 2010). East-northeast of Kilgwyn, the beds became patchier and intermixed with Manatee Grass (*Syringodium filiforme*) and Shoal Grass (*Halodule wrightii*). Indeed, Kilgwyn Bay was one of only two locations along the coast of Tobago where Manatee Grass occurred. The biomass and aerial productivity monitored at La Guira Bay and Kilgwin Bay were higher than that recorded for the Bon Accord Lagoon and in Trinidad (Juman, 2010).

In 2021 reconnaissance dives by Khan within the backreef area east of Kilgwyn Bay noted the presence of very small, localised patches of seagrass that included *Thalassia testudinum* and *Halodule wrightii (*previously incorrectly identified as *Syringodium filiforme), (Refer to* ***Appendix E4 - Biological Environment*** . At present (September 2022), *T. testudinum* is the primary species observed within the backreef of Kilgwyn Bay immediately landward of the project site. The seagrasses which currently occurs are interspersed in the nearshore area. When encountered plants can be described as sparse/thin, beds occupying areas less than 1.2 m^2 *(Refer to* ***Appendix E4 - Biological Environment.*** The majority of remaining beds appeared to be heavily silted in most locations.

The loss of seagrass productivity in Kilgwyn is a significant modification to the marine ecosystem. Seagrasses support a rich diversity of fauna and are important primary producers in the marine environment. Their functions include:

- Coastal sediment stabilization.
- Reducing current speed and wave velocity which can lead to loss of sand and coastal beach erosion.
- They filter suspended sediments and nutrients from land-based runoff which enter the water column.
- They provide shelter and refuge for resident as well as transient marine species which may be of recreational or commercial importance.
- They produce organic matter which is recycled in marine habitats.
- They provide food as primary producers for direct or indirect grazing.
- They produce and trap detritus and secrete dissolved organic matter that tends to internalize nutrient cycling within the ecosystem.

The seagrass beds around Southwest Tobago are major nursery sites for commercially important species such as grunts, snappers and spiny lobsters. They are directly grazed on by sea turtles (which are regarded as environmentally sensitive locally), Sea conch, Sea urchins and adult fish (e.g. Parrot fish, Surgeonfish). However, since 2015, many of the beds have disappeared from La Guira to Kilgwyn Bay (Institute of Marine Affairs, 2016) The loss of beds at Kilgwyn Bay may be directly linked to the decline in fishery productivity within the Bay and the decreased incidence of turtles being observed – Local reference Mr. Othniel Ramsey. Reports have suggested that the decline in seagrass productivity along the windward coast coincided with a sargassum bloom in 2015 where sargassum mats of up to 0.6 m thick washed ashore at Kilgwyn Bay (Institute of Marine Affairs, 2016). In addition to sargassum blooms, many of the *Thalassia* dominated seagrass beds found at Kilgwyn Bay were affected by poor water quality (Institute of Marine Affairs, 2016). Sources of pollutants contributing to reduced water quality levels at Kligwyn Bay over the years have included the continued and cumulative impact of the Crown Point runway extension, airport operations and fuel handling, coastal erosion and illegal sand mining which took place in the 90's (Juman, 2010; Juman and Hassanali, 2013).

The macro algae community in La Guira and Kilgwyn Bays are not as abundant as those observed within other seagrass beds around Tobago. However, at about 0.4 m in depth at ebb tide, macro-algal species such as *Caulerpa* sp., *Halimeda* sp. and *Dictyota* sp. mixed with coral rubble, sandy patches and Finger Coral (*Porites porites*) have been reported (Institute of Marine Affairs, 2016). Juman in 2010 identified that specifically associated with the La Guira and Kilgwyn Bay seagrass beds were the calcarous algae *Halimeda* sp. and *Udotea* sp., the coral *Porites* sp. and *Siderastrea* sp. and the sponges *Ircinia strobilina* and *Halichondria melanadocia*. In rubble channels, algal turf covered many surfaces and the Red Algae *Acanthophora* sp. was abundant. Sediments consisted of fragmented plates of *Halimeda* sp. and, in some areas, the filamentous green and red algae *Hypnea* sp. was present (Juman, 2010). In 2021, Khan identified several species of macroalgae within the backreef just east of Kilgwyn Bay. These included; Y-branching Algae (*Dictoyota sp.*) which was extremely common; Y-twig Algae (*Amphiroa rigida*), Watercress Algae (*Halimedia opuntia*), and Fuzz Ball Algae (*Rhodophyta sp.*), which were very common; Reef Cement (*Rhodophyta sp.*) and Spiny Red Seaweed (*Acanthophora sp.*) which were common; and Paddle Blade Alga (*Avrainvillea longicaulis*) and White Scroll Algae (*Padina sancta-crucis*) which were uncommon *(Refer to **Appendix E4 - Biological Environment).***

Kilgwyn was once a popular harvesting area for Seamoss. Seamoss as it is locally called, is a drink made from the red algae *Gracilaria* sp. The species of *Gracilaria* once observed in the study area were *G. terete, G. Domingensos, G. cervicornis and Gracilaria* sp. (Flattened). These algal forms anchored themselves to the substrate by hold fasts or attached to rubble, (Cheong, 1990). This algal form appears to be no longer present within the nearshore area.

During a recent reconnaissance study of Kilgwyn backreef (September 2022), the two major types of macroalgae were a Red Algae species (*Acanthophora* sp.), and Watercress Alga

(*Halimeda opuntia*), the former being the most widespread and numerous, **(Figures 80 - 5.54 e) and 80 - 5.54 f)**).

a) **Green Feather Algae on coral rubble *Caulerpa sp.***

b) **Mermaids Fans Algae on coral rubble *Udotea sp.***

c) **Sparse area of grazed Turtle Grass between coral rubble**

d) **Sparse area of grazed Turtle Grass between coral rubble**

e) **Large single colony of *Acanthophora sp.* Algae on coral rubble**

f) **Watercress Algae *Halimeda opuntia***

Figure 81 - 5.54: Seagrass and Algal Communities of Kilgwyn Bay and Backreef.

Reef Systems

Coral reefs found within Kilgwyn Bay, are part of three distinct reef systems each associated with the three bays along the windward southwestern coast. Flying Reef is situated in the west and closest to Kilgwyn Bay, whilst Majeston and Cove Reefs are situated in the east closer to Cove coast communities, Hassanali (2009). The reefs are intermittent and interspersed by patches of coral rubble, Palythoabeds, *Thalassia* patches, and sand as previously described in the section above.

Flying Reef fringes the southwest Coast of Tobago, from Petit Trou Lagoon to La Guira Bay and it is named after the strong westerly currents which prevail. It is a popular reef used for recreational drift diving. The reef crests at approximately 6 metres and reaches a maximum depth of 15 metres before meeting the sandy seabed. The reef is approximately 1.5 km long with a total mean live cover of about 48 %. Surveys conducted by the IMA in 1999 identified the presence of eighteen species of hard (scleractinian) corals and 10 horny coral species, four sponges, and one zooanthid. The fore reef was dominated by dense strands of horn coral interspersed with coral boulder areas, coral rubble and sediment. The deeper fore reef area (9-15m) was dominated by stony corals. Twenty-five (25) families of fish and seventy-two (72) species were recorded in the 1999 surveys. Juvenile reefs fish included: snappers, grunts, Parrot fish, Scorpion fish, mojarras slippery dicks, belinnis, and sardines, (Juman, 2010).

Hassanali (2009) reported the presence of 17 species of hard coral on the reef system and these included *Agaricia agaricites*, *Agaricia grahamae*, *Dichocoenia stokes*, *Diploria labyrinthiformis*, *Diploria strigosa*, *Eusmilia fastigiata*, *Madracis decactis*, *Meandrina meandrites*, *Millipora alcicornis, Montastraea annularis*, *Montastraea cavernosa*, *Montastrea faveolata*, *Porites astreoides*, *Porites porites*, *Scolymia cubensis*, *Siderastrea radians* and *Siderastrea siderea*. Of the 11.9% mean hardcoral cover reported*, S. sidereal* and *M. faveolate* combined, accounted for more than half the coverage of hard corals. Gorgonians observed included Briareum, Erythropodium and Pseudopterogorgia. While finally, the zoanthid species *Palythoa* sp. was also observed. Macroalgae had a coverage of 12.9% on the reef, of which *Dictyota* sp. accounted for approximately 10.7%. It should be noted that Hassanali, (2009) focused on the forereef area and the area of interest for this study was the backreef and nearshore environment.

Khan (2021) observed several species of living hard coral in the backreef area east of Kilgwyn. These consisted primarily of the Lesser Starlet Coral (*Siderastrea radians*) and the Clubtip Finger Coral (*Porites porites*) which were very common. Also observed were Golfball Coral (*Favia fragum*), which was uncommon. The zooanthid, Encrusting Zooanthid (*Playthoa caribaeorum*) was also an uncommonly recorded *(Refer to **Appendix E4 - Biological Environment)***

The most recent reconnaissance survey carried out in September, 2022 of the backreef, seaward of the proposed project site, identified that the nearshore area was generally shallow and 1.8 m deep in its deepest area. In the nearshore area depths ranged between 1-1.2 m. Much of the backreef area consisted of coral rubble on the seafloor, that is, small broken pieces of old dead coral, most of it being Finger Coral (*Porites* sp.). These pieces could be loose in some areas, but in most site those pieces had settled tightly into place on the sea floor, possibly because of wave action massaging the pieces into a fit with fine sand holding it in place. Away from the nearshore area dead coral formation could also be found. Largest areas were approximately 2.7 m x 1.8 m. Inshore, dead formations were much smaller (approximately 1 m x 1.2 m), and less frequently observed. Dead coral formation can be described as a formation consisting of dead coral rubble that has been fused together with other rubble, sand, encrusting algae, encrusting coral, and other lifeforms to produce a notable structure of mass and shape much larger than individual rubble pieces. In terms of live coral, Lesser Starlet Coral (*S. radians*) and Club-tip Finger Coral (*P. porites*) were the only two species encountered. They were found alive only as very small fragments. A purple sponge was also observed, but it was more prevalent in the deeper area (**Figure 82 - 5.55**). *(Refer to **Appendix E4 - Biological Environment)***

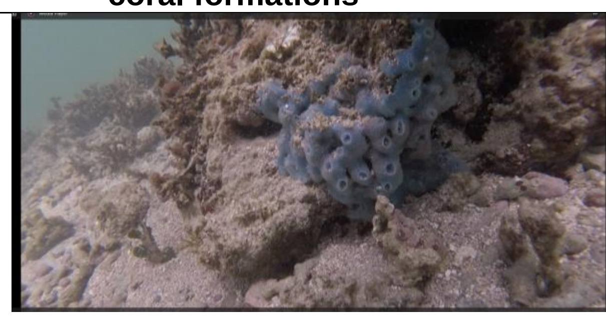
a) Coral Rubble dead Finger Coral

b) Larger pieces of dead coral

c) Sand between two large dead coral formations

d) Sand between two large dead coral formations

e) Living Lesser Starlet Coral



f) Dead coral formation with Purple Sponge

Figure 82 - 5.55: Seafloor Features of Kilgwyn Bay Backreef. Source- OptimalGESL Backreef Survey, 2022.

5.1.11.4 Terrestrial and Marine Faunal Communities

To identify, quantify and assess the health of faunal communities present within the immediate impact zone and the wider study area (i.e. within a 5km radius of the project site) a series of literature reviews and point count studies were conducted to examine the diversity of fauna present on the project site and to assess the cumulative impact of project activities on existing faunal communities within the Kilgwyn Bay/Tyson Hall areas. Emphasis was placed on the presence, type and number of species observed and particular attention was paid to the presence of sensitive, migratory, transient or commercially valuable species. Strategic point count surveys and point sampling of the benthos were conducted at specific locations for; Avifauna, Herpetofauna, Lepidoptera, Invertebrates (both terrestrial and marine) and fishes (were conducted at specific locations for Avifauna, Herpetofauna, Invertebrates (both terrestrial and marine). Incidental and ad-hoc observations were also recorded for each faunal group. The number of sightings, population size, species richness and any behavioral activities were recorded. Other intrinsic field data recorded included:

- Location
- Activity, such as feeding, foraging, mating, nest-building

Kilgwyn Bay and Southwest Tobago, Avifauna

Avifauna are good ecological indicators since their presence or absence tends to represent conditions pertaining to the proper functioning of an ecosystem. Bird communities and their ecological status are linked to land cover. As the land cover of an area changes, so do the types of birds found. Land cover is directly linked to habitat type. A greater diversity of habitats will give rise to an equally diverse avifaunal community.

Collectively a total of 487 species of birds have been confirmed on the islands of Trinidad and Tobago. The islands are within a few miles of Venezuela, and the species are therefore typical of tropical South America. However, the number of species is relatively low compared to the mainland, as would be expected on small islands and Tobago has only half the number of bird species of Trinidad. The resident breeding birds on the island are augmented in the northern winter period by migrants from North America. As such, point counts during appropriate times of year are necessary capture a full picture of an avifaunal population. Focus was therefore placed on the Dry Season month of March 2022 and the Wet Season month of September 2022 which laid within the migratory winter period of August to May when the potential for species occurrence is moderate to high (based on historical knowledge and site records). The point counts were also supplemented with historical records for Kilgwyn Bay documented by nature enthusiasts, bird watchers and experienced ornithologists for the period 2020 to 2022.

The field assessments/counts included vantage point surveys and transects surveys throughout the respective project area. Access paths and hunting trails were generally used for access into the heavily forested areas. The activities undertaken and data collected during the avifaunal survey included:

- Identification of key species (IUCN listed), and Environmentally Sensitive Species (ESS).
- Density surveys for certain key species.
- Bird movements at various vantage points.
- Behavioural aspects of key species especially those that would be impacted upon by the proposed hotel construction and operation e.g., breeding and roosting observations.
- Distribution of species that were not known to previously occur in that area.
- Diurnal Surveys were carried out to estimate spatial and temporal use of the site by resident and migrant birds. Point studies were carried out at dawn (5:30 – 8:00 am) and at dusk (5:00 -6:30 pm) when bird activity was at a peak.

Visual records of birds were collected non-systematically along 1 km of two trails (Refer to **Figure 84 - 5.57**). using a 8 × 40 binoculars and a camera, *(Refer to **Appendix E4 - Biological Environment**)*

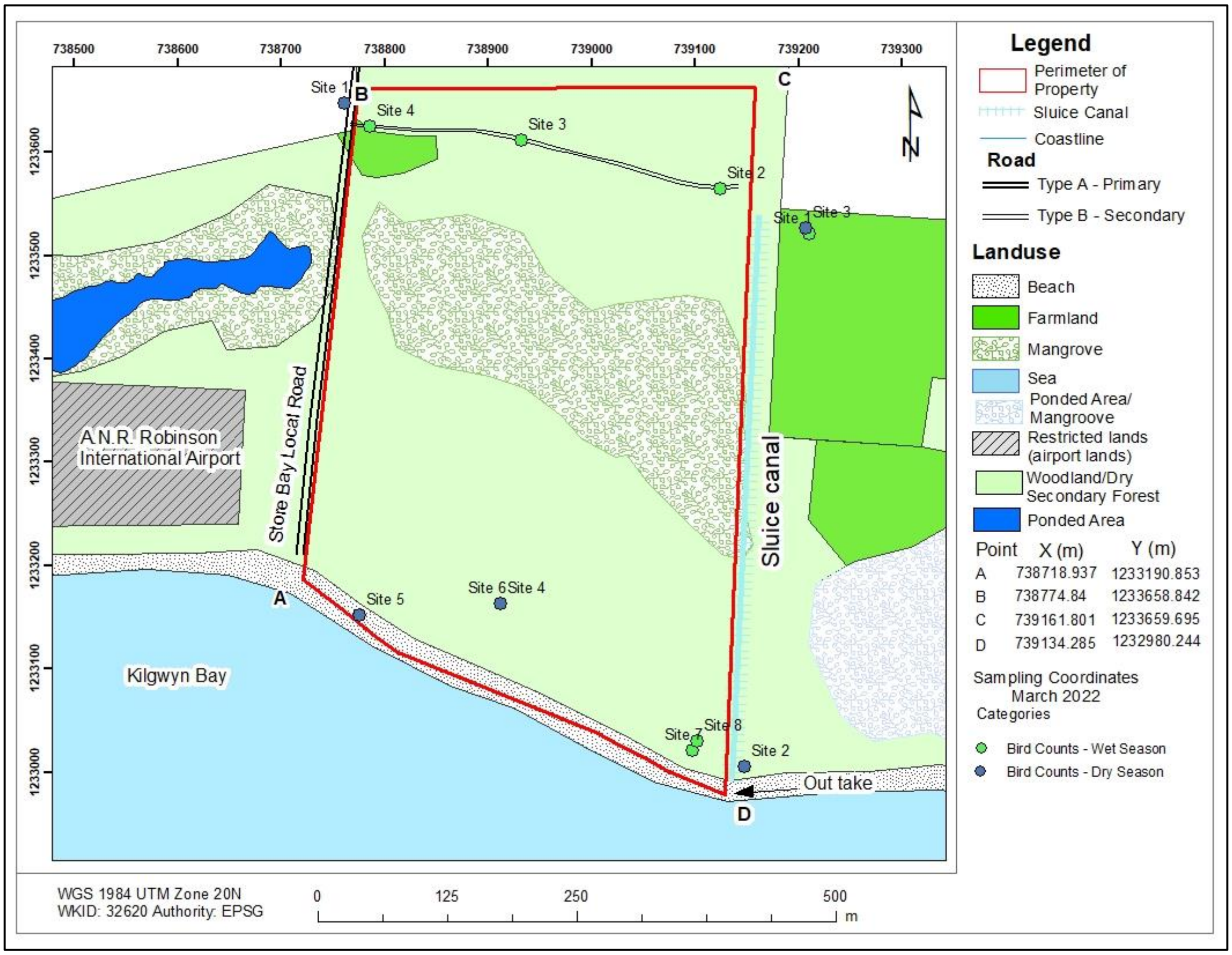


Figure 83 - 5.56: Avifaunal Point Count Locations.

The first real time surveys for the study area were conducted in over the period March 27th and March 29th, 2022 (Dry Season) and the second set of surveys were conducted between 18th September and 19th June 2022 (Wet Season) (**Figure 84 - 5.57**)

Figure 84 - 5.57: Field Technicians Conducting Point Counts.

