4.0 DESCRIPTION OF THE ENVIRONMENT

4.1 Physical

4.1.1 Climate

Rainfall

The 30 Year (1951 – 1980) monthly mean rainfall for Negril ranges from a low of 37 mm in January to a high of 186 mm in October. The rainy season is from May to October and the dry season from November to April (Figure 1). The 10 and 25 Year Return Period, maximum 24-Hour rainfall for Negril is 159 mm and 194 mm respectively.

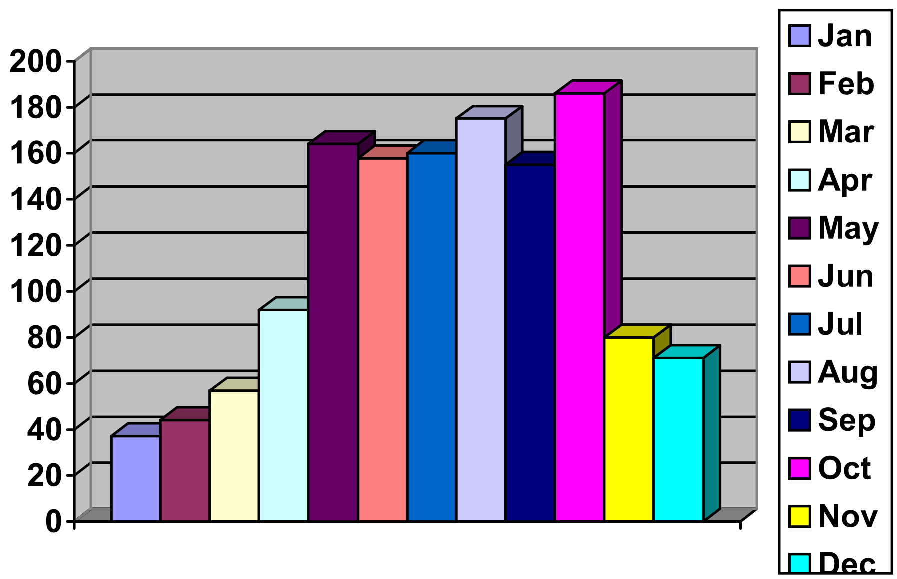

Figure 4.1 - Monthly Rainfall Distribution - Negril Point

The mean monthly temperatures are lowest in January and February (23.6°C) and highest between August and September (26.6 °C). The mean monthly relative humidity ranges between 76.8 and 80 percent. Relative humidity is low in the afternoon and high in the evenings. Mean monthly values of daily sunshine hours range between 7.0 and 8.0.

The dominant wind direction is north-east, with a frequency of 37.2 percent, consistent with the north-east trade winds. Winds from the south south-east has a frequency of 22.9 percent (Table 4.1). No data on wind speed was obtained for the project area. Wind speed for the Sangsters International Airport, Montego Bay , ranges from 4.5 m/s in September and October to 6.0 m/s in July.

Table 4.1: Wind Direction and Frequency - Negril Lighthouse

Wind Direction	***Frequency (%)***
North-East	37.2
East	11.7
South-East	22.9
South	5.2
West	1.4
North	16.0

Source: National Meteorological Service, Jamaica

4.1.2 Topography, Soils and Geology

The proposed site is relatively flat with elevation generally less than 3.0 m above mean sea level and gently sloping towards the north. The Norman Manley Boulevard that forms the southern boundary, separates the site from the Negril Morass.

The soils type at the site is typically dark-brown to black, sandy, organic and typically less than 0.3 m thick. Below the soil layer is a sequence of limestone sands mixed with silt and minor clay fraction. The depth of the sand sequence varies from 5.0 m to 11.0 m below ground level. The thickness of the sand sequence decreases from west to east. Isolated layers of peat were observed in some of the exploratory boreholes drilled at the site. Underlying the sand sequence is a hard compact limestone sequence. The formations occurring below the site are members of the Lower Coastal Group.

Hydrology

The site is located in the Negril Sub-Basin of the Cabaritta Basin. The closest perennial stream is the Orange River, which is north of the site. There are no streams (perennial or seasonal) crossing the site. Surface water hydrology at the site is related primarily to stormwater runoff from the main road to the site, stormwater runoff generated on the site and possible overflow from the wetlands/morass.

Under present conditions, stormwater generated on the main road enters the site via a number of earth drains. Given the high permeability of the sand sequence below the site, no significant surface runoff is generated from the site under present condition. The vegetation cover and burrowing actions of a number of organisms have also significantly improved the infiltration capacity of the soil. With the exception of areas with road, there are no surface water detention ponds on the site as a result of stormwater generated from the main road or on the site.

The main road is higher than the site and the morass on the opposite site of the road. The North and South Negril River and Orange River are in hydraulic continuity with the morass. It is therefore unlikely that there would be overflow from the morass to the site. Reviews of the available literature have not recorded this phenomenon occurring in the past.

The groundwater table at the site was recorded in the exploratory boreholes at approximately 0.5 m below ground level. The groundwater below the site is known to be saline, representing seawater. The groundwater gradient is extremely low and therefore there would be no significant groundwater flow below the site.

4.2 Terrestrial Survey

4.2.1 Terrestrial Flora

4.2.1.1 Introduction

The flora of the proposed sites for the construction of RIU Phase 2 and the parking lot were assessed using transects. At site R1 (allocated for the hotel), four transects were placed from the beach to the road in accordance with the quadrants outlined on the topographic map (Haddad, 2001). The transects were centralized with respect to each lot/quadrant in order to gain a representation of the vegetation present. Each species encountered, was recorded in terms of height, diameter at breast height (DBH), percentage cover and where identification in the field was not possible, a sample was taken.

Based on the hotel design provided, a floral assessment was conducted in a 30m belt (from the sea inwards) in which, trees of DBH >18cm was sprayed/flagged to be used as a guide of the trees to be maintained during vegetation clearance and hence to remain throughout the development.

At site R2 (the proposed parking area), floral assessment was conducted using a belt transect, 60m by 10m. The vegetation encountered were recorded and where necessary, taken as samples. Height, DBH and percentage cover were also recorded.

