ADDENDUM

Environmental Impact Assessment

PROPOSED DEVELOPMENT OF A HOTEL AT CORAL SPRINGS TRELAWNY, JAMAICA

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ADDENDUM TO THE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED DEVELOPMENT OF A HOTEL AT CORAL SPRINGS TRELAWNY, JAMAICA

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1.0 INTRODUCTION

1.1 BACKGROUND

Through a Joint venture with the H10 Hotels Group, Felicitas Limited proposes to develop a hotel resort on approximately 25.33 hectares (0.25 km^2) of land, located in Coral Spring, Trelawny. Based on project information submitted to the National Environment and Planning Agency (NEPA), it was determined that an Environmental Impact Assessment (EIA) was required. EnviroPlanners Ltd. was contracted by Felicitas Limited to undertake the requisite works according to the approved Terms of Reference (ToR).

Subsequent to the receipt and review of the "Environmental Impact Assessment for Proposed Development of a Hotel at Coral Springs Trelawny, Jamaica" by Felicitas Limited, dated October 2016, major gaps in the Report were identified by NEPA. As outlined in a letter dated 7 November 2016 (Appendix 1), these gaps, namely the absence and/or incomplete information on the following were deemed critical:

i. Geo-technical assessment report,
ii. Storm surge assessment report,
iii. Hydrological/Drainage Plan for the development site,
iv. The impact of the marine works on the environment and
v. Ecological carrying capacity.

It was determined by NEPA that the above listed items iii — v must be completed and presented as an Addendum to the EIA Report in order to continue with the project application. It was added that, items i and ii (geo-technical and storm surge assessments respectively) must be completed within three (3) months, should an environmental permit be favourably considered. At this juncture, CL Environmental Co. Ltd. and CEAC Solutions Co. Ltd. were consulted and consequently contracted to undertake the requisite scope of work.

This document serves to present the approach and findings for the following items listed, in order to satisfy the requirements stipulated by NEPA:

1) Hydrological/Drainage Plan (undertaken by CEAC Solutions Co. Ltd.)
2) Impact of the Marine Works on the Environment (CL Environmental Co. Ltd.)
3) Ecological Carrying Capacity (CL Environmental Co. Ltd.)

It must be noted that details of the proposed project or other information duly presented in the submitted EIA are not repeated in this document, but referred to as necessary. Further, items i and ii listed (Geo-technical assessment report and storm surge assessment report) are submitted separately.

1.2 SUMMARY OF PROJECT

The project is located north of North Coast Highway (A1) within the Coral Spring area in the parish of Trelawny. The proposed development is located on approximately 25.3 ha of land which is currently covered in dense vegetation.

The proposed project is a hotel resort development which will be executed in three (3) phases. The estimated number of habitable rooms will be 470, 222 and 560 for phases 1, 2 and 3 respectively, with a proposed density of 1.25 habitable rooms. The total number of parking space is proposed at one (1) space per three (3) guest with the parking spaces totalling 339. Proposed setbacks will be stipulated at 30m from the high water mark and 1.5m from the property boundary per floor.

2.0 HYDROLOGICAL/DRAINAGE PLAN

2.1 OBJECTIVE

CEAC Solutions Co. Ltd. was commissioned to design the drainage infrastructure for the development and in doing so, for the design to meet the requirements of the regulatory agencies. It should be noted that the policy of National Works Agency is such that storm water discharge from any future developments meet the runoff flow rates of the pre-developed conditions. Therefore, any future development within the property must detain the storm water runoff before discharging into the environment.

The following is the approved term of reference:

1. Estimate pre and post project runoff rates;
2. Design hydraulic conveyance systems to meet building drainage needs for the 100- year return rainfall event and site drainage for the 10-year return period; and
3. Design Mitigation measures to reduce both post-development runoff volumes and peak flow rates for the 10-year return period to pre-development levels, thus minimizing flood risks downstream of the site.

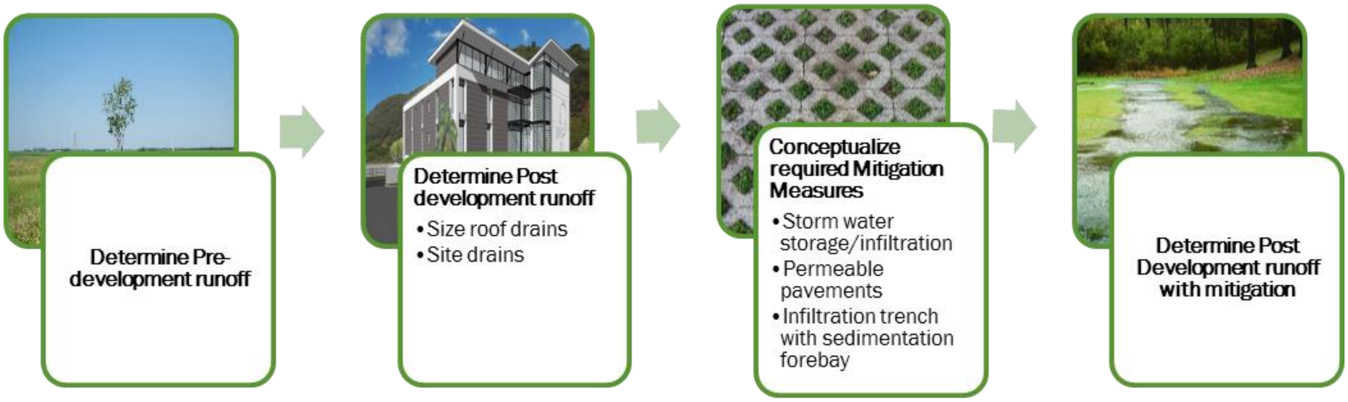
2.2 METHODOLOGY AND DESIGN CRITERIA

2.2.1 Methodology

The methodology adopted is as follows:

- Delineation and hydrological analysis of the drain to the east of the site as well as those within the site.
- Hydraulic analysis of the existing and proposed drains and drainage features.

- Propose grading of the lawns and roads to ensure all runoff is captured.



2.2.2 Regulatory Guidelines

2.2.2.1 NWA Requirements

The recently published "Guidelines for Preparing Hydrological and Hydraulic Design Reports for Drainage Systems of Proposed Development Applications (2015)" was consulted to guide the designs. The following sizing criteria were utilized:

1. The site drainage shall be sized to handle the 10 year return period flow.
2. As for the roof drainage, all conductors (vertical and horizontal) shall be sized to handle the 100 year return runoff.
3. Flood levels be set 0.4 metres above the 100 year return period flood event

The design strategy adopted was to intercept the flows using drop inlets and conduct them through subsurface drain pipes which discharges into the sea via concrete drains.

2.2.2.2 International Plumbing Code[1]

The International Plumbing Code (International Code Council) is a plumbing code and standard which sets minimum requirements for plumbing systems in their design and function, and which sets out rules for the acceptances of new plumbing-related technologies. Guidelines within the plumbing code was used to determine the minimum pipe and conductor sizes as well as the minimum slopes allowable based on the pipe size.

2.3 DESCRIPTION OF ENVIRONMENT

2.3.1 The Development

[1] Woodson, R. D. "International Plumbing Code Handbook"." (2006).

The proposed development will contain 930 junior suites, 100 master suites and 222 villa for a total of 1,252 habitable rooms. The maximum number of floors in any one building is 5 storeys. The floor area ratio is estimated at 0.50:1 and a plot area ratio of 30%. The total floor area will be 126 hectares. Green areas will be provided in various locations around the development.

2.3.1.1 Existing and Proposed Drainage Infrastructure.

There is currently no existing drainage infrastructure within nor in proximity to the proposed development.

2.3.1.2 Current and Proposed Land Use

Currently the area is undeveloped, however it is proposed that the area be developed into a hotel resort (Coral Spring H10 Hotel). See Figure 2-1 for proposed plan of the development.

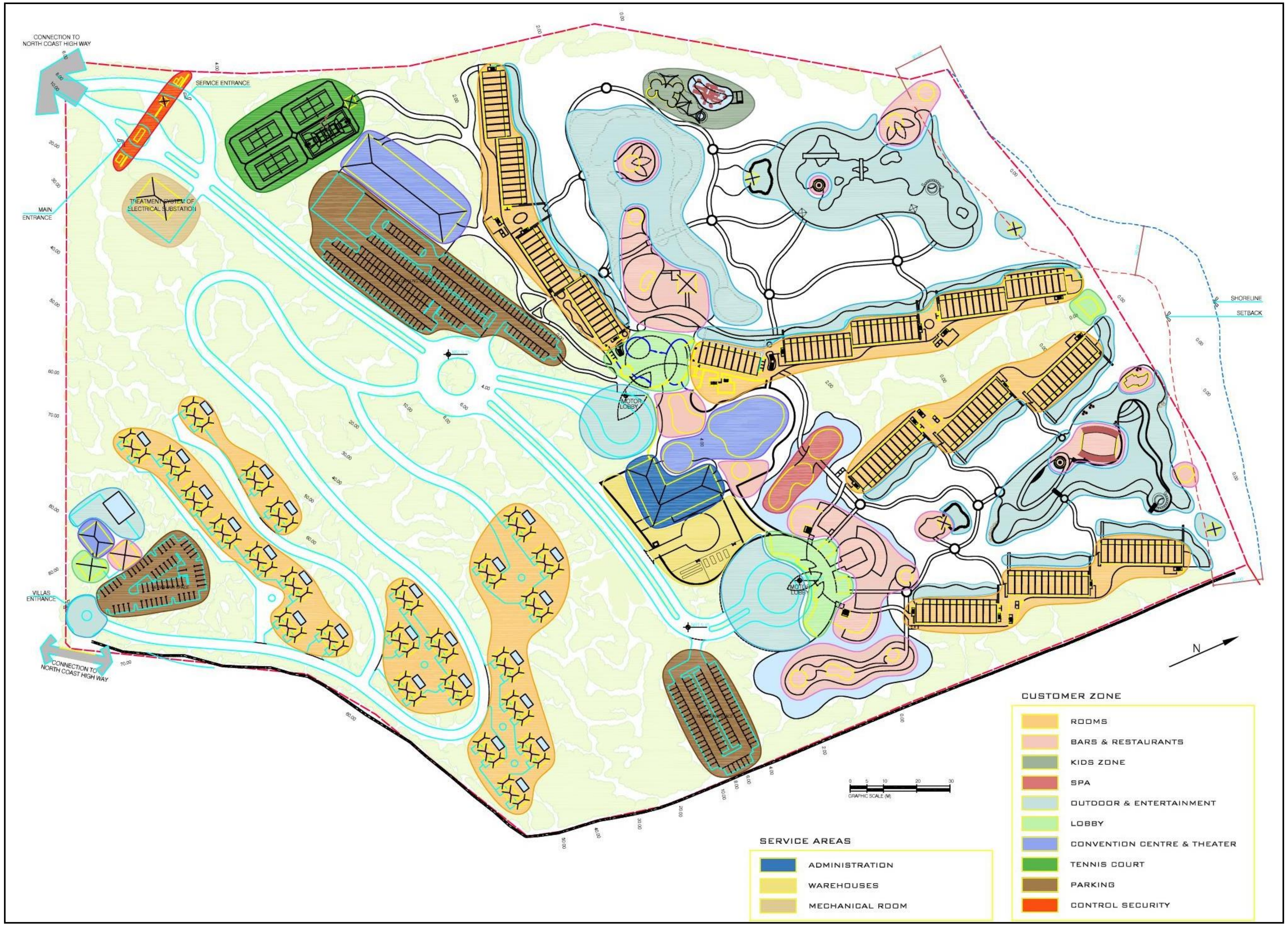


Figure 2-1 Proposed plan of the development

2.3.2 The Catchment

2.3.2.1 Soils

The main catchment was superimposed on the soils map of Jamaica (Figure 2-2). It was noted that the development is situated on Bonnygate Stony Loam as identified in Table 2-1 This soil type is classified as a free draining soil with rapid internal drainage.

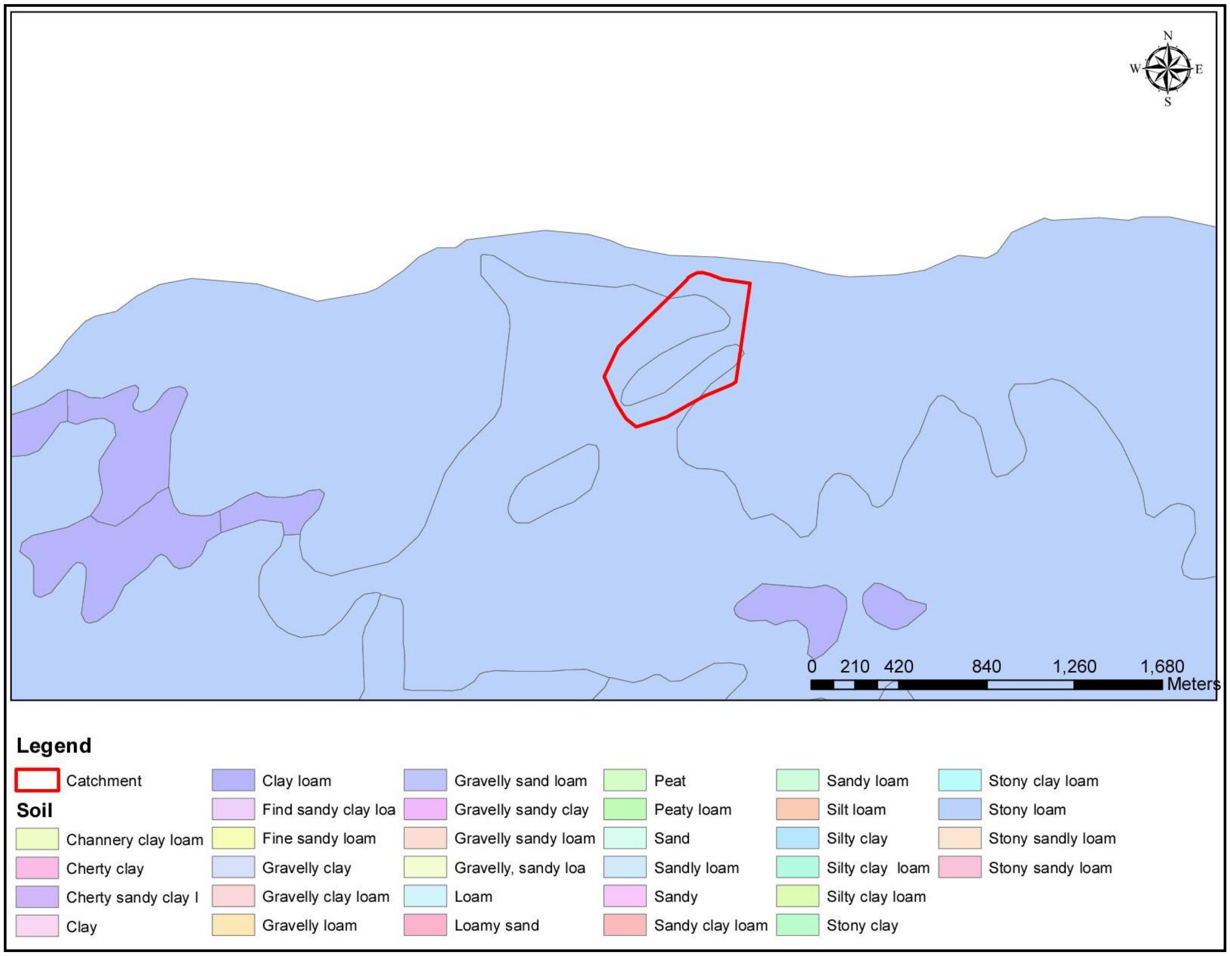


Figure 2-2 Soils Map showing catchment

Table 2-1 Classification of soil identified within proposed development

Name of Soil	Internal Drainage Properties	Erosion Hazard	Comments
Bonnygate Stony Loam	Very Rapid	High	Shallow, Stony, Steep

2.3.2.2 Topography

Topographical data for the proposed site was obtained from a number of sources including:

- The survey departments 12,500 map series;
- Survey points provided by the client;

Survey Department 12,500 map Series

The contour data obtained revealed that the overall catchment is sloping in a South-North direction (towards the coast in the North). The catchments extend 185m south of the proposed development towards the A1 highway (St. James). The catchment is moderately sloping with elevations of 78 metres in the south to approximately mean sea level in the north.

Client Survey Data

Survey data obtained from the client described the elevation of ground within the property boundaries. This data indicates the site elevations within the site varied from 24.8 metres above mean sea level (msl) in the highest areas to a low of 0.1 metres above msl. Figure 2-3 shows the survey data provided by the client of the proposed site. This data confirms the general south to north slopes shown on the Survey department 12500 map series.

2.3.2.3 Catchment Boundaries

The catchments associated with the proposed site were delineated so as to calculate the expected runoff associated with it. Additionally, the delineated catchments will help to quantify the impacts on the environment as a result of the proposed construction. Existing boundary walls will be maintained (on the east) and new walls established (on the west, north and south).

Surface Runoff

The property/development catchment was delineated and the area was found to be 25.3 hectares. The catchment is bounded by the legal property boundaries. Currently, the land itself facilitates as the conveyor of stormwater in the area, conducting the sheet flows towards the shoreline.

Building Roof Runoff

The total roof catchments for the development were delineated and the total area was found to be 3.13 hectares. The roof runoffs will be conveyed using horizontal and vertical conductors.

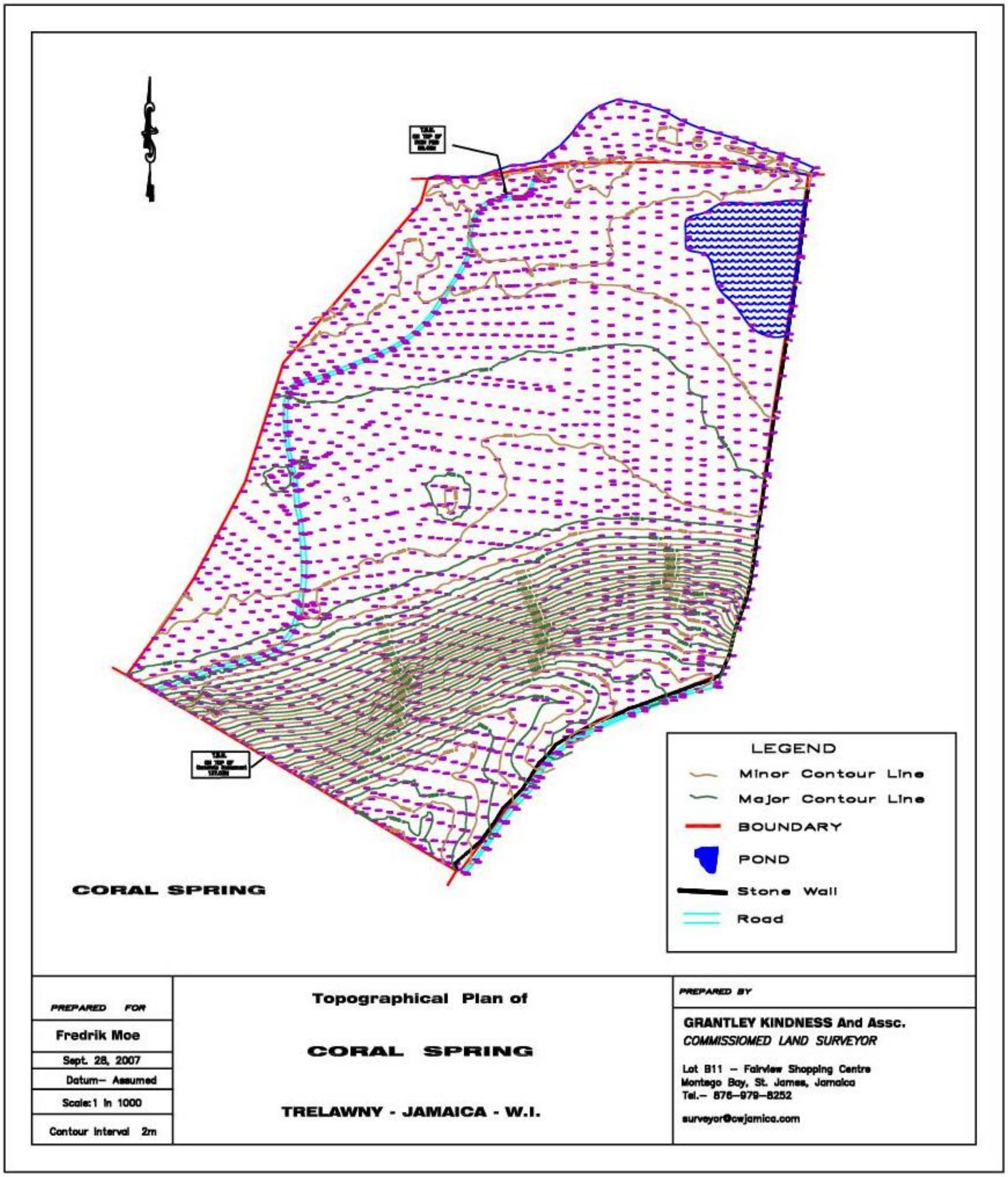


Figure 2-3 Topographical plan of proposed site

2.4 STORM SURGE

A model surge model was created and used to estimate the inundation levels that can be expected on the proposed site. The model was previously used to determine storm surge levels for a site in close proximity, west of the proposed development. The results were used to inform the design approach for the Coral Springs H10 Hotel development.

2.4.1 Methodology

It was necessary to define the deepwater hurricane wave climate at the site as a part of defining the environment in which White Bay exists. Hurricane wave track data in the Caribbean Sea was available and we were able to carry out a thorough statistical analysis to determine the hurricane wind and wave conditions at a deep-water location offshore the site.

A database of hurricanes, dating back to 1886, was searched for storms that passed within a 500km radius from the site. The following procedure was carried out.

1. Extraction of storms and storm parameters from the historical database: A historical database of storms was searched for all storms passing within a 500km radius of the site.
2. Application of the JONSWAP wind-wave model. A wave model was used to determine the wave conditions generated at the site due to the rotating hurricane wind field. This is a widely applied model and has been used for numerous engineering problems. The model computes the wave height from a parametric formulation of the hurricane wind field.
3. Application of extremal statistics. Here the predicted maximum wave height from each hurricane was arranged in descending order and each assigned an exceedence probability by Weibull's distribution.
4. A bathymetric profile from deepwater to the site was then defined and each hurricane wave transformed along the profile. The wave height at the nearshore end of the profile was then extracted from the model and stored in a database. All the returned nearshore values were then subjected to an Extremal Statistical analysis and assigned exceedance probabilities with a Weibull distribution.

2.4.2 Results

Extremal analysis results are summarized in a bi-variant table (Table 2-2). The analysis indicates that the waves generated on the north coast propagate most frequently from a NE to NW direction (Table 2-4). However, the most intense hurricane waves have been noted to come from an Easterly to North Easterly direction.

The results of the search clearly indicate that approximately 109 hurricane systems came within 500 kilometres of the site from the start of records in 1851 (Table 2-3). This speaks to the site's overall vulnerability to such systems and the likelihood of events occurring relatively frequently.

The Extremal analysis results indicate that the 100-year return period event has a deepwater wave height of 6.6 m for NW waves, 5.6 m for N waves, 6.7 m for a NE waves, with a wave period of 12.8s, 11.8s and 12.9s respectively. The largest wave height expected to reach the shoreline is a 0.85m wave. Overall, due to location and elevation of the site no negative impact from the extreme wave climate is expected.