A total of 269 individuals were recorded in the March and 229 individuals were recorded in September. Differences in the Wet Season population/community resulted as a large population of Killdeer (*Charadrius vociferus*), Sanderlings (*Calidris alb*), Lesser Yellow Legs (*Tringa flavipes*) and Spotted Sandpiper (*Actitis macularius*) were observed feeding on mudflats and in shallow ponds within the littoral area of Kilgwyn Bay (**Figure 85 - 5.58 d)**, Lesser Yellow legs feeding in shallow pond). These cleared inundated areas were the result of recent (September 2022), illegal vegetation clearance.

A total of 59 species of birds were observed within the Kilgwyn Swamp area between the period 2021 and 2022 (Inclusive of eBird counts). None of the bird species observed were considered rare or endangered however one species was endemic to Trinidad and Tobago (i.e. Trinidad Mot Mot (*Momotus bahamensis*)). The majority of bird species observed were common residents of both islands and favoured forest edges, open woodlands, and shrubby secondary growth. Several were well adapted to human environments (i.e. built up areas and farmlands). Four species of birds were listed as only present and breeding on the island of Tobago by ffrench (1991). These birds were; the Caribbean Martin (*Progne dominicensis*) Scrub greenlet (*Hylophilus flavipe*), the Rufus-Vented Chacalaca (*Ortalis ruficauda*) and the Black-Faced grassquit (*Melanospiza bicolo*). Eight (8) species were thought to have visitor populations, having potentially inflated counts during their winter migratory period (See **Table 53 - 5-42**).

The most common families were Passeriformes. Sometimes known as perching birds, passerines included more than half of all bird species observed the most common being the Banana Quit (*Coereba flaveola*), the Barred Antshrike (*Thamnophilus doliatu*) and the Rufus-Vented Chacalaca (*Ortalis ruficauda*) (**Figure 85 - 5.58**). Anseriformes birds or waterfowl (e.g., herons) and Charadriiformes (e.g. plovers, sanderlings, sandpipers) were also common. These species were obligatory wetland or shore birds, and their habitat range was limited to the shallow ponds, lagoons and mangrove forest of Kilgwyn Swamp. Birdscaribbean (2002) reported that the swamp lagoon is an important roosting and foraging area for White-cheeked Pintails (*Anas bahamensis*) and Yellow-crowned Night Herons (*Nyctanassa violacea*).

a) Banana Quit

b) Barred Antshrike

c) Trinidad Mot Mot

d) Lesser Yellow Legs

Figure 85 - 5.58: Avifauna Observed During Point Counts (2022).

Table 53 - 5-42: Avifaunal Species Recorded at Kilgwyn, Southwest Tobago (2021-2022).

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
1	Anhinga	*Anhinga anhinga*	Found in wooded swamps, marshes, and ponds.	One individual observed at lagoon	Least Concern		X	
2	American Moorhen	*Gallinula galeata*	Marsh Bird often seen swimming, picking at the water's surface, or walking along the edge of aquatic vegetation.	Common resident: few species observed in lagoon and at shallow ponds.	Least Concern		X	X
3	Bananaquit	*Coereba flaveola*	Forest edge, woodland, and gardens	Common resident observed in all habitats	Least Concern	X	X	X
4	Barred Antshrike	*Thamnophilus doliatu*	Thickets, forest edge, and other tangled vegetation.	Common resident observed in Littoral and Secondary Forest.	Least Concern	X	X	X

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
5	Blue-grey Tanager	*Thraupis episcopus*	Open and semi-open areas with larger trees and hedges, towns, villages, and gardens.	Common resident observed in Littoral and Secondary Forest	Least Concern	X	X	X
6	Black-faced Grassquit	*Melanospiza bicolo*	Found in pairs or small groups in shrubby or grassy areas and forest edge, typically on or near the ground. Listed as not being recorded in Trinidad	Observed once in Littoral woodland	Least Concern		X	X
7	Black-throated Mango	*Anthracothorax nigricollis*	Found in open habitats including forest edge, open woodlands, and shrubby secondary growth.	Observed in along access trail in Secondary Forest	Least Concern		X	X

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
8	Blue-Black Grassquit	*Volatinia jacarina*	Found in weedy and brushy fields, farmland, and other open grassy areas in tropical lowlands	Observed in along access trail in Secondary Forest	Least Concern	X	X	X
9	Blue-tailed Emerald	*Chlorostilbon mellisugus*	Found in a variety of rainforest habitats, but most common around forest edges, including in agricultural areas.	Observed in along access trail in Secondary Forest		X		
10	Brown-crested Flycatcher	*Myiarchus tyrannulus*	Forest edge and woodland habitats especially near water.	Common but local resident in Tobago.	Least Concern	X	X	X
11	Brown Pelican	*Pelecanus occidentalis*	Strictly coastal	Common resident. One observed roosting on a moored	Least Concern	X		X

ID	**Common Name**	**Species Name**	**Habitat**	**Distribution in 2022**	**IUCN Red List Category**	**Wet**	**Dry**	**Lit Rev. 2021-2022**
				fishing boat.				
12	Carib Grackle	*Quiscalus lugubris*	Open habitats, including towns and cities, especially abundant along the coast	Common resident. Observed along forest edge at agricultural plot	Least Concern		X	X
13	Caribbean Martin	*Progne dominicensis*	Found over a wide variety of open habitats, especially near water, including marshes and towns.	Resident of Tobago. Breeding population on the island. Observed along the shore and along the access trails and electrical wires.	Least Concern	X		
13	Cattle Egret	*Bubulcus ibis*	frequently seen in dry habitats	Common but local resident. Observed	Least Concern	X	X	

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
				near farmstead.				
14	Cocoa Woodcreeper	*Xiphorhynchus susurrans*	Found in wooded habitats, often in more open forest, edge, or second growth	Uncommon Resident. Observed in Secondary Forest.	Least Concern		X	X
15	Copper-rumped Hummingbird	*Saucerottia tobaci*	Usually in forest edges, second growth woodland, and garden	Common resident. Observed along access trail in Secondary Forest	Least Concern	X	X	
16	Eared Dove	*Zenaida auriculata*	Found in open and disturbed habitats including agricultural fields, towns and cities, and shrubby areas.	Common resident. Observed along access trail in Secondary Forest	Least Concern	X	X	X

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
17	Green Heron	*Butorides virescens*	Partly concealed in vegetation.	Common resident with a migrant population. Observed along lagoon edges.	Least Concern	X	X	X
18	Green-rumped Parrotlet	*Forpus passerinus*	Open habitats	Common resident. Observed near agricultural plot and Litoral Woodland.	Least Concern		X	X
19	Golden-olive Woodpecker	*Colaptes rubiginosus*	Widespread ‘in tropical and subtropical forest. Prefers mid-upper levels of forest.	Seen on dry trees in Secondary Forest. Three individuals observed nesting.	Least Concern	X	X	X
20	Killdeer	*Charadrius vociferus*	Often nests near human development: parking lots, school roofs,	Uncommon but regular winter-passage migrant.	Least Concern	X		

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
			road edges, and farms, usually on bare gravel.	Observed at shallow ponds				
21	Kiskadee	*Pitangus sulphuratus*	Occurs in shrubby woodlands, often near clearings or bodies of water.	Common resident in Littoral Woodland and Secondary Forest	Least Concern	X	X	
22	Little Blue Heron	*Egretta caerulea*	Found in a variety of wetland habitats, especially shallow marshy pools.	Common resident with a migrant population. Observed in Lagoon	Least Concern		X	
23	Lesser Yellow Legs	*Tringa flavipes*	Forages actively on mudflats and in shallow pools and marshes,	Common resident with a migrant population. Observed on the banks of shallow ponds	Least Concern	X	X	X

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
24	Magnificent frigate	*Fregata magnificens*	seabird of warm tropical oceans and coastlines	Observed once overhead	Least Concern		X	X
25	Mangrove Cuckoo	*Coccyzus minor*	Found in shrubby woodland (especially mangroves)		Least Concern			X
26	Northern Waterthrush	*Parkesia noveboracensis*	Dense vegetation near water. near the ground	Common winter resident. Observed within the Littoral Woodland	Least Concern		X	X
27	Palm Tanager	*Thraupis palmarum*	A habitat generalist often found around palm trees and in open shrubby areas, gardens, and forest edge	Common resident. Observed in Littoral Woodland and Secondary Forest.	Least Concern	X	X	X
28	Peregrine Falcon	*Falco peregrinus*	Seen in a wide range of habitats; often encountered	Observed once roosting on	Least Concern		X	

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
			in areas with steep cliffs, as well as around coastal mudflats and open areas with shorebirds.	a Coconut Palm				
29	Ruby-Topaz Hummingbird	*Chrysolampis mosquitus*	Fairly common in open habitats, including savannah, forest edge, and gardens.	Common resident. Observed in Littoral Woodland and Secondary Forest	Least Concern		X	
30	Ruddy Ground Dove	Columbina talpacoti	open and semi-open areas, often in villages and even towns	Common resident. Observed in Littoral Woodland and Secondary Forest.	Least Concern	X	X	X
31	Rufous - vented Chacalaca	*Ortalis ruficauda*	Ground-dwelling bird of scrub and woodlands	Common resident, only found in Tobago. Observed	Least Concern	X	X	X

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
				in all habitats (i.e. Swamp, Littoral Woodland and Secondary Forest)				
32	Rufous-tailed Jacamar	*Galbula ruficaud*	Lives in evergreen forest, often at edges and around adjacent clearings		Least Concern			X
33	Sanderling	*Calidris alb*	Flocks are usually seen on open beaches, well known for running back-and-forth chasing waves and feeding actively in the sand. Also occurs on mudflat.	Common visitor. Observed on shore and edges of ponds.		X		X

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
34	Scrub Greenlet	*Hylophilus flavipe*	Prefers scrubby second growth, usually low.	Breeding population fond in Tobago. Observed in Littoral Woodland			X	X
35	Semipalmated Plover	*Charadrius semipalmatus*	Feeds on mudflats and beaches	Common visitor. Observed on shore and edges of ponds.	Least Concern	X	X	X
36	Smooth-billed Ani	*Crotophaga ani*	Open and semi-open habitats in tropical lowlands and foothills, typically staying low in shrubs and grasses	Common resident. Observed within agricultural plot.	Least Concern		X	X
37	Spectacled Thrush	*Turdus nudigenis*	Open woodland	Common resident in Littoral Woodland and	Least Concern	X	X	X

ID	**Common Name**	**Species Name**	**Habitat**	**Distribution in 2022**	**IUCN Red List Category**	**Wet**	**Dry**	**Lit Rev. 2021-2022**
				Secondary Forest				
38	Spotted Sandpiper	*Actitis macularius*	Edges of streams, ponds, and lake	Common winter visitor. Observed on shore and edges of ponds.	Least Concern	X		X
39	Tricoloured Heron	*Egretta tricolor*	Occurs in shallow wetlands, marshes, and mudflats	Uncommon in Tobago. Resident in Trinidad. Seen once near lagoon	Least Concern		X	
40	Trinidad Mot Mot	*Momotus bahamensis*	Endemic to Trinidad and Tobago	Common Resident. Observed in Littoral Forest	Least Concern	X	X	X
41	Tropical Kingbird	*Tyrannus melancholicus*	Prefers open areas with some trees and water. Most abundant in	Common Resident. Found in Littoral Forest	Least Concern		X	X

ID	Common Name	Species Name	Habitat	Distribution in 2022	IUCN Red List Category	Wet	Dry	Lit Rev. 2021-2022
			lowlands and foothills					
42	Tropical Mockingbird	*Mimus gilvus*	Common and often conspicuous in open and semi-open lowland tropical areas, perching on roadside wires	Common resident. Observed in Littoral woodland and Secondary Forest.	Least Concern	X	X	X
43	White-cheeked Pintail	*Anas bahamensis*	Found in both fresh and saline wetlands.	Uncommon Resident observed in ponds	Least Concern		X	X
44	White-fringed Antwren	*Formicivora grise*	Lower levels of dense shrubby woodland	Common resident. Observed in Littoral woodland and Secondary Forest.	Least Concern	X	X	X
45	White-tipped Dove	*Leptotila verreauxi*	Found in a variety of wooded habitats; more likely to be	Common resident. Observed in Littoral woodland	Least Concern	X	X	X

ID	**Common Name**	**Species Name**	**Habitat**	**Distribution in 2022**	**IUCN Red List Category**	**Wet**	**Dry**	**Lit Rev. 2021-2022**
			found in disturbed or scrubby areas	and Secondary Forest.				
46	Yellow-breasted Flycatcher	*Tolmomyias flaviventris*	woodlands, forests, and secondary growth	Common resident	Least Concern	X	X	X
47	Yellow-crowed Night heron	*Nyctanassa violacea*	Often inconspicuous heron, roosts in trees by day	Common resident observed roosting in trees near lagoon	Least Concern	X	X	X
48	Yellow-headed Caracara	*Daptrius chimachima*	Found in open habitats, such as fields and river edges, where it often perches conspicuously	Common resident. Observed in Littoral woodland	Least Concern	X	X	
49	Yellow Warbler	*Setophaga petechia*	Favors brushy habitats near water, often foraging in shrubs fairly low to the ground	Common winter visitor. Seen in Littoral woodland	Least Concern	X	X	X

Kilgwyn Emergent Wetland Aquatic Fauna

Fishes

Tobago’s geological history differs somewhat from that of Trinidad. The South-western portion of Tobago is a raised coral platform, whereas the Main Ridge mountains of Tobago and the Northern Range mountains of Trinidad are considered to be the eastern end of the Andean Mountain range, contiguous with that of the Paria Peninsula in Venezuela. The three land masses are separated by drowned valleys. Tobago, however, was never part of the Orinoco River system. These differences in their development are mirrored by differences in the freshwater fauna of the two islands. Tobago’s fauna more closely resembles that of the Antillean islands to the north, streams of Trinidad’s north coast (Phillip 1998, Rostant 2005), and the continental islands off northern Venezuela (e.g., Debrot 2003), and generally lacks organisms from the Orinoco Delta region (Philip et. al. 2013, Phillip 1998, Rostant 2005). The diversity of fish fauna observed within Kilgwyn Swamp was quite low even for Tobago. This habitat feature was attributed to the impact human activities (i.e. dumping of garbage, high sediment loading of channels, diversion of water courses, surface water pollution) were having on the local hydrology and water quality of the area. Field technicians also encountered difficulties accessing the interior of the swamp/ lagoons and deploying nets within the mangrove system due to the water depth and the unconsolidated nature of sediments within inundated areas. Sampling locations for benthic invertebrate and aquatic fish fauna are provided in **Figure 86 - 5.59**.

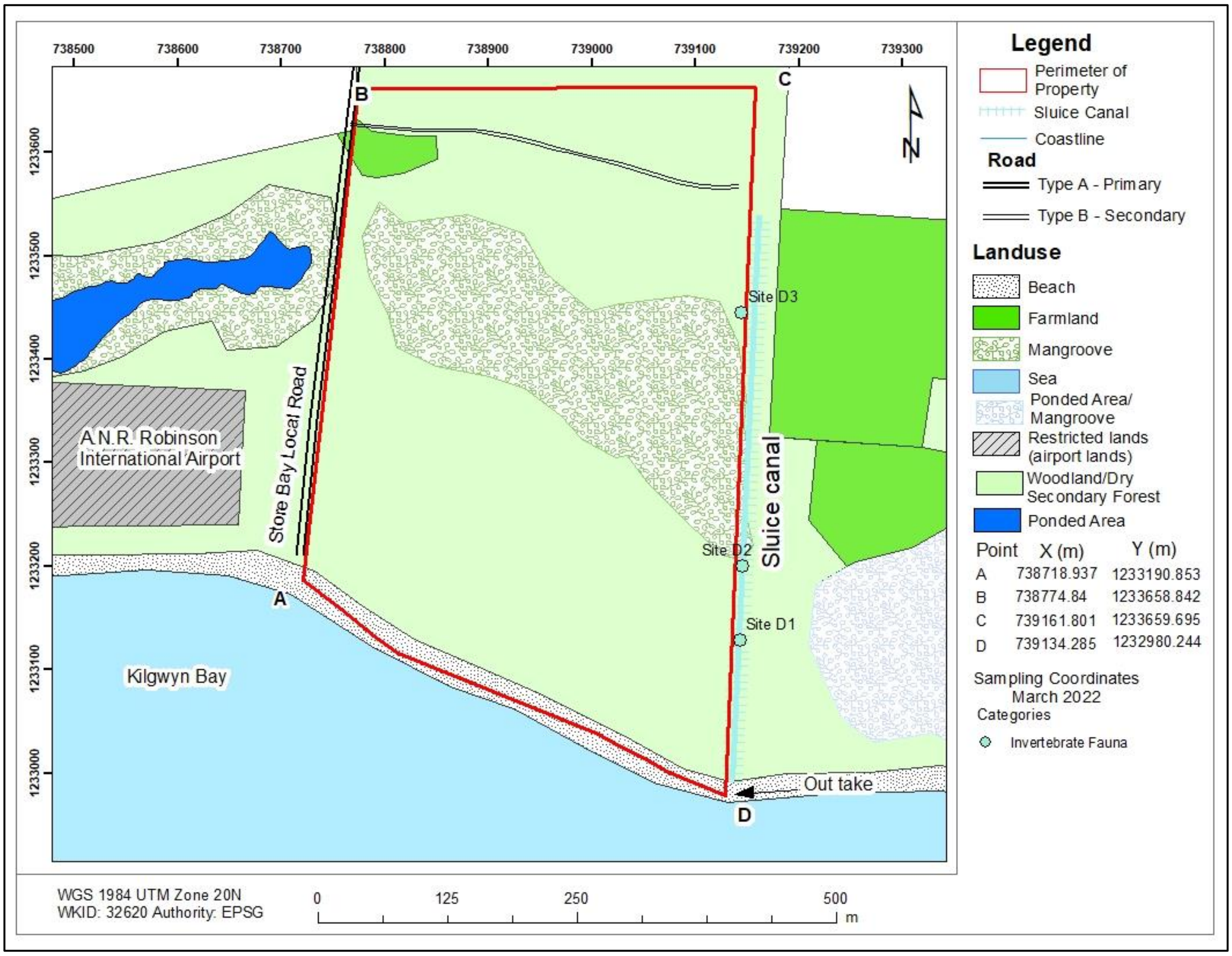


Figure 86 - 5.59: Invertebrate and Fish Sampling Locations.