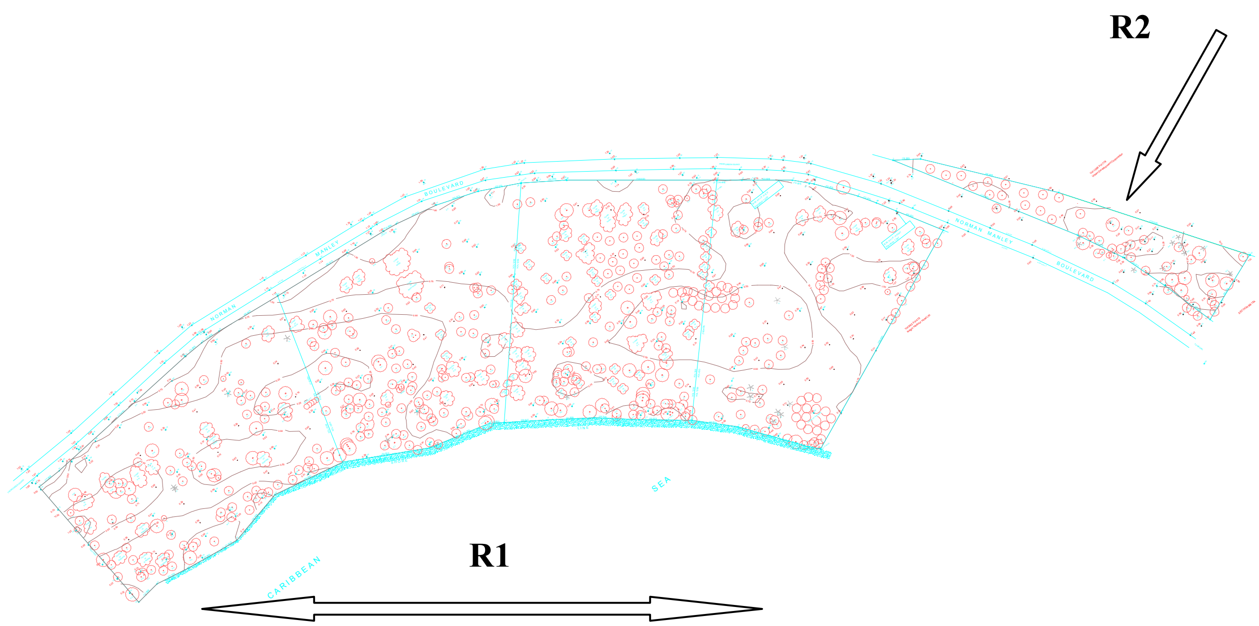

Figure 4.2: Topographic Map showing sites R1 & R2

4.2.1.2 Description of the Floral Environment

Site R1

The proposed site for the construction of the hotel (shown as R1) consisted mainly of trees and few herbs and exhibited a zonation from the beach to the road. The beach, at the beginning of the property was relatively sparse except for the presence of coastal vegetation such as *Cocoloba uvifera* (Sea grape), *Conocarpus erectus* (Button mangrove), *Thespesia populnea* (Seaside mahoe), *Ipomoea pes-caprae* (Beach morning glory), the coastal grass, *Sporobolus*, and large trees of *Calophyllum calaba* (Santa Maria), *Dalbergia ecastaphyllum* and *Terminalia catappa* (West Indian Almond). The striking Spider Lily, *Hymenocallis littoralis* was fairly abundant. The width of the beach decreased towards the edge of the property due to overgrowth of the above-mentioned vegetation and ended in a stand of *Rhizophora mangle* (Red mangrove). Associative species of this stand were *Ipomoea* sp., Seaside Mahoe and Almond.

The change in vegetation was evident approximately 3m - 14m from the shoreline and was dependent on the section of the beach being assessed. The dominance of microphyllous leaved trees, for example, *Bucida buceras* (Black Olive) and *Haematoxylum campechianum* (Logwood), allows this forest to be classified as strand woodland. Species typically found in this type of woodland are *Piscidia piscipula* (Dogwood), *Morinda citrifolia* (Hog Apple) and *Colubrina asiatica* (Hoop With), all of which were observed on-site. These trees were also found in association with coastal plants, such as Sea grape, Button mangrove, Seaside mahoe and *Dalbergia ecastaphyllum*. Occasionally, smaller palms were observed in the under-storey. At the edges of the woodland (by the road) were grassland clearings, with herbs such as *Sida acuta* (Broomweed), *Bidens pilosa* var. *radiata*, *Rhynchospora nervosa* (Stargrass), *Stachytarpheta jamaicensis* (Vervine) and *Wallenia tribolata* (Marigold).

The floral assessment conducted within the 30m belt transect (shore towards inland) of the strand woodland revealed a forest floor with little or no leaf litter, straggling vines {*Ipomoea* sp. and

Mikania micrantha (Guaco)}, climbers {*Philodendron* sp. and *Syngonium auritum* (Five finger)} and an intra-zonation between under-storey and trees. This was evident as the forest changed from dense under-storey to tree dominated (GPS 781 243E, 2031 560N) and then from tree dominated to a dense under-storey (GPS 781 355E, 2031560N). Approximately 85 trees were sprayed/flagged along this transect, including the endemic, *Roystonea princeps* (Swamp Cabbage). The trees exhibited DBH >18cm and should be used as a guide, prior to vegetation clearance. The presence of *Cecropia peltata* (Trumpet Tree) and *Piper amalago* (Jointer) in abundance indicates that the woodland is disturbed and as such, may be described as a disturbed strand woodland. Although the site is considered disturbed, the upper canopies of the trees provide a feeding and nesting area for birds present. The significance of the forest for food is not limited to avifauna but to other animals, which may be present, for example, lizards and frogs (epiphyte).

In total, site R1 exhibited approximately 64 species of plants (Appendix 6), of which, three were endemic and two rare. The endemics observed were *Roystonea princeps* (Swamp Cabbage), *Thrinax* sp. and *Hohenbergia negrilensis*. The rare specimens found on-site were the orchid, *Tropida polystachya* and the tree, *Phyllanthus acuminatus*.