Table 2-2 Extremal analysis of wave heights for White Bay, Trelawny

Return Periods	Wave height (m)																	
	All		SW		W		NW		N		NE		E		SE		S	
	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp
1	2.0	7.2			1.0	5.1	1.0	5.1	1.0	5.1	1.0	5.1	1.0	5.1				
2	3.7	9.7			3.8	9.7	3.8	9.8	3.4	9.3	3.8	9.8	4.4	10.5				
5	5.0	11.1			4.8	11.0	4.8	10.9	4.2	10.3	4.8	11.0	5.7	11.9				
10	5.7	11.9			5.4	11.5	5.3	11.5	4.6	10.8	5.4	11.6	6.3	12.5				
20	6.4	12.6			5.8	12.0	5.8	12.0	5.0	11.2	5.9	12.0	6.8	13.0				
25	6.6	12.8			6.0	12.1	5.9	12.1	5.1	11.3	6.0	12.2	7.0	13.1				
50	7.2	13.3			6.3	12.5	6.3	12.4	5.4	11.6	6.4	12.5	7.4	13.5				
75	7.6	13.6			6.5	12.7	6.5	12.6	5.5	11.7	6.6	12.7	7.7	13.7				
100	7.8	13.8			6.7	12.8	6.6	12.8	5.6	11.8	6.7	12.9	7.8	13.9				
150	8.1	14.1			6.9	13.0	6.8	12.9	5.8	12.0	6.9	13.0	8.0	14.0				
200	8.3	14.3			7.0	13.1	6.9	13.0	5.9	12.1	7.0	13.1	8.2	14.2				

Table 2-3 Hurricane names and years for storms that came within 500 km of White Bay, Trelawny

Storm No.	Name	Date	Max. SS Category	
3	NOTNAMED	1851	3-	EXTENSIVE
26	NOTNAMED	1855	1-	WEAK
50	NOTNAMED	1859	3-	EXTENSIVE
89	NOTNAMED	1865	3-	EXTENSIVE
127	NOTNAMED	1870	2-	MODERATE
150	NOTNAMED	1873	3-	EXTENSIVE
157	NOTNAMED	1874	2-	MODERATE
160	NOTNAMED	1875	3-	EXTENSIVE
165	NOTNAMED	1876	1-	WEAK
168	NOTNAMED	1876	2-	MODERATE
181	NOTNAMED	1878	2-	MODERATE
187	NOTNAMED	1878	2-	MODERATE
194	NOTNAMED	1879	1-	WEAK
198	NOTNAMED	1880	4-	EXTREME
199	NOTNAMED	1880	1-	WEAK
227	NOTNAMED	1884	2-	MODERATE
240	NOTNAMED	1886	2-	MODERATE
241	NOTNAMED	1886	2-	MODERATE
242	NOTNAMED	1886	3-	EXTENSIVE
246	NOTNAMED	1887	1-	WEAK
248	NOTNAMED	1887	1-	WEAK
256	NOTNAMED	1887	2-	MODERATE
288	NOTNAMED	1891	1-	WEAK
312	NOTNAMED	1893	1-	WEAK
313	NOTNAMED	1893	1-	WEAK
316	NOTNAMED	1894	3-	EXTENSIVE
324	NOTNAMED	1895	3-	EXTENSIVE
329	NOTNAMED	1896	3-	EXTENSIVE
348	NOTNAMED	1899	3-	EXTENSIVE
351	NOTNAMED	1899	2-	MODERATE

Storm No.	Name	Date	Max. SS Category	
352	NOTNAMED	1900	4-	EXTREME
364	NOTNAMED	1901	1-	WEAK
375	NOTNAMED	1903	3-	EXTENSIVE
383	NOTNAMED	1904	1-	WEAK
385	NOTNAMED	1904	1-	WEAK
391	NOTNAMED	1905	2-	MODERATE
403	NOTNAMED	1906	1-	WEAK
413	NOTNAMED	1908	2-	MODERATE
418	NOTNAMED	1909	4-	EXTREME
420	NOTNAMED	1909	3-	EXTENSIVE
422	NOTNAMED	1909	4-	EXTREME
427	NOTNAMED	1910	3-	EXTENSIVE
433	NOTNAMED	1911	1-	WEAK
438	NOTNAMED	1912	2-	MODERATE
439	NOTNAMED	1912	4-	EXTREME
446	NOTNAMED	1915	4-	EXTREME
448	NOTNAMED	1915	2-	MODERATE
453	NOTNAMED	1916	3-	EXTENSIVE
454	NOTNAMED	1916	2-	MODERATE
466	NOTNAMED	1917	3-	EXTENSIVE
492	NOTNAMED	1923	1-	WEAK
503	NOTNAMED	1924	2-	MODERATE
522	NOTNAMED	1927	1-	WEAK
523	NOTNAMED	1927	1-	WEAK
525	NOTNAMED	1928	1-	WEAK
534	NOTNAMED	1930	4-	EXTREME
542	NOTNAMED	1931	1-	WEAK
553	NOTNAMED	1932	4-	EXTREME
556	NOTNAMED	1933	2-	MODERATE
557	NOTNAMED	1933	1-	WEAK

Storm No.	Name	Date	Max. SS Category	
560	NOTNAMED	1933	1-	WEAK
572	NOTNAMED	1933	4-	EXTREME
573	NOTNAMED	1933	2-	MODERATE
585	NOTNAMED	1934	1-	WEAK
590	NOTNAMED	1935	3-	EXTENSIVE
591	NOTNAMED	1935	1-	WEAK
630	NOTNAMED	1939	2-	MODERATE
653	NOTNAMED	1942	1-	WEAK
654	NOTNAMED	1942	2-	MODERATE
675	NOTNAMED	1944	3-	EXTENSIVE
686	NOTNAMED	1945	2-	MODERATE
698	NOTNAMED	1947	1-	WEAK
708	NOTNAMED	1948	3-	EXTENSIVE
721	NOTNAMED	1949	2-	MODERATE
734	KING	1950	3-	EXTENSIVE
739	CHARLIE	1951	4-	EXTREME
745	ITEM	1951	1-	WEAK
753	FOX	1952	4-	EXTREME
763	NOTNAMED	1953	1-	WEAK
776	HAZEL	1954	4-	EXTREME
786	HILDA	1955	3-	EXTENSIVE
811	ELLA	1958	3-	EXTENSIVE
813	GERDA	1958	1-	WEAK
816	JANICE	1958	1-	WEAK
842	GERDA	1961	1-	WEAK
857	FLORA	1963	4-	EXTREME
864	CLEO	1964	4-	EXTREME
886	INEZ	1966	4-	EXTREME
923	ALMA	1970	1-	WEAK
960	GILDA	1973	2-	MODERATE

	Storm No.	Name	Date	Max. SS Category	
91	974	CAROLINE	1975	3-	EXTENSIVE
92	976	ELOISE	1975	3-	EXTENSIVE
93	1011	CLAUDETTE	1979	1-	WEAK
94	1012	DAVID	1979	5-	CATASTROPHIC
95	1014	FREDERIC	1979	4-	EXTREME
96	1018	ALLEN	1980	5-	CATASTROPHIC
97	1029	ARLENE	1981	1-	WEAK
98	1032	DENNIS	1981	1-	WEAK
99	1039	KATRINA	1981	1-	WEAK
100	1067	DANNY	1985	1-	WEAK
101	1068	ELENA	1985	3-	EXTENSIVE
102	1095	GILBERT	1988	5-	CATASTROPHIC
103	1154	GORDON	1994	1-	WEAK
104	1201	GEORGES	1998	4-	EXTREME
105	1224	DEBBY	2000	1-	WEAK
106	1228	HELENE	2000	1-	WEAK
107	1259	ISIDORE	2002	3-	EXTENSIVE
108	1262	LILI	2002	4-	EXTREME
109	1263	IVAN	2004	5-	CATASTROPHIC

Table 2-4 Bivariant table for White Bay, Trelawny

Wind direction- NW

Tp(s)	Wave height(m)										Total
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6											
8		19	1								20
10		48	13								61
12		9	42	1							52
14				3							3
16											
18											
20											
Total		76	56	4							136

Wind direction- N

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6											
8		12	2								14
10		11	2								13
12			5								5
14											
16											
18											
20											
Total		23	9								32

Wind direction- NE

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6											
8		9									9
10		23	7								30
12			14								14
14			1								1
16											
18											
20											
Total		32	22								54

Wind direction- W

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6											
8		9									9
10		33	8								41
12		9	23								32
14			2	2							4
16											
18											
20											
Total		51	33	2							86

All directions

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6											
8		54	3								57
10		130	40								170
12		20	106	5							131
14			5	8							13
16											
18											
20											
Total		204	154	13							371

Wind direction- E

Tp(s)	Wave height(m)										
<value	2	4	6	8	10	12	14	16	18	20	
2											
4											
6											
8		5									5
10		15	10								25
12		2	22	4							28
14			2	3							5
16											
18											
20											
Total		22	34	7							63

Wind direction- SW

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

Wind direction- S

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

Wind direction- SE

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

2.4.3 Storm Surge and Floor Levels

The likely magnitude of storm surge was determined in order to arrive at reasonable recommendations for the minimum floor levels, for infrastructure. This was done by considering: wave setup, Inverse barometric pressure rise, wind setup and global sea level rise. The worst case direction was chosen to be from the North which is approximately perpendicular to the development shoreline area. As seen in Table 2-5, the 100 year return period event, from the Northern direction has an average storm surge of 0.85 metres.

Overall, due to location and elevation of the site no negative impact from the estimated storm surge level is expected. An appropriate return period value should be chosen for the project and the corresponding storm surge can then be selected and a reasonable factor of safety or free board applied in order to arrive at a floor level. It is recommended to use the 100 year return period for the worst case scenario with an additional freeboard of 0.3m to required floor levels.

Table 2-5 Extremal Storm surge predictions for White Bay, Trelawny.

Return Period	Total setup (m) All	SW	W	NW	N	NE	E	SE	S
1									
2									
5	0.16		0.15	0.14	0.19	0.19	0.30		
10	0.26		0.23	0.20	0.30	0.27	0.50		
20	0.39		0.33	0.28	0.44	0.35	0.71		
25	0.43		0.37	0.31	0.49	0.38	0.77		
50	0.58		0.48	0.40	0.66	0.46	0.98		
75	0.67		0.54	0.46	0.77	0.50	1.11		
100	0.74		0.59	0.51	$\boxed{0.85}$	0.53	1.20		
150	0.83		0.66	0.57	0.96	0.58	1.32		
200	0.91		0.71	0.62	1.05	0.61	1.41		

2.5 HYDROLOGY

The hydrology of the catchment was analysed following the general guidance of the NWA Hydraulic and Drainage Report Manual. Both the Soil Conservation Method (SCS) and Rational Method were used to determine peak runoff rates as it is the most suitable method for small urban watersheds that do not have storage such as ponds or swamps.

2.5.1 Extreme Rainfall

2.5.1.1 Rainfall Stations

The 24-hour rainfall data for approximately 250 gauges across Jamaica was obtained from the Meteorological Office of Jamaica (Figure 2-4). Information for the gauges spanned the 1930 to 1980 period and the 1992 to 2008 period. Both sets of data were subjected to Weibull analysis for the extreme rainfall data ranging for the 5, 10, 25, 50 and 100 year.

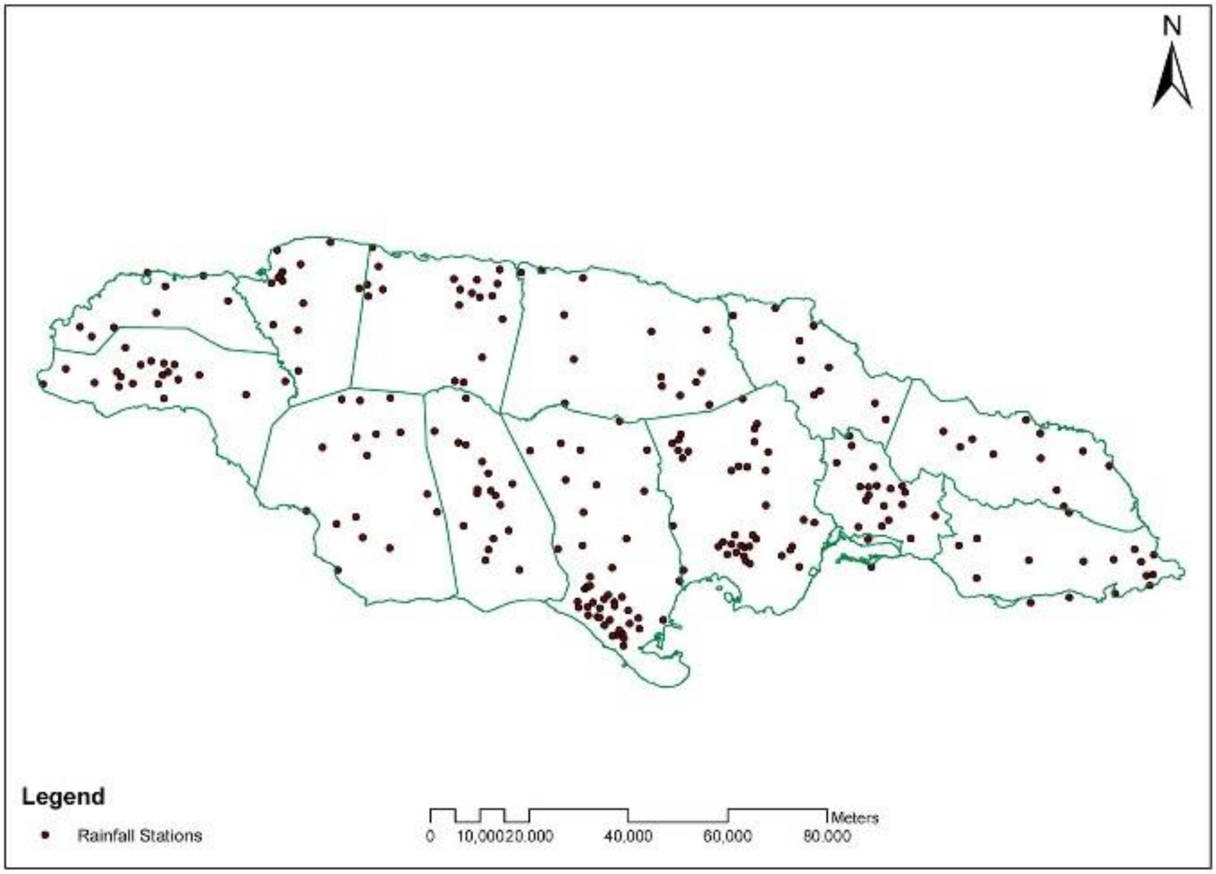


Figure 2-4 Rainfall stations across Jamaica

2.5.1.2 Climate Change Resilience

The analysis indicates that there has been an overall increase in the average rainfall ranging from 6.1% (for the 5 year Return Period event) to 42.1% (for the 100 year return period event) and 5% (for the 5 year Return Period event) to 56.6% (for the 100 year return period event) for the Norman Manley International Airport (NMIA) and Sangster's International Airport (SIA) weather stations. This increase will occur over a time frame of 90 years (2010 to 2100) (Figure 2-5). These were further verified in Burgess et al (2014)[2].

The design life for drainage infrastructure is typically 50 years[3] and as such, due consideration should be given to the changes in extreme rainfall as the old data appears to be irrelevant in light of the new data supplied by the Met Office of Jamaica.

[2] Burgess, Christopher P., Michael A. Taylor, Tannecia Stephenson, and Arpita Mandal. "Frequency analysis, infilling and trends for extreme precipitation for Jamaica (1895–2100)." Journal of Hydrology: Regional Studies (2014).

[3] *BS EN 1990, EUROCODE - BASIS OF STRUCTURAL DESIGN*

Table 2-6 Summary of 24 hour intensities for 2010 and 2100 period.

Return Period (yrs)	Stationary (2010)	Mean Varying (2100)	Mean + std. dev. Varying (2100)	Mean + std. dev. + skewness Varying (2100)	Mean (2100) Predictions	Average % Increase
5	178 [132.6]	170.9 [132.8]	160.2 [133.1]	166.5 [120.8]	165.9 [128.9]	**−7%** [−3]
10	220.5 [163.6]	216.3 [166.2]	212.4 [172.4]	248 [157.4]	225.6 [165.3]	**2%** [1]
25	271.7 [202.7]	275.1 [209.0]	283.5 [229.2]	378.6 [224.3]	312.4 [220.9]	**15%** [9]
50	308.1 [231.7]	319.8 [241.1]	351.2 [280.0]	562.1 [292.0]	411 [271.0]	**33%** [17]
100	342.9 [260.5]	365.1 [273.3]	426.7 [336.9]	845.1 [381.2]	545.6 [330.5]	**59%** [27]

Table 2-7 Present (1895–2010) climate RP and projected RP (2100) for NMIA and SIA from statistical trend analysis of frequency analysis parameters based on corresponding the present climate intensities for each station.

Present Return Period (1895 - 2010)	NMIA (2100)	SIA (2100)
5	6.1	5
10	9.3	9
25	17.5	19
50	26.3	32.9
100	42.1	56.6

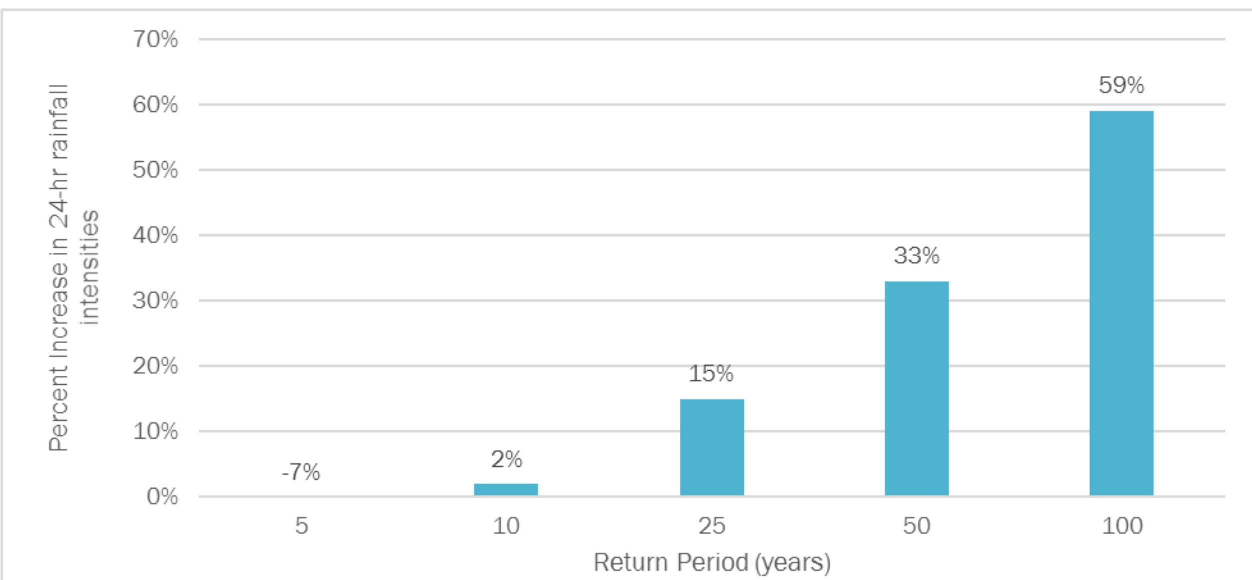


Figure 2-5 Overall increase in 24-hours rainfall intensity for the period between 2010 and 2100

2.5.2 Soil Conservation Service (SCS) Method

SCS method is an empirical model for rainfall runoffs based on the potential for the soil to absorb a certain amount of moisture. On the basis of field observations, the soil type and land use was related to a 'curve number' which ranges from 30 to 100; where lower numbers indicate low runoff potential.

2.5.2.1 Curve numbers (CN)

The curve numbers used in the SCS method were extracted from the recommended set of values given in Mays (2001).[4]

Pre-development Scenario

The nature of the catchment during pre-development stages is assumed to be 100% fallow or grassland. No infrastructure or buildings would have been established at this time, making the catchment mainly permeable. The composite curve number was determined to be 74.

Post construction (proposed development)

The proposed land use within the catchment is predominantly commercial. It is proposed that 48% of the total catchment area be constructed of permeable material. The runoff generated by the remaining 58% of impermeable will be directed to infiltration trenches. At build out, the percentage of impermeable surfaces is expected to increase significantly as more structures are built. Based on the soil type and current land use for the existing scenario, the CN for the catchment was determined to be 87.9.

2.5.2.2 Rainfall Distribution and SCS runoff

The surface runoff was calculated using the Type III rainfall distribution. The primary inputs into the model are as follows:

- Drainage area size (A) in square miles (square kilometres);
- Time of concentration (Tc) in hours;
- Weighted runoff curve number (RCN);
- Rainfall distribution;
- Total design rainfall (P) in inches (millimetres).

2.5.3 Rational Method

The Rational Method is widely used in Jamaica, for example Stanley Consultants (2012)[5] and Mandal et al (2012)[6] . The rational method is used to determine peak flows in drainage systems by the equation:

[4] Mays, Larry W. Stormwater collection systems design handbook. New York: McGraw-Hill, 2001

[5] Stanley Consultants, 2012, Jamaica Master Drainage Plan, National Works Agency, Kingston, Jamaica (2012)

[6] Mandal, Arpita, and Anuradha Maharaj. "Flooding in Jamaica with assessment of riverine inundation of Port Maria, St Mary." Bulletin de la Societe Geologique de France 184, no. 1-2 (2013): 165-170.

$$Q = CIA$$

Where,

Q = Design peak flow (runoff), (m^3/s)
C = Coefficient of runoff
I = Average rainfall intensity, in millimetres per hour for a given frequency and for the duration usually equal to the time of concentration.
A = Drainage area, in m^2.

When using the Rational Method, the following assumptions are made:

1. The rainfall intensity is uniform over the entire catchment during the entire storm duration;
2. The maximum runoff rate occurs when the rainfall lasts as long or longer than the time of concentration, and;
3. The time of concentration is the time required for the runoff from the most remote part of the watershed to reach the point under design.

2.5.3.1 Coefficient of Runoff (C)

The determined runoff coefficient (c) is a function of both the soil type and drainage basin slope. Less frequent higher intensity storms will require the use of higher coefficients because infiltration and other losses have a proportionally smaller effect on runoff (Table 2-8).

Table 2-8 Recommended coefficient of runoff for pervious surfaces by selected Hydrological Soil Grouping and slope ranges

Slope	A	B	C	D
Flat (0 - 1%)	0.04-0.09	0.07-0.12	0.11-0.16	0.15-0.20
Average (2 - 6%)	0.09-0.14	0.12-0.17	0.16-0.21	0.20-0.25
Steep (Over 6%)	0.13-0.18	0.18-0.24	0.23-0.31	0.28-0.38

2.5.3.2 Rainfall Intensity (I)

The rainfall intensity to be used in the Rational Method for determining peak flow should be for the design frequency, and of a duration equal to the time of concentration. The rainfall intensity is typically found from Intensity Duration Frequency (IDF) curves for rainfall events in the geographical region of interest. The duration is usually equivalent to the time of concentration of the drainage area. IDF curves for Sangsters International airport were adopted for this design and analysis.

2.5.3.3 Time of Concentration (t_c)

The time of concentration (t_c) is the time required for runoff to arrive at the point of concentration (such as the inlet to an infiltration system) from the most remote point of the drainage area. Time of concentration is generally developed relative to the initial point of concentration.

2.5.4 Runoff Modelling Scenarios

Two scenarios were considered:

2.5.4.1 Pre-development Scenario

The nature of the catchment during pre-development stages is assumed to be 100% grassland. No infrastructure has been introduced to the site at this time, making the catchment 100% permeable.

2.5.4.2 Post Development Scenario

It is proposed that 48% of the total catchment area be of permeable material. The permeable material will consist mainly of grass paver and lawn areas. The runoff generated by the remaining 52% of impermeable area will either be directed to an infiltration trench or be allowed to run over land towards the proposed drainage system for the subdivision. Based on the soil type and expected land use, the composite runoff coefficient (C) for the catchment was determined to be 87.9.

2.5.4.3 Design Parameters

After development, each catchment area will consist of both impervious and pervious surfaces. To better model this scenario, a weighted runoff coefficient (C) was calculated by considering the percentage of impermeable and permeable surfaces on the site. The time of concentration for the catchment was determined to be less than 30 minutes. As such the rainfall intensities were calculated using IDF curve equations produced by the Water Resources Authority (WRA)[7] specifically to handle storms with durations less than 30 minutes. As discussed earlier, climate change factor was considered and added to the rainfall intensities. The parameters used in the analysis are shown in Table 2-9 below:

Table 2-9 Rainfall Intensity and Runoff Parameters

Storm Event (Years)	2	5	10	25	50	100
Rainfall Intensity (mm/hr)	112.58	153.76	186.16	230.32	264.57	299.44
Pre-Development Runoff Coefficient	0.35	0.35	0.35	0.35	0.35	0.35
Post- Development Runoff Coefficient	0.60	0.60	0.60	0.60	0.60	0.60

The mitigation measures are expected to reduce runoff to levels below that of pre-development conditions during minor storm events (2, 5, 10 year). However, the proposed mitigation methods will become ineffective for storm events greater than a 10-year storm.

[7] Jentech Consulting Engineers, Environmental Solutions Ltd., Dessau Soprin; Highway 2000 Project Preliminary Design Phase, " Drainage and Hydrology Report Volume 1"; June 2000

2.6 BUILDING DRAINAGE

2.6.1 The Catchments

The total roof catchments for the development were delineated and the total area was found to be 3.13 hectares. The roof runoffs will be conveyed using horizontal and vertical conductors.

The general drainage strategy involves draining the roof in either two (2) or four (4) sub-divided areas. Vertical conductors will then to take the flows to ground level in two (2) or more streams, on the north and south or east and west of the building, depending on the discharge point.

2.6.2 Stormwater Conductors

2.6.2.1 Design of Conductors and Drain Pipes

Strainers

It is proposed that all roof drains should have strainers immediately adjacent to the roof drain. This will aid in prohibiting debris items (such as leaves, plastics and rocks) from entering the roof drains. The strainers were selected based on the criteria stipulated within Section 1105 of the International Plumbing Code (IPC) guidelines.