At all locations where there was an opening in the prop root system, sampling was conducted using baited fish pots, pull seins, cast nets and dip nets (**Figure 87 - 5.60**).

a) Baited Fish Pot

b) Cast net

c) Benthic Ponar Grab

Figure 87 - 5.60: Aquatic Fauna Sampling Methods (2022).

Only two fish species were observed within the Kilgwyn Swamp these were Gyppy (*Poecilia reticulata*) and Granticai/Tarpon (*Megalops atlanticus*), (**Figure 88 - 5.61**). The guppy was widely introduced to local streams and has been established, mainly for mosquito control.

The species is quite hardy and can be found in clear streams as well as heavily perturbed/polluted drains and ditches. The fish historically had rare to non-existing effects on mosquitoes but is also considered to have negative to neutral effects on native fish species. Tarpon generally inhabit coastal waters, bays, estuaries, mangrove-lined lagoons, and rivers (Whitehead and Vergara, 1978). Often found in river mouths and bays entering fresh water, schools may frequent particular spots for years (Lieske and Myers, 1994). The species feeds on fishes like sardines, anchovies, Mugilidae, *Centropomus*, Cichlidae and crabs. It is thus likely that these species of fish may also be present within Kilgwyn Bay coastal waters and or trapped within the swamp's lagoon system. Additionally, based on local literature, another species likely be present within Kilgwyn Swamp (given the environmental conditions and historical records) is the Giant Goby (*Gobiomorus dormitory*), (Phillip, 1998).

a) Guppies

b) Tarpon

Figure 88 - 5.61: Fish Species Observed within the Kilgwyn Swamp.

Aquatic Invertebrates

Three (3) stream locations within the earthen sluice drain were surveyed in March 2022 (Dry Season) and September 2022 (Wet Season), (**Figure 90 – 5.63**). Location D1 was situated downstream at the mouth of the Sluice Drain, Location D2 was mid-course and Location D3 was situated upstream at the base of a land terrace and a homestead where subsistence agriculture occurs. The three (3) sampling sites were chosen based on (a) accessibility and (b) rate of stream flow.

At each location sampling was carried out using a petit ponar grab (**Figure 87 – 5.60 c)**). The petit ponar grab collected triplicate, sediment samples from a stream bed surface area of 152 x 152 mm. The drain appeared to support a low population of invertebrates. The channel and the samples collected were depauperate of specimens during both study periods. In March 2022, a total of forty-nine (49) organisms were collected from the three (3) locations surveyed. Taxonomic investigation of the invertebrate fauna identified the presence of five (5) unique species within the drainage system. Of these species, one (1) belonged to the Arthropoda phylum and three (3) to the Mollusca phylum. In September 2022, only seven (7) organisms were collected at the same three locations. These specimens represented one species belonging to the Mollusca phylum. **Table 54 - 5-43** provides a list of the species observed.

Table 54 - 5-43: Aquatic Invertebrate Species Recorded at Kilgwyn Sluice Drain, Southwest Tobago (2022).

Phylum	**Class**	**Order**	**Family**	**Species name**	**Common Name**	**D 1** (March)	**D 2 (March)**	**D 3) (March)**	**D 2 (September)**
Mollusca	Branchiopoda	Anostraca	Artemiidae		Brine Shrimp	**1**			
Mollusca	Gastropoda	Neotaenioglossa	Thiaridae	*Tarebia granifera*	Quilted melania	1	11		
Mollusca	Gastropoda	Neotaenioglossa	Thiaridae	*Melanoides tuberculata*	Red-rimmed melania	1	34		
Mollusca	Gastropoda	Basommatophora	Physidae		Bladder Snail		1		7

As shown, the most abundant taxa observed within the drainage system was the freshwater snail Red-rimmed melania (*Melanoides tuberculate*). Native to eastern Africa and the Middle East, this species has established widely throughout the tropics. It has demonstrated that it can rapidly colonize many types of habitats and can reach very high densities up to several thousands of individuals per m2 (Dundee and Paine, 1977). It is a ubiquitous species and can tolerate a broad spectrum of environmental conditions. It is capable of colonizing disturbed habitats (especially man-made habitats) such as garden ponds, artificial lakes and irrigation systems in Tobago. Like the Red-rimmed Melania the Quilted melania (*Tarebia granifera*) was also observed in large numbers. This is also an invasive species. Both these snails have expanded distributions on the island.

The diversity of species collected within the Kilgwyn earthen drain was quite low. The Shannon-Weaver index of diversity calculated for all locations was less than 1.5 *(Refer to* ***Appendix E4 - Biological Environment***). Similar studies for tropical regions showed that rivers with a Shannon-Weaver index of $\geq$3.0 were found in pristine rivers, while $\leq$ 1.5 were found in rivers that were heavily perturbed. Moderately polluted rivers had indices ranging > 1.5 but < 3.0 (Barbosa *et. al.*, 2001). In addition to the low diversity, the taxa observed in the current survey (Wet and Dry Season) were tolerant of impaired to moderately impaired environmental conditions.

Other benthic invertebrates observed in marshy areas were the snail *Pomeca diffusa* and the Blue-land Crab. Both these species were commonly encountered on the proposed development site throughout the Swamp (**Figure 89 - 5.62**).

a) ***P. diffusa***	b) **Blue Land Crab (*Cardisoma guanhumi*)**

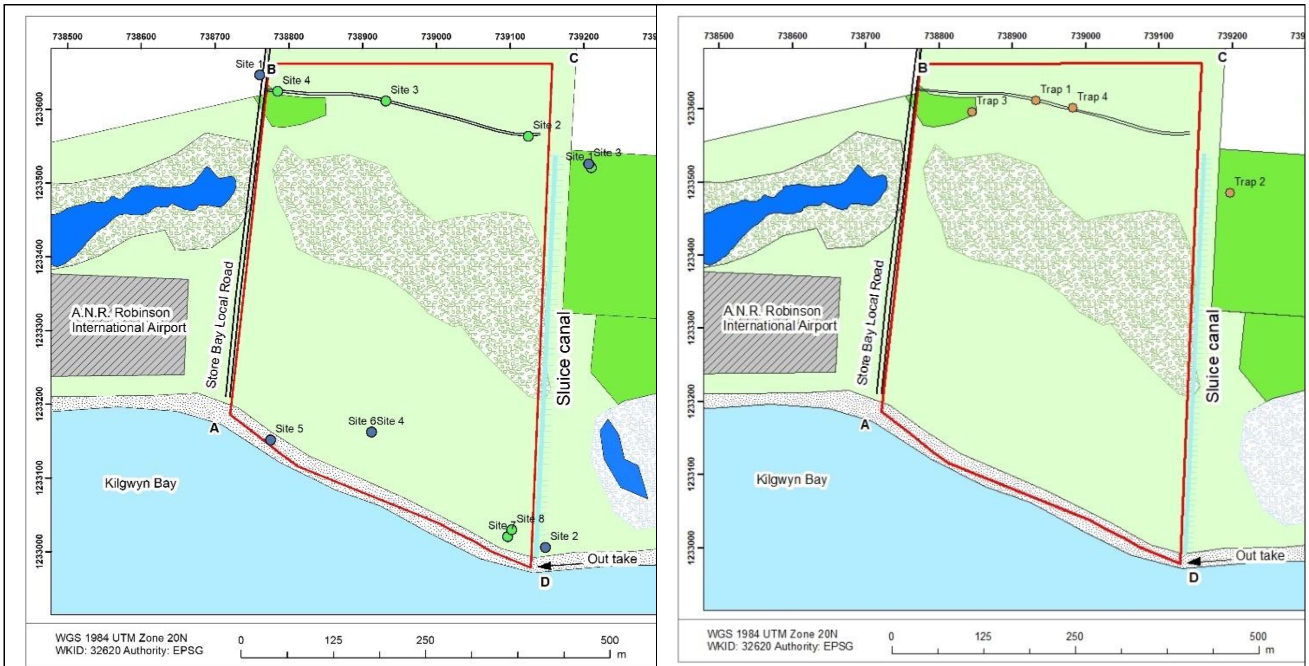
Figure 89 - 5.62: Terrestrial Invertebrate Fauna Kilgwyn Swamp, 2022.

Reptiles and Amphibians

An Environmental Impact Assessment (EIA) is an important tool used to help mitigate threats to biodiversity during human development and anthropogenic modification. Ecological surveys of fauna and flora are a core component of EIAs to gauge potential threats to wildlife in a proposed area. Among fauna surveyed, herpetofauna (amphibians and reptiles) are often overlooked because of their cryptic nature. However, amphibians are among the most threatened animals globally. They are sensitive to both terrestrial and aquatic pollution and are especially susceptible to habitat loss. In addition to their sensitivity to habitat alteration, they make up important components of ecosystems, acting as predator and prey to a variety of other animals, and also can provide health benefits to people through research on their medically important compounds and their diet comprising disease carrying mosquitoes. Reptiles on the other hand are mostly predators but also prey for many other animals. Unlike amphibians, they do not make species specific calls and tend to be more challenging to survey quantitatively. Some reptiles (e.g., lizards), do tend to sometimes exhibit site fidelity. This can be used to assess preferred habitat types. Point Counts along two access trails and strategically placed camera traps were used to assess the herpetofauna diversity on the project site. These counts were carried out at dawn (5:30-8:30 am) and dusk (4:30 -6:00 pm) between March 27th and March 29th, 2022 (Dry Season) and 18th September and 19th June 2022 (Wet Season). The location of point counts and camera traps are provided in **Figure 90 - 5.63** below.

Based on the cryptic nature of the two faunal classes very low population counts and species numbers were recorded during both the Wet and Dry Seasons. Each species was represented by a range of one to three observed specimens. The amphibians were represented by three frog species these included Ditch frogs (*Leptodactylus validus*), Cane toad (*Rhinella marina*), Flying tree frog (*Hyla sp.*). All three species are widespread on both islands and favour open areas, savannahs and forest edges were ditches or pools can be found. A greater number of reptiles were observed. Six (6) species belonged to the Sauria suborder (Lizards) and one (1) to the Serpentes suborder (Snakes). The seven species for lizards observed included three *Anolis* spp. (including *Anolis richardii*), Green Iguana (*Iguana*

iguana), Matte (*Tupinambis teguixin*) and Zandolie (*Ameiva ameiva*). The only snake observed was the Parrot or Horsewhip snake (*Leptophis ahaetulla coeruleodorsus*). Parrot snakes exploit a wide range of habitats and can be found in moist or wet forests, rainforests and even in dry forests. They can also be found in shrubbery near sources of water. This species is arboreal and mostly spend it's time within the low to middle elevations of trees. The snake is diurnal which means they are active during the day and would normally sleep in vegetation or within trees at night. Its diurnal nature is likely the reason for this species being observed during the 2022 rapid field surveys.



a) Herpetofauna Point Count Locations

b) Camera Trap Locations

Figure 90 - 5.63: Herpetofaunal Point Count and Camera Trap Locations (2022).

a) *Anolis* sp.

b) Green Iguana

c) Parrot Snake

Figure 91 - 5.64: Reptiles Observed in Kilgwyn Swamp (2022).

Mammals

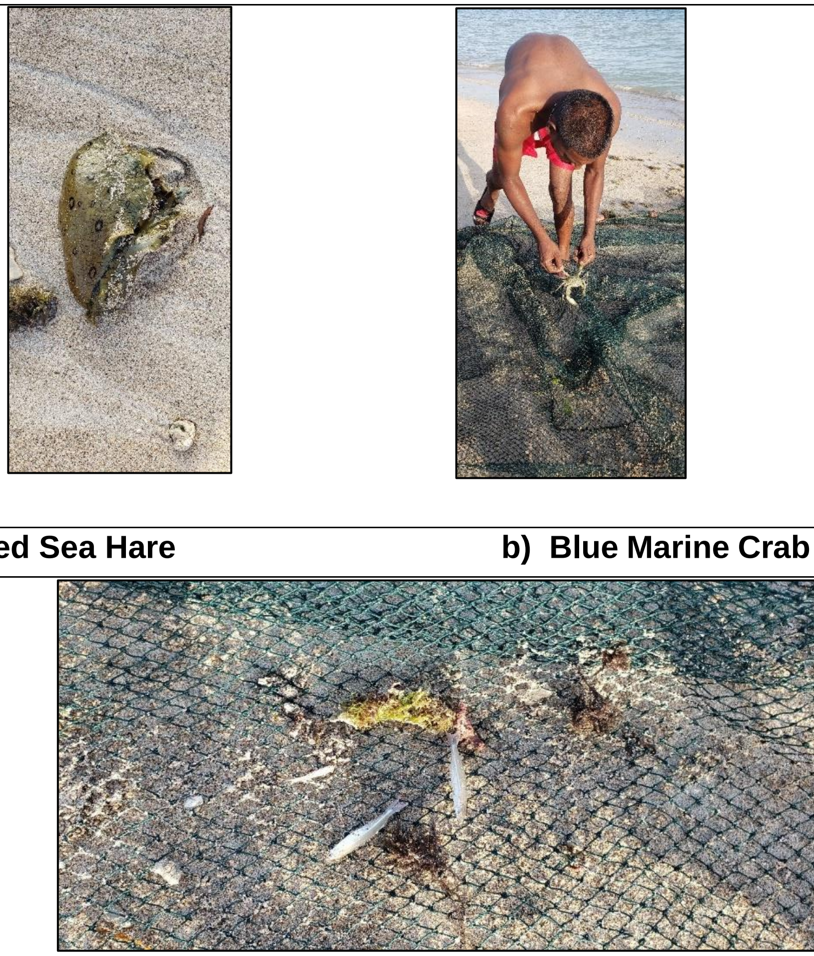
Only two mammalian species were observed during the March 2022 and September 2022 rapid biological surveys these were the Red-rump agouti (*Dasyprocta leporine)*, the Red-tailed squirrel (*Sciurus granatensis*). Footprint evidence at mudflats around shallow ponds suggested that Lappe (*Cuniculus paca*) may also be present within the study area. Based on anecdotal references other common species of mammals which may traverse the secondary forest and wetland of Kilgwyn include and the Common opossum (*Didelphis marsupialis*) and the Crab-eating Raccoon (*Procyon cancrivorus*) although it should be noted there was no definite evidence of either species being present at the time surveys were conducted in 2022.

Marine Fauna

Fish assemblages found within the reefs at La Guria Bay (i.e. including Flying Reef, Majeston Reef and Cove Reef) were studied and discussed by Alemu (2014). While there was no species listing specific for Kilgwyn Bay, reef fish species from the families Pomacentridae, Labridae, Scaridae, Haemulidae, Acanthuridae and Serranidae were noted, with Flying Reef found to have a species richness of 20. Alemu (2014) gave a brief description of the fish fauna at Kilgwyn Bay as being dominated by families of parrotfish (Scaridae) particularly *Scarusiseri* sp., *S. taeniopteus*, *Sparisoma viride*, and *S. aurofrenatum*) and wrasse (Labridae) particularly *Thalassoma bifasciatum,* and *Clepticus parrae*. The fish assemblage observed was found to be that of intermediate relief low-coral cover. It must be noted that Alemu, (2014) focused on the forereef area and the area of interest for this study is the backreef. Alemu (2014), also recorded the presence of the invasive Lionfish (*Pterois* sp.) within the general area of Kilgwyn Bay.

During an earlier, more comprehensive beam trawl survey from La Guira Bay to Canoe Bay (Juman and Alexander, 2006), species caught included Red-band Parrotfish (*Sparisome aurofrenatum*), Green-blotch Parrotfish (*Sparisoma atomarium*), Rainbow Parrotfish (*Scarus croicensis*), Slippery dick (*Halichoeres bivittatus*) and Crab (*Callinectes* sp.). Other marine fauna documented for the general Kilgwyn Bay area include Hawksbill Turtle (*Eretmochelys imbricate*) (Walker, et al., 2015) (Dow, Eckert, Palmer, and Kramer, 2007) which have been recorded as nesting on Kilgwyn Beach, Queen Conch (*Strombus gigas*) (Georges, Ramdeen, and Oxenford, 2010), Sea Slugs (Nudibranch) including the Spotted Sea Hare (*Aplysia dactylomela*) and Chain Moray Eel (*Echidna catenata*) (Khan 2021, ***Appendix E4 - Biological Environment*****).**

During a September 2022 reconnaissance swim of the backreef zone within Kilgwyn Bay several Parrotfish (Scaridae) species, Sargent Major (Abudefduf saxatilis) and Wrasse (*Halichoeres* sp.) were observed *(Refer to* ***Appendix E4 - Biological Environment*****).** A beach seine of the nearshore area conducted in March 2022 resulted in the collection of the Blue marine Crab (*Callinectes* sp.), *Anchoa* sp. and the Spotted Sea hare (*Aplysia dactylomela*) (**Figure 5.65**).



a) **Spotted Sea Hare**

b) **Blue Marine Crab (*Callinectes* sp.)**

c) **Anchovies**

Figure 92 - 5.65: Marine Fauna Observed in Kilgwyn Bay Nearshore Environment (2022).

The study area of Kilgwyn Bay appeared to be depauperate of benthic infauna having a small invertebrate population with low species diversity (i.e. Index values < 1.5). The poor sample population observed in March and September 2022 may have been directly influenced by sediment loading and smothering resulting from terrestrial sediment transport from onshore construction activities (i.e. new airport runway expansion) and the movement of pollutants from land-based activities into the marine environment. The fauna observed/collected favored habitats with fine sediments, which appeared to typify the sediment channels found within the bay.

Five (5) marine benthic locations were surveyed on the 28th of March 2022 (Dry Season) and September 19th (Wet Season), (**Figure 93 - 5.66**). At each location sampling was carried out using a petit ponar grab. The petit ponar grab collected replicate, sediment samples from a surface area of 152 x 152 mm of the seabed. The five sampling sites were chosen based on (a) distance from the coastline, (b) reef location and (c) sediment availability. The Bay's floor consisted of coral rubble, coral, boulders, and sediment channels. Finding appropriate sediment channels for sampling was a limitation posed by the site characteristics. As such, triplicate sediment samples were not obtained at each sample location. During the Dry season eleven (11) replicate samples were collected *(Refer to* ***Appendix E4 - Biological Environment*** for raw data and sample breakdown) and in the Wet Season only five samples were collected (one at each location).