Site R2

Site R2, the proposed site for the parking area is located in the remainder of the mixed-swamp margin forest bordering the Negril Morass. This type of forest was characterised by Coke *et al* (1983), of which three types were identified, namely, *Roystonea*, *Conocarpus* and *Sabal* swamp margin forests.

The swamp forest that coincides with the present location of site R2 is the *Conocarpus erectus* (Button mangrove) swamp forest. This association was found to the east and west of the Morass. There were also located in the centre of the Morass surrounded by hummocks of *Cladium*. Coke *et al* (1983) reported that on the western side of the Morass, *Conocarpus* was found with *Roystonea*, *Terminalia latifolia* (broad-leaf), *Hibiscus tiliaceus* (seaside mahoe), *Thespesia* *populnea*, *Bucida buceras* (black olive), *Ficus maxima* (fig), *Artocarpus altilis* (breadfruit) and *Spathodea campanulata* (flame-of-the-forest). Shrubs and scramblers formed impenetrable thickets on the fringes of the *Cladium* formation. Shrubs included *Dalbergia ecastaphyllum* (malanti), *Chrysobalanus icaco* (coco plum), *Pavonia spicata*, *Malpighia* and the giant fern *Acrostichum aureum*. Climbers included *Urechites*, *Rhabdadenia*, *Philodendron*, *Passiflora oblongata* and *Ipomoea tiliacea*. *Tillandsia* represented the epiphytes.

On-site investigation revealed that some of the vegetation denoted for this type forest was not present. However, a few were observed, namely, *Roystonea princeps*, *Ficus* sp., *Philodendron* sp., *Ipomoea* sp. and *Tillandsia* as the dominant epiphyte. Although species listed for this type forest were not encountered in the sample areas, it does not mean they do not exist. The site, however, does reveal signs of disturbance. This is indicated by the presence of *Cecropia peltata* (Trumpet tree) and *Bursera simaruba* (Red Birch).

Generally, the vegetation consisted mainly of an open canopy forest divided into two strata. The first strata consisted of trees, 16m – 30m tall (two *Roystonea* encountered were 13m – 15m tall) and the second (the under-storey), 8m tall. Majority of the trees observed had DBH >20cm. The forest floor exhibited saplings ≤1m in height, and was devoid of leaf litter. The forest is also a climax (mature) community in which the saplings present on the forest floor will replace the existing plants over a period of time. Some of the trees observed, were over 100 years old, for example, a *Haematoxylum campechianum* (Logwood) tree that supported at least 6 clumps of the endemic epiphyte, *Hohenbergia negrilensis*. The importance of this forest is not limited to the growth of new species or supporting orchids and bromeliads, but serves as a nesting area for birds, especially in the upper canopy of the trees and therefore, should remain intact and be preserved.

In total, twenty-four (24) species (Appendix 7) were identified at this site, of which two were the endemics, namely *Roystonea princeps* and *Hohenbergia negrilensis*.

4.2.1.3 Endemic, Rare and Endangered Species

Floral assessment of both sites has revealed the presence of three (3) endemics and two (2) rare species.

Table 4.2: Endemics and rare plants of site R1

Species	***Growth form***	***DAFOR Rating***	***#'s found***	***Notes***
Roystonea princeps	Tree	O	10	***Endemic***. Restricted to western parishes. Found in all four quadrants (as outlined on the topographic map).
Thrinax sp.	Tree	R	3	***Endemic***. Found in the fourth quadrant.
Hohenbergia negrilensis	Epiphyte	R	2	***Endemic***. Restricted to western parishes. Found on two trees in the third quadrant, which were flagged. GPS 781 443E, 2031 554N GPS 781 388E, 2031 615N
Tropida polystachya	Orchid	R	1	***Rare***. Found in central and western parishes in deep leaf litter and shady forest. Found along 30m transect.
Phyllanthus acuminatus	Tree	R	1	***Rare***. Known in Jamaica and limited only from Bloody Bay and Booby Cay.

Table 4.3: Endemics of site R2

Species	***Growth form***	***DAFOR Rating***	***NOTES***
Roystonea princeps	Tree	F	***Endemic***. Restricted to western parishes. Found in all four quadrants (as outlined on the topographic map).
Hohenbergia negrilensis	Epiphyte	F	***Endemic***. Restricted to western parishes. Found on two trees in the third quadrant, which were

4.2.1.4 Keystone species

Keystone species are present within diversified ecosystems located in Jamaica and the removal or decline of such, would trigger changes. Three species observed on both sites would serve as keystone species. These are the tree, *Roystonea princeps* (Swamp Cabbage), the epiphyte, *Hohenbergia negrilensis* and the bromeliads, *Tillandsia* sp. Swamp Cabbage, due to its height and spreading branches would serve as a nesting and food source for avifauna present on-site. Both *Hohenbergia* and *Tillandsia* would provide food, water, nesting and breeding ground for avifauna present as well as for frogs and invertebrates.

4.2.2 Terrestrial Fauna

4.2.2.1 Survey Methodology

Site #1 - The proposed RIU Hotel development site:
A preliminary walk through survey of terrestrial fauna, frequenting and inhabiting the proposed RIU hotel development site, was conducted on September 12, 2001; between the hours of 5:30 am and 10:00 am. The type of terrestrial fauna, and the sections of the project site of highest faunal activity, was determined. Bird counts, and non-quantitative (cursory) surveys of other fauna, were subsequently conducted within the determined areas of highest activity over the four days of ensuing field surveying (from September 13 to September 16, 2001).

With regards to avifauna, two locations were identified as areas of dominant bird activity. These were, respectively:

- in the vicinity of the proposed tennis courts/proposed Hotel Block #1 (in the center of the site, at GPS coordinates:CUTM **Zone 17** 781378E 2031614N (WGS84)); and
- in the vicinity of proposed Hotel Blocks #3 and #4 (in the underbrush/woodland, within the northwestern section of the site, at GPS coordinates:CUTM **Zone 17** 781202E 2031622N (WGS84)).