Vertical Conductors

The vertical conductors and leaders were sized for the maximum projected roof area as stipulated within Table 1106.2(1) of the International Plumbing Code (IPC) guidelines. The vertical conductors were designed based on a determined rainfall rate of 275.24 mm/hr (10.84 in/hr).

Horizontal Drain Piping

The horizontal conveyors were sized for the maximum projected roof area in accordance with Table 1106.3 of the International Plumbing Code (IPC) guidelines. The vertical conductors were designed based on a determined rainfall rate of 275.24 mm/hr (10.84 in/hr).

Semi-circular Roof Gutters

The roof gutters were sized for the maximum (pitched) roof area in accordance with Table 1106.6 of the International Plumbing Code (IPC) guidelines. The vertical conductors were designed based on a determined rainfall rate of 275.24 mm/hr (10.84 in/hr).

2.7 ON-SITE DRAINAGE

2.7.1 Pre-development Baseline Flows

2.7.1.1 Proposed Site Catchment

Currently, the land use within the catchment can be considered 100% grassland in its natural state. At current, there exists no natural drainage features such as drains, rivers or gullies near or on the site. The area is normally drained via surface sheet flow along the natural slope of the land.

2.7.1.2 Estimated Peak Flows

The peak runoff was generated for the overall site catchment using the average of the SCS and Rational Methods. The curve numbers (CN) utilized were determined using a weighted average. After development, each catchment area will consist of both impervious and pervious surfaces. To better model this scenario, a CN of 74 was used. This was determined by estimating the percentage of the total area that will be developed. Using this percentage along with its corresponding CN, the weighted average CN is established. For the pre-development scenario, the determined peak runoff for the 10-year return period is 0.98 m^3/s (Table 2-10).

Table 2-10 Estimated 24-hour runoff volumes and peak flows generated on project site for the 10 year return period.

Parameter	Return Period (yr)						Unit
	2	5	10	25	50	100	
Area	25.33	25.33	25.33	25.33	25.33	25.33	Ha
Design Rainfall (with climate change)	112.58	153.76	186.16	230.32	264.57	299.44	mm/24hr
Tc	44.21	44.21	44.21	44.21	44.21	44.21	min
Peak Runoff (pre-dev)	**1.20**	**1.39**	**1.56**	**1.78**	**1.96**	**2.15**	**m3/sec**

2.7.2 Existing Flows (post-development)

At current, no natural drainage features such as drains, rivers or gullies near the site. The area is normally drained via surface sheet flow along the main road.

2.7.2.1 The Proposed Site Catchment

The main catchment associated with the surface runoff generated on the ground from the impervious areas measured 14.7 hectares. Currently, the land use within the catchment can be considered 100% grassland in its natural state. There exist no infrastructures relating to drainage on the site presently.

The National Works Agency (NWA) requires flood protection works minor drainage system which consists of inlets, street and roadway gutters, road side ditches, small channels and swales and small underground pipe systems which collect stormwater runoff and transport it to control facilities,

previous areas and/or the major drainage system (i.es natural waterways, large impoundments, gullies, rivers etc) to be deign for the 10 year return period.
The major drainage system which consist of natural waterways, rivers, large man-made conduits, depression storage areas and large water impoundments be design for up to the 100 year event.

2.7.2.2 Estimated Peak Flows

The peak runoff was generated for the catchment using the Rational Method. The curve numbers (CN) utilized were determined using a weighted average. After development, the main catchment area will consist of both impervious and pervious surfaces. To better model this scenario, a composite CN of 87.9 was used. This was determined by estimating the percentage of the total area that will be developed. Using this percentage along with its corresponding CN, the weighted average CN is established. For the post-development scenario, the determined peak runoff for the 10-year return period is 1.12 m^3/s (Table 2-11).

Table 2-11 Estimated 24-hour runoff volumes and peak flows generated on project site for the 10year return period.

Parameter	Return Period (yr)						Unit
	2	5	10	25	50	100	
Area	25.33	25.33	25.33	25.33	25.33	25.33	Ha
Design Rainfall (with climate change)	112.58	153.76	186.16	230.32	264.57	299.44	mm/24hr
Tc	44.21	44.21	44.21	44.21	44.21	44.21	min
Peak Runoff (post-dev)	**2.36**	**2.73**	**3.02**	**3.41**	**3.71**	**4.02**	**m3/sec**

2.7.3 Post-Construction Flows (with mitigation)

2.7.3.1 Stormwater Infiltration Trench

Background

Several infiltration trenches are proposed to receive stormwater runoff from the developed site wherein the water will naturally percolate into the earth. The proposed trench will be rock-filled with no outlet. Once the capacity of the infiltration trench has been reach it will overflow through the last manhole, to sheet flow onto the roadway with a discharge that is less than the pre-development flow.

Some activities could generate runoff with high sediment and debris loading in excess of those typically found in stormwater. Infiltration trenches should not receive runoff directly from contaminated stormwater, unless the stormwater has already been treated by another stormwater management practice. A sedimentation forebay is proposed for this purpose.

The stormwater runoff will passes through a proposed bottomless sedimentation forebay before entering the main infiltration trench. There, runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is an oily-water separator

Design Assumptions and Criteria

It was assumed within the design that all runoff generated on site (pavement and building roof) be directed towards the infiltration trench during a 10-year rainfall event without discharge outside of the property.

Infiltration rates were determined based on the classified soil type identified. It was previously established that the predominant soil on the project site Bonnygate Stony Loam. Using Table 4-A-1 found within the Highway Administration (FHWA) for underground disposal of stormwater runoff[8], the permeability and percolation characteristics of the soil when compacted and saturated ranges from 0.01 cm/sec to 10 cm/sec for rapid draining soils (very pervious). Based on the characteristics of the soil (), It was conservatively assumed that the soil would have a permeability (K) and percolation characteristic of 0.1 cm/sec (86.4 m/day) as shown in Table 2-12 below.

Results

The proposed storm water infiltration trench was designed in accordance with the Federal Highway Administration (FHWA) for underground disposal of stormwater runoff. The resulting infiltration trenches are as follows:

Table 2-12 Summary of parameters used within calculations

Parameter	Infiltration Trench									Unit
	1	2	3	4	5	6	7	8	9	
Catchment Area	4724	3608	5020	6002	7034	6148	3090	14652	29211	m2
K	86.4	86.4	86.4	86.4	86.4	86.4	86.4	86.4	86.4	m/d
i	1	1	1	1	1	1	1	1	1	
A	220	160	200	300	300	320	158	875	1300	m2
q capacity	0.293	0.213	0.267	0.400	0.400	0.427	0.210	1.167	1.733	m3/sec
Factor of Safety	2	2	2	2	2	2	2	2	2	
Dimensions										
Length	**20**	**16**	**20**	**20**	**20**	**20**	**15**	**35**	**50**	**m**
Width	**11.0**	**10.0**	**10.0**	**15.0**	**15.0**	**16.0**	**10.5**	**17.5**	**26.0**	**m**
Depth	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**m**

[8] Hannon, Joseph B.,"Underground Disposal of Storm Water Runoff", FHWA-TS-80-218, Federal Highway Administration (FHWA), February 1980.

2.7.3.2 Stormwater Sediment Forebay

A sedimentation forebay will be integrated into the storm water management system to pre-treat the roof runoff before discharging it into the infiltration trench. The purpose of this practice is to provide retention for a portion of the storm water runoff and allow sediment to settle out from the incoming storm water before it reaches the larger infiltration trench. During more extreme rainfall events, excess rainfall will overflow into the infiltration trench after passing through the forebay (Table 2-13). The resulting designs are as follows:

Table 2-13 Summary of parameters used within calculations

Design Parameters	Sediment Forebay									Units
	1	2	3	4	5	6	7	8	9	
Inflow	0.28	0.21	0.25	0.39	0.40	0.41	0.20	0.81	1.73	m3/s
Catchment area	4724	3608	5020	6002	7034	6148	3090	14652	29211	m2
Design										
Holding time	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	hours
Runoff	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	m
Storage volume	30.00	22.91	31.88	38.11	44.67	39.04	19.62	93.04	185.49	m3
Dimensions of Forebay										
Length to width ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Design Forebay Storage	30.00	22.91	31.88	38.11	44.67	39.04	19.62	93.04	185.49	m3
Depth of Forebay	**1.50**	**1.50**	**1.50**	**1.50**	**1.50**	**1.50**	**1.50**	**1.50**	**1.50**	**m**
Length	**4.47**	**3.91**	**4.61**	**5.04**	**5.46**	**5.10**	**3.62**	**7.88**	**11.12**	**m**
Width	**4.47**	**3.91**	**4.61**	**5.04**	**5.46**	**5.10**	**3.62**	**7.88**	**11.12**	**m**

2.7.3.3 Estimated Reduction in Peak Flows

The peak runoff was generated for the catchment using the average of the SCS and Rational Methods. The curve numbers (CN) utilized were determined using a weighted average. After development, the main catchment area will consist of both impervious and pervious surfaces. This modeling scenario included the mitigation measures aforementioned to retain the site runoff from the impervious areas. For the post-development scenario with mitigation, the determined peak runoff for the 10-year return period is 0.64 m^3/s (Table 2-14).

Table 2-14. Estimated 24-hour runoff volumes and peak flows generated on project site for the 10year return period.

Parameter	Return Period (yr)						Unit
	2	5	10	25	50	100	
Area	25.33	25.33	25.33	25.33	25.33	25.33	Ha
Design Rainfall (with climate change)	112.58	153.76	186.16	230.32	264.57	299.44	mm/24hr
Tc	44.21	44.21	44.21	44.21	44.21	44.21	min
Peak Runoff (pre-dev)	**0.73**	**0.87**	**0.98**	**1.14**	**1.26**	**1.38**	**m3/sec**
Peak Runoff (post-dev)	**0.85**	**1.00**	**1.12**	**1.27**	**1.40**	**1.52**	**m3/sec**
Peak Runoff (post-dev w/ mitigation)	**0.53**	**0.59**	**0.64**	**1.20**	**1.35**	**1.50**	**m3/sec**
Reduction	-27.0%	-13.0%	-2.0%	14.0%	26.0%	38.0%	

Figure 2-6 below compares the peak runoff generated for the project site based on a 10-year rainfall event. Implementing the proposed infiltration trench demonstrates a reduction in runoff peak flows of 2%, as shown in Table 2-14 above, between existing (pre-development) and proposed scenarios. This indicates that the project site will be generating less runoff than originally being discharged by the site in its natural state.

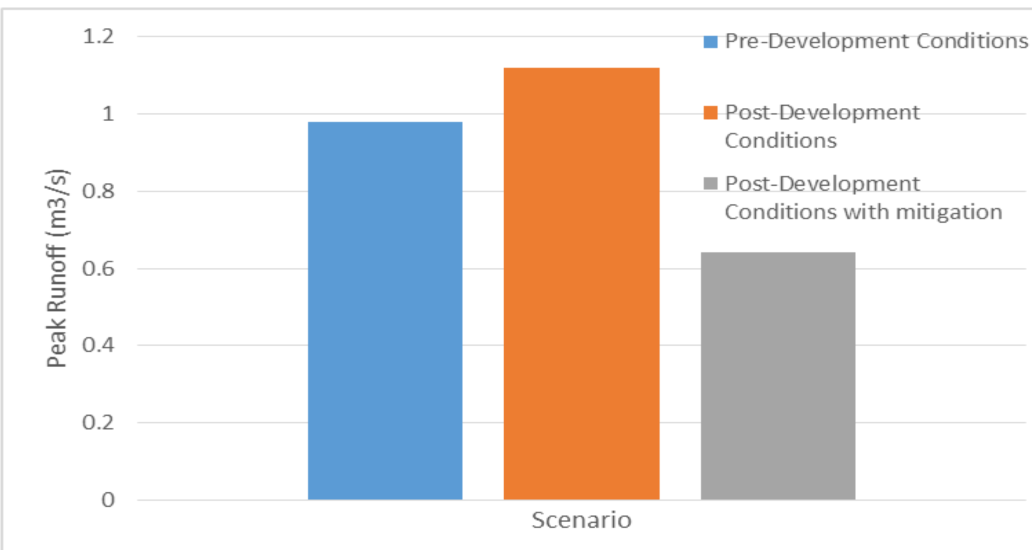


Figure 2-6 Graph showing estimated peak runoff generated under various conditions after mitigation measures (infiltration trench).

2.8 STORM WATER HYDRAULICS

2.8.1 Drain Network

The peak runoff for the roof was determined using the Rational Method. Sangsters International Airport IDF curve data for a 10 and 100 year return period was used for site and roof peak flows respectively. Table 2-15 shows the pipe sizes that will be required to convey the stormwater across the proposed development.

2.8.2 Pipe Conveyance System

The peak runoff for the roof was determined using the Rational Method. Sangsters International Airport IDF curve data for a 10 and 100 year return period was used for site and roof peak flows respectively. Table 2-16 shows the pipe sizes that will be required to convey the stormwater across the proposed development.

Table 2-15 Hydraulic analysis of box drains and swales within proposed drainage network

Parameter	Box Drains									Concrete Swales					Earth Swale	Unit
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	1	
Catchment Area	4724	3608	5011	1955	1058	5454	910	910	1110	865	819	819	952	2494	3501	m2
Mannings Coefficient	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013		0.035	
Width	0.45	0.45	0.6	0.45	0.45	0.6	0.3	0.3	0.45	0.6	0.6	0.6	0.6	0.60	0.6	m
Depth	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.3	0.3	0.3	0.3	0.450	0.3	m
Depth + freeboard	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.375	0.375	0.375	0.375	0.56	0.375	m
R	0.16	0.16	0.20	0.16	0.16	0.20	0.12	0.12	0.16	0.13	0.13	0.13	0.13	0.2	0.13	m
P	1.65	1.65	1.8	1.65	1.65	1.8	1.5	1.5	1.65	1.34	1.34	1.34	1.34	1.50	1.34	m
A	0.27	0.27	0.36	0.27	0.27	0.36	0.18	0.18	0.27	0.18	0.18	0.18	0.18	0.27	0.18	m2
Velocity	3.25	3.25	3.72	3.25	3.25	3.72	2.65	2.65	3.25	2.02	2.02	2.02	2.02	1.7	0.75	m/s
Flow Capacity	**1.05**	**0.88**	**1.34**	**0.95**	**0.88**	**1.34**	**0.48**	**0.48**	**0.88**	**0.36**	**0.36**	**0.36**	**0.36**	**0.47**	**0.39**	**m3/sec**
Required Flow	**0.212**	**0.156**	**0.227**	**0.085**	**0.045**	**0.244**	**0.042**	**0.042**	**0.048**	**0.046**	**0.043**	**0.043**	**0.051**	**0.13**	**0.203**	**m3/sec**
Tt	0.044	0.044	0.039	0.044	0.044	0.039	0.054	0.054	0.044	0.072	0.016	0.016	0.016	0.02	0.043	hours

Table 2-16 Sizing of pipes conveying stormwater

Pipe Location	Diameter	Area	Perimeter	R	Minimum Slope	Mannings no.	Velocity	Capacity (full)	Design flow	Travel time	Flow	Velocity
	(mm)	(mm²)	(mm)	(A/P)	(1/n)	(n)	(m/s)	(l/s)	(l/s)	(sec)		
Parking Lot Surface (66 spaces)												
MH2 to MH3	250	39491	524	75.4	250	0.01	1.13	45	23.61	18.5	OK	OK
MH3 to MH4	250	39491	524	75.4	250	0.01	1.13	45	38.25	18.5	OK	OK
MH4 to MH5	300	56867	628	90.5	300	0.01	1.16	66	49.20	17.9	OK	OK
MH6 to MH7	250	39491	524	75.4	250	0.01	1.13	45	19.25	18.5	OK	OK
MH7 to MH5	250	39491	524	75.4	250	0.01	1.13	45	35.48	18.5	OK	OK
MH5 to Drain 1	450	127950	942	135.8	450	0.01	1.25	159	129.92	16.8	OK	OK
MH10 to MH7	250	39491	524	75.4	250	0.01	1.13	45	16.23	9.7	OK	OK
MH8 to MH9	250	39491	524	75.4	250	0.01	1.13	45	18.50	4.0	OK	OK
MH9 to MH5	250	39491	524	75.4	250	0.01	1.13	45	23.69	43.8	OK	OK
Entertainment area to Drain 1	250	39491	524	75.4	250	0.01	1.13	45	15.24	1.8	OK	OK
Residential Villas Roof												
Villa to Drain 2	250	39491	524	75.4	250	0.01	1.13	45	5.12	7.9	OK	OK
MH12 to MH13	250	39491	524	75.4	250	0.01	1.13	45	10.26	7.9	OK	OK
MH13 to MH14	250	39491	524	75.4	250	0.01	1.13	45	20.52	5.9	OK	OK
MH14 to Drain 2	250	39491	524	75.4	250	0.01	1.13	45	25.98	8.4	OK	OK
MH15 to MH16	250	39491	524	75.4	250	0.01	1.13	45	5.12	8.4	OK	OK
MH16 to Drain 3	250	39491	524	75.4	250	0.01	1.13	45	9.89	8.4	OK	OK
MH17 to MH18	250	39491	524	75.4	250	0.01	1.13	45	11.00	50.0	OK	OK
MH18 to MH19	250	39491	524	75.4	250	0.01	1.13	45	22.00	50.0	OK	OK
MH19 to MH20	250	39491	524	75.4	200	0.01	1.26	50	33.00	21.1	OK	OK
Villa to Earth Swale 1	250	39491	524	75.4	200	0.01	1.26	50	11.00	49.2	OK	OK
Villa to Drain 6	250	39491	524	75.4	200	0.01	1.26	50	5.12	17.8	OK	OK
Parking Lot Surface (78 spaces)												
MH21 to MH22	250	39491	524	75.4	200	0.01	1.26	50	49.50	17.8	OK	OK
MH22 to MH23	300	56867	628	90.5	200	0.01	1.43	81	67.86	15.8	OK	OK
MH24 to MH25	250	39491	524	75.4	200	0.01	1.26	50	26.43	17.8	OK	OK
MH25 to MH23	300	56867	628	90.5	200	0.01	1.43	81	56.47	15.8	OK	OK

Pipe Location	Diameter	Area	Perimeter	R	Minimum Slope	Mannings no.	Velocity	Capacity (full)	Design flow	Travel time	Flow	Velocity
	(mm)	(mm²)	(mm)	(A/P)	(1/n)	(n)	(m/s)	(l/s)	(l/s)	(sec)		
MH26 to Forebay 8	800	404385	1676	241.3	200	0.01	2.74	1108	350.56	8.2	OK	OK
Kerb Inlet to MH26	300	56867	628	90.5	200	0.01	1.43	81	69.85	15.8	OK	OK
Drain 8 & 9 to MH26	450	127950	942	135.8	200	0.01	1.87	239	159.60	12.1	OK	OK
MH27 to MH28	250	39491	524	75.4	200	0.01	1.26	50	14.03	17.8	OK	OK
MH28 to MH29	250	39491	524	75.4	200	0.01	1.26	50	18.75	17.8	OK	OK
MH29 to MH30	250	39491	524	75.4	200	0.01	1.26	50	41.26	17.8	OK	OK
MH30 to Forebay 7	300	56867	628	90.5	200	0.01	1.43	81	78.54	15.8	OK	OK
MH31 to Forebay 7	450	127950	942	135.8	200	0.01	1.87	239	156.84	12.1	OK	OK
MH32 to MH31	450	127950	942	135.8	200	0.01	1.87	239	135.68	12.1	OK	OK
MH33 to MH34	800	404385	1676	241.3	200	0.01	2.74	1108	410.60	8.2	OK	OK
MH34 to Forebay 6	800	404385	1676	241.3	200	0.01	2.74	1108	465.63	8.2	OK	OK
MH35 to MH36	300	56867	628	90.5	200	0.01	1.43	81	47.56	15.8	OK	OK
MH37 to MH36	300	56867	628	90.5	200	0.01	1.43	81	45.32	15.8	OK	OK
MH36 to Forebay 6	450	127950	942	135.8	200	0.01	1.87	239	126.54	12.1	OK	OK
MH38 to Forebay 6	300	56867	628	90.5	200	0.01	1.43	81	46.28	15.8	OK	OK
MH39 to MH40	250	39491	524	75.4	200	0.01	1.26	50	15.32	17.8	OK	OK
MH40 to Junction D	250	39491	524	75.4	200	0.01	1.26	50	42.00	17.8	OK	OK
Junction A to Junction B	250	39491	524	75.4	200	0.01	1.26	50	27.90	17.8	OK	OK
Junction B to Junction C	250	39491	524	75.4	200	0.01	1.26	50	35.68	17.8	OK	OK
Junction C to Junction D	250	39491	524	75.4	200	0.01	1.26	50	42.59	17.8	OK	OK
Junction D to Forebay 5	450	127950	942	135.8	200	0.01	1.87	239	84.59	12.1	OK	OK
Junction E to Junction F	250	39491	524	75.4	200	0.01	1.26	50	18.56	17.8	OK	OK
Junction F to Junction G	250	39491	524	75.4	200	0.01	1.26	50	46.39	17.8	OK	OK
Junction G to Forebay 5	450	127950	942	135.8	200	0.01	1.87	239	124.56	12.1	OK	OK
Junction H to Forebay 5	250	39491	524	75.4	200	0.01	1.26	50	41.23	17.8	OK	OK
MH41 to Forebay 4	300	56867	628	90.5	200	0.01	1.43	81	45.65	15.8	OK	OK
MH42 to Forebay 4	250	39491	524	75.4	200	0.01	1.26	50	29.65	17.8	OK	OK
MH43 to MH44	250	39491	524	75.4	200	0.01	1.26	50	12.50	17.8	OK	OK
MH44 to Forebay 4	450	127950	942	135.8	200	0.01	1.87	239	95.64	12.1	OK	OK

Pipe Location	Diameter	Area	Perimeter	R	Minimum Slope	Mannings no.	Velocity	Capacity (full)	Design flow	Travel time	Flow	Velocity
	(mm)	(mm²)	(mm)	(A/P)	(1/n)	(n)	(m/s)	(l/s)	(l/s)	(sec)		
Parking Lot Surface (164 spaces)												
MH45to MH46	250	39491	524	75.4	200	0.01	1.26	50	25.61	17.8	OK	OK
MH46to MH47	250	39491	524	75.4	200	0.01	1.26	50	40.25	17.8	OK	OK
MH47to MH48	450	127950	942	135.8	200	0.01	1.87	239	72.35	12.1	OK	OK
MH49 to MH50	250	39491	524	75.4	200	0.01	1.26	50	26.91	17.8	OK	OK
MH50 to MH51	250	39491	524	75.4	200	0.01	1.26	50	46.87	17.8	OK	OK
MH51 to MH52	450	127950	942	135.8	200	0.01	1.87	239	71.56	12.1	OK	OK
MH53 to MH54	250	39491	524	75.4	200	0.01	1.26	50	26.68	17.8	OK	OK
MH54 to MH55	250	39491	524	75.4	200	0.01	1.26	50	44.35	17.8	OK	OK
MH55 to MH52	300	56867	628	90.5	200	0.01	1.43	81	69.97	15.8	OK	OK
MH52 to Forebay 9	600	227467	1257	181.0	200	0.01	2.26	515	213.88	10.0	OK	OK
Concrete Swale 2 & 3 to Forebay 9	250	39491	524	75.4	200	0.01	1.26	50	18.50	17.8	OK	OK
Concrete Swale 4 to Forebay 9	250	39491	524	75.4	200	0.01	1.26	50	20.15	17.8	OK	OK
Main Entrance to Junction I	450	127950	942	135.8	200	0.01	1.87	239	123.66	12.1	OK	OK
Junction I to Forebay 9	450	127950	942	135.8	200	0.01	1.87	239	129.65	12.1	OK	OK
Concrete Swale 1 to Junction J	250	39491	524	75.4	200	0.01	1.26	50	26.70	17.8	OK	OK
Junction K Junction L	250	39491	524	75.4	200	0.01	1.26	50	25.68	17.8	OK	OK
Junction L to Junction M	250	39491	524	75.4	200	0.01	1.26	50	34.40	17.8	OK	OK
Junction M to Junction N	300	56867	628	90.5	300	0.01	1.16	66	52.46	9.4	OK	OK
Junction N to Junction O	450	127950	942	135.8	450	0.01	1.25	159	85.49	3.6	OK	OK
Junction O to MH56	450	127950	942	135.8	450	0.01	1.25	159	132.68	39.7	OK	OK
Junction P to Forebay 9	450	127950	942	135.8	250	0.01	1.67	214	115.60	15.4	OK	OK

2.9 CONCLUSIONS AND RECOMMENDATIONS

2.9.1 Conclusions

Based on data analysis and design, the following conclusion can be made:

1. The proposed site has a catchment area of 25.3 ha with 0.98 m3/s peak flows for the pre-developed conditions and 0.64 m3/s for the proposed post-construction (with mitigation measures in place) conditions for a 10 year return period. This indicates a 2% reduction in peak flows by introducing infiltration trenches to retain stormwater flows.
2. The analysis revealed the limitations of the infiltration trench as it was determined that the trench would be ineffective for storm events with RP greater than 25 years.
3. The existing site will need to be filled and graded to accommodate the proposed drainage design.
4. The worst case storm surge magnitude is estimated at 0.85m from the Northern direction.