In March 2022, a total of thirty-two (32) organisms were collected from the five (5) locations surveyed by Optimal. Taxonomic investigation of the invertebrate fauna identified the presence of five (5) unique species. Of these species, one (1) belonged to the Annelida phylum and four (4) to the Arthropoda phylum. In September 2022, a total of fifteen (15) organisms were collected from the same five locations. These species encompassed the presence of six (6) unique species, four (4) belonged to the Arthropoda phylum, one (1) to the Mollusca phylum and one (1) to the Nemertean phylum (**Table 55 - 5-44**).

The most abundant taxa observed within the Bay in March and September was the amphipod *Ampelica* sp. These amphipods are benthic, found at the bottom of seas and oceans. They are distributed worldwide and are often abundant in areas with fine sediments. They live in infaunal tubes, constructed from "amphipod silk" and sediment (King, 2009). The Potamididae snails observed at KBMS 4 during the wet season (September) are typically a family of small brackish water snails that live on mud flats, mangroves, and similar habitats (Reid et. al. 2008). Their presence may have reflected the increased influence of terrestrial freshwater runoff to the Bay during the Wet Season.

Table 55 - 5-44: Aquatic Invertebrate Species Recorded at Kilgwyn Bay, Southwest Tobago (2022).

STATION				KBMS Dry 1	KBMS Dry 2	KBMS Dry 3	KBMS Dry 4	KBMS Dry 5	KB MS Wet 1	KB MS Wet 2	KB MS Wet 3	KB MS Wet 4	KB MS Wet 5
Phylum	**Class**	**Family**	**Taxon Name**										
Annelida	Polychaeta	Oweniidae	*Owenia* sp.				3						
Arthropoda	Malacostraca	Ampeliscidae	*Byblis* sp.	2		1							
Arthropoda	Malacostraca	Ampeliscidae	*Ampelisca* sp.a	1	7	1	8	3	1		1		1
Arthropoda	Malacostraca	Ampeliscidae	*Ampelisca* sp.*b*	1			2	1				1	
Arthropoda	Malacostraca	Gammaridae	*Gammarus* sp.			1		1					4
Arthropoda	Malacostraca	Panopeidae	*Panopeus* sp.								1		
Mollusca	Gastropoda	Potamididae	*Cerithidea* sp									3	
Nemertean												1	

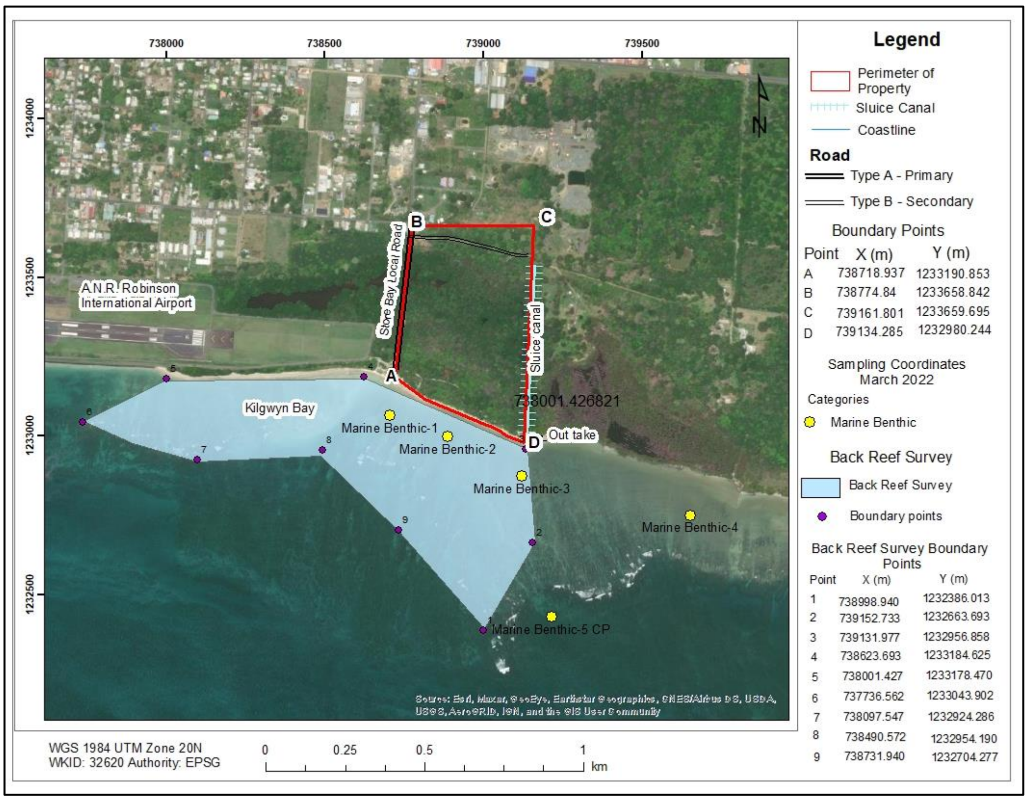


Figure 93 - 5.66: Marine Fauna Sample Locations Kilgwyn Bay Nearshore Environment (2022).

5.1.11.5 Environmental Services of Wetlands

Coastal wetlands play a critical role in protecting and maintaining coastlines, for example, mangroves, coral reefs and seagrasses absorb wave energy, filter sediments and reduce storm surges. More than just being a buffer, they are part of dynamic processes that generate, trap and distribute sediment across shorelines. Beaches, sandbanks, and dunes serve as physical buffers to damaging waves. Coral reefs themselves are integral to the economy of Tobago. They are a magnet for tourism and recreation, provide food and livelihood to Tobago's residents through coastal fisheries, and shelters its shorelines from storms. Tobago's reefs are highly diverse and possess unknown bio-pharmaceutical value. The economic values that coral reefs support can be overlooked or underappreciated in coastal development, management and policy evaluations, resulting in decisions that do not maximize the long-term economic potential of coastal areas (Burke et. al., 2008). This section examines the environmental services offered by the Kilgwyn Swamp, Kilgwyn Bay and its associated Reef system.

Climate Regulation

Wetlands have a positive effect on the global climate in the form of carbon dioxide sequestration and managing the release of carbon into the biosphere. They are sinks for carbon and remove significant amounts of carbon in sediments and dead organic which are transported to the sea. Based on initial calculations the Kilgwyn mangrove forest on the project site which accounts for approximately 10.3 Ha (**Figure 73 - 5.47**) sequesters approximately 585 metric tons of carbon dioxide *(Refer to **Appendix E4 - Biological Environment***) (EcoMatcher 2022).

Storm Protection

Wetlands along the windward coast of Tobago can mitigate against the impacts of climate change and sea level rise by limiting the potential damage which may be incurred by storm surges, coastal erosion and flooding. Wetlands lower the impact of storms via friction and absorption. On average 0.3 metres of storm surges can be absorbed for every 1.6- 4.8 kilometers of wetland and more than half of normal wave energy is dissipated within the first three meters of encountering marsh vegetation, (Juman 2010). Coral reefs play a vital role protecting this shoreline from both routine waves as well as the harsher conditions associated with storms. About 50 percent of Tobago's shoreline is protected by coral reefs. The services reefs provide in reducing erosion and wave damage is valued between USD$18 and $33 million per year, (Burke et. Al., 2008). Valuable tourist resorts and residential developments dot Tobago's shoreline (Burke et. al. 2008). About six percent of land in Tobago was identified as vulnerable to erosion and damage from waves and much of the high value development of Tobago is in the low-lying southwestern quadrant where the coastline is protected by fringing reef systems such as Flying reef. The relative share of protection provided by coral reefs varies greatly with coastal context; the elevation and slope of the shore, the geologic origin of the area (and resistance to erosion), and the wave energy along the coast. A 2008 study documented for the World Resources Institute by Burke et. al., identified that in all areas where corals are present in Tobago, they are estimated to provide at least 20 percent of the shoreline stability, while in some areas, this share is over 40 percent. Using an "avoided damages" approach, the annual value of shoreline protection services provided by coral reefs was estimated to be between US$ 18 and 33 million for Tobago in 2007. Like the terrestrial wetland systems, the importance of coral reefs in protecting the shorelines will increase with the rising sea level and increased storm intensity associated with climate change and warming seas. According to IPCC AR4 global Sea level is projected to rise between (1980-1999) and the end of this century (2090-

2099) by 0.35 m (0.23 to 0.47 m) for the A1B[2] scenario. More recent evidence published, indicates that the mean global sea level rise is projected to increase above that of IPCC AR4 predictions by the end of the century (Trinidad and Tobago Meteorological Office, 2022).

The vulnerability of Tobago coastlines and Kilgwyn Bay to Seas Level Rise is significantly higher since recent studies have also suggest that because of the proximity of the Caribbean including Trinidad and Tobago to the equator, sea level rise may be more outstanding than some other regions. If future projections materialize, coastal inundation, inland flooding, storm surge damage, and coastal erosion are likely to increase in Southwest Tobago, however uncertainty remains high (Trinidad and Tobago Meteorological Office, 2022).

Water Regulation

Inland wetlands like Kilgwyn swamp, are valuable because they greatly influence the flow and quality of water within the study area of Tyson Hall and Kilgwyn Bay. Wetlands in general are sources of renewable freshwater and play a major role in detoxifying various waste pollutants found in freshwater. These systems help improve water quality by intercepting surface runoff and removing or retaining inorganic nutrients, processing organic wastes, and reducing suspended sediments before they reach open marine habitats. As the runoff water from local human activities (e.g. agricultural farming, animal husbandry, washing, domestic cleaning, sewerage and industrial processing) passes through wetlands, they retain or process excess nitrogen and phosphorus, decompose organic pollutants, and trap suspended sediments that would otherwise clog waterways and affect fish and invertebrates. Wetlands can reduce environmental problems, such as algal blooms, dead zones, and fish kills, that are generally associated with excess nutrient loading.

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[2] *A1B - A balanced emphasis on all energy sources for greenhouse gas emissions*.

In fact, some wetlands can notably reduce concentration contaminants such as suspended solids by more than 80 percent while metals and organic compounds are absorbed into sediments that are filtered out by wetlands. Pathogens can lose their virulence or viability and in terms of bacteria they may be consumed by other organisms as they slowly pass through a wetland system (Juman, 2010). In addition to improving water quality through filtering, wetlands maintain stream flow during dry periods ensuring infiltration rates are high and there is a slow release of interstitial water to surface streams and groundwater aquifer stores.

The capacity for the Kilgwyn wetland to function as a treatment system is however not unlimited. Too much surface runoff carrying sediments, nutrients, and other pollutants can degrade the wetland system and thus the natural detoxifying services they provide. Indeed, water quality and sediment testing conducted in 2022 within the Kilgwyn Wetland system identified that the area is a hot spot for hydrocarbon, heavy metal (i.e. As, Cu, Cr, Pb), and pathogenic bacterial (i.e. *E. Coil*) contamination. Tests identified that the levels observed exceeded ambient local and international standards for the protection of aquatic life and contact recreational use (Refer to Section 5.1.10 - Surface Water and Sediment Quality). There is the potential for pollutants to accumulate and become toxic or lethal to wildlife and flora.

Habitat for Diverse Flora and Fauna (Inclusive or Migratory Species)

The Kilgwyn Wetland supports a diverse Avifauna community which encompasses a number of obligatory wetland and marsh species as well as coastal migratory species. During the rapid biological surveys of the study area, a total of fifty-nine (59) species of birds were noted (via real time point counts or literature reviews between the period 2021 and 2022) as present within Kilgwyn. Several species were observed roosting in the logon area of the swamp and as noted in section, Birding websites such as e-bird, Caribbean birds and Caribbean outdoor life has identified Kilgwyn as an easily accessible site for bird watching. Indeed, birding tours on the island of

Tobago can be a good source of local income in the tourism industry. Based on an internet review of operator pages, land-based nature tours currently cost between 50 -90 USD per person on the island. The swamp itself is currently used for subsistence hunting by a few locals from Tyson Hall for land crabs or iguanas (See Section 5.1.11.6 - Existing Human Impacts on the Kilgwyn Wetland Systems and Coastal Habitats). On rare occasion fishing may also be carried out within the lagoon and drainage ditches/channels.

Figure 94 - 5.67: Abandoned Crab Trap Kilgwyn Swamp (2022).

Kilgwyn Bay was once a lucrative fishing ground. However, given the changes to the backreef and ongoing disturbances along the coast resulting from land reclamation and airport development/operation activities, the Bay is no longer used for fishing and only one fishing boat currently shelters at Kilgwyn beach. Further offshore, coral reef fisheries associated with the Flying Reef, Majeston Reef and Cover Reef are an important cultural tradition, safety net, and livelihood. In Tobago the annual economic benefits garnered from reef fishing is estimated at between USD $0.8 – 1.3 million (Burke et. al., 2008). In an economic valuation of fisheries focused on species associated with coral reefs for at least a portion of their lives (e.g. snappers, groupers, parrotfish, squirrelfish, lobsters and sea urchins) available data suggest that fishing of coral reef associated species in Tobago is near its sustainable limit. The annual direct economic contribution of coral reef associated fisheries is estimated at USD$ 0.7 – 1.1 million. Additional indirect impacts from the need for boats, fuel, nets, etc. is estimated at about USD$ 0.1 – 0.2 million, resulting in a total economic impact of about USD $ 0.8 – 1.1 million per year in Tobago. Coral reef-associated fisheries have a small economic impact when compared to tourism on the island (Burke et. al., 2008).

Supply of Nutrients to Coastal Marine Ecosystems

Wetlands produce great quantities of food for fauna. The combination of shallow water, high levels of inorganic nutrients, and high rates of primary productivity (the synthesis of new plant biomass through photosynthesis) in many wetlands is ideal for the development of complex food webs for the transfer of energy from wetland vegetation. Some animals consume the above-ground live vegetation (herbivore-carnivore food web); others utilize the dead plant leaves and stems, which break down in the water to form small, nutrient-enriched detritus. As the plant material continues to break down into smaller and smaller particles, it becomes increasingly enriched (nutritious) due to bacterial, fungal and protozoan activity. This enriched proteinaceous material, including the various microbes that colonize it, feeds many small aquatic invertebrates and small fish and can been transported offshore to open marine habitats in connected/contiguous wetland systems. Invertebrates and fish which feed on enriched detritus then serve as food for larger predatory amphibians, reptiles, fish, birds, and mammals both within the wetland and marine nearshore habitats.

5.1.11.6 Cultural services

Coral reef-associated tourism and recreation was estimated to contribute between US$100 and $130 million to the national economy in 2006[3]. The importance of reef and wetland systems to Tobago cannot be overlooked and in particular the economic and socio-cultural services provided by Flying Reef which is an important dive site on the Southwestern coast of the island. Tourism is Tobago's largest economic sector, contributing about 46% of GDP and employing about 60% of the workforce in 2005, according to the World Travel and Tourism Council. Burke et. al. (2008) estimated that in 2006 tourists visiting Tobago (at least in part due to coral reefs) represented 40% of all visitors to Tobago. Spending by these tourists on accommodation, reef recreation, and miscellaneous expenses is estimated at US$ 43.5 million, which comprises about 15% of Tobago's GDP.

Visiting white sand beaches of coralline origin is popular with both visitors to the island and local residents. Indeed, the Kilgwyn Beach appeared to be quite popular with residents who prefer quiet long beach front stretches for relaxing. In March 2022, during a reconnaissance visit to the project site a religious ceremony by members of the local Baptist faith was noted on the beach front of Kilgwyn Bay.

Decisions on how to manage coastal tourism development and visitor pressure on Flying reef and Kilgwyn Bay have important implications for the existing fringing reef system, the wetland, the beach health, and the future overall attractiveness of Kilgwyn Bay as a destination.

Existing Human Impacts on the Kilgwyn Wetland Systems and Coastal Habitats

Farming

Nearly all of the lower lands in Tobago which was formerly seasonal or littoral forest has been taken up for agriculture, tourism activities or housing (Beard, 1944). Within the Tyson Hall area of Southwest Tobago, there are a few small animal farms and subsistence garden plots within a 1-5 Km radius of the project site however, the majority of land use can be described as medium to low-income housing combined with tourism activities (i.e. guest homes, small hotels and large resort facilities). Within the immediate project area and on the periphery of the proposed resort site

[3] It is not clear how these values have transitioned given the most recent decline in global travel as a result of covid between the period 2019-2021.

there is one agricultural plot and one livestock farm. Runoff from both these activities go directly into the adjacent wetland.

Figure 95 - 5.68: Livestock Farm at Northeastern Property Boundary.

Illegal Dumping of Garbage

The swamp is currently used as an illegal garbage dump for domestic solid waste and industrial bulk items (**Figure 96 – 5.69**). The problem of illegal dumping has been reported as far back as 1986 (Scott and Carbonell, 1986). In 2003, however, the NGO Environment Tobago began work to rehabilitate the wetland by removing waste and opening blocked channels. Environmental Tobago has been lobbying for Kilgwyn Swamp to be declared a scientific reserve, as proposed in 1980 to protect the only remaining parcel of littoral forest on the island, (Birdscaribbean, 2022). The use of the wetland for illegal dumping is directly related to the accessibility of the site via roads and trails and the remoteness of the location.

Figure 96 - 5.69: Illegal Dumping of Solid Waste

Non-Point Sources of Chemical Contaminants from Community Effluent Runoff

The swamp exceeded regulatory limits for pathogenic bacteria i.e. *E. Coli* and *Enterococci* and well as Chemical Oxygen Demand during 2022 field surveys. These results suggests that the area is affected by untreated municipal wastewater entering the site.

Illegal Sand Quarrying

Kilgwyn and Friendship mangroves were impacted by the construction of a channel and sand mining activities in the early 90's (IMA, 1990). Attempts were made to drain the eastern part of the swamp, and there is still evidence of channels traversing the swamp area and relicts of an old pump station on the coast. Illegal sand quarrying has significantly affected the hydrology of the swamp. Mined out areas have created ephemeral ponds on the site and the surface topography has a hummock characteristic because of the existing sand mounds and ditches. Both the Kilgwyn and Friendship mangrove were once hydrologically connected and were considered part of a contiguous system, however illegal sand mining (coastal beach sand as well as within the swamp) and other human intervention has modified the surface hydrology of the coastal beach morphology and the swamp area to the extent that mangrove die-off can be observed along steep banks (**Figures 97 - 5.70** and **98 - 5.71**). There is a significant zonation of tree species based on inundation potential, flushing rates and surface water salinity. In 2007, the IMA reported that modification to the local hydrology of the area was responsible for a large die-off area in the centre of wetland system (Juman and Hassanali. 2013).