On September 13, 14 & 15, 2001, three bird counts (i.e. one morning and two evening counts) were conducted at Avifauna Site #1, located at the proposed tennis courts/proposed Hotel Block #1; UTM **Zone 17** 781378E 2031614N (WGS84). The results of these counts are presented in Table 4.4. A fourth (combined) morning count was subsequently carried out on September 16, 2001 beginning at Avifauna Site #1 and concluding at Avifauna Site #2, located at proposed Hotel Blocks #3 and #4; UTM **Zone 17** 781202E 2031622N (WGS84). The results of this fourth count are also presented in Table 4.4.

As indicated in Table 4.4, morning avifauna counts were typically three hours in duration and was conducted between the hours of 5:30 am and 8:30 am; whilst evening counts were one hour in duration and was conducted between the hours of 5:30 pm and 6:30 pm. A 100 m radius, around Avifauna Sites #1 and #2, was surveyed during each given point count event. This 100 m radius effectively encompassed and included habitats representative of all the major terrestrial habitats found at the site; namely grassed clearings, thick understorey vine/shrub woodland and the closed canopy woodland with negligible understorey vegetation.

With regard to turtles, special attention was paid to the beach during the five day period of terrestrial surveys, specifically for evidence of site use by the five species of sea turtle known to frequent Jamaican coastal waters. In this respect, the entire length of site shoreline was surveyed (at least once a day during the early morning hours of September 12 to September 16, 2001) for signs of turtle activity and turtle tracks.

Site #2 - The proposed RIU parking lot site:

Terrestrial fauna at the proposed RIU parking lot site was surveyed only once during field work for the EIA. A single two hour "walk through"-type avifauna survey was conducted, along the length of the proposed site, to obtain an indication of species diversity and individual abundance through listing and counting the number of species and individuals observed and heard during the walk. The survey was conducted on September 16, 2001, between the hours of 9:30 am and 11:30 am and the results of the census are presented in 4.5. Other fauna was surveyed and qualitatively recorded during the two-hour walk.

4.2.2.2 Avifauna

Birds are good indicators of environmental quality. Species diversity (the relative numbers of different species) is dependent upon the diversity of habitats available for roosting, foraging and feeding in an area. In general, high species diversity and high numbers of individuals (i.e. individual abundance) are indicative of a healthy and diverse ecosystem.

Table 4.4 lists the species observed during the fours (4) days of bird counts at the proposed RIU hotel development site, and Table 4.5 lists the species observed during the two hour walk through survey at the proposed RIU parking lot site. A total of eighteen (18) different bird species, and seventy-four (74) individuals, were observed during the count and the walk through surveys conducted at the two sites.

Overall, it was surprising to find that species diversity was so low (i.e. only 18 different species of observed birds) considering the fact that both the proposed hotel and proposed parking lot sites are both relatively remote and undisturbed. The most plausible explanation for the low species diversity (and individual abundance numbers) is probably the correspondingly low habitat diversity and the overall nature of the floral habitat observed at the sites. With the exception of grassed clearings and those sections of the proposed hotel site that did support heavy understorey vines, both proposed sites were typically woodlands with little or no understorey vegetation/growth with bare, exposed ground cover, devoid of leaf litter. There were, therefore, few available habitats for concealment, foraging and nesting, other than within the tree canopy itself, and therefore both sites were found to be less than ideal for supporting large and diverse bird populations.

Table 4.4 Bird species observed at the proposed RIU hotel site.

FAMILY	SPECIES NAME	COMMON NAME	NUMBERS 13th Sept. 2001 5:30-8:30 am	14th Sept. 2001 5:30-6:30 pm	15th Sept. 2001 5:30-6:30 pm	16th Sept. 2001 5:30-8:30 am	STATUS*
Apodidae	*Streptoprocne zonaris*	White-collared Swift	-	-	3	2	CR
Apodidae	*Tachornis phoenicobia*	Antillean Palm Swift	-	3	2	-	VCR
Columbidae	*Columba leucocephala*	White-crowned Pigeon	1	-	2	-	CR
Columbidae	*Columbina passerina*	Common Ground Dove	-	-	1	1	VCWR
Columbidae	*Zenaida aurita*	Pea Dove	3	-	-	-	CR
Emberizidae	*Coereba flaveola*	Bananaquit	3	1	2	4	CWR
Emberizidae	*Dendroica petechia*	Yellow Warbler	1	1	3	2	CR
Emberizidae	*Mniotilta varia*	Black-and-white Warbler	2	1	1	1	CWV
Emberizidae	*Tiaris bicolour*	Black-faced Grassquit	3	1	-	2	CR
Picidae	*Melanerpes radiolatus***	Jamaican Woodpecker	-	-	1	-	CWR
Trochilidae	*Mellisuga minima***	Vervain Hummingbird	-	-	-	1	VCR
Tyrannidae	*Myiarchus barbirostris***	Sad Flycatcher	1	2	2	1	CR
Tyrannidae	*Tyrannus caudifasciatus*	Loggerhead Kingbird	4	2	1	2	CW
TOTAL			**18**	**11**	**18**	**16**	

* Based on Downer & Sutton, 1990

Table 4.4's STATUS KEY: ** Endemic species

R	=	*Rare*	*VCWR*	=	*Very Common &Widespread Resident*
C	=	*Common*	*CSR*	=	*Common Summer Resident*
CR	=	*Common Resident*	*AR*	=	*Abundant Resident*
VCR	=	*Very Common Resident*	*VCSR*	=	*Very Common Summer Resident*
CW	=	*Common & Widespread*	*WV*	=	*Winter Visitor*
CWR	=	*Common & Widespread Resident*	*CWV*	=	*Common Winter Visitor*

Table 4.5 Bird species observed during the walk through survey at the proposed RIU parking lot site.