2.9.2 Recommendations

The following are our recommendations based on the analysis and designs conducted to date:

1. The roof and site should be graded to facilitate the surface runoff towards the storm water infiltration network via conduits and drainage pipes. The runoff mitigation system consists of:
    - Nine (9) Sedimentation Forebays;
    - Nine (9) Storm water Infiltration Trenches.
2. Oil-water separators should be implemented to receive runoff generated from the parking lots for primary treatment.
3. The proposed site should be filled to a minimum elevation of 2m above MSL within northern areas of the site so as to accommodate the stormwater infiltration systems without saltwater intrusion.
4. It is recommended that all critical infrastructures be constructed with finished floor levels minimum 0.3 above this storm surge level (1.15m).

3.0 IMPACT OF THE MARINE WORKS ON THE ENVIRONMENT

3.1 EXISTING ENVIRONMENT

3.1.1 Biological

3.1.1.1 Nearshore Environment

The nearshore environment includes a mixed seagrass bed with a fringing reef system and sections of beach rock/pavement. The proposed project area was previously modified by illegal sand mining; this has likely impacted the shape, form and function of the existing nearshore/beach environment. In order to assess the impacts of the proposed marine works on the biological environment, rapid roving surveys were conducted (Figure 3-1) and a photo inventory and species list generated. Further, seagrass beds were mapped using a Trimble Geo XT 6000 series GPS.

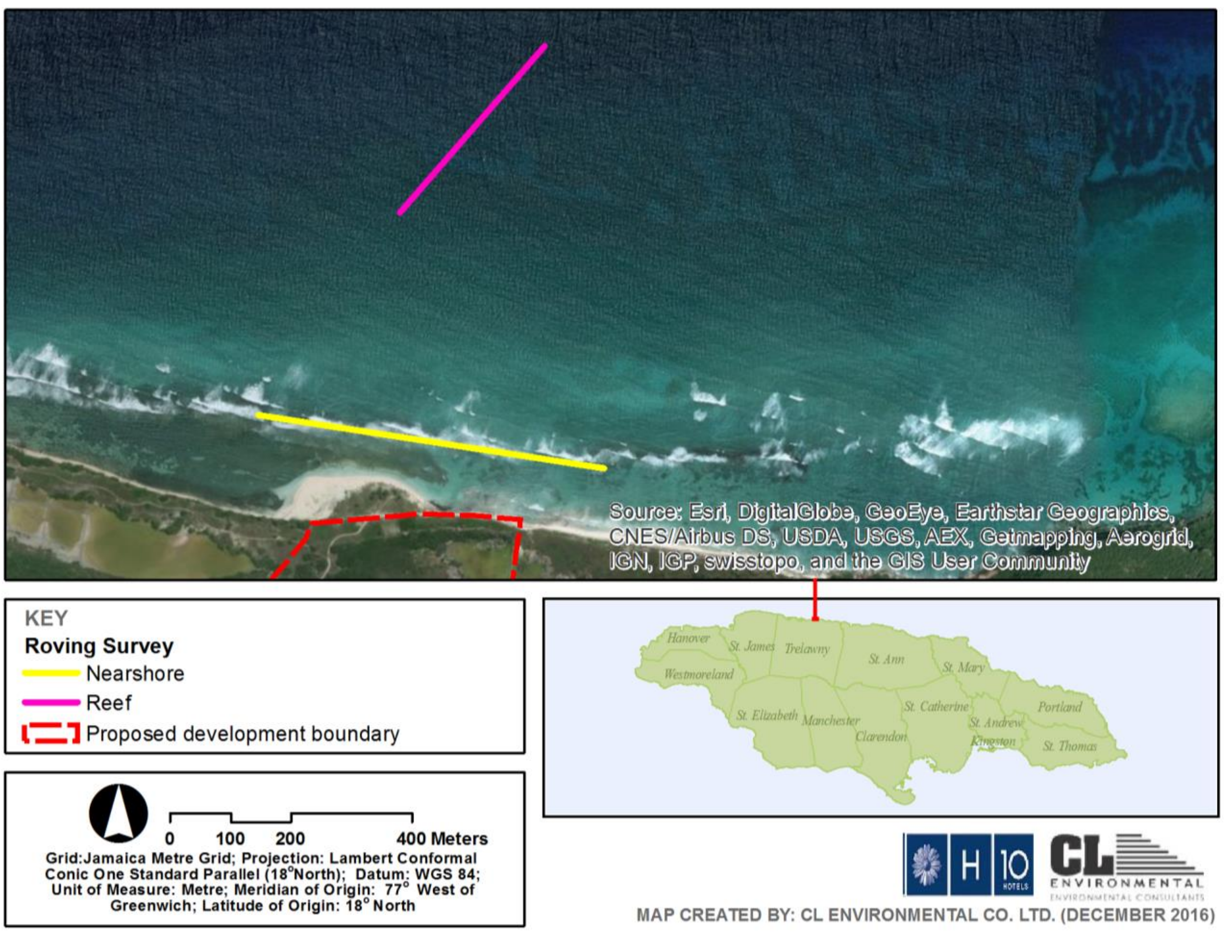


Figure 3-1 Map depicting nearshore and reef roving survey locations

The nearshore environment is not uniform along the length of the property. The eastern section of the site is dominated by sand and pavement with small patches of seagrass and reef crest composed mainly of rubble and turf algae (Plate 3-1). The area tends to be rough with constant sediment resuspension making visibility here poor. A boat ran aground early in 2016; the hull of the boat remains intact on the reef while the rest has been washed ashore and scattered along the reef (Plate 3-2).

Moving westward, there are dense and shallow seagrass beds and more defined reef crest continue towards the end of the property (Plate 3-3 and Plate 3-4). Sections of the reef and seagrass bed are periodically exposed during low tide. Sections along the western most beach area are composed of very lose sand and seagrass. In this area the sand is so soft and loose, a person may sink approximately 0.5 metres in some areas. This section also has a much wider beach area, with several small dunes being formed.

Plate 3-1 This shows the start of the dense seagrass bed (middle to west of the property) and the pavement area further east

Plate 3-2 Boat wreckage on the reef

Plate 3-3 The western side of the property with a continuous seagrass bed and the fringing reef

Plate 3-4 The middle of the property with a dense seagrass bed and fringing reef

The beach area has several coastal plant species, along with the dense seagrass bed create a suitable sea turtle nesting and foraging habitat (Plate 3-5 and Plate 3-6). No nesting or turtle activity has been noted on the site, however local fishermen have stated the presence of turtles in the general area as well as sightings on the beach. Manatees have been sighted in Falmouth harbour but not within the project area. The beach is littered with debris and dead seagrass and these tend to accumulate more towards the eastern side of the property. The beach is eroded along the middle and eastern sections. The eastern section also has more exposed beach rock and coral rubble.

Plate 3-5 Coastal vegetation with very small dune formations on the western side of the property

Plate 3-6 Seagrass debris accumulated in sections along the site

Seagrass Community

The shallow seagrass beds are dense and appear to be healthy, however the beds seemed to lack fish and invertebrates. The bed is composed mainly of a dense *Thalassia testudinum* (turtle grass) bed, but all three species of seagrass are found in the area, (*Halodule wrightii* and *Syringodium filiforme*). *Halodule wrightii* is mostly found closest to the shoreline, while *Syringodium* and *Thalassia* are found further away from the shoreline (Plate 3-7 through to Plate 3-9).

The most common invertebrate seen was the green sea urchins (*Lytechinus variegatus*) and *Tripneustes ventricosus,* a few *Diadema antillarum* and *Echinometra lucunter* observed at the eastern boundary of the property where very rocky substrate dominated nearshore. Other typical seagrass faunal species were conspicuously absent, that is very few juvenile fish were observed during the survey and no sea cucumbers were observed in the beds. A few hard corals were seen just along the seagrass reef crest margin (very small colonies of *Porites divaricata*).

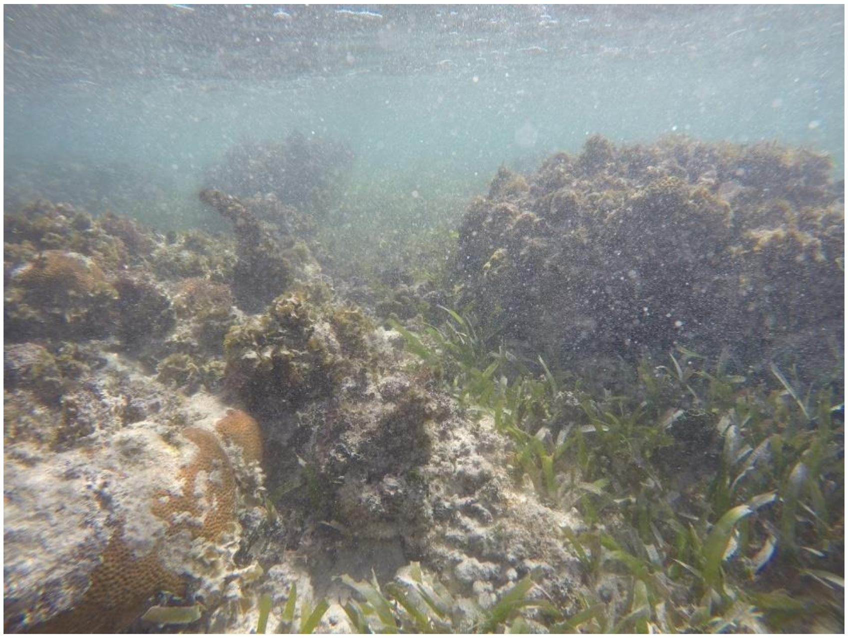


Plate 3-7 *Thalassia testudinum* found in the reef crest area

Plate 3-8 *Halodule wrightii* found nearshore

Plate 3-9 Seagrass Zone where *Halodule wrightii* interspersed with *Thalassia testudinum*

The seagrass beds mapped directly in front the project boundaries may be seen in Figure 3-2. The intended area of bathing beach (30 metres from the highwater mark), along with the seagrass areas to be impacted from the creation of the bathing beach between the site boundary and 30 metres from the highwater mark are also shown. Approximately 3,459 m^2 and 185 m^2 of *Thalassia testudinum* and *Halodule wrightii* respectively, will be impacted in order to create the bathing beach.

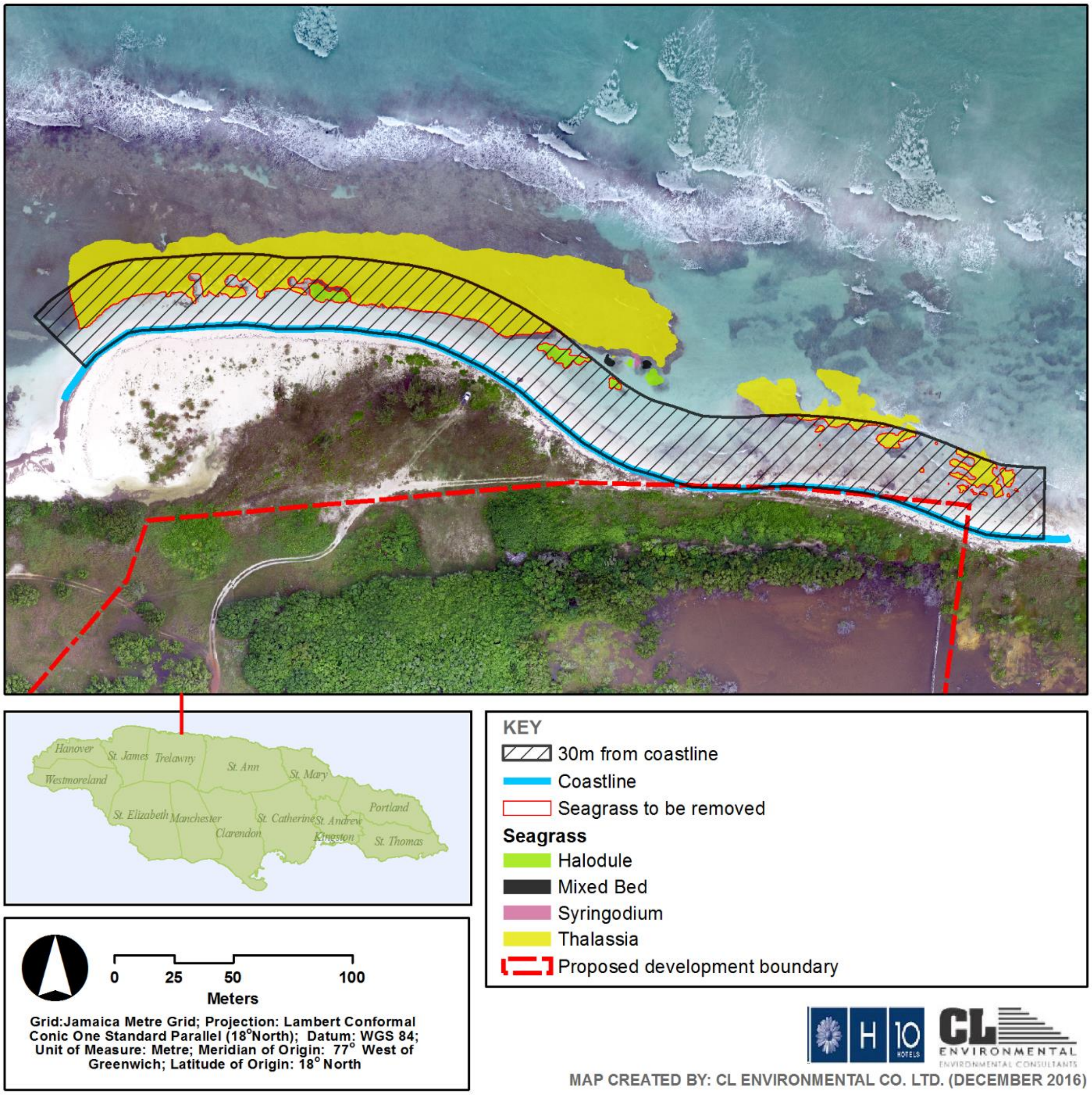


Figure 3-2 Mapped seagrass species in nearshore project area and areas of seagrass to be impacted from creation of bathing beach 30m from highwater mark

Reef Community

The eastern most section of the property has a less well defined reef crest, large pieces of dead *A. palmata* and pavement are covered with turf and macroalgae, various encrusting species and rock boring urchins. Small patches of seagrass can be found behind, in front of and within the crest. The coral community here is very sparse and composed mainly of encrusting species such as *Diploria sp*. There debris from a recent boat grounding. The beach here is heavily littered with debris but little to none was seen in survey area.

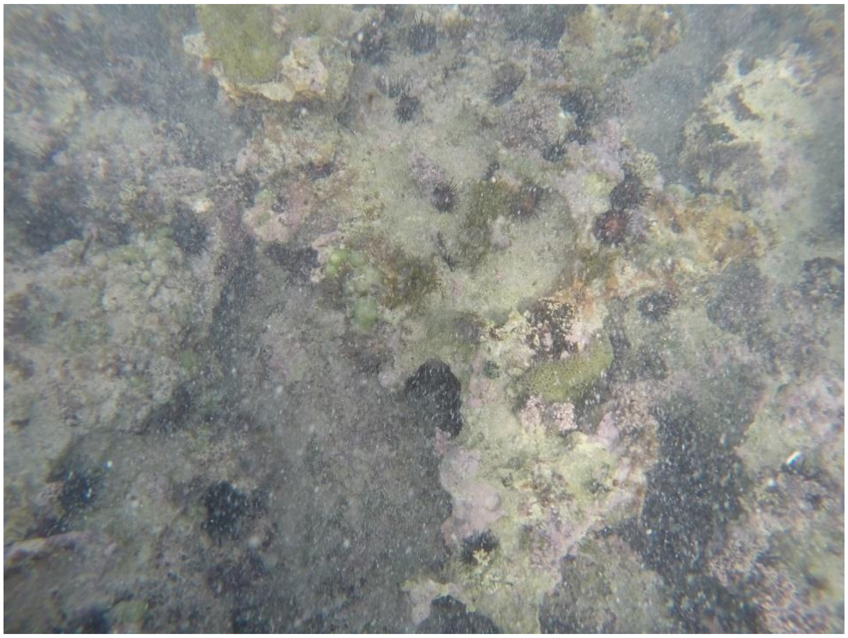


Plate 3-10 Section of the reef crest with rock boring urchins, macroalgae and encrusting species

Plate 3-11 Reef crest pavement and small *A. palmata* rubble

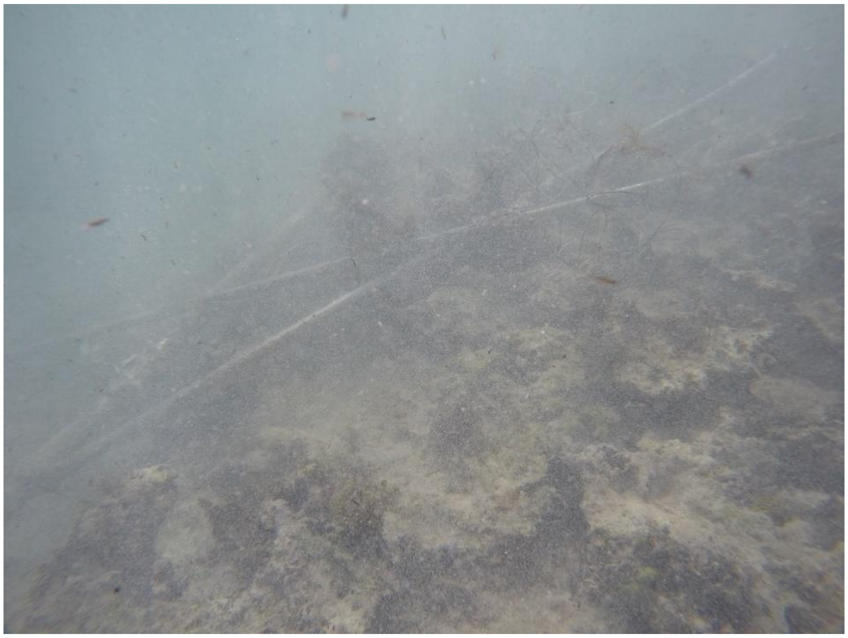


Plate 3-12 Debris from recent boat wreckage

Plate 3-13 Encrusting *Diploria* colony in pavement

Plate 3-14 Rubble/pavement area with sparse patches of seagrass

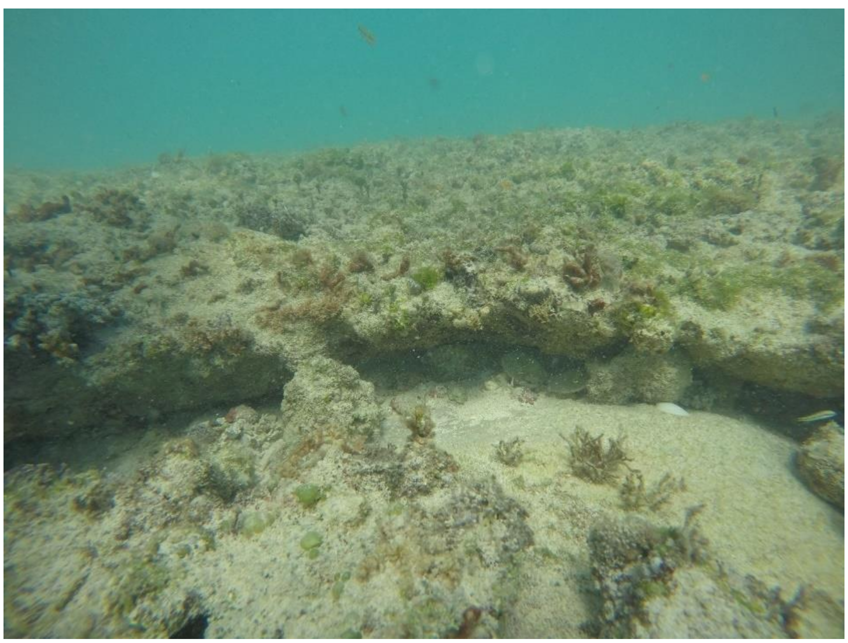


Plate 3-15 Octopus layer in the pavement area dominated by turfs and macroalgae

Plate 3-16 Overturned Diploria boulder, likely as a result of bio-erosion and wave action

Towards the middle of the property, in the pavement area small patch reefs and rubble begin to form a more defined reef crest heading eastwards (Plate 3-17 and Plate 3-18).

Plate 3-17 Small patch reef with Soft coral, *Millipora* and *Palythoa*

Plate 3-18 Large *Orbicella faveolata*

The reef crest is composed of large pieces of dead *Acropora palmata* and massive boulders of *Orbicella sp., Diploria sp.* and *Siderastrea sp.* The crest is dominated by macroalgae and turfs and large colonies of Millipora. Other notable feature includes the presence of endangered species *Acropora palmata* and *Acropora prolifera.* Several large boulders of various star coral species were also seen in the area. The occurrence of disease/stress and bleaching was low, however a very sick colony of *Orbicella* was seen suffering from and an aggressive disease and possible predation. (Plate 3-19 -Plate 3-23).

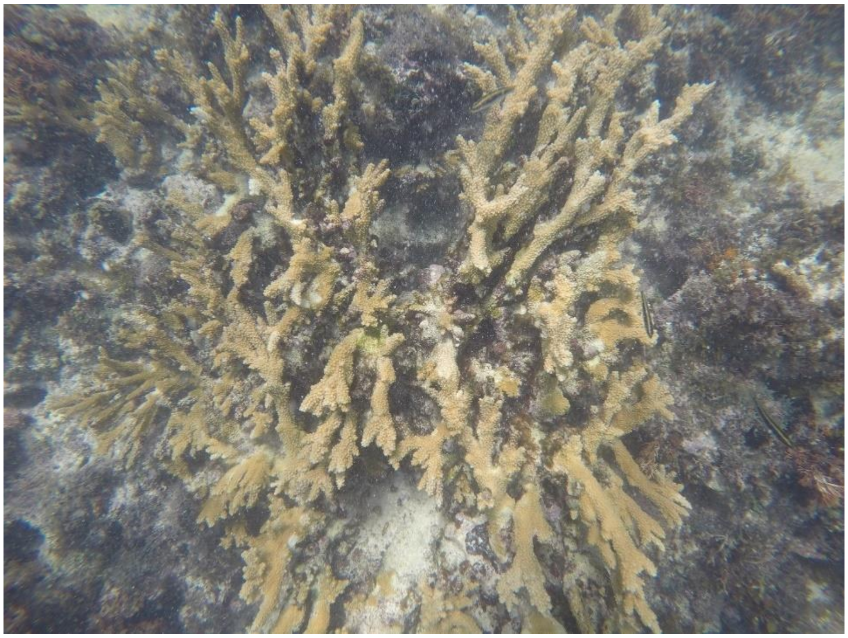


Plate 3-19 *A. prolifera* colony

Plate 3-20 *A. palmata* colony

Plate 3-21 Large colony of *Millepora* (dominate species on the reef crest)

Plate 3-22 Overturned *Siderastrea* colony

Plate 3-23 Diseased *Orbicella* colony

Sections of the crest and fore reef area are composed of areas of sand and pavement and some seagrass. Some sections of have a dense distribution of Gorgonians as well as several very large boulder colonies (Plate 3-24 - Plate 3-28).