Figure 97 - 5.70: Pond Created by Illegal Sand Mining.

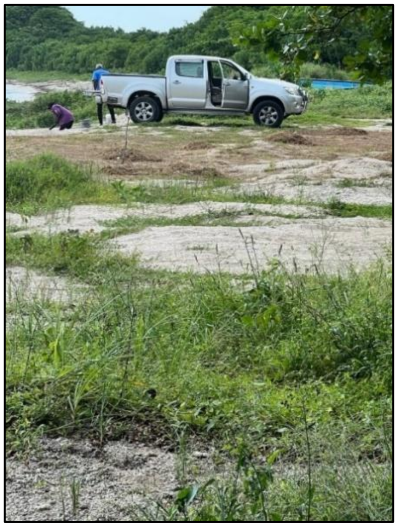


Figure 98 - 5.71: Evidence of Coastal   Beach Mining at Kilgwyn Bay 2022.

Recreational Hunting

Historical precedence for recreational hunting within the Kilgwyn Bay swamp mainly for larger mammals such as iguanas and lowland paca (locally referred to as 'lappe'). During the wet season field data acquisition exercises OptimalGESL scientists encountered hunters within the Kilgwyn Bay swamp as evidenced by **Figure 99 - 5.72** below.

Figure 99 - 5.72: Mr. Sylvester Sandy during his Daily Hunting Season Routine in Kilgwyn Bay Swamp, 2022.

Airport Operations

In the late 90's, part of Kilgwyn Swamp was reclaimed for the extension of the Tobago's airport runway and a beach access road (**Figure 100 - 5.73**). Only a thin fringe of mangrove was left around the west, northwest and southwest boundaries of the lagoon (IMA 1990). Impact to the western boundaries of Kilgwyn continues today with the present construction activities at the ANR International Airport. The new airport development includes a further expansion of the runway and new building infrastructure to support the increased traffic capacity. The new airport expansion represents both the government and the Tobago House of Assembly's invested commitment to the tourism sector in Tobago.

The western boundary of the project site is approximately 303.6 meters from the airport and contaminants such as hydrocarbons (i.e., PAHs) and heavy metals were persistent in Kilgwyn Swamp use (Refer to Section 5.1.10 - Surface Water and Sediment Quality). Airport emissions are likely to be the chief sources of these pollutants. For example, metals used in flame retardants and combustion emissions from jet fuel can become entrained in surface runoff.

Figure 100 - 5.73: Proximity of Airport Runway to Wetland.
Source: Google Earth.

5.1.11.7 Natural mitigation

Actions to reduce pressure on coastal habitats and species such as fisheries management and pollution control can play a vital role in increasing the health and resilience of ecosystems. While a variety of restoration techniques exist for areas that have been degraded, in many cases nature-based solutions applied to coastal ecosystems provide multiple benefits (Nature based solutions).

Nature-based solutions to reducing disaster and climate risk start with drawing up a long-term plan for the coastline, which might also include the watershed or estuary that brings fresh water and harbors the fish and food that people depend upon. Nature-based initiatives work best where local governments collaborate with local communities, including fisherfolk, tourism operators and others to manage tradeoffs in full consultation. Such an approach is known as integrated coastal zone management.

The proposed project will seek to mitigate the loss of natural floral through several design concepts and preservation strategies. The mangrove forest is being sold as a unique feature intrinsic to the property. As such, the final architectural designs and hotel footprint will conserve 32,867m^2 of mangrove primarily for its aesthetic appeal and for the preservation of the local biodiversity. The forested areas will be monitored biannually for changes in key features such as tree die-offs, surface hydrology, biomass, tree density, tree health and faunal biodiversity. Maintenance of the mangrove system will also ensure the detoxifying and water regulation services provided by the wetland system remains functional. To ensure monitoring and management of the wetland is successful, property developers will encourage the establishment of a stewardship program where local ecologist, biologist, researchers and eco-tour operators (with skills and knowledge about the ecosystem) work with the planners and hotel managers to oversee, preserve and improve the health of the wetland system. This can be done through facilitated support, training by the property developers and access to equipment necessary for monitoring activities.

Access trials and roads which may dissect the mangrove system are expected to affect a minimal 12% of the forested area. Roads and footpaths will be built on stilts to ensure hydrological connectivity is maintained. Additionally, lighting for the hotel will be directed away from the mangrove and sensitive beach area. In the case of access paths, and roads through the wetland and along the beach, amber or red lights which are fauna friendly will be used as much as possible.

The Littoral Woodland will be maintained to preserve the protective cover it provides to the beach berm and to prevent beach loss due to coastal erosion. A few of the trees will be culled (in particular the toxic Manchineel (*Hippomane mancinella*)), to provide appropriate access to the beach. To compensate for the loss of these trees, native woodland species will be incorporated into the landscaping and ornamental garden layout for the property. Bioswales, and retention ponds will be established to help manage both the nutrients which may be added to the environmental as a result of landscaping and garden management and the flow of increased surface freshwater input to the environment.

A concerted effort will be made by developers to use intrinsic trees to the area such as *Coccoloba uvifera, Citharexylum spinosum, Bursera simarubs, Pithecellobium unguis-cati, Terminalia catappa, Thespesia populnea, Dodonea viscosa, Conocarpus erectus, Spondias mombin*, *Tamarindus indica and Morinda citrifolia* for ornamental spaces and marsh species such as *Eleocharis* spp, *Cyperus* spp, *Fimbristylis* spp and *Acrostichum aureum* in bioswales to maintain similar floral habitats were possible.

5.2 Socio-cultural Environment

This section gives a description of the socio-economic baseline conditions for the Kilgwyn Bay study area. A mix of Primary and Secondary data sets were acquired through various sources. A review of existing literature, public consultations and an independent consultation were the data collection methods used in the conduct of this study. Literature review included Statistical Office of Trinidad and Tobago, documents, relevant documents from the Ministry of Planning and Development and Ministry of Social Development and Family Services, THA, EIAs conducted for projects within the region and other existing reports, maps and articles relevant to the socio-economic characteristics of the study area.

Given that the proposed project is primarily land based and is located within a 2km radius of the most densely populated area of Tobago, the main area of impact for the proposed activities of the hotel development project was determined to encompass the coastal areas of Kilgwyn Bay/Tyson Hall, Bon Accord and Canaan. This area was selected based on the fact that the communities within this boundary support the main socio-economic activities which take place in and around the areas of the proposed project, the main transportation arteries and associated commerce which passes through these communities.

In order to assess the various social elements of the proposed project, a Socioeconomic Community Impact Area (SCIA) is established. An SCIA may be described as the estimated spatial extent of the proposed project's effect on the surrounding communities. Demographic analyses are carried out utilizing this SCIA demarcation, and social services, infrastructure and industrial facilities are described in relation to this area as well. For the purposes of this project, the SCIA encompasses a five (5) kilometre buffer around the proposed project area (**Figure 101 - 5.74**). The total land portion of the SCIA is 51.9 sq. km in area, with the remaining north, east and western section of the SCIA extending over the Atlantic Ocean.

The project is located in the community of Tyson Hall; however, the SCIA extends fully or partially over three communities in the parish of St. Patrick:

1. Canaan
2. Crown Point
3. Bon Accord

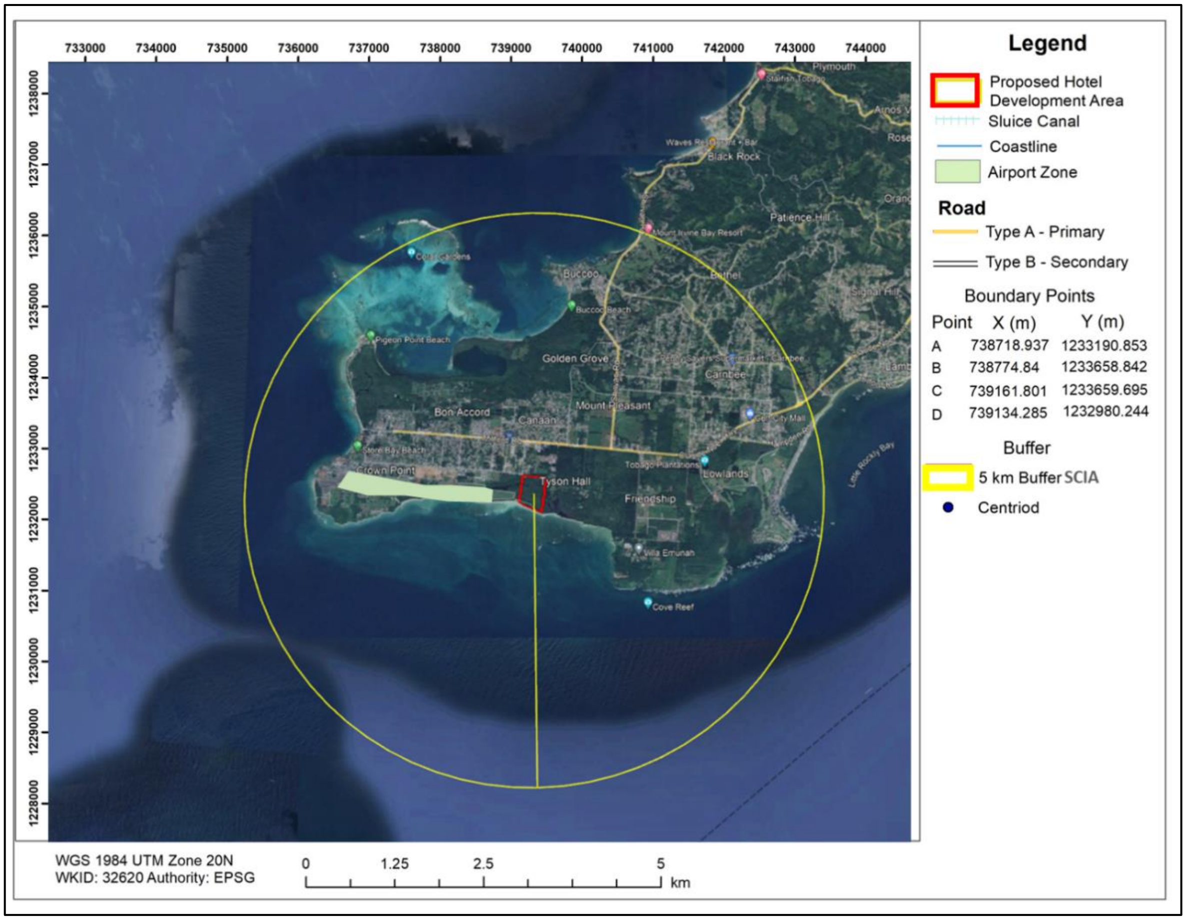


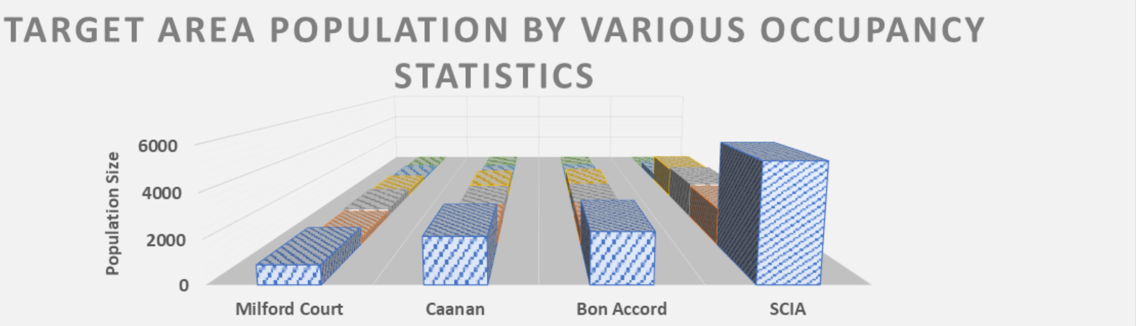
Figure 101 - 5.74: Map Showing Community Settlements along Southwest Tobago that form the Socio-Economic Impact Area (SCIA) Study Area.
Source; OptimalGESL, 2022.

5.2.1 Population Demographics

Population data from the Central Statistical Office of Trinidad & Tobago (CSO) 2011 Population Census database by enumeration district (ED) was the main input to the demographic analyses. It should be noted that all Census data relates to the resident population and does not take into consideration persons working in or visiting the ED.

Study area communities are characterised by typical ribbon development patterns with settlements existing primarily within the surrounding communities of the study area. Bon Accord and Canaan are the largest community districts within the study area, each with populations of over 2,000 (**Figure 102 - 5.75** and **Table 5-44**). Although these settlements provide a certain level of commercial activity, the main commercial and administrative hubs for the region is Crown Point.

According to the 2011 National Census, communities in the project target area have the second highest population density on the island. Data from this census (CSO) are provided in **Figure 102 - 5.75** and **Table 5-44**. The population of the target area represents more than 10% of the island’s overall human resource and continues to grow as evidenced by the data shown in **Figures 102 - 5.75** and **103 - 5.76**. These graphs present information collected for the community in the past 3 years and reinforce the fact that the target area is a significant population centre on the island.



	Milford Court	Caanan	Bon Accord	SCIA
Total Population	881	2120	2327	5329
No. of Households	312	716	858	1886
No.of Commercial Buildings	442	692	865	1999
No.of Dwelling Units	313	714	854	1881
No of Buisiness Places	130	119	227	476
No. of Institutions	1	0	0	1

Figure 102 - 5.75: Graph Showing Target Area Population by Various Occupancy Statistics.

<u>Table 56 - 5-45: Demography of the Milford Court, Canaan, and Bon Accord Areas (CSO 2011).</u>

Community	Total Population	No. of Households	No.of Commercial Buildings	No.of Dwelling Units	No of Buisiness Places	No. of Institutions
Milford Court	881	312	442	313	130	1
Caanan	2120	716	692	714	119	0
Bon Accord	2327	858	865	854	227	0
SCIA	**5329**	**1886**	**1999**	**1881**	**476**	**1**

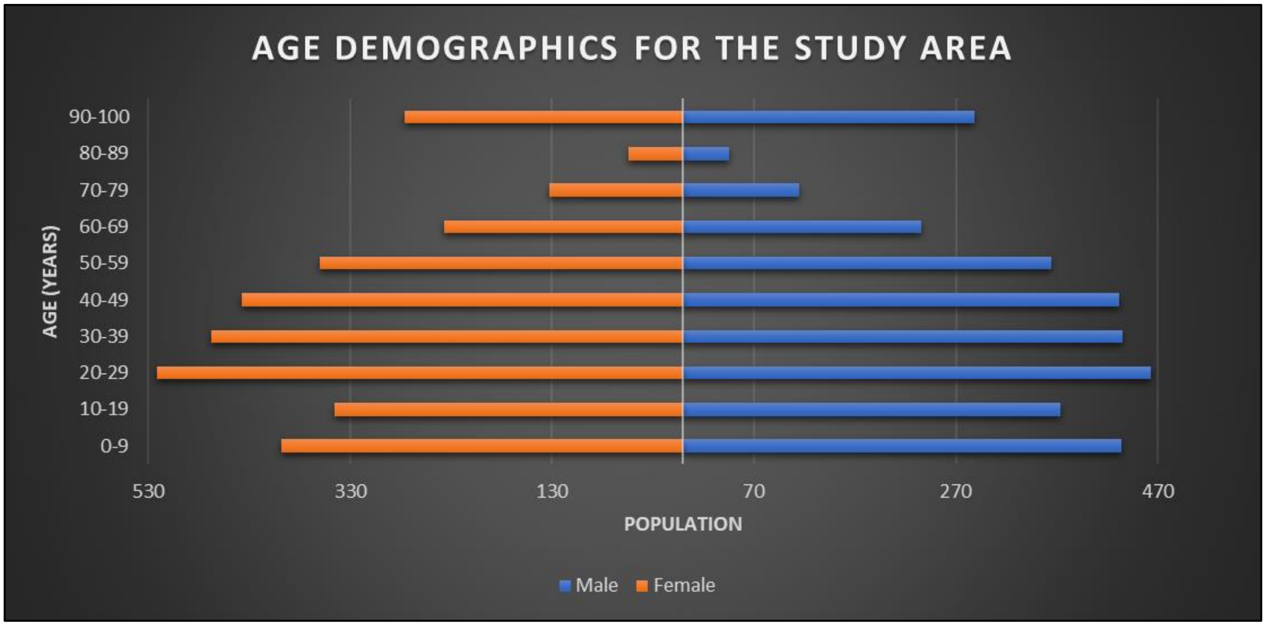


Figure 103 - 5.76: Graph Showing Compilation of Sex-Age Data for All Three Study Areas.

The segment of a population that is considered more vulnerable are the young (children less than five years old) and the elderly (60 years and over). In the SCIA population, 13.0% comprised the vulnerable young category, and 21.5% comprised the elderly. **Figure 103 - 5.76** shows the percentage composition of each age category of the population. This is compared on a national, regional and local (SCIA) level. Percentage age distribution in the SCIA for the 0-14 years' age cohort (24.2%) is comparable to the regional figure for Tobago (28.4%). As mentioned previously, elderly persons aged 60 years and greater make up 21.5% of the SCIA population; and this value is also comparable to the regional figure for Tobago (7.3%). Within the SCIA, the 15-64 years' age category accounted for 54.0% and can therefore be considered a working age population, similar to that for the nation (65.9%)

5.2.2 Land Use

The main socio-economic activities within the study area are; subsistence agriculture, commercial fishing, domestic tourism, religious and limited commercial activities (small and micro enterprises. The area is also host to a number of state-managed forest reserves; however, forestry is not a well-established industry within the area. These areas more often support recreational hunting activities during the appropriate hunting season. **Figure 104 - 5.77** indicates the general land uses found within the study area.

5.2.3 Industrial Activity

Cove Eco Industrial Estate and Business Park is located less than 2km from the proposed hotel development site at Kilgwyn Bay. The Park has modernized the existing infrastructure to accommodate increased industrial development of the region, it is expected that employment opportunities in the area would be increased within the next few years. There are also plans to further develop the park with renewable sources of energy and IT commerce.