FAMILY	*SPECIES NAME*	*COMMON NAME*	*NUMBERS 16th Sept., 2001 9:30-11:30 am*	*STATUS**
Corvidae	*Corvus jamaicensis***	Jamaican Crow	2	C
Emberizidae	*Coereba flaveola*	Bananaquit	2	CWR
Emberizidae	*Loxigilla violacea*	Greater Antillean Bullfinch	3	CR
Picidae	*Melanerpes radiolatus***	Jamaican Woodpecker	1	CWR
Trochilidae	*Anthracothorax mango***	Jamaican Mango	1	CR
Trochilidae	*Trochilus polytmus polytmus***	Red-billed Streamertail	1	CR
Turdidae	*Turdus aurantius***	White-chinned Thrush	1	VCR
TOTAL			**11**	

* *Based on Downer & Sutton, 1990*

STATUS KEY: ** Endemic species

R	=	*Rare*	*CSR*	=	*Common Summer Resident*
C	=	*Common*	*AR*	=	*Abundant Resident*
CR	=	*Common Resident*	*VCR*	=	*Very Common Resident*
UCR	=	*Uncommon Resident*	*WV*	=	*Winter Visitor*
CW	=	*Common & Widespread*	*CWV*	=	*Common Winter Visitor*
CWR	=	*Common & Widespread Resident*	*E*	=	*Endangered*

As a result most of the birds observed during the bird counts conducted at the proposed hotel site were mainly restricted to those areas of the hotel site which were characterised by (a) disturbed/grass clearings (found adjacent to Norman Manley Boulevard) and, to a lesser extent, (b) fairly dense understorey vines and growth. In the remaining sections of the hotel site, where bare sand and large phanerophytes were typical, bird species and numbers were low and restricted to the canopy of the trees.

At the proposed parking lot site, where ground and understorey vegetation was virtually absent, avifauna activity was restricted to the canopy of tall trees; and the *Acrosticum aureum* wetland/morass adjacent to, and east of, the site. Particularly at the proposed parking lot site, tree cover and the relatively closed forest canopy is extremely important to avifauna activity and should therefore left intact and undisturbed. Individuals were characteristically absent within the understorey, and on the forest floor, and were only observed and heard within the tall tree canopy at this site. Despite the overall low total numbers of species observed during the 4 days of surveying, an overall total of seven (7) different endemic bird species were observed between the two sites.

<u>Details of Avifauna at The Proposed RIU Hotel Site</u>

Thirteen (13) different species were observed during the three hour morning and one hour evening counts conducted between the hours of 5:30-8:30 am and 5:30-6:30 pm (on September 13, 14, 15 and 16, 2001) at the proposed RIU hotel site (see Table 4.4). Sixty-three (63) individuals were observed, however, a number of these individuals (particularly the quits, warblers and tyrant flycatchers) are believed to reside on the site and were therefore probably surveyed more than once during the 4 day survey period. Site resident species and individuals are believed to include *Coereba flaveola* (Bananaquit), *Dendroica petechia* (Yellow Warbler), *Mniotilta varia* (Black-and-white Warbler), *Tiaris bicolor* (Black-faced Grassquit), endemic *Myiarchus barbirostris* (Sad Flycatcher) and *Tyrannus caudifasciatus* (Loggerhead Kingbird).

Of the thirteen (13) species observed during the survey, three (3) are reported as endemic to Jamaica. These were *Melanerpes radiolatus* (the Jamaican Woodpecker), *Mellisuga minima* (Vervain Hummingbird) and *Myiarchus barbirostris* (Sad Flycatcher). These endemic species, along with the species that are thought to be resident on the site, are discussed and described in greater detail below.

Melanerpes radiolatus (the Jamaican Woodpecker) is an endemic widespread and common resident at all elevations throughout the island. It is found from coastal coconut groves to forested mountain summits, including both dry and wet forests, forest edges, woodlands, shade coffee plantations and gardens. *M. radiolatus* feeds on insects and larvae by characteristically chipping away at rotten wood and tree barks to get at these organisms. *M. radiolatus* breeds most of the year, primarily from December to August, with two to three broods being raised each year. Nests are primarily excavated by the male and are typically a hole in a tall dead tree.

The Vervain Hummingbird (*Mellisuga minima*) is a very common year-round resident, found only in Jamaica and Hispaniola. *Mellisuga minima minima* is an endemic subspecies to Jamaica. *M. minima* is generally found in all open areas which support small flowers inclusive of open woodlands, but tends to be absent in dense forests. It feeds on the nectar of small flowering plants. The single individual, observed at the proposed hotel site, is believed to be a site visitor and probably does not reside or nest on the project site.

Myiarchus barbirostris (Sad Flycatcher) is the only endemic species believed to reside on the project site. This species was observed (as single individuals and in pairs) on more than one occasion frequenting surrounding vegetation and *Coccoloba* stands, found in the vicinity of proposed RIU Hotel Block #1 (at GPS coordinates CUTM **Zone 17** 781416E 2031587N (WGS84)). This tyrant flycatcher typically perches 3 - 9 m above ground and sallies to catch small insects from leaves and surrounding vegetation. Preferred habitats include forests and woodlands, from lowlands to middle elevations. *M. barbirostris* nests are typically constructed of vegetation in a diverse range of cavities, including woodpecker holes and house eaves.

The site-resident quits (*Coereba flaveola* and *Tiaris bicolor*) and the site-resident warblers (*Dendroica petechia* and *Mniotilta varia*) generally all inhabit and nest within surrounding vegetation of a given site, which may be a range of environments. *D. petechia* tends to prefer to nest within mangroves and coastal scrub. With regard to food, *C. flaveola* (Bananaquit) prefers the nectar of flowering plants and *T. bicolor* prefers small grass seeds. The warblers (*D. petechia* and *M. varia*) tend to feed on insects and spiders.

Details of Avifauna at The Proposed RIU Parking Lot Site

Seven (7) different species were observed during the two-hour walk through survey conducted at the proposed RIU parking lot site (see Table 4.5). A total of eleven (11) individuals were observed.

Of the seven (7) different species observed during the survey, five (5) are reported as endemic to Jamaica. These were *Corvus jamaicensis* (the Jamaican Crow), *Melanerpes radiolatus* (the Jamaican Woodpecker), *Anthracothorax mango* (Jamaican Mango), *Trochilus polytmus polytmus* (the Red-billed Streamertail Hummingbird) and *Turdus aurantius* (White-chinned Thrush); and are discussed and described in greater detail in the remain paragraphs that follow.