Plate 3-24 Gorgonian flat

Plate 3-25 Gorgonian flat

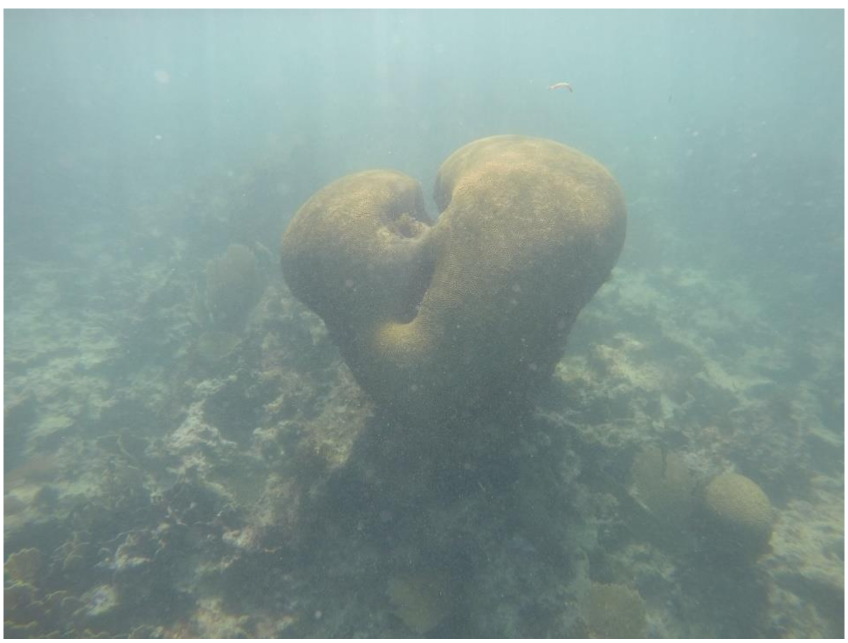


Plate 3-26 Large *Diploria* colony

Plate 3-27 Large Orbicella colony

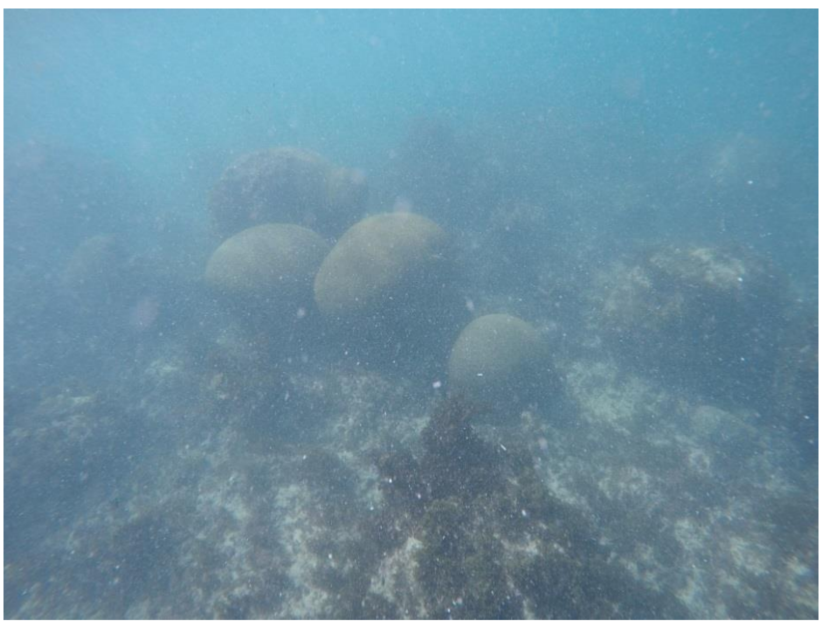


Plate 3-28 Several large boulder coral colonies

Fish Community

A roving fish survey was conducted along the length of the property, where possible and a species list collected (Table 3-1). Most of the seagrass beds were too shallow to swim in and sections along the reef crest and forereef had very poor visibility. A species list for invertebrates was also generated (Table 3-2).

Table 3-1 Fish Species List

Functional Feeding Group	Scientific Name	Common name	Comments
Carnivore	*Thalassoma bifasciatum*	Bluehead Wrasse	
	Halichoeres bivittatus	Clown Wrasse	
	Halichoeres poeyi	Slippery Dick	
	Lutjanus mahogoni	Blackear Wrasse	Very Rare
	Dasyatis americana	Mahogany Snapper	
	Sparisoma aurofrenatum	Southern sting ray	
Herbivores	*Scaus iserti*	Redband Parrotfish	
	Sparisoma viride	Striped Parrotfish	
	Sparisoma atomarium	Stoplight Parrotfish	
	Acanthurus bahaianus	Greenblotch Parrotfish	
	Acanthurus	Ocean Surgeon	
	Acanthurus coeruleus	Doctorfish	
	Haemulon flavolineatum	Blue Tang	
	Haemulon plumierii	French Grunt	Rare
	Stegastes diencaeus	Blue-Striped Grunt	
Algae Gardeners	*Microspathodon chrysurus*	Longfin Damselfish	
	Aulostomus strigosus	Yellowtail Damselfish	
	Chaetodon striatus	Atlantic trumpetfish	
	Abudefduf saxatilis	Reef Butterflyfish	
Omnivore		Sergeant Major	

Table 3-2 Invertebrate Species list

Invertebrates		
Common Name	**Scientific Name**	**Comment**
Collector Urchin	*Tripneustes ventricosus*	Found in seagrass and sections of the reef crest
Rock Boring Urchin	Echinometra lucnter	Found in the pavement and beach rock areas in the seagrass and along the reef crest
Rock Boring Urchin	Echinometra viridis	Found in the pavement and beach rock areas in the seagrass and along the reef crest
Green Urchin	Lytechinus variegatus	Found mainly in seagrass areas
Black/long Spined Urchin	Diadema antillarum	Found in deeper sections of the reef area
Heart Urchin	Meoma ventricosa	Found along the reef crest and pavement areas towards the eastern sections of the site mainly
Carpet/sun Anemone	Stichodactyla helianthus	Found on various hard surfaces at various depths
Giant Anemone	Condylactis gigantea	Found in Reef and seagrass at areas at varying depths
Blue Crab	Callinectus spp.	Found in sand and seagrass areas

3.1.1.2 Area of Influence

In addition to areas that may be directly impacted by marine works, an additional roving survey was conducted in deeper sections of the forereef (Figure 3-1). Spur and groove formations begin at a depth of approximately 21m up to 10m. The reef appears to be similar to reefs in nearby area. Baseline data, including percentage cover for major categories such as hard and soft corals and macroalgae was not collected, Plate 3-29 through to Plate 3-33 are typical examples of the reef area.

Plate 3-29 *A. cervicornis* thicket with a small school of blue chromis

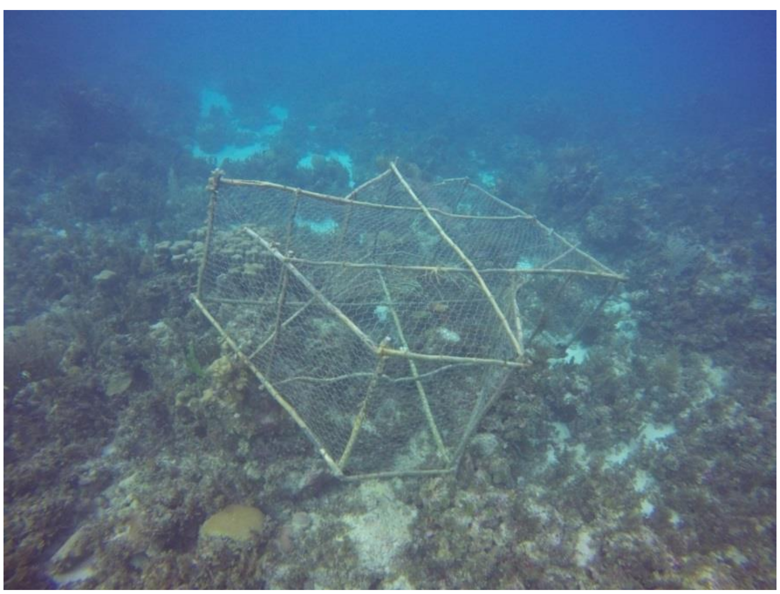


Plate 3-30 Fishpot on the reef

Plate 3-31 Large *M. mirabilis* colony

Plate 3-32 Small spur and grooves of the reef

Plate 3-33 Large Barrel sponge, several of these were seen during the survey

3.1.2 Water Quality

3.1.2.1 Methodology

One (1) water quality sampling exercise was conducted at six (6) stations on November 30, 2016. Stations 1-4 are located within the marine environment, while Stations 5 and 6 are located within a pond which spans a portion of the project property. The pond is separated by a stone wall which demarcates the property boundaries. Station 5 was taken on the western side of the boundary wall (on proposed project property), while Station 6 was taken on the eastern side of the boundary wall (outside of proposed project property).

Weather conditions were fair and sunny during sampling. The sampling location coordinates are listed in Table 3-3 and depicted in Figure 3-3.

Table 3-3 Coordinates of water sampling stations

STATION #	LOCATION (JAD2001)	
	NORTHINGS (m)	EASTINGS (m)
WQ1	705266.41	689718.32
WQ2	704344.16	689697.71
WQ3	704272.12	690048.95
WQ4	704407.34	689258.59
WQ5	704237.45	689787.81
WQ6	704199.75	689822.32

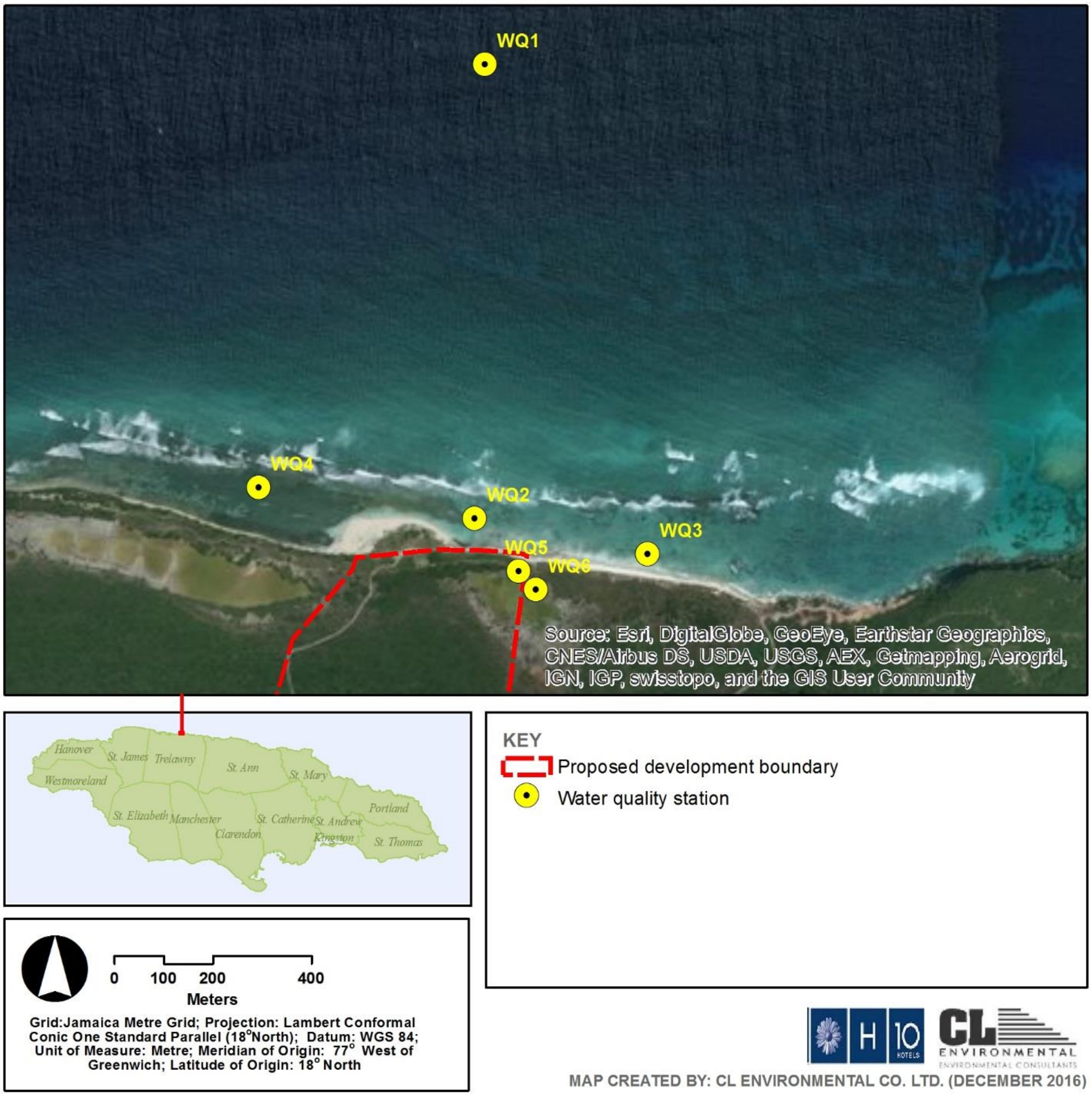


Figure 3-3 Map showing water quality sampling stations

Temperature, conductivity, salinity, dissolved oxygen, turbidity, total dissolved solids, pH and Photosynthetically Active Radiation (PAR) were collected in situ using a Hydrolab water quality multi probe meter (calibration certificate can be seen in Appendix 3). Whole water samples were collected in pre-sterilized bottles, stored on ice and taken to Caribbean Environmental Testing and Monitoring Services Limited (CETMS Ltd.) for analysis of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), phosphates, nitrates and faecal coliform. Each of the water quality samples was collected at a depth of approximately 0.5 m; this was facilitated with the use of a boat where necessary.

3.1.2.2 Results

Table 3-4 shows the average physical data while Table 3-5 shows the biological and chemical data for the stations sampled.

Table 3-4 Average physical water quality data

Stn	TEMP. °C	COND (mS/cm)	SAL (ppt)	pH	PAR (uE/cm/s)	D.O. (mg/l)	Turb (NTU)	TDS (g/l)
WQ1	26.15	55.84	37.15	8.28	263.77	6.26	0.12	35.73
WQ2	27.32	56.03	37.29	8.34	268.00	6.51	2.65	35.85
WQ3	27.42	55.97	37.24	8.35	399.00	6.55	3.45	35.82
WQ4	26.61	55.72	37.05	8.20	578.00	6.25	5.60	35.64
NEPA Marine Standard	-	-	-	*8 – 8.4*	-	-	-	-
WQ5	26.06	21.16	12.66	8.42	368.00	2.46	8.00	13.52
WQ6	26.10	21.21	12.67	8.35	341.00	2.34	4.60	13.55
NEPA Freshwater Standard	-	*0.15 – 0.6*	-	*7 – 8.4*	-	-	-	*0.12 – 0.3*

N.B. Values in red are non-compliant with respective NEPA standards

Table 3-5 Biological and chemical water quality data

Station	BOD (mg/l)	TSS (mg/l)	NITRATE (mg/l)	PHOSPHATE (mg/l)	F. COLI (mpn/100ml)	COD (mg/l)
WQ1	0.18	<5	2.4	2.53	11	2390
WQ2	0.84	<5	1.8	0.41	<11	2436
WQ3	0.81	<5	1.8	1.3	36	2469
WQ4	0.48	<5	1.4	0.09	<11	2437
NEPA Marine Standard	*1.16*	-	*0.007 – 0.014*	*0.001 – 0.003*	*13*	
WQ5	1.59	6	0.7	2.32	22	262
WQ6	1.5	5	0.7	0.1	69	257
NEPA Freshwater Standard	0.8 - 1.7	-	0.1 – 7.5	0.01 – 0.8	-	

N.B. Values in red are non-compliant with respective NEPA standards

Temperature

Temperature values varied across the stations ranging from 26.06 – 27.42 °C. Highest temperatures were obtained at station 3 whereas the lowest was obtained at stations 5 and 6 (in the pond). The water temperatures recorded for Stations 1 - 4 were expected in a tropical marine area influenced by the Trade Winds (≈27 –30 °C).

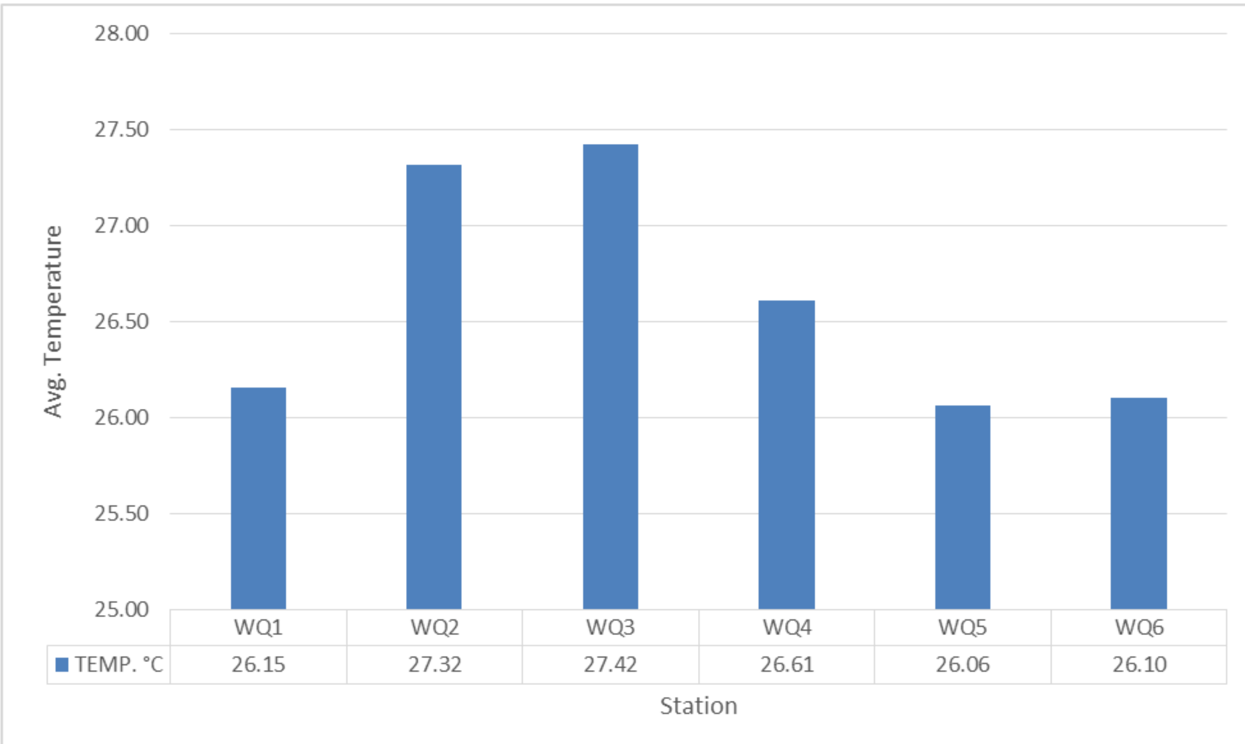
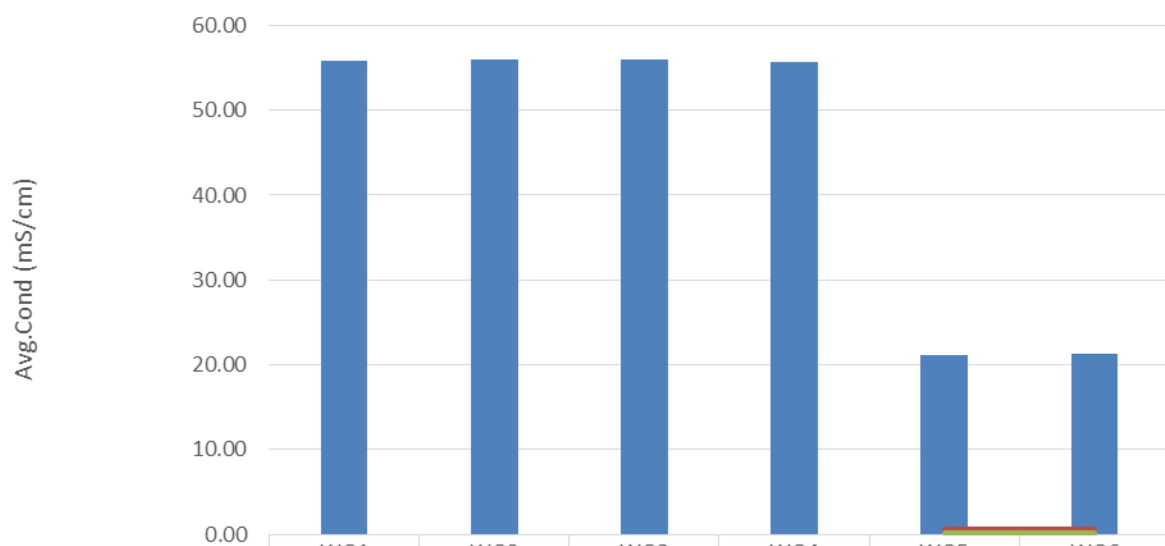


Figure 3-4 Temperature values at the various stations

Specific Conductivity (SpC)

Specific conductivity varied across the stations ranging from 21.16 – 56.03 mS/cm. Highest specific conductivity was obtained at station 2, whereas the lowest specific conductivity was obtained at stations 5 and 6 (in the pond). Stations 5 and 6 were complaint with the NEPA freshwater standard of 0.15 – 0.6 mS/cm.

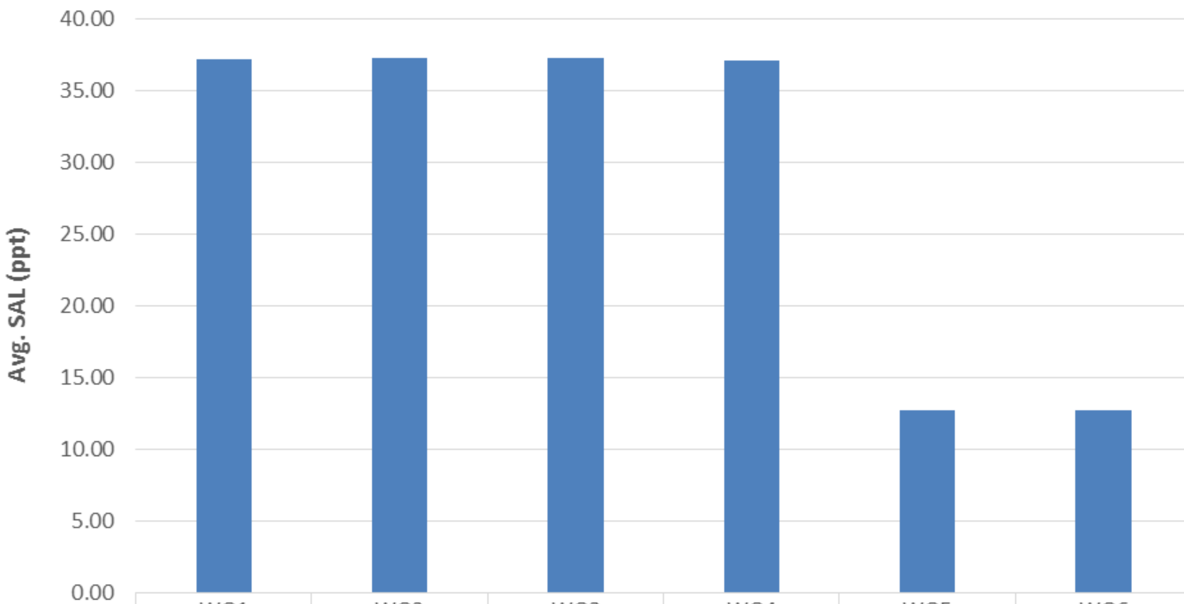


	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6
COND (mS/cm)	55.84	56.03	55.97	55.72	21.16	21.21
Nepa Stnd (upper)					0.60	0.60
Nepa Stnd (lower)					0.15	0.15

Figure 3-5 Conductivity values at the various stations

Salinity

Salinity varied across the stations ranging from 12.66 – 37.29 ppt. Station 2 had the highest salinity values whereas stations 5 and 6 (in the pond) had the lowest values.



	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6
SAL (ppt)	37.15	37.29	37.24	37.05	12.66	12.67

Figure 3-6 Salinity values at the various stations

pH

The pH values showed little variation across the stations ranging from 8.20 - 8.42. The highest pH values were obtained at station 5 whereas the lowest pH obtained at station 4. In marine waters, pH levels tend to range between 8-9 pH units. Higher pH indicates the possibility of photosynthesis changing the pH within the zone. All pH values obtained were compliant with their respective NEPA marine (8 – 8.4) and freshwater (7 – 8.4) standards, except for Station 5 which had a pH of 8.42 just above the NEPA standard of 8.4.