5.2.4 Agriculture

Agriculture was one of the first commercial activities established in the immediate study region and continues to play an integral role though on a smaller scale. Local micro-farming and small to medium scale government Agricultural fishponds developed in primarily the Canaan and Bon Accord Areas. Local micro farming (home grown) continues to exist only because of the older generational practises. Overtime the study area has migrated away from agriculture into more of an infrastructurally developed and urban area, with the main target aimed at tourism.

A major problem for the growth of the agricultural industry within this area is the land space. This is compared to spaces outside of the 5km buffer zone which lie towards the Agricultural production zones on the eastern section of the island. What is primarily grown within the micro-agricultural space (ground provisions and flowered crops such as tomatoes and cucumbers) are sold street side for local consumption. Interest in agriculture has waned, particularly in the face of growth in other economic sectors. Success in agriculture requires planning, patience, time, and land, whereas other livelihoods, such as fishing or oil and gas work, require fewer upfront costs and offer much larger and faster pay. It is reported that youth do show interest in agriculture, but these factors are a strong disincentive for them to pursue it. As a result, local youth are not moving into agriculture, and do not see agriculture growing in the future. The Division of Food Production (Tobago House of Assembly) has guaranteed support to local entrepreneurial farmers willing to develop their space for agricultural use. As stated above a part of the Cove Eco Industrial development plans within the area of study is to establish state-of-the-art greenhouses that can produce above grown crops on a commercial level, together with incentivizing nearby farmers to set up poultry farms to facilitate a commercial egg market.

5.2.5 Fishing

Fishing has traditionally formed an integral part of the socio-economic and socio-cultural fabric of the study area, although the number of local residents who earn a living solely from fishing has declined over the years. Nevertheless, fishing remains a significant source of livelihood and continues to attract new people, particularly as a part-time income earning option. The community of local fisherfolk is highly organized, both within the study area and with fisherfolk in other coastal communities. Businesses such as restaurants and hotels to food carts and school feeding programmes depend on the fisherfolk within this region to supply. Apart from providing employment and income to fisherfolk, it also contributes to the island’s food security. The area is also home to part time and seasonal fishers. Further, the individuals involved in fishing is representative of small village communities that assist each other in developing fishing zones and sein retrieval activities.

The primary sites of fishing activity in this coastal region are: Crown Point, Kilgwyn Bay, Low Land, Lambeau, Buccoo, Pigeon Point and Rockly Bay area (**Figure 104 - 5.77**). There are in addition several minor sites of more limited activity including the Cove Reef area and Mount Irvine Area to the North of the island. However, these sites support only a small number of vessels. Although places such as Studley Park and Charlotteville lie outside of the study area, fishing vessels migrate from these areas to Kilgwyn Bay during the peak fishing seasons. Landing sites within the study area are generally inadequate with poor or makeshift docking and mooring facilities for vessels. Fuel supply, storage and service facilities for engines and fishing equipment as well as ice making and cold storage facilities for catches are exist primarily in the Scarborough and Castara areas, east and northeast of the buffer zone. Lack of proper facilities adds to the challenges and operating costs faced by local fishers as equipment/ gear, ice and fuel must be transported daily.

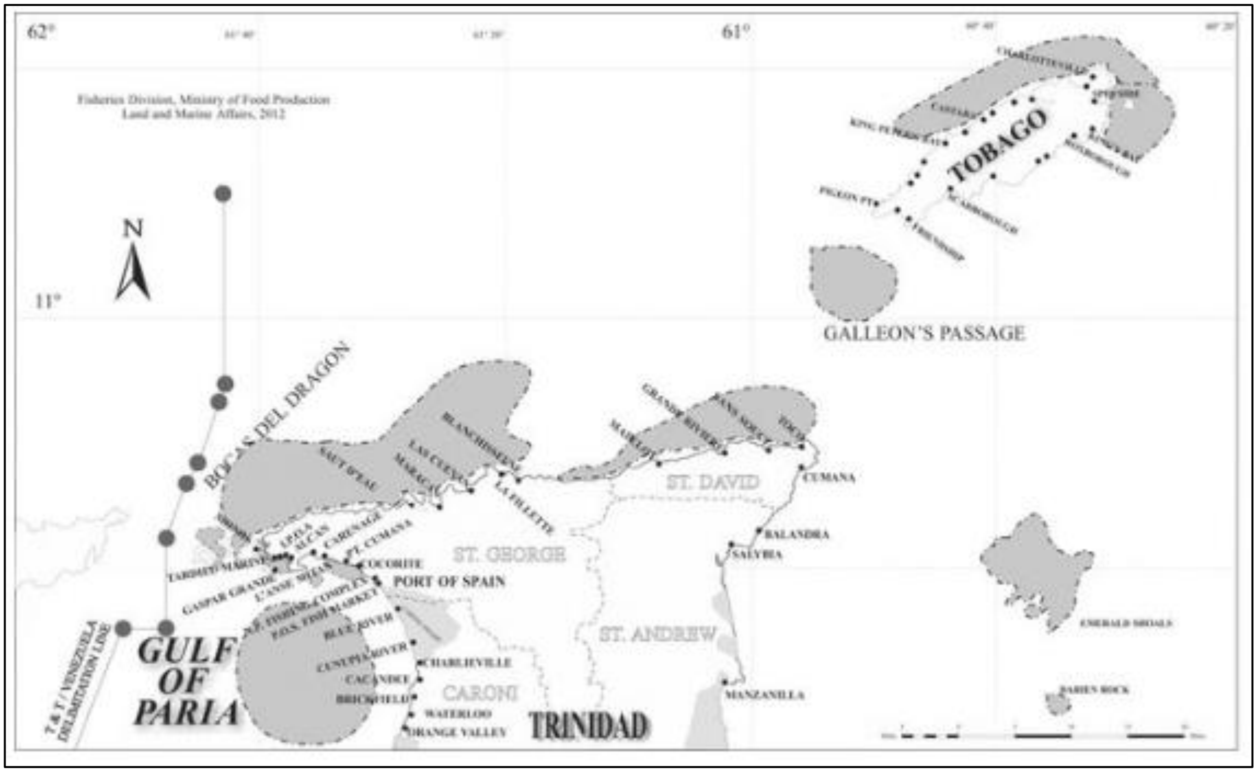


Figure 104 - 5.77: Map Showing Some Popular Recreational Fishing Areas Off Trinidad and Tobago (Shaded).
Source: Fisheries Division, Ministry of Food Production, Land and Marine Affairs, Trinidad and Tobago.

Fisherfolk throughout the study area reported significant declines in both fish size and catch over the last several years. Blame for these declines are multifaceted and are placed primarily on:

1. The operations of the oil and gas companies along the North Coast Marine Area. Fisherfolk claim that the seismic surveys and the 500 m safety zones around rigs and platforms are cited as contributing to the decline of fish yields, however, no studies have been done to make a direct link. Fisherfolk claim that seismic surveys are conducted and platforms are erected in prime fishing grounds; that the seismic surveys alter the landscape of the seabed, making the areas undesirable for fish,

sometimes for years; and that the platforms attract fish while the safety zones prevent fisherfolk from accessing them. As a result, fisherfolk have to travel further out to sea to find fish, spending more fuel and time in the process.

2. Trawlers and net drag vessels from neighbouring islands North and west of Tobago. Many incidents of non-locals fishing illegally in waters within the study area has been a reality for years. This, according to the fisherfolk has led to depleted fishing grounds due to disregard of spawning fish spots identified by local fisherfolk.

In terms of fisher demographics, those involved in fishing are predominantly males between 35 – 60 years of age, however, women are noted to have an increasingly active support role in the industry, such as selling of fish, mending of nets and as boat owners. Younger people tend to be encouraged to pursue their education so as to have the training required to pursue alternative livelihoods. The fishing industry is under constant challenge from declining fish stocks, reduced fishing grounds and other competition for the natural resources, increased losses due to equipment damage and theft, and lack of state support for the industry. Fishing is further discussed in the subsequent sections.

Fishing Landing Sites

The major sites of fishing activity in southwest Tobago and specifically in the immediate study which is inclusive of areas such as Lowlands, Lambeau and Kilgwyn Bay (**Figure 104 - 5.77**). There are in addition several minor sites of more limited activity including Bloody Bay, Castara and notably Charlotteville which lie east of the study area.

Mostly all landing sites in the study area are generally lacking in adequate mooring facilities for the vessels, and storage and service facilities for engines and fishing equipment. The landing site of Kilgwyn Bay is situated on the beach. There is no jetty at this facility which results in fishermen having to anchor 1- 2 km offshore or beaching there fishing vessels. With no locker rooms and relevant fish processing facilities available in the area, sales of the catch from this area are distributed across the island. Cold storage units are commonly in the form of small ice bins used for short-term storage of fish prior to intended sale.

Fishing Areas

There is no geo-referenced data available on fishing areas around Tobago. All available information on fishing areas or fishing grounds is anecdotal and descriptive, and generally gathered from fisherfolk who operate in the area. This includes maps of fishing areas around Tobago produced by the Fisheries Division (2011) and specific to methods of fishing (Fisheries Division 2002). A Fisheries Division 2011 map outlines popular fishing areas around Tobago (**Figure 104 - 5.77**) Predominant fishing methods differ at the sites studied and reflect the topography, marine conditions and the fisheries resources available.

Focus group discussions with fisherfolk from the Kilgwyn area in 2022 (OptimalGESL, consultations) indicated that they also fished as far as 60 km – 100 km offshore usually during the middle of the year (June/July) when traditional fishing areas closer to their home base were less productive. At this time, they use drift gillnets and lines to target kingfish, bonito, cavalli and shark. They indicated that it was at this time they often fished around the platforms to the south Tobago.

5.2.6 Ecotourism

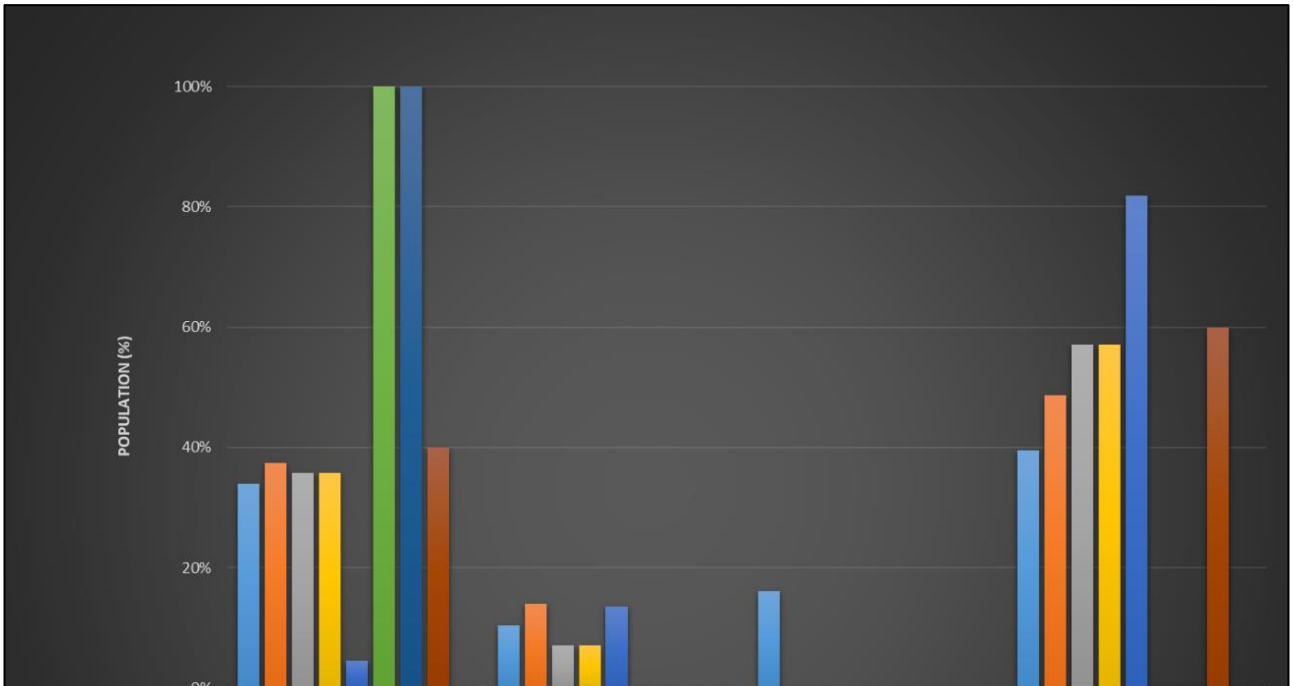
The natural amenities found on Tobago south-western (SW) coast have long been a draw for domestic and international tourists. The coastline of the study area consists of three main features: sandy beaches, coral reefs and rocky headlands (Coraline limestone). Numerous studies have estimated that during public and school holidays the local tourism industry along the SW coast is supported by high visitation figures. Although the industry is still growing and developing, tourism plays a primary economical role in the area and provides employment in a growing number of tourists centred commercial enterprises such as guest houses and hotels, food establishments, recreation, catering and tour guiding. Nature lovers are drawn to the Pigeon Point Recreational facility and Buccoo Reef and Nylon Pool marine attractions. The mangrove swamp at Kilgwyn is also a major tourist attraction and is home to a significant percentage of Tobago's mammalian, avian, reptilian and amphibian species. The beaches of the study area as well as those further up the coast annually welcome the leatherback turtles which return to the area to lay eggs during the March – August nesting season. The Kilgwyn Beach, however, has narrowed overtime due to the impact of erosion from the swells of the Atlantic Ocean, likely reducing the nesting success for sea turtles.

Kilgwyn Bay, located on the south-western coast, is a long continuous stretch of sandy beach which extends for approximately 17 km. It is a popular recreational beach, attracting visitors throughout the year for religious, recreational and other cultural purposes. Although sea conditions are sometimes rough along this stretch of the coast, the main activities are sea-bathing and line-fishing.

All of the coastal villages that line the southwestern coast of Tobago are also known for several distinctive cultural practices and traditions, such as Harvests and local Fisherman Fetes which is an occasion where fishermen hold celebrations marking their successes in the village throughout year. Others cultural festivities include Sports Day and Best Village and Spear fishing competitions. Another poignant cultural celebration commonly showcasing its local attributes is that of the Shouter Baptist Liberation Day. These celebrations are all regarded as an integral part of the culture of the people who reside within the area (OptimalGESL, 2022 consultations).

5.2.7 Infrastructure and Amenities

Figure 105 - 5.78 indicates the location of key elements of the study area's social infrastructure. Transportation and Utilities of the wider study area are discussed in the following sections.



	Canaan	Crown pt	Milford Ct/ Pigeon Pt.	Bon Accord
Public Piped Dwelling	34%	10.40%	16.10%	39.50%
Public Piped Yard	37.40%	14%	0%	48.60%
Public Standpipe	35.70%	7.10%	0%	57.10%
Private Piped Dwelling	35.70%	7.10%	0%	57.10%
Private Catchment	4.50%	13.60%	0%	81.80%
Truck Borne	100%	0%	0%	0%
Spring/River/Well/Pond	100%	0%	0%	0%
Other	40%	0%	0%	60%
Not Stated	0%	0%	0%	0%

Figure 105 - 5.78: Graph Showing Key Elements of the Study Area's Social Infrastructure.

Traffic

The main transportation artery is the Milford Road which is met by narrow interconnecting side streets that connect the villages within the Study Area. The Milford Road is connected further east to the Claude Noel Highway which runs along the southerly end of the island. With the arrival of new infrastructural developments such as the construction of the nearby ANR Robinson International Airport, the connecting roads that encompass the area of study are air-marked to be widen into major thoroughfares. This is to facilitate the expectance of heightened vehicular traffic within the area.

All roads are dual carriageway asphalt pavement roadways and are in fair condition, although there are sections of each road which need repair. Maintenance and upgrading of the primary roads within the study area is currently undertaken by the Division of Infrastructure Quarries and Urban Development (DIQUD). The Division has also indicated its dedication to the maintenance of the road network in all areas of Tobago using the “Show Me A Road Tobago- SMART Programme” which is a community assisted initiative. The idea is that communities would utilise an easy-to-use social media application to report to the division roadways that re in need of urgent repair.

Traffic in the area is generally light, however, there is an increase in traffic during the morning (6am – 12pm) which is representative of a peak period for construction within the area. In the afternoon (6pm – 12am) in the Bon Accord and Canaan areas, the nightlife of clubs and local bars facilitate, heightened vehicular traffic in the area. Road traffic is primarily private cars, buses, taxis, construction vehicles and rented vehicles procured by tourists looking to experience the areas Tourism Product. Given that much of the traffic in the area is Tourism related, it is not unusual that traffic is considerably lighter on weekends than during the week as most recreational activity take place during the weekend. Most of the Construction works in the area are conducted by the DIQUD and is reserved primarily for weekdays.

Public transport is provided by route taxis, maxi taxis and PTSC buses and is generally considered reliable. Routes run either from Crown Point to Scarborough or Crown Point to Plymouth. Access to public transportation has implications for community participation in industry consultations however, this can be averted with the introduction of several virtual meeting platforms.

Air Transport

The area of study is enclosed to the west by the only airport on the island. The ANR Robinson International Airport is the main location for air travel on the island. The facility caters to international and regional passenger and cargo air traffic that cater to the business and tourism development of the island. At the time of this EIA study the Airport expansion project was under construction. The project, which is being executed by NIDCO, aims to create an international airport with sufficient capacity and level of service to support tourism development and air travel in Tobago. The expansion will facilitate more direct flights between the island and New York, Orlando, Houston, Miami, Newark, and Fort Lauderdale in the US.

When completed, our new airport facility will be able to boast of these Special

Features:

- LEED (Leadership in Energy and Environmental Design) Certification
- International Air Transport Association (IATA) Level Optimum design
- Fully compliant with International Civil Aviation Organisation (ICAO) standards
- Capacity of 3M passengers per year (3 times the capacity of the existing airport)

Utilities

Water

Water in the study area is obtained from the Water and Sewerage Authority -WASA Courland Water Treatment Plant which is the main source of supply to the South-west of Tobago. Supply is at 2 million gallons daily (mgd) to the areas of Crown Point, Bon Accord, Buccoo, Black Rock and Plymouth. According to CSO statistics (CSO 2011), approximately 33.3% of the households in the study area have an indoor supply of water from public sources, a further 30.5% get their water supply from public yard and standpipe services. Production and delivery systems are constantly being upgraded to improve services as WASA has new test wells that were recently commissioned at Mary's Hill, Triangle Wood and Calder Hall. These wells are air-marked to assist in the distribution to the areas by adding approximately 1 mgd into the distribution system.