Site resident species could not be firmly ascertained, based on the single two-hour walk through count carried out at this site. However, the possibility of site resident species, based upon the type of vegetation at the site and the nesting characteristics of the species observed, is also discussed within the remainder of this subsection.

Corvus jamaicensis (the Jamaican Crow) is a locally common endemic to Jamaica. It is most often encountered in the Cockpit Country, the John Crow Mountains and, to a lesser extent, Moneague and Worthy Park. However, it is also thought to be extending its range into Westmoreland and Manchester (Downer & Sutton, 1990).

C. jamaicensis is omnivorous, commonly feeding on fruit, the eggs of other birds, and lizards. This species also typically forages in bromeliads and under tree bark working its way through tree epiphytes and tree crevices for invertebrates, frogs and water. It is also known to take crabs, larvae and grub.

Given the expanding range of *C. jamaicensis*, coupled with the number of tree bromeliads observed in the relatively secluded and undisturbed proposed parking lot site, it is not all that surprising to find that this species of bird has found a suitable feeding habitat in the area. No actual *C. jamaicensis* nests were observed during the avifauna survey; however, this does not exclude the fact that this endemic may also be nesting on the proposed parking lot site. *C. jamaicensis* nests are typically built high within a tall tree and are usually recognised as a crude platform of sticks and other plant material.

The endemic *Anthracothorax mango* (Jamaican Mango) is widespread and common throughout the island, particularly in coastal and lowland areas. It feeds on insects and the nectar of flowers of trees, cacti and shrubs and is the only Jamaican hummingbird that feeds extensively at cactus flowers. *A. mango* breeds and nests year-round within forest edges, banana plantations, gardens and mangroves.

Trochilus polytmus polytmus (the Red-billed Streamertail Hummingbird) is similar in status and range as *A. mango*, with the exception that it is not found in the extreme eastern sections of Jamaica (including the John Crow Mountains). *T. polytmus polytmus* is found seasonally along the coast, feeds on nectar and small insects and breeds year-round; mainly from October to March.

Although no actual nests of *A. mango* and *T. polytmus polytmus* were observed, it is also highly possible that these hummingbirds not only feed within the tall flowering trees on the site, but also nest there as well.

Endemic *Turdus aurantius* (White-chinned Thrush) is also widespread and common throughout the island. It forages primarily on the ground for a wide range of prey including slugs, lizards, insects, berries, frogs, mice and even small birds. Its primary habitats are forests, woodlands, road edges, cultivated areas and gardens in mountains at mid and high elevations. It is regularly observed in lowlands and appears to be somewhat tolerant of disturbed vegetation, although it is less frequently observed at these elevations. *T. aurantius* tends to be found at lower elevations during its non-breeding season which occurs most of the year. This species breeds from May to July and typically builds its nest in a shrub, tree or at the base of a palm frond.

Given the flight range of *T. aurantius*, its preferred mid to high elevation habitat and the relatively close proximity of the hills east of the project site and the Great Morass, it is unlikely that the White-chinned Jamaican Thrush actually breeds and nests on the proposed parking lot site. The site is most likely used primarily as a hunting and foraging ground for this species.

For similar reasons, although it cannot be ascertain for sure, the Jamaican Woodpecker (*Melanerpes radiolatus*) also probably does not actually nest on the proposed parking lot site preferring the woodlands and forested hills towards the east of the site. Having said this, *M. radiolatus* is more likely to be found nesting in one of the trees of the proposed parking lot site than *T. aurantius* (White-chinned Thrush). If present, it will prefer one of the softer wood palms on the site, or a similar tall dead tree (typically 5-10 m in height), for nesting.

4.2.2.3 Other Terrestrial Fauna

In addition to avifauna, several species of crab were observed and are believed to frequent and inhabit both the proposed hotel and the proposed parking lot sites. These species include:

- *Gecarcinus lateralis* (Black Land Crab),
- *Ucides cordatus* (Mangrove Land Crab), and
- *Cardisoma guanhumi* (Great Land Crab).

All three crab species tend to feed on fruit and leaves, however; only *G. lateralis* (Black Land Crab) and *C. guanhumi* (Great Land Crab) are themselves edible by humans.

G. lateralis and *U. cordatus* crab holes were numerous throughout both sites, averaging one hole per m^2; with as many as three to four holes per m^2 in the northwestern section of the proposed RIU hotel site and over most of the proposed RIU parking lot sites. Dead individuals of *C. guanhumi* (Great Land Crab) were observed along the Norman Manley Boulevard, adjacent to the proposed hotel site (i.e. killed by cars as they attempted to cross the road onto the site). The Fiddler Crab (*Uca sp*.; known for its large (unequal) claw and common at the edge of marshes and mangrove swamps), and the Ghost Crab (*Ocypode sp*.; an active crab on sandy beaches), were not observed during the site visit.

Small garden frogs (Genus *Eleutherodactylus*) were heard throughout various sections of the proposed RIU hotel site (during the late evening bird counts) and are believed to be inhabitants of both the proposed hotel and the proposed parking lot site. Nineteen (19) species of *Eleutherodactylus* are known to occur in Jamaica, 17 of which are endemic, the remaining two being introduced species. These frogs are all small, generally ranging between 25 and 38 mm in length. They are typically dull coloured shades of brown and grey and are mostly nocturnal spending the day in or beneath logs, under rocks or hidden in the leaf litter of forests. The specific species heard during the site visit could not be identified down to species level (based solely on their calls) but are thought to be one of the four species identified by DHV International Limited (1999); namely *E. cundali, E. johnsoni, E. luteolus* and/or *E. pantoni*.