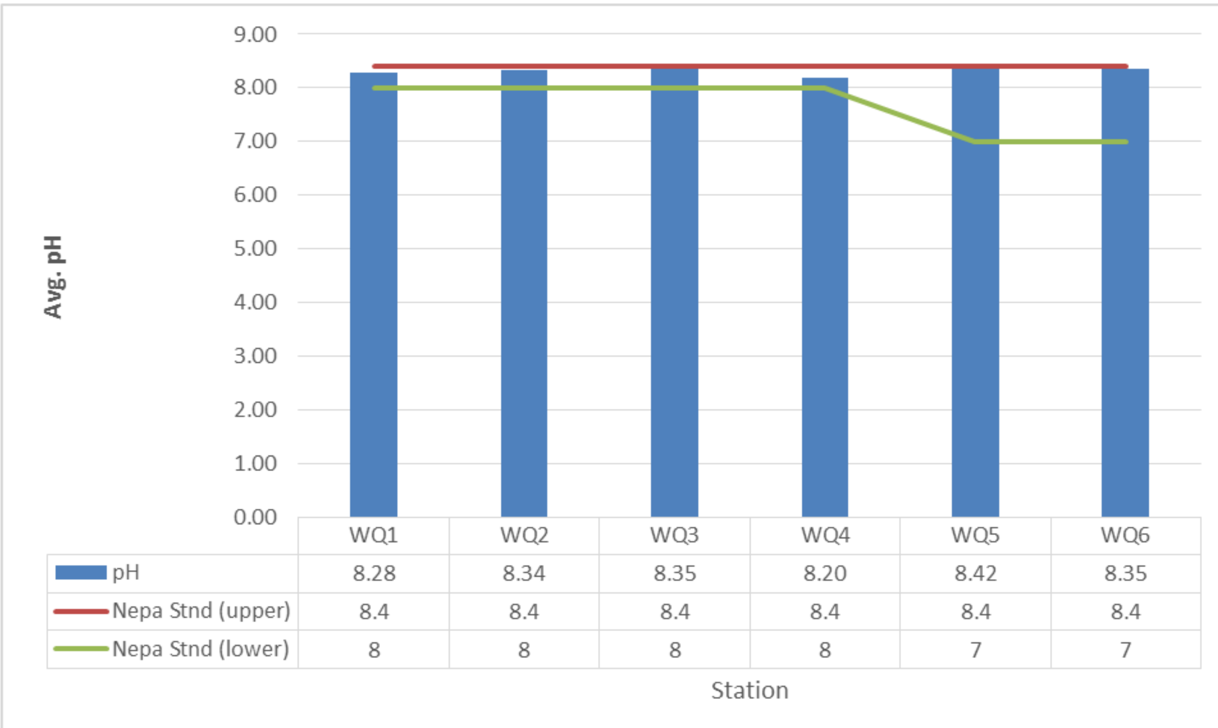


Figure 3-7 pH values at the various stations

Dissolved Oxygen (DO)

Dissolved oxygen values varied across the stations ranging from 2.34 – 6.55 mg/l. Station 3 had the highest dissolved oxygen value whereas the lowest was obtained at station 6 (in the pond). Dissolved oxygen levels at marine locations were all within acceptable levels (>4 mg/l) and above the level that would be considered detrimental to aquatic life (≤ 3 mg/l).

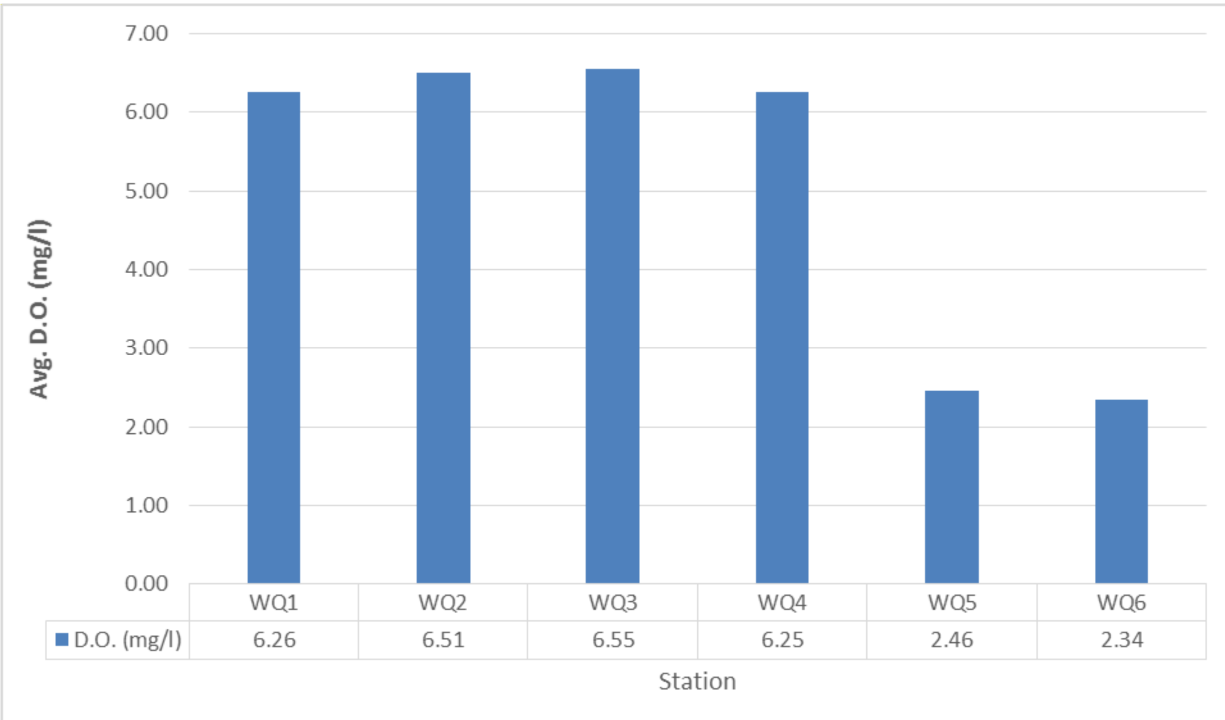


Figure 3-8 Dissolved oxygen values at the various stations

Turbidity

Turbidity varied across the stations ranging from 0.12 NTU at Station 1 to 8 NTU at Station 5.

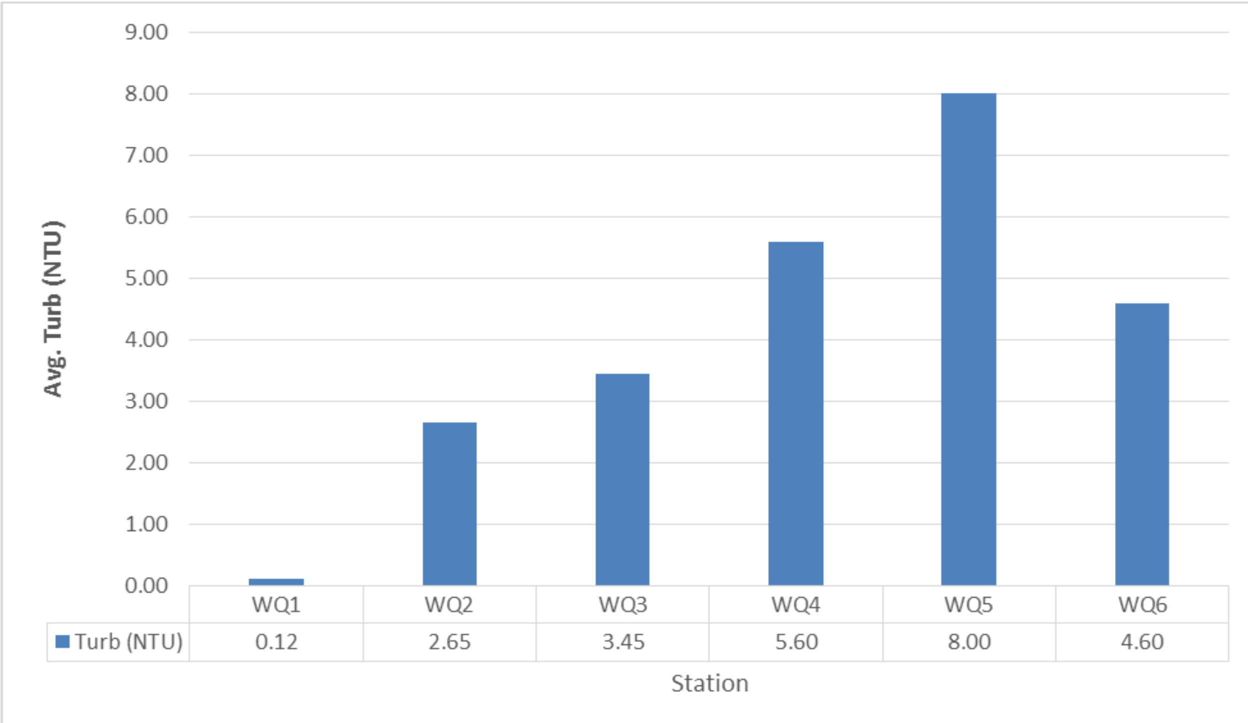


Figure 3-9 Turbidity values at the various stations

Total Dissolved Solids (TDS)

The TDS values varied across the stations ranging from 13.52 – 35.85 g/l. Highest values were obtained from station 2 whereas the lowest value was obtained at station 5 (in the pond). Stations 5 and 6 were non-compliant with the NEPA freshwater standard of 0.12 - 0.3 mg/l.

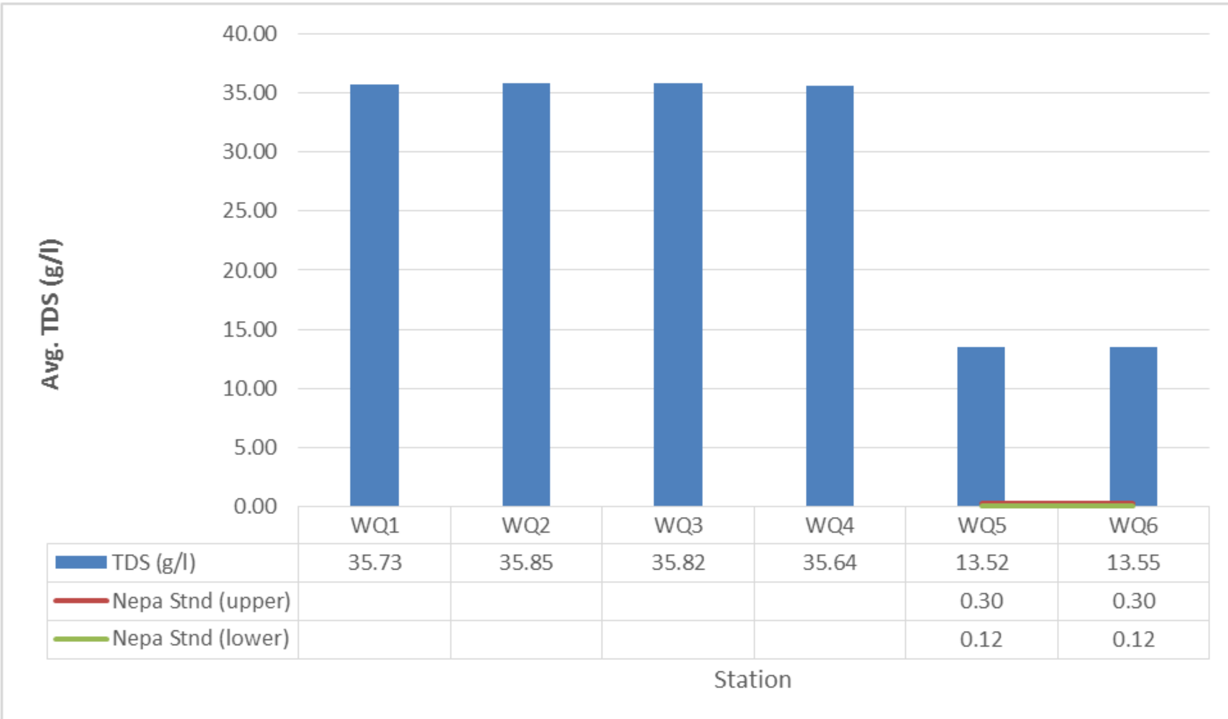


Figure 3-10 TDS values at the various stations

Photosynthetically Active Radiation (PAR)

PAR varied across stations ranging from 263.77 – 578 uE/cm²/s. Highest PAR values were observed at station 4, whereas the lowest value was reported at station 1. The decrease in PAR with depth is expected as less light is able to penetrate with increasing depth. Cloud cover, time of day and the presence of organic and inorganic material also affect the amount of PAR available. No PAR value was available for Stations 5 and 6 due to the shallow nature of the salt pond where the sample was taken, thus the water quality probe was unable to submerge entirely.

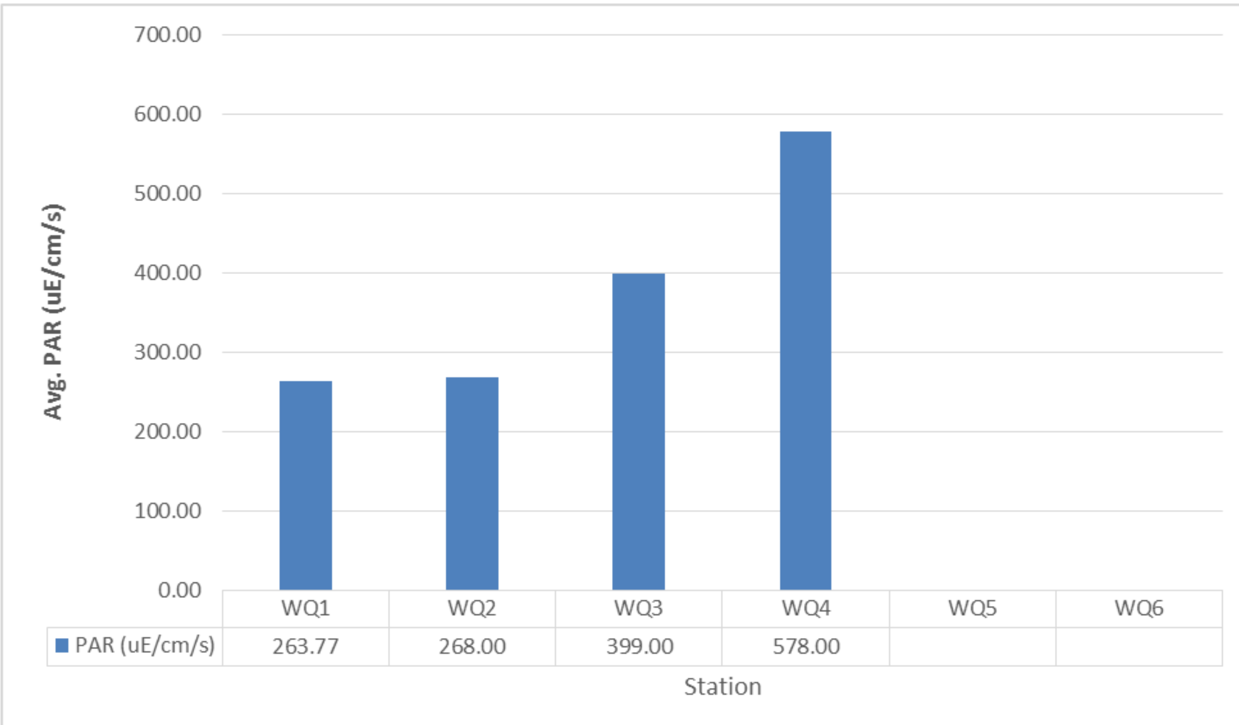


Figure 3-11 PAR values at the various stations

Biochemical Oxygen Demand

BOD values varied across the stations ranging from 0.18 – 1.59 mg/l. Station 5, located in the pond, reported the highest value while the lowest value was reported at station 1 (0.18 mg/l). All stations had BOD values compliant with NEPA marine and freshwater standards.

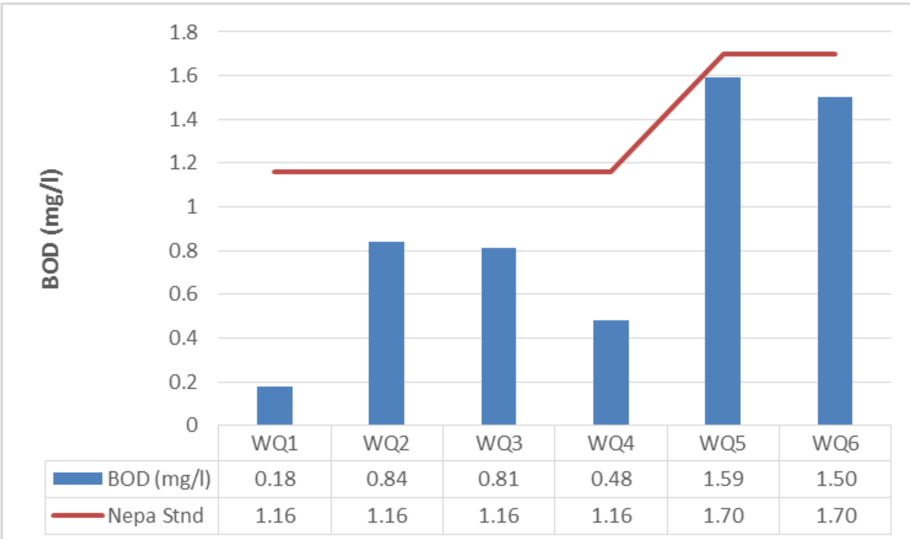


Figure 3-12 BOD values at the various stations

Total Suspended Solids

TSS concentrations were all <5 mg/l in the marine environment while Stations 5 and 6 had values of 6 mg/l and 5 mg/l respectively. These concentrations indicated clear water as they were below 20mg/l.

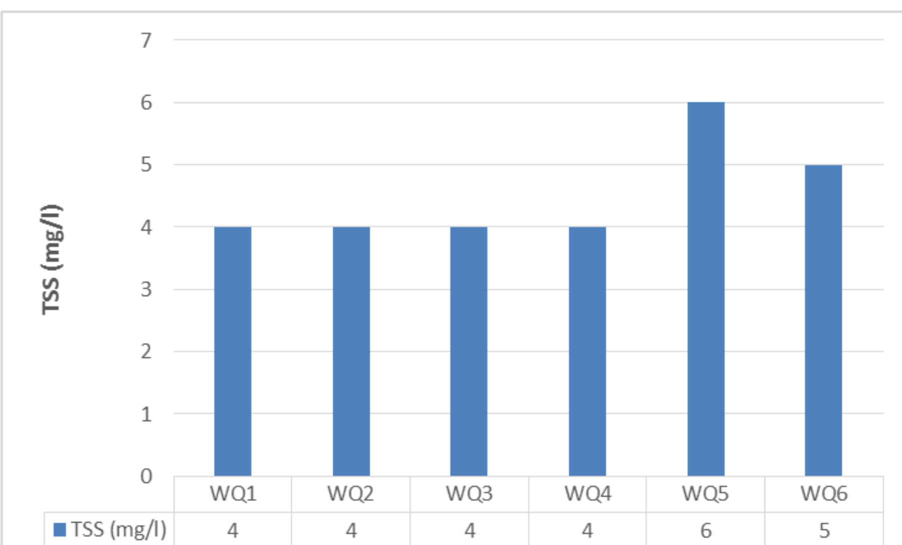
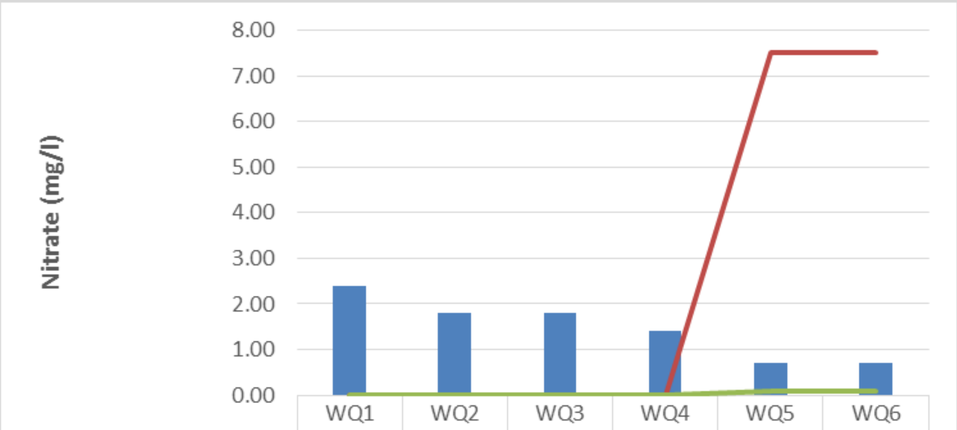


Figure 3-13 TSS values at the various stations

Nitrate

Nitrate values varied across the stations ranging from 0.7 – 2.4 mg/l. The lowest nitrate values were reported at stations 5 and 6 whereas the highest value was observed at station 1. All marine stations were above the NEPA marine standard for Seawater for nitrates, while stations 5 and 6 was compliant with the NEPA freshwater nitrate upper standard. These nitrate values are typical for Jamaican coastal waters.



	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6
Nitrate (mg/l)	2.40	1.80	1.80	1.40	0.70	0.70
Nepa Stnd (upper)	0.014	0.014	0.014	0.014	7.500	7.50
Nepa Stnd (lower)	0.007	0.007	0.007	0.007	0.100	0.10

Figure 3-14 Nitrate values at the various stations

Phosphate

Phosphate values varied across the stations ranging from 0.09 – 2.53 mg/l. The lowest phosphate values were reported at station 4 whereas the highest value was observed at station 1. All marine stations were above the NEPA marine standard for Seawater for phosphates, while station 6 was compliant with the NEPA freshwater phosphate standard. These phosphate values obtained are typical for Jamaican coastal waters.

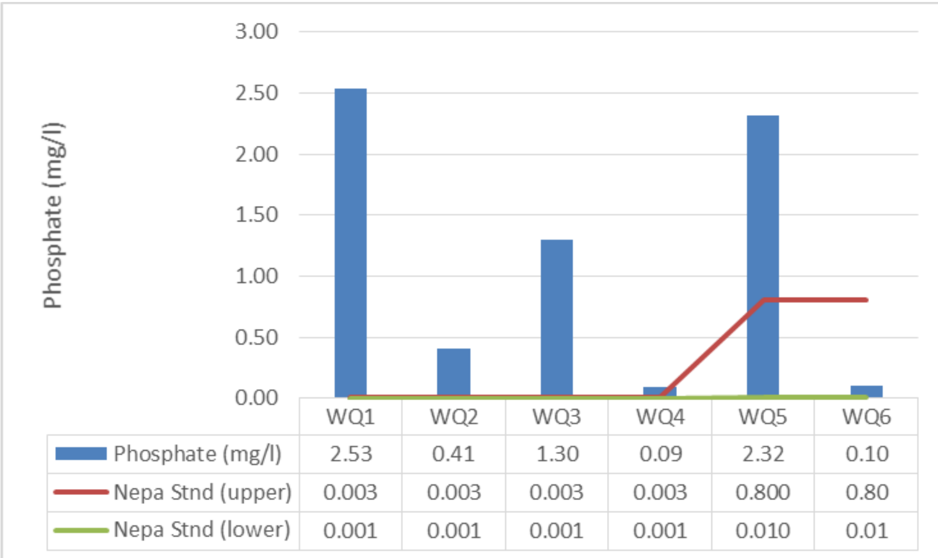


Figure 3-15 Phosphate values at the various stations

Faecal Coliform

Faecal coliform (F. Coli) values varied across the stations ranging from <11 – 69 MPN/100ml. All marine stations were complaint with NEPA marine standards except for Station 3 (36 MPN/100ml). Faecal coliform values in the pond were both slightly elevated.

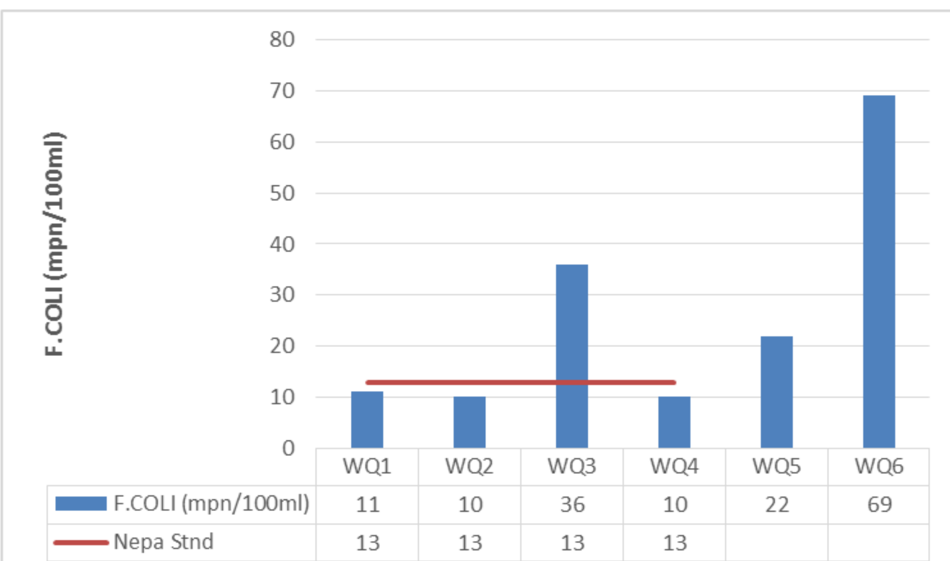


Figure 3-16 Faecal coliform values at the various stations

Chemical Oxygen Demand (COD)

COD values varied across the stations ranging from 257 – 2469 mg/l. Stations 5 and 6, located in the pond, had the lowest COD values while the marine stations had higher COD values.