Electricity

The Tyson Hall area is supplied with electricity from the Trinidad and Tobago Electricity Commission- TTEC Cove Power Station. The 64MW diesel powered Cove Power Station was put in place to reduce transmission losses and to upgrade the transmission from the underground marine cables between Trinidad and Tobago. The already existing 11MW substation at Scarborough serves as a supplementary backup to any decreases in transmission at Cove.

Although a significant portion of the population receives an electrical supply, residents have reported a decline in level and quality of service. Ninety-eight (98%) of residents utilise electricity as their primary source of lighting within the Area of Study.

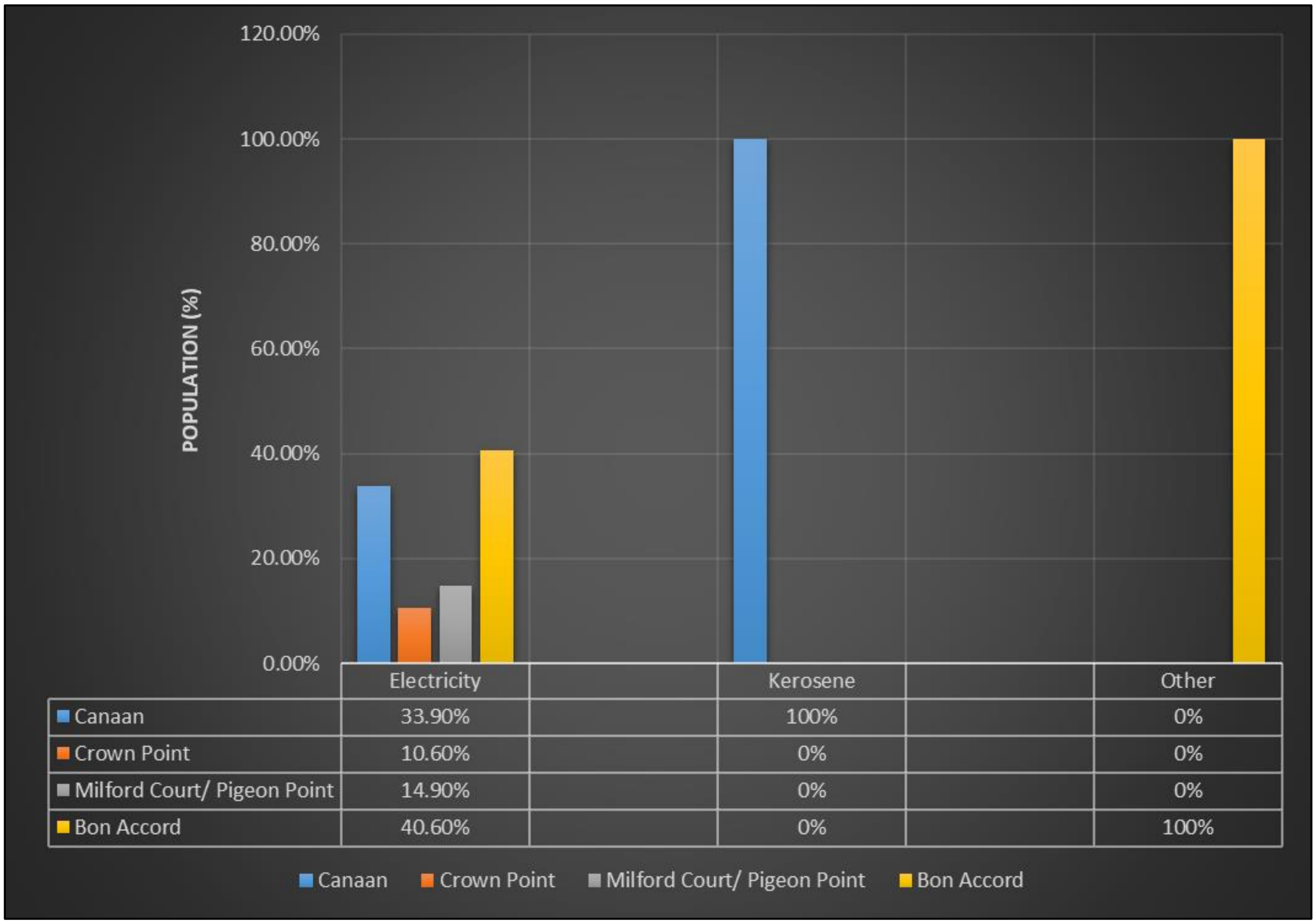


Figure 106 - 5.79: Graph Showing the Percentage of the Population with Access to Utilities.

Telecommunications

Telecommunication Services of Trinidad and Tobago (TSTT), Digicel and Flow are the telephone and internet service providers within the study area. Public internet access is limited and is only accessed in proximity to the Main terminal of the ANR Robinson International Airport. Residents normally access their internet needs through private installations provided by one of the above service providers. Cellular phones are owned by the majority of the population, with several having services operated by Digicel and B-mobile. Fifty-eight (58%) percent of residents reported not having access to an internet supply while 42.4% percent of residents stated they had a reliable supply of internet service.

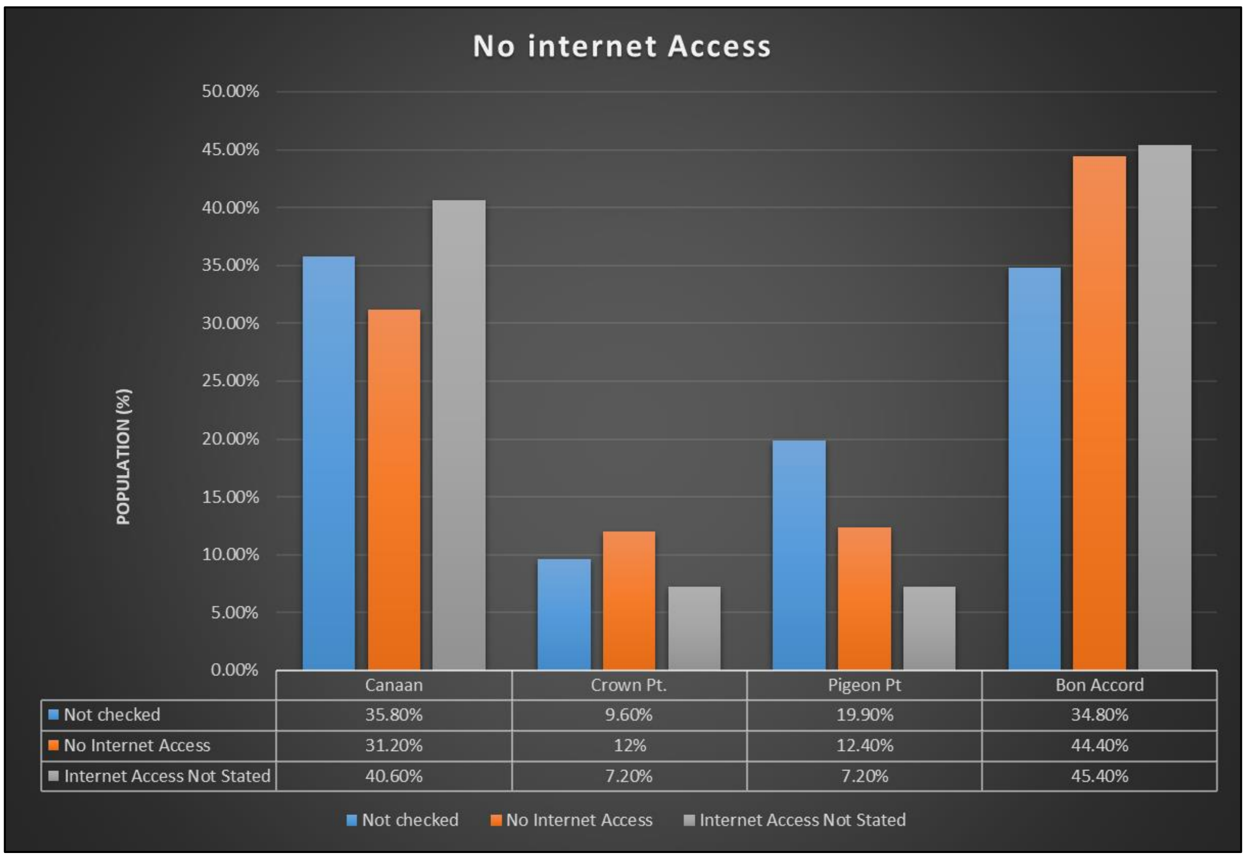
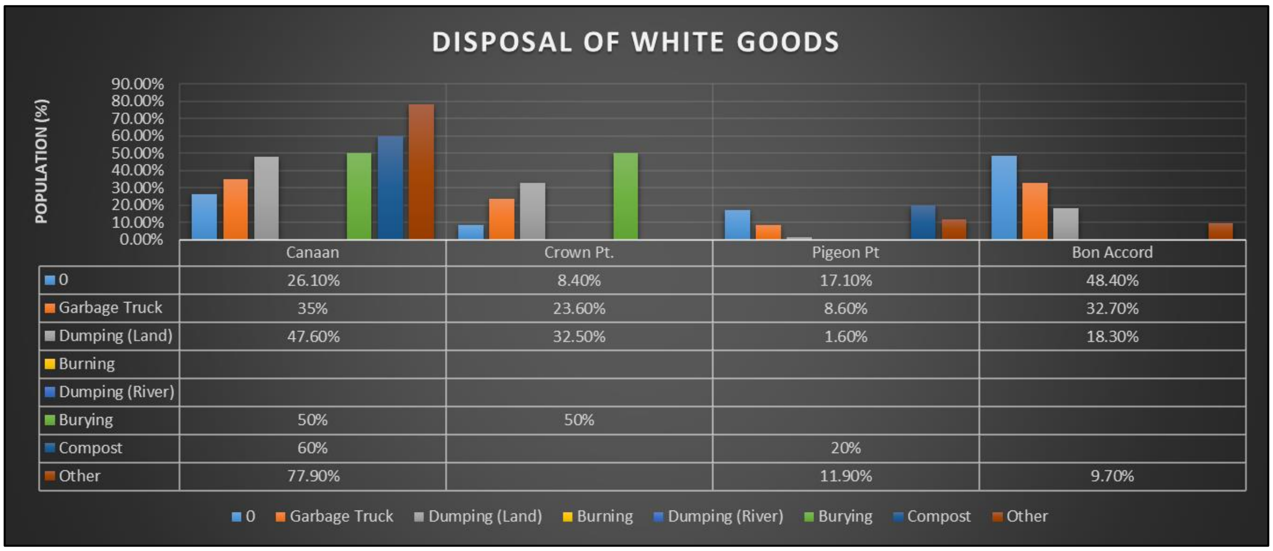


Figure 107 - 5.80: Graph Showing Percentage of the Population with No Internet Access in Areas of Interest.

Waste Management

Waste collection is handled approximately three times per week by the Division of Health, Wellness and Social Protection. Domestic, hazardous and other special waste materials are disposed of at an approved landfill in Studley Park. Burning of solid waste by residents is also frequently observed. There is no facility for the disposal of hazardous waste in the study area. The Studley Park facility accepts low level hazardous waste that has been stabilised, solidified and containerised. Non-eco-friendly dumping of refuse is as popular an option as placing waste material for garbage truck removal when it comes to disposal of common household garbage.



	Canaan	Crown Pt.	Pigeon Pt	Bon Accord
0	26.10%	8.40%	17.10%	48.40%
Garbage Truck	35%	23.60%	8.60%	32.70%
Dumping (Land)	47.60%	32.50%	1.60%	18.30%
Burning				
Dumping (River)				
Burying	50%	50%		
Compost	60%		20%	
Other	77.90%		11.90%	9.70%

Figure 108 - 5.81: Graph Showing Methods for Disposing White Goods.

Emergency Services

Health Care Facilities

Public health care facilities within the immediate study area are limited to a Health Centre in Canaan. The Health Centre offers basic medical services on an outpatient basis Monday through Friday. While there are plans by the Division of Health, Wellness and Social Protection to upgrade and expand the size of the Canaan facility, the level of services is not expected to increase. The facility is regarded as “transfer station” as anyone needing in-patient care is required to go to the hospital in Scarborough. Emergency ambulance service is provided by one vehicle stationed at the Canaan facility.

Several private energy companies operating in the area offer medical services to their employees and their families. The region, however, is lacking in its capacity to provide emergency treatment to members of the public for injury resulting from industrialised accidents.

Protective Services

Police protective services are available either from Police Stations at Crown Point or Shirvan Road. These areas are encompassed with the area of study. Public Fire protective services are available from the Scarborough Fire station which is outside of the buffer zone. There is a Fire Station at Crown Point within the perimeter of the Airport and so serves primarily incidents emanating from the Airport only.

The response time from Scarborough to Crown Point is approximately 15 minutes for a fire appliance. However, the Police response time is significantly shorter (5 minutes) due to the proximity of the stations to the area of study. There are two fire trucks, one utility vehicle, and one ambulance attached to the Scarborough Fire Station, with a steady team of nine persons per shift.

Community Emergency Response Capability

While the emergency response capability of essential services within the study area is limited, existing communication, health care and security services are working with the Tobago Emergency Management Agency – TEMA to develop systems and capacities which can effectively handle the potential emergency situations associated with Aircraft accidents, Tsunamis, earthquakes and other natural disasters.

Education and Training

A range of educational facilities are found within the study area. Pre-primary (early childhood care education) and primary schools are generally found within most of the communities; however, secondary schools are only found in major cities such as Scarborough and Orange Hill which lie outside of the Area of Study. The area supports one public primary school and one private primary/ECCE school. Mostly all students who require advanced level secondary school education travel to Signal Hill (1 Secondary School) or Scarborough (Three Secondary Schools) or further east from Goodwood to Speyside. There is one developmental/Vocational School located within the study area that provides a technical tertiary education to students on the island. The MIC Institute of Technology is a Vocational School located in the Canaan Area and teaches students technical skills relevant to them becoming skilled tradesmen.

Other Services

The financial institutions in the wider study area provide a range of financial products to the community and the business sector. There are two banks and the Mt Pleasant Credit Union.

There are limited governmental agencies located within the study area to which include primarily the Division of Settlements, Public Utilities and Urban Development, Ministry of Works and Transport Licensing Division at Shirvan, Division of Food Security, Natural Resources, the Environment and sustainable development.

The other main organizations that are located in the study area include: Canaan Recreational Grounds, Canaan Community Centre and tour boat operators at Pigeon Point and Buccoo.

The majority of available social services are located in the capital city of Scarborough. The smaller villages are lacking many of these services, having access mainly to health centres, recreational grounds and community centres.

Community Organisations

The social capital of the study area, if measured by the number of community-based organisations operating in the region, is quite strong. The study area is well represented by organisations which have been established to address the many social and economic challenges faced by the local communities. The Canaan Village Council, Tobago fisherfolk organisation and Tobago Chamber of Industry and Commerce are a few such organisations. These organisations help support and represent a range of other community needs and issues.

Active civic, political, and fraternal organisations, composed of well-meaning and active citizens, work voluntarily to improve the quality of life in the community as well as the quality of life of the less fortunate. This sense of assistance has deep roots in the historic circumstances of the region and its population (CSA 2009).

Many of these organisations have established working relationships with the various divisions within the Tobago House of Assembly. The Assembly through its respective Divisions engage the community groups and non-governmental organisations to develop partnerships and programmes to address social and economic concerns of the local community. Consistent with the Division's focus are several initiatives that target education and programmes aimed at poverty alleviation, including housing needs.

Archaeological and Cultural Resources

There have been findings of pottery deposits along the Kilgwyn Bay Road. There are numerous caves between Store Bay and Crown Point. Though some of the caves have been destroyed throughout the years, at least four of the caves are intact and are common tourist sites. A conical stone pestle, grindstones and stone mano dating from the Archaic Age during the construction of drains in the Bon Accord Area in the early 1990's. All artefacts are stored in the Tobago Museum of History. **Figure 109 - 5.82** illustrates the distribution of prehistoric archaeological sites across Tobago; notably none of these sites are located in the Kilgwyn Bay proposed hotel development site. Closest offset sites are Crown Point and Friendship/Cove (**Figure 110 - 5.83**).

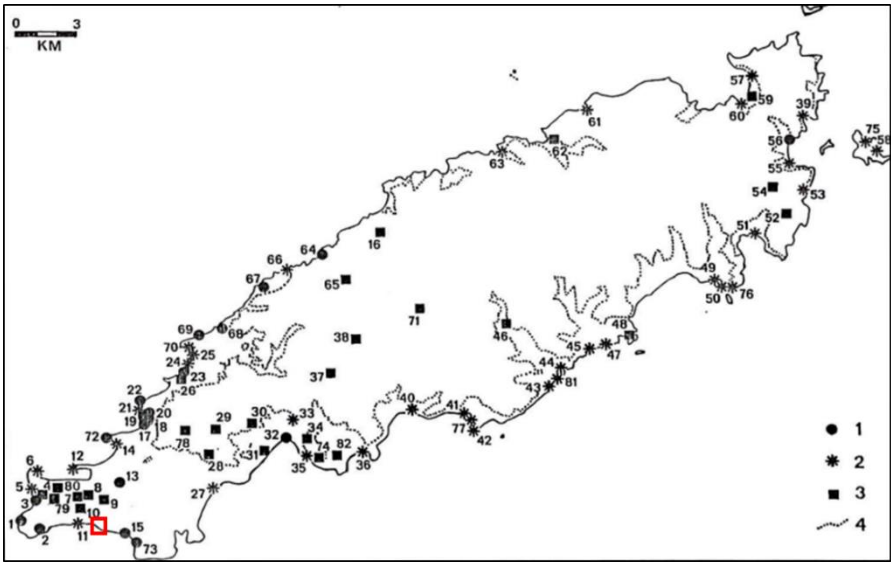


Figure 109 - 5.82: Distribution of Prehistoric Archaeological Sites.
Legend: (I) Midden sites; (2) Pottery deposits; (3) Individual finds; (4) 200-feet contour line. Red polygon represents the Kilgwyn Bay proposed hotel development site.
Sourced and modified from Arie Boombert, 1996.