Four species of tree frog are known to live in Jamaica. *Osteopilus brunneus*, an endemic yet widespread species, is one of these species. It is found at all elevations, may be as large as 75 mm in length and is capable of considerable colour change ranging from dark brown to light grey. *O. brunneus* inhabits and breeds within water trapped with wild tree bromeliads (i.e. 'tank' bromeliads like as *Hohenbergia sp*.), often in large numbers. At least two individuals of *Hohenbergia sp.* were observed on both the proposed RIU hotel site and the proposed RIU parking lot site. *Hohenbergia sp.*, which was particularly abundant at the proposed parking lot site, is most likely supporting at least one species of Jamaican tree frog, along with several other insects and larvae upon which the endemic bird *Turdus aurantius* (White-chinned Thrush) is probably feeding on (see section 4.2.1).

With regards to reptiles, at least two individuals of the endemic green lizard *Anolis garmani* were observed at both the proposed hotel and parking lot sites. This species is characterised by its bright green colour and saw-toothed ridged back.

No turtles, turtle tracks or turtle nests were observed along the shoreline or on the sandy beach of the proposed hotel site. DHV International Limited (1999) reported on the possibility that at least one species of turtle (*Eretmochelys imbricata*) uses the beaches of Bloody Bay and Booby Cay as nesting environments. However, given the small width of the beach, coupled with the dense terrestrial vegetation which grows right up to the waters edge, the possibility that the proposed RIU site is used by nesting turtles is very remote and unlikely. The beaches south of the site, particularly in the vicinity of Grand Lido, are more likely preferred nesting habitats for sea turtles frequenting Bloody Bay than the shoreline of the proposed hotel site. Environmental Solutions Limited (1996) reported that a female Hawksbill (*E. imbricata*) was observed on the Grand Lido Bloody Bay beach in 1995. Approximately, 100 hatchlings were reported to have returned to the sea from a nest on that beach (ESL, 1996).)

Dragonflies and butterflies were few in number; given the absence of significant onsite vegetation capable of supporting large numbers of these animals. However, several termite-like nests of the small black (‘duck’) ant *Crematogaster sp.* were noted within several trees and the dense vegetation on both sites. This ant species helps attract and support the insect eating avifauna which inhabits and frequents the proposed sites.

Mosquitoes are definite pests at both sites and a single individual of the introduced Indian Mongoose (*Herpestes auropunctatus*) was observed, scurrying across Norman Manley Boulevard.

4.3 Marine Ecology

4.3.1 Marine and Benthic Survey Methodology

Seagrass bed communities, immediately offshore of the proposed RIU hotel site and within the proposed fish sanctuary, were snorkelled, assessed and photographed on September 14 and 15, 2001. The coral reef and seagrass bed extent, in and around the fringing reef ecosystem of Little Bloody Bay, was also assessed and photographed on September 14 and 15, 2001 by a combination of exploratory SCUBA diving, snorkelling, towed-diver transects and boat patrolling.

Existing literature and recent aerial photographs on the extent, coverage and nature of existing coral reefs and seagrass beds within and offshore of Bloody Bay were consulted and reviewed. The accuracy and recentness of these accounts was verified during the boat patrolling exercise for an oceanographic/storm surge modelling bathymetric survey carried out on September 15, 2001.

4.3.2 Introduction and Setting

The morphology of the offshore Negril and Bloody Bay marine environments has been extensively surveyed and described by Hendry (1982). The main features of his findings are summarised in Figure 4.3.

Two coastal shelves characterise the offshore topographic, submarine environment of both Negril and Bloody Bay. The first, an inner shelf, is a relatively flat shallow shelf which coincides with the inshore area of Bloody Bay and the offshore region immediately outside the extent of Bloody Bay itself. This inner shelf terminates at a submarine patch reef/cliff structure, approximately 1.3 km offshore, beyond which is found an outer shelf, inner slope, deep reefs and outer slope as described by Hendry (1982) and shown in Figure 4.4.

Seaward of the outer shelf is an offshore region described as the inner slope by Hendry (1982). This inner slope is approximately 400 m wide and dips approximately 1-8^{o} from a depth of 7 m to a depth of approximately 60 m (cp. Figure 4.4). At 60 m water depth, there is a small sill reef which marks the beginning of the sandy outer slope and which eventually drops off to deepwater depths of several hundreds of meters. Figure 4.4 (Line 5) visually depicts these bathymetric features and changes as a vertical (cross-shore) profile, adapted from Hendry (1982). Figure 4.5, summarises the vegetation and benthic-type distribution within Bloody Bay, as reported by Hendry (1982).

A recent marine biology survey was conducted by DHV International Limited (1999), as part of an Environmental Impact Assessment of the existing RIU Tropical Bay all-inclusive hotel. This survey involved a series of SCUBA dives and towed-diver transects, and extensively covered the marine flora and fauna of Bloody Bay, along with its corresponding offshore spur-and-groove/patch reef ecosystems. However, DHV survey **did not** cover or describe in detail the immediate area offshore of the presently proposed RIU hotel site; nor the fringing reef environment of Little Bloody Bay both of which lie (or partially lie) within the buoyed area of the recently proposed Bloody Bay fish sanctuary.

The proposed fish sanctuary has already been demarcated by the Negril Marine Park with delineating marker buoys but its precise boundaries could not be verified by NEPA. It encompasses Little Bloody Bay, Pelican Cay, most of the northern section of Bloody Bay and: of the nearshore/inshore area of the proposed hotel site. The corresponding location of the DHV International Limited (1999) dives and transects is shown in Appendix 8; along with summary lists of the DHV-observed fish, coral, algal, sponge and invertebrate fauna.