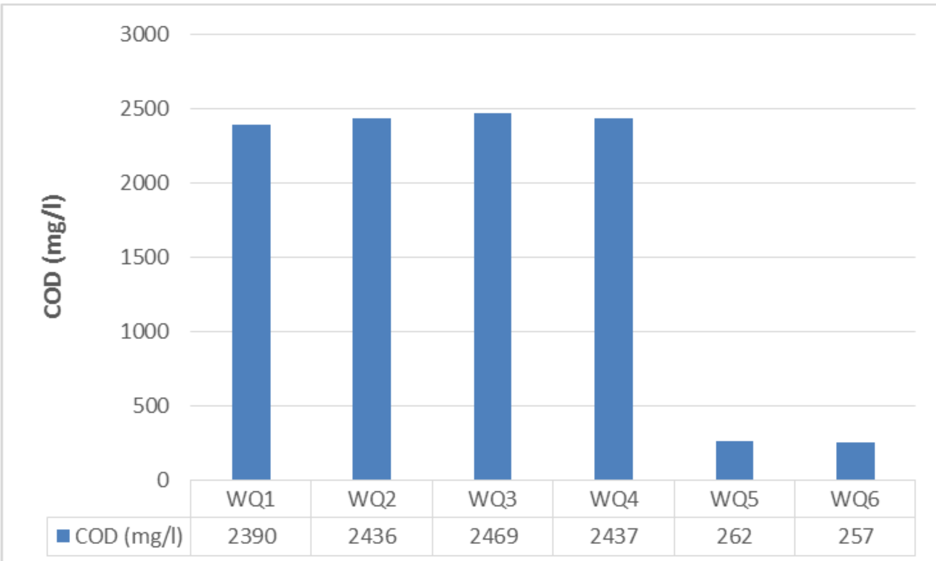


Figure 3-17 COD values at the various stations

3.2 POTENTIAL IMPACTS AND MITIGATION

Table 3-6, Table 3-7 and Table 3-8 below show the potential impacts of seagrass removal, dredging and beach nourishment activities on the three major marine categories (seagrass, reef and fish respectively), as well as recommended mitigation measures.

Table 3-6 Potential Impacts on Seagrass and Recommended Mitigation

Activity	Potential Impacts on Seagrass	Recommended Mitigation
Seagrass Removal	Sedimentation and Smothering of seagrass and associated epiphytes	Use of Turbidity barriers / Silt Screens
	Habitat and Species loss	A detailed Seagrass Removal and Relocation Plan should be submitted to The Agency for approval prior to any seagrass removal. Only remove seagrass within the designated area approved by The Agency
	Habitat Fragmentation	
	Increased water turbidity and suspended solids	Use of Turbidity barriers / Silt Screens
	Reduced light penetration as a result of decreased water quality	
Dredging	Sedimentation and Smothering of seagrass and associated epiphytes	Use of Turbidity Barriers / Silt Screens
	Species Loss	A detailed Dredge Management Plan should be submitted to The Agency for approval prior to any dredging. Only dredge in areas approved by The Agency
	Increased water turbidity and suspended solids	Use of Turbidity Barriers / Silt Screens
	Reduced light penetration as a result of decreased water quality	
Beach Nourishment	Sedimentation and Smothering of seagrass and associated epiphytes	Use of Turbidity barriers / Silt Screens. Berms and trenches should also be used where possible to minimize runoff into marine environment
	Increased water turbidity and suspended solids	
	Reduced light penetration as a result of decreased water quality	

Table 3-7 Potential Impacts on Benthic community and Recommended Mitigation

Activity	Potential Impacts on Reef	Recommended Mitigation
Seagrass Removal	Increased water turbidity and suspended solids	Use of Turbidity barriers / Silt Screens
	Species loss	Small hard coral colonies and other sessile invertebrates will need to be relocated prior to any seagrass removal. The number of small hard coral colonies is very low and as such no hard coral relocation plan is necessary.
	Reduced light penetration as a result of decreased water quality	Use of Turbidity barriers / Silt Screens
Dredging	Sedimentation and Smothering of reef and associated sessile flora and fauna	Only dredge in areas approved by The Agency. Use of Turbidity barriers / Silt Screens

Activity	Potential Impacts on Reef	Recommended Mitigation
	Species Loss	A detailed Dredge Management Plan should be submitted to The Agency for approval prior to any dredging. Only dredge in areas approved by The Agency
	Sedimentation and Smothering of meiofauna	Use of Turbidity barriers / Silt Screens
	Reduced light penetration as a result of decreased water quality	
Beach Nourishment	Sedimentation and Smothering of reef and associated sessile flora and fauna	Use of Turbidity barriers / Silt Screens. Berms and trenches should also be used where possible to minimize runoff into marine environment
	Species Loss	
	Sedimentation and Smothering of meiofauna	
	Reduced light penetration as a result of decreased water quality	

Table 3-8 Potential Impacts on Fish and Recommended Mitigation

Activity	Potential Impacts on Fish	Recommended Mitigation
Seagrass Removal	Destruction of nursery habitat for juveniles	A detailed Seagrass Removal and Relocation Plan should be submitted to The Agency for approval prior to any seagrass removal. Only remove seagrass within the designated area approved by The Agency. Use of Turbidity barriers / Silt Screens
	Destruction of feeding habitat	
Dredging	Clogging of gill filaments resulting from sedimentation	A detailed Dredge Management Plan should be submitted to The Agency for approval prior to any dredging. Only dredge in areas approved by The Agency. Use of Turbidity barriers / Silt Screens
Beach Nourishment	Clogging of gill filaments resulting from sedimentation	Use of Turbidity barriers / Silt Screens. Berms and trenches should also be used where possible to minimize runoff into marine environment

4.0 ECOLOGICAL CARRYING CAPACITY

The ecological carrying capacity of the proposed area is best described in sections.

4.1 MARINE ENVIRONMENT

The marine works which will include the removal of seagrass beds as well as dredging and filling of the nearshore environment will directly impact both the seagrass and meiofauna communities and indirectly impact the associated reef community. This will result in the loss of habitat, and potentially lower the water quality. However, due to the low diversity and abundance of the biota (both flora and fauna) found here, the surrounding seagrass areas will be sufficient to maintain both the directly and indirectly impacted communities. That is the marine works should not result in major changes in the ecological carrying capacity of the area.

4.2 TERRESTRIAL ENVIRONMENT

In order to assess the ecological carrying capacity of the proposed development on the existing environment, additional field surveys were conducted.

4.2.1 Flora

4.2.1.1 Introduction

This report details the findings of a terrestrial vegetation field survey carried out on November 29, 2016. The focus of the survey was to provide supplementary information to the already completed "Environmental Impact Assessment for the Proposed Development of a Hotel Resort at, Coral Springs Trelawny, Jamaica". This EIA was completed in October 2016. However, the regulatory authority (NEPA) had concerns regarding some inadequacies presented in the document. Further inconsistencies were found by this research team and these relate to the methodologies employed and well as what appeared to be missing or erroneous data.

Therefore, the primary goal of this report was to facilitate information to determine the approximate carrying capacity of the ecosystem surveyed. The areas presented include a further characterisation of the flora, a brief description of the ecosystem services provided by some plant species, as well as a description on endemism in the area.

4.2.1.2 Methodology

Based on the requirements for this assessment (i.e. the provision of supplementary information to that provided in the original EIA), a series of walk-through exercises were conducted, one in each of three community types determined. These were a beach/coastal community, inclusive of wetland vegetation; a mesic limestone forest community; and a transitional community separating both. Owing to time constraints, the sorties were limited to the northern and western borders of the planned development site (Figure 4-1).

For each walk-through the degree of occurrence for each species was subjectively recorded via a DAFOR ranking. This was similar to the original EIA; however, no percentage covers were determined during this exercise. As much as possible, each species encountered was identified in-situ. But for those where this could not be done, samples were collected for proper identification at the University of the West Indies Herbarium.

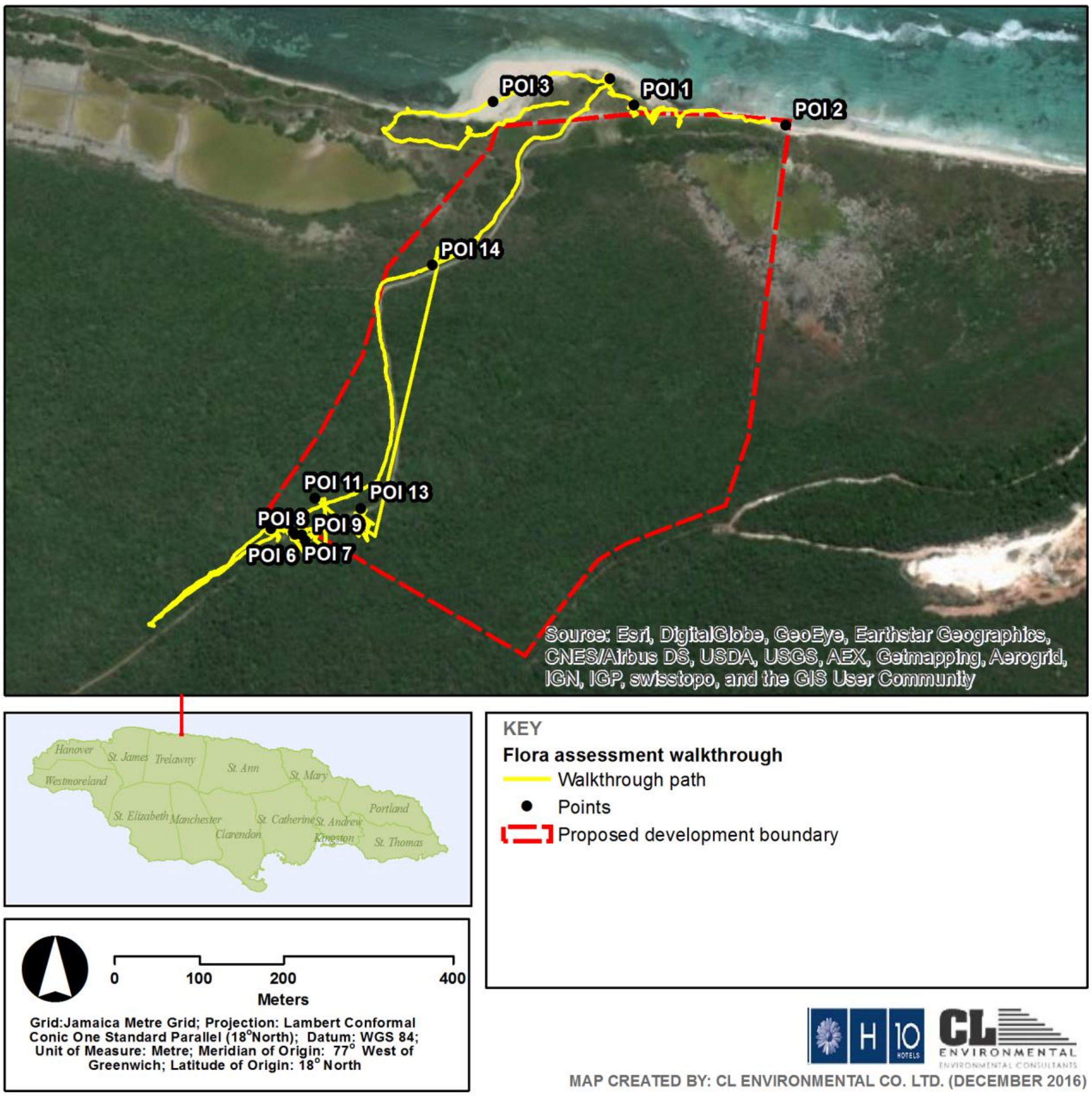


Figure 4-1 Flora assessment walkthrough path

4.2.1.3 Observations and Findings

The Coastal Community

A total of 38 species were encountered in this area of the planned development site. Trees were the least represented growth form encountered and tended to occur in isolated groupings surrounded by grasses and sedges (Plate 4-1) or bodies of standing water. These tree-stands were constituted primarily by *Avicennia germinans* (Black Mangrove), *Conocarpus erectus* var. *erectus* (Buttonwood) and *Thespesia populnea* (Seaside Mahoe). The former two species were typically found adjacent to areas of standing water. Average tree height ranged between 4 – 6 m, with *Cocoloba uvifera* (Seaside Grape) being a conspicuous emergent (Plate 4-2).

Grasses and sedges constituted most of the flora here, in particular the common beach grass, *Sporobolus domingensis* was ubiquitous and occurred in swathes along with *Fimbristylis cymosa* and *F. spadicea*. These species are particularly suited for this arid, saline environment with their rolled leaves to reduce transpiration and the presence of salt excretion glands (as seen with *S. domingensis*).

Plate 4-1 Clusters of *Conocarpus erectus* (Buttonwood) surrounded by swaths of the sedge and grass species, *Fymbristilis spp*. and *Sporobolus spp.*

The leafy exotic, *Scaevola taccada* (Plate 4-3) was quite abundant and conspicuous; dominating and potentially hybridising with its native relative *S. plumieri*. Occurring between the grasses were scattered individuals of the milkweed, *Euphorbia mesembrianthemifolia*. Other commonly occurring shrubs included, *Capraria biflora* (Goatweed) *Mallotonia gnaphalodes* (Seaside Lavender) and *Suriana maritima* (Bay Cedar).

Plate 4-2 Stand of *Thespesia populnea* (Seaside Mahoe) shrubs (foreground) and trees (background) with emergent *Cocoloba uvifera* (Seaside Grape) (tallest, midfield).

Plate 4-3 Flowers and fruits of S*caevola taccada*

Limestone Forest

Here the substrate was elevated and comprised of limestone outcroppings; however, there was a notable soil layer present along with a significant layer of detritus. This, coupled with the prevalence of species with lower xerophytic adaptations (such as the prevalence of species with compound leaves, sclerophyllous leaves and leaves reduced to spines) lead to the conclusion that this was more a mesic limestone forest than a dry limestone forest.

What was observed was a healthy stand of mesic limestone forest vegetation that provided 85 – 90% cover. The substrate did consist of limestone outcroppings; however, a thin but appreciable soil cover was present as well as a significant detritus layer (Plate 4-4). It appeared that both substrate constituents provided enough moisture retention to sustain non-xerophytic species, such as ferns and mosses.

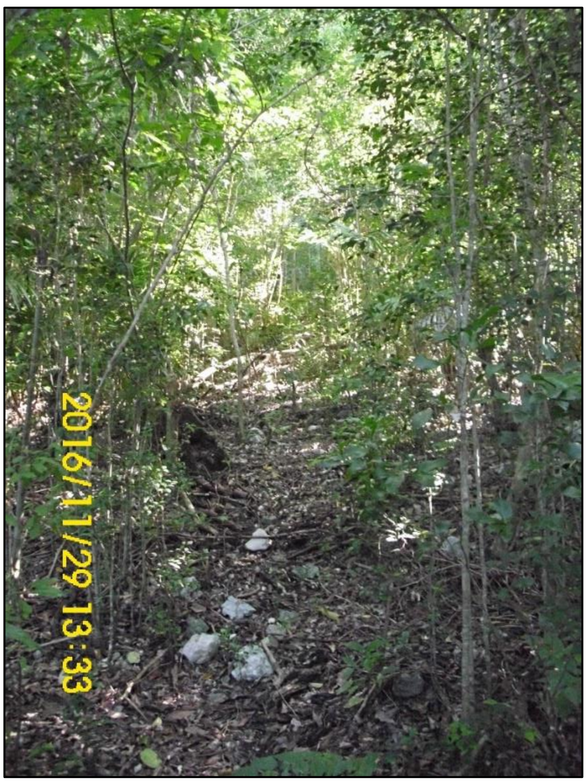


Plate 4-4 Section of Limestone Forest showing relatively thick canopy cover. Also, substrate shows appreciable organic content.

Melicoccus bijugatus (Guinep) was the dominant canopy constituent in this locale. Potentially scattered by the avifaunal constituents of the community. Although the mature individuals were not bearing fruit, several Guinep seedlings were observed indicating how productive the species was in this area. As productive was the endemic palm, *Thrinax parviflora* (Broom Thatch), where several individuals (some over 2 m tall) were seen fruiting (Plate 4-5). Other common tree species were *Bumelia salicifolia* (White Bullet) and *Bursera simaruba* (Red Birch).

Typical of other limestone forests was the prevalence of thin-boled trees in this area. This is usually as a result of the reduced availability of nutrients and water provided by the rocky substrate. The mean tree DBH (Diameter at Breast Height) ranged from 5 – 12 cm. These trees formed the main canopy at a height of approximately 4 m. Emergents, such as Guinep and Red Birch, ranged in DBH between 22 – 25 cm and attained heights of up to 20 m in some cases.

Plate 4-5 A mid-size representative of the endemic palm, *Thrinax parviflora* (Broom Thatch).

Shrubs and herbaceous constituents were mainly relegated to the fringes of the forest community, along the banks of pathways. However, there was a scant understory component that included *Abutilon* sp., *Ateramnus lucidus* (Crab Wood), shrubby forms of *Capparis flexuosa* (Bottle Cod Root) and *Diospyros tetrasperma* (Clamberry).

The Bamboo Grass (*Lasiacis divaricata*) and *Rhoeo spathacea* (Oyster Plant) were notable constituents of the low lying vegetation in the forest. However, the herbs, *Antigonon* sp., *Stylosanthes hamata* (Cheesy Toes) and *Stachytarpheta jamaicensis* (Vervine) were common constituents of disturbed locations.

Fifteen epiphytes were found in this area adding to the dense appearance of community. Two of these were endemic: the legume, *Galactia pendula* (Plate 4-6) and the night blooming cactus, *Hylocereus triangularis* (God Okra).

Plate 4-6 Endemic climber, *Galactia pendula* in bloom.

The Transition Zone/Ecotone

Located between the two prior discussed communities, it was expected that a blending of coastal and limestone forest constituents would occur. Twenty-two species were recorded in this area, 18 of which occurred in the other communities, with a predisposition towards forest flora. *S. hamata* continued to be abundant in this region, particularly along pathways. The tree *Leucaena leucocephala* (Lead Tree) became more important in this area. An indicator of disturbance, it grew well on the more accessible, alluvial slopes. Other more frequently occurring species included the timber trees, *Piscidia piscipula* (Dogwood) and Peltophorum linnaei (Braziletto).

Possibly due to an opening of the canopy cover, less epiphytic species occurred here. Nonetheless, of those that did occur: *Centrosema ternatea*, *C. virginianum* and *Galactia pendula* were ubiquitous.

Ecosystem Status and Services Provided

According to the NEPA Trelawny Parish Provisional Development Order 2013, the majority of the site is zoned as Shrub Woodland, while the northern boundary of the site is zoned for Conservation. The site is also in relatively close proximity to the Coral Springs protected area. Based on these facts, development of this area and the type of development proposed should warrant careful consideration.

Historically, the site has had a history of illegal sand removal from the beach. Despite this the beach and dune vegetation appears to be recovering. The recovery of the latter is particularly important as dune vegetation serves the dual purpose of aiding the stabilisation and accretion (otherwise) motile sand.

The fruits of coastal trees, such as the Seaside Mahoe and Grape, may be a food source for several avifaunal and mammalian species. While mangrove species are known to provide a habitat for waterfowl (Ramsar 1971).

The Mesic Limestone Forest vegetation is disturbed; as evidenced by a dirt roadway that bisects the community and leads to the beach. This roadway appears to have been in existence for a while and is possibly partly responsible for the introduction of *Melicoccus bijugatus* to the flora. The other likely sources may have been via birds and mammals that use the fruits as a source of food. Several mature Guinep trees were encountered. Other phanerophyes found fruiting here were Red Birch, the endemic Broom Thatch, *Eugenia* sp., *Canella winterana* (Wild Cinnamon) (another emergent species) and both *Bumelia* spp.

Therefore, despite the habitat fragmentation caused by the dirt track, the forest community appeared healthy with several productive species observed. It is estimated that the community may be in the mid to late seral stages of its successional development.

A total of 126 species were identified for this survey, eight of which were endemic (Appendix 4). These endemic species appeared to be more common in the limestone forest areas, near the southern sections of the property. Their preservation would be important to maintaining the natural history of the area.

Based on our findings, regarding the species richness, productivity and coverage of the vegetation in the highland areas, any significant removal of plant species could in turn significantly affect the carrying capacity of the limestone forest community. It may be inferred that based on the health of the flora, that sufficient ecosystem resources are available for the floral community present. Furthermore, because the flora is thriving, it also provides a habitat and resources for animal constituents. Therefore, the current carrying capacity may be considered as being high.

The productivity observed in the coastal zone was notably less. As stated earlier, the coastal areas presented an open community with a dominant herbaceous component. Taking into account the potential stressors experienced by the flora here could explain the lower species richness. The plant constituents of the coastal zone have to mitigate against excess solar radiation; potentially saline soils; saline intrusion of the groundwater; salt spray; inundation caused by the tides and rainfall events; as well as fast drainage or evaporation of water – commonly seen in sandy soils. As such, the resources (and hence the carrying capacity), although capable of sustaining the present community, would/could not be high enough to sustain a higher level of diversity and stature. These factors, with the exception of edaphic factors, are minimal to absent in the limestone forest. Compared to the limestone forest community the carrying capacity of the coastal zone would be less.

4.2.2 Fauna

4.2.2.1 Site Description

The area was zoned into four categories for the purpose of the avifauna assessment (Figure 4-2).

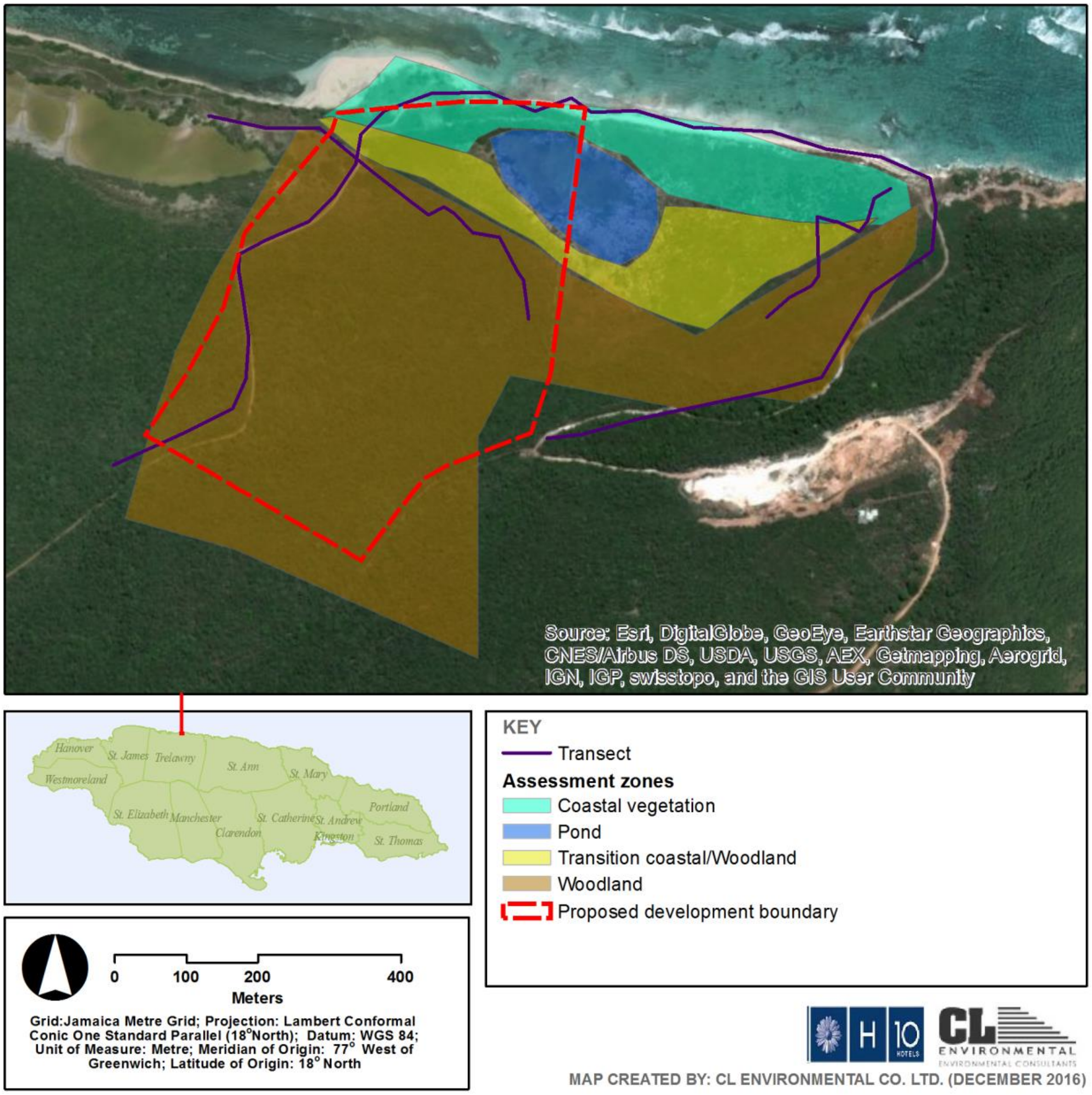


Figure 4-2 Zones and transects used for the avian assessment.

Coastal Ponds

The coastal ponds are influenced by tide. The water is brackish and several dead mangroves were observed in the ponds. An old stone wall was seen bordering the ponds, which suggest that they could be manmade. It is possible that the ponds on the property are old salt ponds.

Plate 4-7 Salt pond observed on the Coral Springs property

Rocky Shore

Sections of the shoreline on the property are rocky. It's alleged that sand was removed from the beach leaving the rock base. Several small tidal pools were observed in the rocky shore.