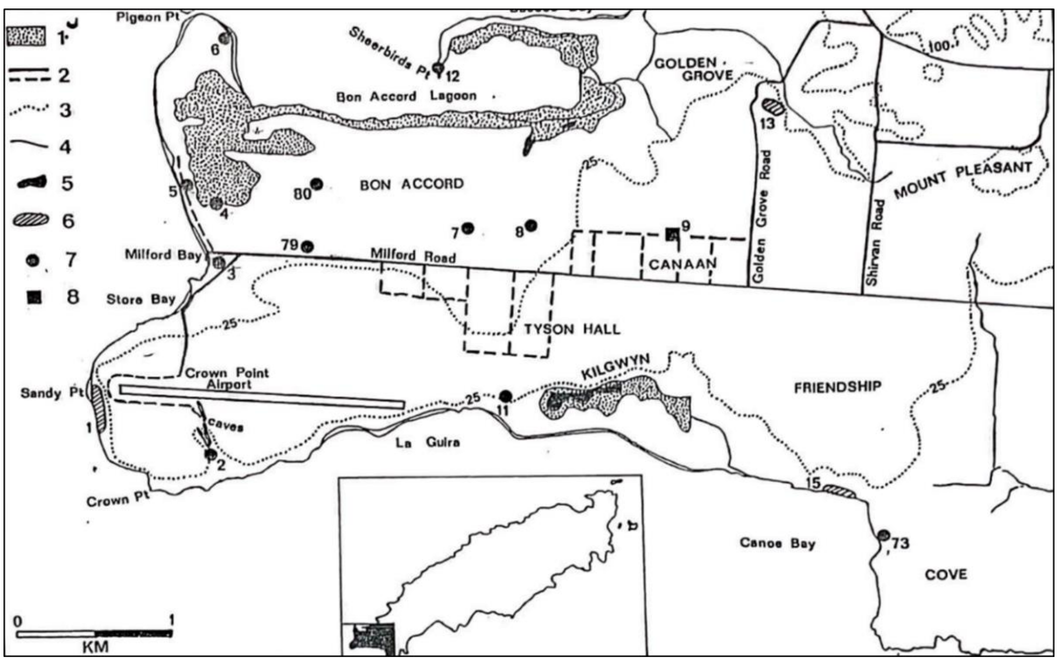


Figure 110 - 5.83: Graph Distribution of Prehistoric Archaeological Sites in Pan of Southwest Tobago.
Legend: (1) Mangrove swamps; (2) Major roads; (3) Contour lines (feet); (4) Streams; (5) Salt marshes; (6) Archaeological site of large extension; (I) Archaeological site of limited extension: (8) Archaeological sites, exact location unknown
Source: Arie Boombert, 1996.

5.2.8 Stakeholder Interactions

As part of the EIA consultation process, Apple Leisure Group and its consultant OptimalGESL has had interactions with the relevant project stakeholders to update them on the project as well as to assess their concerns. Two public consultations were held on 07th September 2022 and 05th December 2022. Upon request an independent consultation with site visit, was held in person on 19th November 2022, at the Kilgwyn Bay with the NGO CBC Gateway Pioneers and Kilgwyn Bay Farmers and Fisherfolk. Details of these meetings are found **in Section 7.0: Stakeholder Engagement a**nd ***Appendices G2*** and ***G3***.

5.3 Natural Hazards

5.3.1 Seismicity and Earthquakes

The Trinidad and Tobago area, as shown in the epicentral plot, is one of the more seismically active zones in the Eastern Caribbean, with an annual average output of about 260 earthquakes of magnitude greater than 2.0. However, the activity rate is not uniform across the area. The rate in the Tobago area has picked up since 1990 and whereas in the past the rate was on par with that seen on land Trinidad, it is now closer to that seen north of Trinidad. Following are details of the significant magnitude events observed in the zones making up the area:

1. West of Tobago – The largest in the instrumental period occurred on 1997/04/02 Mt=5.6 and 2016/12/06 Mt=6.1. There was some damage in south-west Tobago for the 1997 event. This includes the Kilgwyn Bay and Tyson Hall areas.
2. South of Tobago – The largest known occurred on 1997/04/22 Mt=6.1. There was significant damage in south-west Tobago, with flooding in some areas from large-scale groundwater discharge.

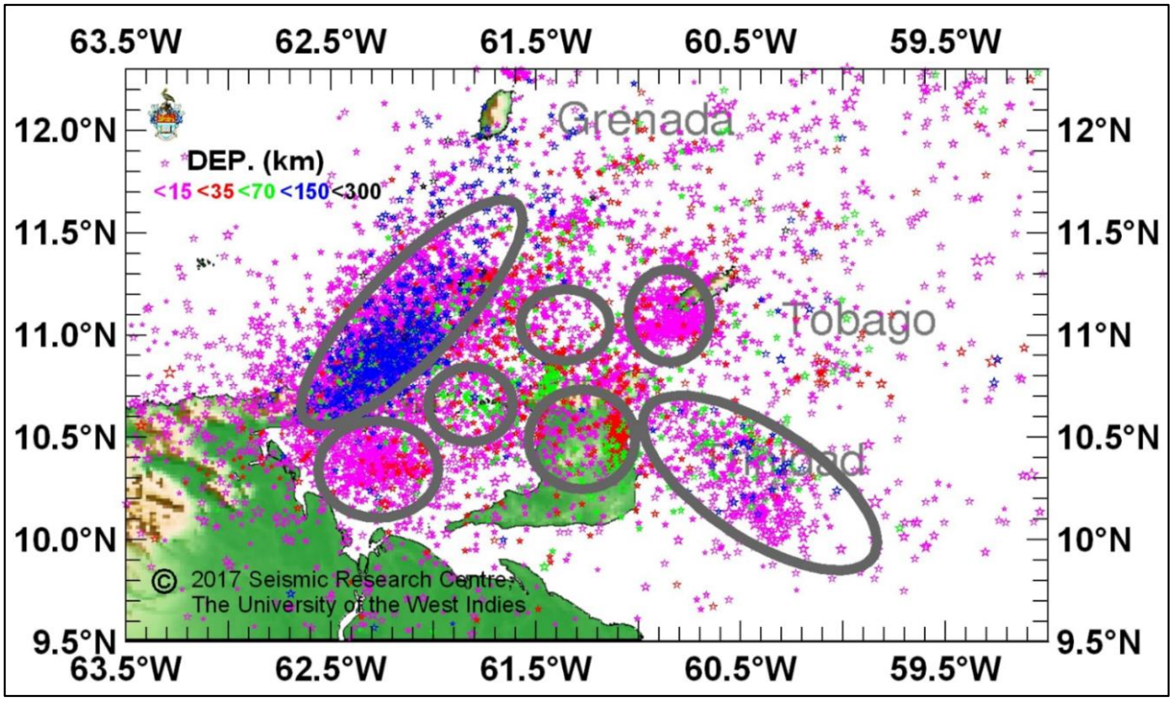


Figure 111 - 5.84: Trinidad and Tobago Area as shown in the Epicentral Plot for Seismic Activity.
Source:UWI Seismic Research Unit.

Although the underlying geology in the Kilgwyn Bay area is hard crystalline limestone the inherent regional tectonics classifies the area as susceptible earthquakes; the relative unconsolidated nature of the Kilgwyn Bay beach sands, soils and sediments above the crystalline limestone subsurface adds further risk as supports natural P and S-wave movement.

5.3.2 Hurricanes and Storm Surges

As part of the North Atlantic/Caribbean region its official hurricane season runs from June 1 to November 30. Although Trinidad is less vulnerable than other Caribbean islands, it can be hit by tropical cyclones. Tobago is however much more vulnerable even though it is only 35 km north east of Trinidad.

As reported by the Meteorological Office, of the thirty-four (34) cyclones which affected the country during the periods 1725 to 1847 and 1878 to 1993, twenty-six (26) cyclonic disturbances affected Tobago, and thirteen (13) Trinidad. The most significant cyclonic event in Trinidad and Tobago was Hurricane Flora in 1963. Of the 7,500 houses in the island of Tobago, 2,750 were destroyed and 3,500 damaged. There was no significant damage to the healthcare facilities. Total damage in the two islands amounted to US$4.8 M. The most recent cyclonic disturbances (1993-1994) on record to affect the southwestern of the island were: -

Table 57 - 5-46: History and Impact of Major Hurricanes/Tropical Storms/Storm Surges in Tobago.

Name of Hurricane	Date/s and Year of Occurrence	Category	Impact
Hurricane Flora	30th September, 1963	4	- 6,250 houses out of the total 7,200 on the island were damaged/destroyed - 18 persons were killed - Property and crop damage amounted to $30 million
Tropical Storm Arthur	25th July, 1990	-	- A major bridge collapsed - Damaged water and electrical services - Caused several landslides across the island - A total of 1,000 persons were affected
Tropical Storm Joyce	1st October, 2000	Initially category 1, then became Tropical Storm status	- Caused significant wind damage
Hurricane Ivan	Passed near Tobago on 6th September, 2004	4	- Extensive rainfall leading to heavy flooding - One home collapsed - 45 roofs were blown off houses
Hurricane Felix	Passed near Trinidad and Tobago on 31st August, 2007	Intensified to category 5	- Damage to Tobago estimated to be around $250,000

Name of Hurricane	Date/s and Year of Occurrence	Category	Impact
Tropical Storm Karen	Passed near Trinidad and Tobago on 24th – 25th September, 2019	-	- Severe flooding - Tobago Emergency Management Agency (TEMA) estimated approximately $24 million in damages caused by the effects of the storm
Hurricane Ian	19th September – 2nd October, 2022	4	- Affected mainly Scarborough
Hurricane Julia	2nd – 10th October, 2022	1	- Affected mainly Scarborough

5.3.3 Flooding

Flooding has continued perennially throughout the southwestern part of Tobago (Crown Point, Bon Accord and Canaan, particularly flash flooding along the low-lying areas of Crown Point and Tyson Hall-Kilgwyn Bay corridor; road ways and Mangrove Basins, more so in recent years. There is generally an increasing concern about an apparent inability of the public authorities to institute satisfactory measures of flood control based on current drainage engineering designs. Within recent years the concept of flood management in the Kilgwyn Bay area and environs has been assuming greater significance where recognition is being given to the integral link between the flooding problem and management of local watersheds.

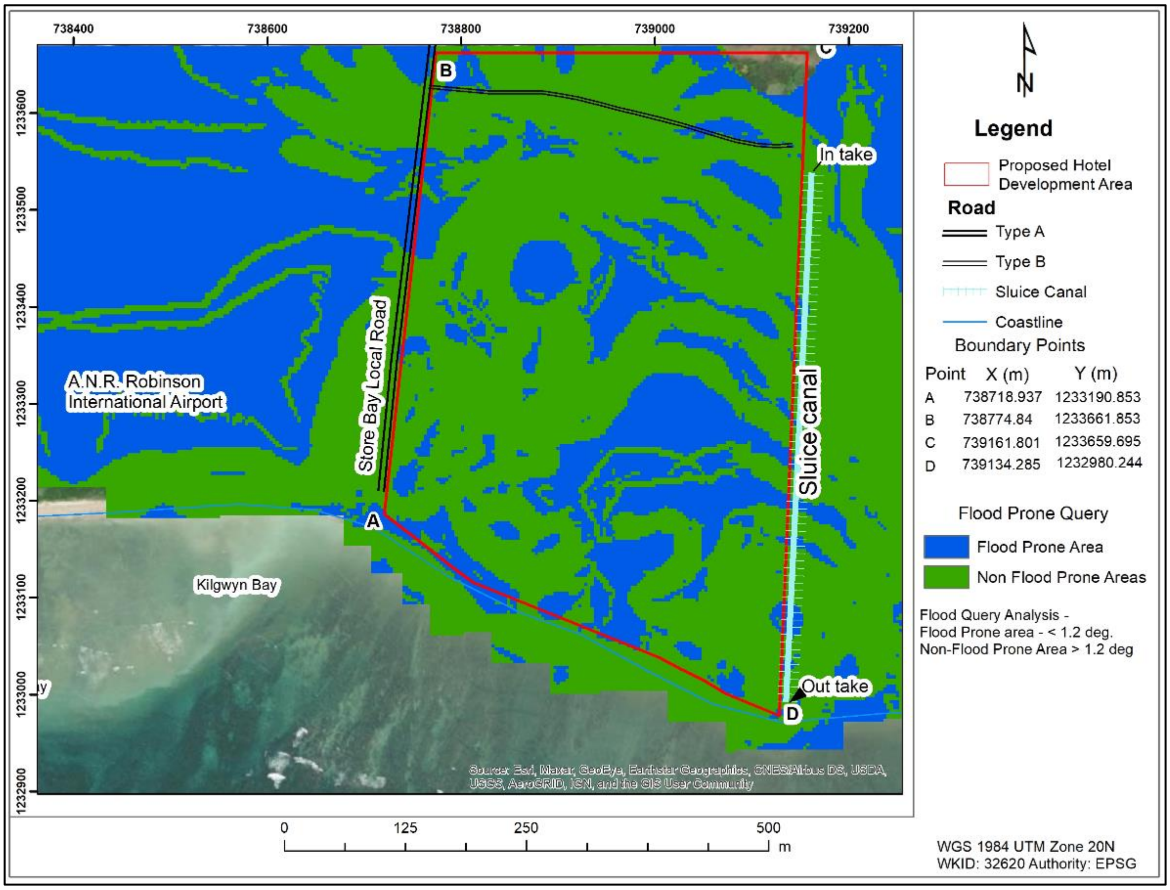


Figure 112 - 5.85: Graph GIS Flood Prone Query Map, Kilgwyn Bay, Tobago.
Source: OptimalGESL.

5.3.4 Sargassum Seaweed

The Tobago House of Assembly has declared the invasion of the Sargassum Seaweed that of a natural disaster that has profound impact on the tourism product of the island.

Pelagic sargassum is a brown alga, or seaweed that floats free in the ocean and never attaches to the ocean floor. These free-floating forms are only found in the Atlantic Ocean and are prevalent along the southern coast of Tobago inclusive of the Kilgwyn Bay coastline. Sargassum provides refuge for migratory species and essential habitat for some 120 species of fish and more than 120 species of invertebrates. It's an important nursery habitat that provides shelter and food for endangered species such as sea turtles and for commercially important species of fish such as tunas. There are two species of sargassum involved in the sargassum influx: Sargassum natans and Sargassum fluitans.

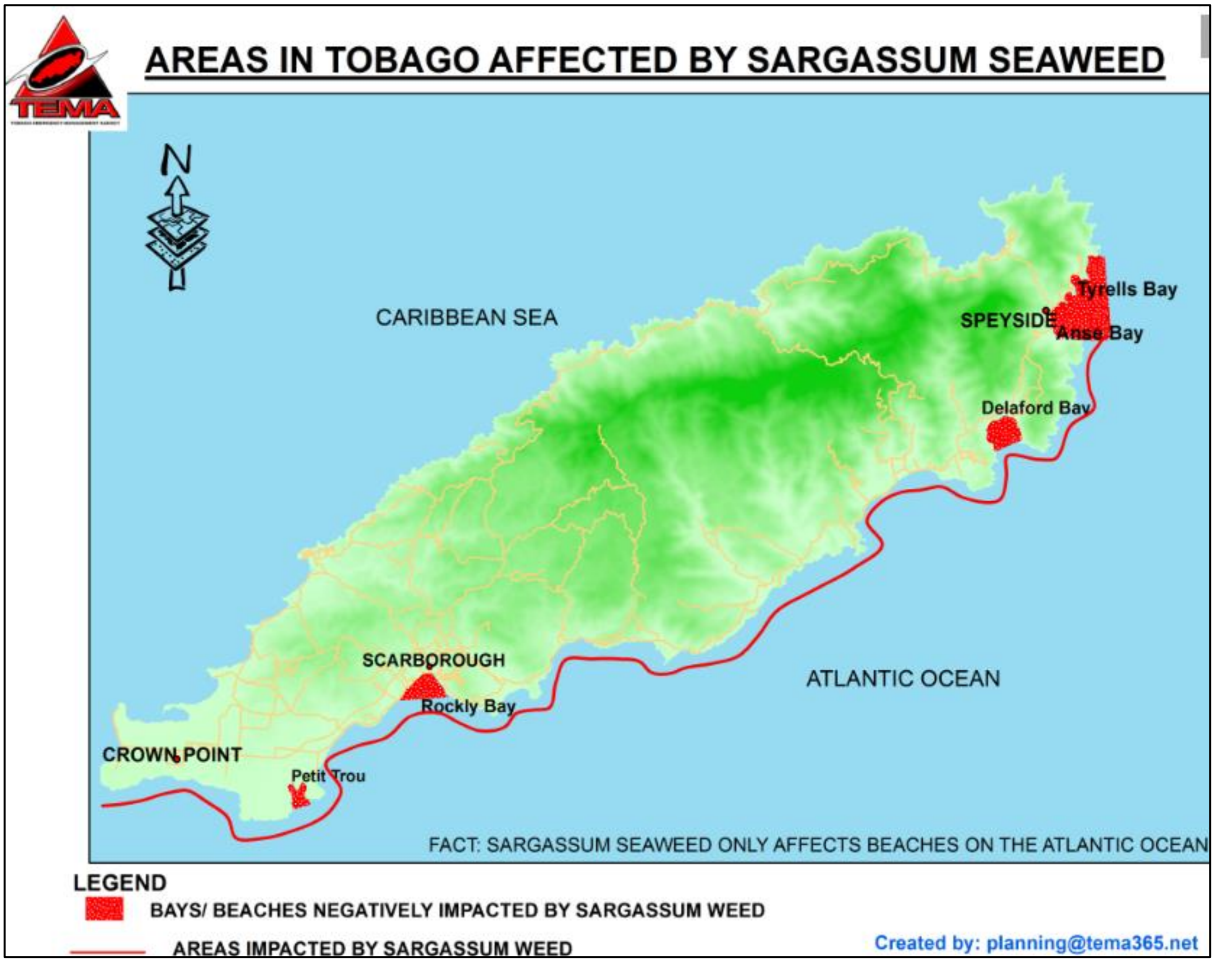


Figure 113 - 5.86: Areas in Tobago Affected by Sargassum Seaweed.
Source: Tobago Emergency Management Agency.

At this time the Tobago House of Assembly is in the process of addressing the issue of the Sargassum Seaweed and a subcommittee of the THA has been set up to address this issue