Plate 4-8 Rocky Shore observed on the property

Woodland

The vegetation on the property has characterises of a dry limestone forest. It seems the area was once cleared and has regrown into the woodland. Dry limestone plants such as agaves, cactus, orchids and palms were observed in the area.

Plate 4-9 Woodland vegetation observed on the property

Coastal Vegetation: Seaside Mahoe and Mangroves

The coastal vegetation consists mainly of Seaside Mahoe, Button wood and Mangroves. It should be notes that grasses were found between the trees in the area.

Plate 4-10 Coastal vegetation observed on the property.

4.2.2.2 Methods

The avifauna surveys were conducted within the zones established in the study and were carried out over 2 days and 1 night (Figure 4-2).

- **Line transect** - Due to the vast road networks, footpaths and the uniformity of most of the vegetation throughout the property, lines transect were selected for the avian survey. The line transect method entails walking at a steady pace along a selected path for a given distance while recording all bird species seen or heard (Bibby et al. 1998). It should be noted that "phishing method" was used to assist in the identification of the migrant warbler. Additionally, audio playbacks were used during the survey of the nocturnal birds.
- **Observance of the pond** - This method is based on the principle of counting birds at an area where water has accumulated. Species and their numbers are then recorded for a time period usually 20 – 30 minutes. Identification of species was done through sight (visual identification) and sound (audio identification for 30 minutes).

4.2.2.3 Results

Avifauna

A total of 63 species of birds were observed during the avifauna assessment (Table 2 and Table 3). Of the 63 birds identified, 17 were wetland/coastal species and 46 terrestrial species. 90 species of birds were identified in a study carried out in the Coral Springs Mountains Protected Area (NEPA, 2013), which is approximately 2km from the project area. This indicates that the overall avian diversity in the area is very high.

Wetland /Coastal birds

Twelve of the 17 wetland/coastal bird species were observed in the ponds on the property. The dominant species was the Blue wing teal, which were seen foraging in the ponds. The high number of wetland birds in the area was as a result to the time of the year the survey was carried out. The survey was conducted after the arrival of the winter migrants which is usually from September to May. There were a few herons and egrets at the ponds and also in the mangroves. It should be noted that coastal ponds are an important habitat for several wetland birds.

The Semipalmated Plover, Solitary Sand Pipers and Black bellied plover were seen foraging on the rocky shore. Due to the size of the area more shore birds were expected in the area. The coastal birds observed included the Brown Pelican and Magnificent Frigate.

Table 4-1 DAFOR scale used to categorized the birds

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

Table 4-2 Wetland/ coastal bird species observed in the study

Proper Name	*Scientific Name*	Status	Coastal Pond	Shore	Mangroves
Magnificent Frigatebird	*Fregata magnificens*	Resident		R	
Black-Crowned Night Heron	*Nycticorax nycticorax*	Resident	R		R
Cattle Egret	*Bubulcus ibis*	Resident	O		R
Great Blue Heron	*Ardea herodias*	Migrant	R		
Great Egret	*Casmerodius albus*	Resident / Migrant			R
Little Blue Heron	*Egretta careulea*	Resident	R		
Yellow-Crowned Night Heron	*Nycticorax violaceus*	Resident			R
Brown Pelican	*Pelecanus occidentalis*	Resident	R	R	
Black-Bellied Plover	*Pluvialis squatarola*	Resident / Migrant		R	
Semipalmated Plover	*Charadrius semipalmatus*	Resident / Migrant		O	
Kildeer	*Charadrius vociferus*	Resident	R		
Solitary Sandpiper	Migrant	Shore bird	O	R	R
Back-necked Stilt	*Himantopus mexicanus*	Resident	A		
Short-billed Dowitcher	Limnodromus griseus	Resident	R	R	
Blue-Winged Teal	*Anas discors*	Migrant	A		
Nothern Shoveler	Anas clypeata	Migrant	R		
Belted KingFisher	*Ceryle alcyon*	Resident / Migrant		R	R

Warblers (Downer & Sutton, 1990). In addition, the high number of migrant bird was as a result of the time of the year the study was carried out after the arrival of the migrants.

Table 4-3 Terrestrial bird species observed in the study

Proper Name	Scientific Name	Status	DAFOR
American Kestrel	*Falco sparverius*	*Resident*	*R*
American Redstart	*Setophaga ruticilla*	*Migrant*	*R*
Bananaquit	*Coereba flaveola*	*Resident*	*A*
Black and White Warbler	*Mniotilta varia*	*Migrant*	*R*
Black-faced Grassquit	Tiaris bicolor	*Resident*	F
Blackpoll Warbler	*Dendroica striata*	*Migrant*	*R*
Black-throated Blue Warbler	*Dendroica caerulescens*	*Migrant*	*R*
Black-whiskered Vireo	*Vireo altiloquus*	*Resident*	*R*
Caribbean Dove	*Leptotila jamaicensis*	*Resident*	*O*
Common Ground Dove	*Columbina passerina*	*Resident*	*F*

Proper Name	Scientific Name	Status	DAFOR
Common Yellowthroat	*Geothypis trichas*	*Migrant*	*R*
Giant Kingbird	*Tyrannus cubensis*	*Resident*	*R*
Greater Antillean Bullfinch	*Loxigilla violacea*	*Resident*	*R*
Greater Antillean Grackle	*Quiscalus niger*	*Resident*	*O*
Green-rumped Parrotlet	*Forpus passerinus*	*Resident*	*O*
Jamaican Crow	*Corvus jamaicensis*	*Endemic*	*R*
Jamaican Elania	*Myiopagis cotta*	*Endemic*	*R*
Jamaican Euphonia	*Euphonia Jamaica*	*Endemic*	*A*
Jamaican Lizard Cuckoo	*Saurothera vetula*	*Endemic*	*R*
Jamaican Mango	*Anthracothorax mango*	*Endemic*	*R*
Jamaican Oriole	*Icterus leucopteryx*	*Endemic*	*O*
Jamaican Pewee	*Contopus pallidus*	*Endemic*	*O*
Jamaican Tody	*Todus todus*	*Endemic*	*R*
Jamaican Vireo	*Vireo modestus*	*Endemic*	*O*
Jamaican Woodpecker	*Melanerpes radiolatus*	*Endemic*	*O*
Loggerhead Kingbird	*Tyrannus caudifasciatus*	*Resident*	*A*
Nothern Mockingbird	*Mimus polyglottos*	*Resident*	*F*
Olive-throated Parakeet	*Aratinga nana*	*Resident*	*A*
Ovenbird	*Seiurus aurocapillus*	*Migrant*	*R*
Praire Warbler	*Dendroica discolor*	*Migrant*	*R*
Red-billed Streamertail	*Trochilus polytmus*	*Endemic*	*O*
Red-tailed Hawk	*Buteo jamaicensis*	*Resident*	*R*
Sad Flycatcher	*Myiarchus barbirostris*	*Endemic*	*O*
Smooth-billed Ani	Crotophaga ani	*Resident*	A
Stolid Flycatcher	*Myiarchus stolidus*	*Resident*	*O*
Turkey Vulture	*Carthartes aura*	*Resident*	*A*
Vervain Hummingbird	*Mellisuga minima*	*Resident*	*O*
White Crowned Pigeon	*Columba leucocephala*	*Resident*	O
White-chinned Thrush	*Turdus aurantius*	*Endemic*	*R*
White-eyed Thrush	*Turdus Jamaicensis*	*Endemic*	*R*
White-Winged Dove	*Zenaida asiatica*	*Resident*	*O*
Yellow Warbler	*Dendroica petechia*	*Resident*	*O*
Yellow-faced Grassquit	*Tiaris olivacea*	*Resident*	*F*
Yellow-Shouldered Grassquit	*Loxipasser anoxanthus*	*Endemic*	*O*
Yellow-throated Warbler	*Dendroica dominica*	*Migrant*	*R*
Zenaida Dove	*Zenaida aurita*	*Resident*	*O*

Of the 15 endemic birds, 6 were non forest dependent and 9 were forest dependent (Table 4-4). The high number of the forest dependents was as a result of the quality of the habitat. It should be noted that the property is surrounded by forest which help supports the high number of forest specialist.

Table 4-4 The endemic birds identified during the study

Proper Name	Scientific Name	DAFOR	Forest specialist
Jamaican Tody	*Todus todus*	*R*	*No*
Jamaican Crow	*Corvus jamaicensis*	*R*	*Yes*
Jamaican Elania	*Myiopagis cotta*	*R*	*Yes*
Jamaican Euphonia	*Euphonia Jamaica*	*A*	*No*
Jamaican Lizard Cuckoo	*Saurothera vetula*	*R*	*Yes*
Jamaican Mango	*Anthracothorax mango*	*R*	*No*
Jamaican Oriole	*Icterus leucopteryx*	*O*	*No*
Jamaican Pewee	*Contopus pallidus*	*O*	*Yes*
Jamaican Vireo	*Vireo modestus*	*O*	*Yes*
Jamaican Woodpecker	*Melanerpes radiolatus*	*O*	*No*
Red-billed Streamertail	*Trochilus polytmus*	*O*	*No*
Sad Flycatcher	*Myiarchus barbirostris*	*O*	*Yes*
White-chinned Thrush	*Turdus aurantius*	*R*	*Yes*
Yellow-Shouldered Grassquit	*Loxipasser anoxanthus*	*O*	*Yes*
White-eyed Thrush	*Turdus Jamaicensis*	*R*	*Yes*

4.2.2.4 Bats

Bats were identified foraging on fruits and insects on the property and notably bats were also seen foraging over the sea (these are likely to be fishing bats). No bats were observed roosting in the large trees on property. Of not a study carried out in the Coral springs Mountain protected area has identified 12 bat species in the area including the endemic tree-roosting Jamaican Fig-eat Bat (*Ariteus flavescens*) (NEPA, 2013). This suggests that several bat species could be foraging in the area.

4.2.2.5 Herpeto fauna

Four herps were observed during the bird assessment (Table 4-5). This includes 2 amphibians that were introduced to Jamaica. The reptiles were endemic however they are not threatened. It should be noted that the number of herps species will increase if a more detailed study is carried. It should also be noted that crocodiles could be using the ponds on the property.

Table 4-5 Herpeto fauna observed during the study

Species	Common name	Species Status	IUCN Status	DAFOR
AMPHIBIANS				
Rhinella marina	Cane Toad	Introduced	Least concern	O
Eleutherodactylus johnstonei	Lesser Antillean Frog	Introduced	Least concern	A

Species	Common name	Species Status	IUCN Status	DAFOR
REPTILES				
Anolis garmani	Jamaican Giant Anole	Endemic	Near threatened	O
Anolis lineatopus	Jamaican Gray Anole	Endemic	Near threatened	D

4.2.3 Conclusion

Avian species diversity was very high, 63 birds were observed on the property over two days. The proposed development will have a negative impact on the avian community. The loss of habitat will result in decreases in diversity and abundance. The development will entail filling the coastal ponds which will impact wetland birds while the removal of vegetation will affect the general bird community and in particular the forest specialist. However, some of the terrestrial birds will use the nearby forest vegetation.

4.2.4 Ecological Carrying Capacity

The term ecological carrying capacity in an environment refers to the maximum number of species held by or sustained by an ecosystem in the existing conditions (Wang, 2010). During the assessment of the Coral Spring property, the area was zoned as coastal including mangroves and rocky shore, woodland and the waterbodies on the property. They provide a habitat for fauna observed during the assessment, which include terrestrial, and wetland birds, insects and reptiles.

The proposed development will have a negative impact on the ecological capacity for the area. For example, the filling of the coastal ponds will result in the loss of habitat for several species of wetland birds including herons and ducks and also shore birds in the area. However, no wetland fauna with emphasis on the birds had any special conservation requirements were observed in the coastal ponds.

The large scale removal of the vegetation including mangroves and the woodland will also have a negative impact on the faunal community. Habitat loss will result in decreases in species diversity and abundance, in particular the forest specialist. It should be noted that the landscaping of the property would provide a habitat for most of the generalist fauna species. However, a few forest specialists may utilize the adjacent forest on the hill .

4.2.4.1 Recommendations

- There should not be a large clear cut of the vegetation during the development of the hotel.
- The hotel development should be integrated with the natural environment of the area.

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6.0 APPENDICES

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Appendix 1 – NEPA Request Letter for Addendum

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Reference Number: 2016-07017-EP00284

7 November 2016

Mr. Garfield O. Wood
Managing Director
GW Architects Limited
4 Hillcrest Avenue
Kingston 6

Dear Mr. Wood,

Re: Draft Environmental Impact Assessment for a Proposed Hotel or Resort Project at Coral Spring, Trelawny

We write to confirm receipt of the revised Environmental Impact Assessment Report titled, **"Environmental Impact Assessment for Proposed Development of a Hotel at Coral Springs Trelawny, Jamaica"** by Felicitas Limited, dated October 2016, and received and date stamped 25 October 2016.

The review revealed major gaps in the Report which are critical to a complete review, namely the absence and/or incomplete information on the following:

i. Geo-technical assessment report;
ii. Storm surge assessment report;
iii. Hydrological/Drainage Plan for the development site;
iv. The impact of the marine works on the environment and
v. Ecological carrying capacity.

With the foregoing as outlined, the Agency has determined that items iii – v, must be completed and presented as an Addendum to the EIA Report to move the process forward. To support this requirement, the Consultant may wish to review the following EIA and technical Reports:

- Environmental Impact Assessment Report for the Treasures of Trelawny Resort Development
- Environmental Impact Assessment Report for the Coral Springs Residential Development
- Final Draft Environmental Impact Statement of The Proposed Luxury Villas At White Bay, Trelawny and
- Royalton Technical Assessment Report for its hotel expansion.

Finally, you will be required to complete the geo-technical and storm surge assessments within three (3) months, should an environmental permit be favourably considered by the Natural Resources Conservation Authority/Town and Country Planning Authority.

As soon as the Addendum is received to the Agency's satisfaction, the documents will be posted on the website and circulated. The Agency will simultaneously facilitate the arrangement of the public consultation meeting.

Mr. Garfield O. Wood
Re: 2016-07017-EP00284; Draft Environmental Impact Assessment for a Proposed Hotel or Resort Project at Coral Spring, Trelawny
7 November 2016
Page 2 of 2

Should the foregoing be complied with, then hopefully the Agency will be able to make a recommendation on the development to the Board of the NRCA at its meeting scheduled for 17 January 2016.

The Agency is available to respond to questions or provide further clarification if needed. Please do not hesitate to contact the undersigned at 754-7540 ext. 2114 or email rlacey-sherrard@nepa.gov.jm.

Sincerely,
National Environment and Planning Agency

Peter Knight, JP
Chief Executive Officer/Government Town Planner

RL-S

Appendix 2 – Study Team

- **CL Environmental Co. Ltd.:**
    - Carlton Campbell, Ph.D., CIEC (Client Liaison, Project Coordinator)
    - Matthew Lee, M.Sc. (Marine Benthic Survey)
    - Rachel D'Silva, B.Sc. (Marine Benthic Survey)
    - Karen McIntyre, M.Sc. (GIS)
    - Kimani Kitson-Walters, M. Phil (Water Quality)
    - Achsah Mitchell, M. Phil (Water Quality)
    - Philip Rose (Vegetation Survey)
    - Patrick Lewis (Vegetation Survey)
    - Damion Whyte (Faunal Survey)

- **CEAC Solutions Ltd.:**
    - Christopher Burgess M.Sc. Eng., PE (Drainage, Hydrology and Hydraulics)
    - Carlnenus Johnson, B.Sc Eng. (Drainage, Hydrology and Hydraulics)
    - Kristifer Freeman, B Sc, Eng. (Drainage, Hydrology and Hydraulics

Appendix 3 – Hydrolab Water Quality Multi-Probe Calibration Certificate

OTT Hydromet

Certificate of Instrument Performance

Company Name: CL ENVIRONMENTAL — Certification for Job#:5248974

Part/Model Number: MS5 — Serial Number: 100500049186

RECEIVED CONDITION:
(One must be checked)

- [x] Within Tolerance
- [ ] Within Tolerance but Limited *(*see service report)*
- [ ] Out of Tolerance (**see service report)*

RETURNED CONDITION:
(One must be checked)

- [x] Within Tolerance
- [ ] Within Tolerance but Limited (**see service report)*

Test Equipment Used, (ID#): N.I.S.T. - traceable glass thermometer (H-B Thermometer, Serial ***X-8244)*** and a Cole-Parmer "*PolyStat*" Constant Temperature Circulator

Environmental Conditions:

Actual Temperature:	Instrument Reading:	Error
10 °C	10.02°C	0.02°C
20 °C	20.00°C	0.00°C
30 °C	30.01°C	0.01°C

OTT Hydromet does hereby certify that the above listed equipment meets or exceeds all Manufacturers' Service Specifications (unless limited conditions apply). Test equipment used for performance verification are calibrated using standards traceable to the National Institute of Standards and Technology (NIST). Where such standards do not exist, the basis for calibration is documented. The proper operation of the above instrument was established at the time of certificate issuance. To insure continued performance, user must adhere to all requirements listed in the instrument manual.

Certified by: Dale Kinney

Title: Certified Instrument Service Technician

Certification Date: 03/16/2016

5600 Lindbergh Drive • Loveland, CO 80538
(800) 949-3766 / FAX (970) 461-3921

ADCON TELEMETRY OTT HYDROLAB

Appendix 4 - Flora Species List

Species	Common Name	Growth Form	Beach	Transition	Highlands
Abrus precatorius	Wild Licorice	Epiphytes			R
Abutilon sp.		Shrubby Herbs			F
Adiantum pyramidale	Maiden-Hair Fern	Ferns			O
Allophylus cominia		Trees			R
Amyris plumieri	Candlewood	Trees			R
Antigonon sp.		Herbs			F
Astrocasia tremula		Shrubs			O
Ateramnus lucidus	Crab Wood	Shrubs			F
Avicennia germinans	Black Mangrove	Trees	F		
Batis maritima		Runners	O		
Bauhinia divaricata	Bull Hoof	Trees			R
Borrichia arborescens	Seaside Ox-eye	Shrubs	R		
Bourreria baccata[9]		Trees			R
Brosimum alicastrum	Breadnut	Trees			R
Bumelia nigra[1]	Black Bullet	Trees			R
Bumelia salicifolia	White Bullet	Trees			F
Bursera simaruba	Red Birch	Trees			F
Caesalpinia major	Yellow Nickal	Shrubs	R		
Canavalia maritima	Seaside Bean	Runners	R		
Canella winterana	Wild Cinnamon	Trees			R
Capparis ferruginea	Mustard Shrub	Trees			R
Capparis flexuosa	Bottle Cod Root	Trees			O-F
Capraria biflora	Goatweed	Shrubby Herbs	O	O	
Casearia guianensis	Wild Coffee	Trees			R
Casuarina equsetifolia	Whistling Pine	Trees	R		
Celtis trinervia	Bastard Fustic	Trees			O
Centrosema ternatea	Blue Pea	Epiphytes		F	O-F
Centrosema virginianum		Epiphytes		F	O-F
Cestruum sp.		Trees			O
Chiococca alba	David's Root	Epiphytes			O
Chloris petraea		Herbs	O		
Cissus sicyoides	Pudding Withe	Epiphytes		O	
Cocoloba diversifolia		Trees			O
Cocoloba longifolia[1]		Trees			R
Cocoloba uvifera	Seaside Grape	Trees	O		

[9] Endemic

Species	Common Name	Growth Form	Beach	Transition	Highlands
Colubrina asiatica	Hoop Withe	Shrubs	R		
Commelina sp.		Runners			R
Comocladia pinnatifolia	Maiden Plum	Trees			R
Conocarpus erectus var. erectus	Buttonwood	Trees	F	R	
Conocarpus erectus var. sericeus	Silver Buttonwood	Trees	R		
Cordia brownei	Black Sage	Shrubs		R	
Cordia gerascanthus	Spanish Elm	Trees			R
Crescentia cujete	Wild Calabash	Trees			R
Croton eluteria	Cascarilla Bark	Trees			R-O
Croton humilis var. humilis	Pepper Rod	Shrubs			A
Croton linearis	Rosemary	Shrubs			O
Cupania glabra	Wild Ackee	Trees			R
Cyperus ligularis		Herbs	R		R
Dactyloctenium aegyptium	Crow-Foot Grass	Herbs	R-O		
Desmodium canum		Epiphytes			R-O
Diospyros tetrasperma	Clamberry	Shrubs			F
Erythroxylum rotundifolium		Trees			O
Eugenia maleolens		Trees			O
Eugenia sp.		Trees			R
Euphorbia mesembrianthemifolia		Shrubby Herbs	F-A		
Euphorbia sp.		Herbs			R
Fimbristylis cymosa		Herbs	F		
Fimbristylis spadicea		Herbs	A	O	
Galactia pendula[10]		Epiphytes		F	O
Haematoxylum campechianum	Logwood	Trees		O	R
Helicteres jamaicensis	Screw Tree	Shrubs			R
Hibiscus clypeatus	Congo Mahoe	Shrubs			O
Hibiscus lavateroides		Shrubby Herbs			O
Hylocereus triangularis[1]	God Okra	Epiphytes		O	O
Hypelate trifoliata	Ketto	Trees			R
Ipomoea jamaicensis?		Epiphytes		O	F
Lantana camara	Wild Sage	Shrubs			O
Lasiacis divaricata	Bamboo Grass	Herbs			O-F
Leucaena leucocephala	Lead Tree	Trees		F	O
Lippia nodiflora		Runners	R		
Lippia strigulosa		Herbs		O-F	
Mallotonia gnaphalodes	Seaside Lavender	Shrubs	O		
Malvastrum coromandelianum		Shrubby Herbs	R		

[10] Endemic

Species	Common Name	Growth Form	Beach	Transition	Highlands
Malvaviscus arboreus	Mahoe Rose	Trees			R
Mandevilla torosa		Epiphytes			R
Melicoccus bijugatus	Guinep	Trees			D
Melochia nodiflora		Shrubs			R
Melochia pyramidata		Shrubby Herbs		R-O	
Merremia dissecta	Know You	Epiphytes			O
Merremia quinquefolia	Rock Rosemary	Epiphytes			R
Metopium browneii	Burn Wood	Trees			R
Morinda royoc	Strongback	Shrubs			R
Oeceoclades maculata	Ground Orchid	Herbs			R-O
Oplonia armata var. armata		Trees			R
Panicum maximum	Guinea Grass	Herbs	R	O	R
Paspalum distichum		Herbs	O		
Peltophorum linnaei	Braziletto	Trees		F	
Pimenta dioca	Allspice	Trees			R
Piper amalago var. amalago		Shrubs			R
Piscidia piscipula	Dogwood	Trees		F	O-F
Pisonea aculiata	Cockspur	Epiphytes		O	O
Pithecellobium unguis-cati	Privet	Trees	R		O
Pluchea carolinensis	Wild Tobacco	Shrubs	R		
Polygala jamaicensis	White Linum Vitae	Trees			O
Polypodium sp.		Ferns			O
Priva lappulacea	Clammy Bur	Herbs			O
Rhizophora mangle	Red Mangrove	Trees	R		
Rhoeo spathacea	Oyster Plant	Herbs			O
Ruellia tuberosa	Duppy Gun	Herbs			R
Scaevola plumieri		Shrubs	O		
Scaevola taccada	Beach Cabbage	Shrubs	A		
Schaefferia frutescens		Trees			R-O
Scleria lithospermerma		Herbs			O
Sesuvium portulacastrum	Seaside Purselane	Runners	O		
Smilax domingensis		Herbs			O
Smilax sp.		Epiphytes			O-F
Solanum erianthum	Wild Susumber	Shrubs			O
Spilanthes urens	Pigeon Coop	Herbs	R	O	
Sporobolus domingensis		Herbs	D		
Sporobolus pyramidatus		Herbs	R-O		O
Stachytarpheta jamaicensis	Vervine	Herbs			F
Stenotaphrum secundatum	Pimento Grass	Herbs	R		
Stylosanthes hamata	Cheesy Toes	Shrubby Herbs		A	F-A

Species	Common Name	Growth Form	Beach	Transition	Highlands
Suriana maritima	Bay Cedar	Shrubs	O		
Tecoma stans		Shrubs			O
Teramnus labialis		Epiphytes			O
Terminalia catapppa	West Indian Almond	Trees	R		
Thespesia populnea	Seaside Mahoe	Trees	F-A	O	
Thrinax parviflora[11]	Broom Thatch	Trees			F
Tragia volubilis	Twining cowitch	Epiphytes			R
Trophis racemosa	Ramoon	Trees			R-O
Turnera ulmifolia	Ram Goat Dashalong	Shrubs	R-O		R
Waltheria indica	Raichie	Shrubby Herbs	R	R	
Wedelia trilobata	Creeping Ox-eye	Runners	R		
Ziziphus sarcomphalus[1]		Trees			R
Zuelania guidonia	Cuffey Wood	Trees			R

[11] Endemic