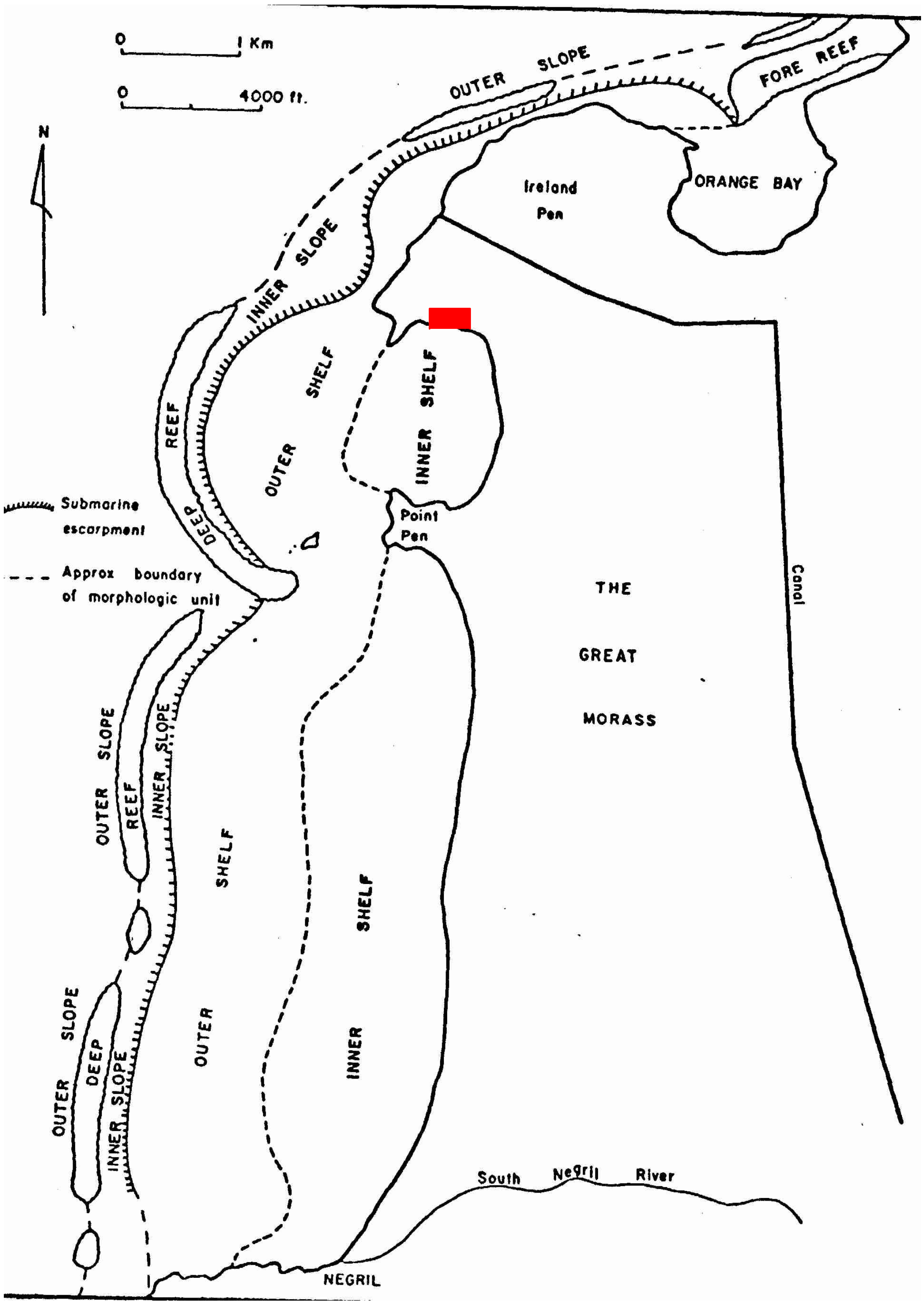

Figure 4.3: Showing approximate location of proposed site and offshore morphology at Bloody Bay

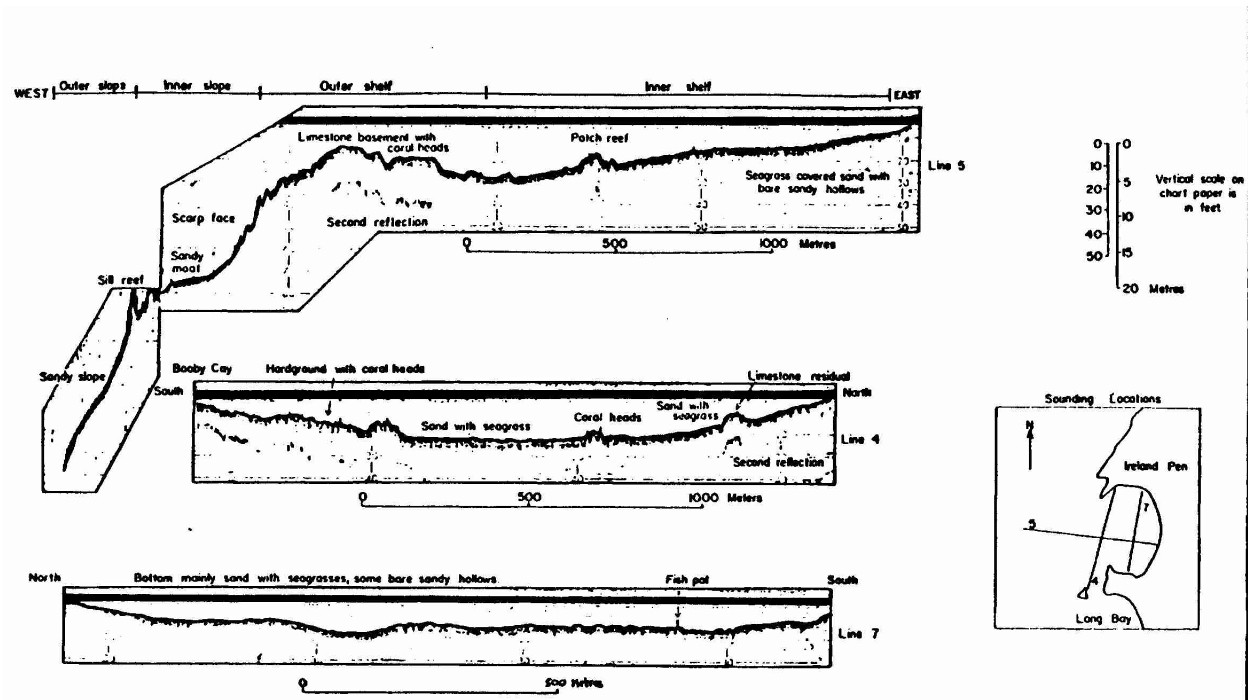

Figure 4.4: Vertical (cross-shore) Profile depicting bathymetric features and changes (adapted from Hendry,1982)

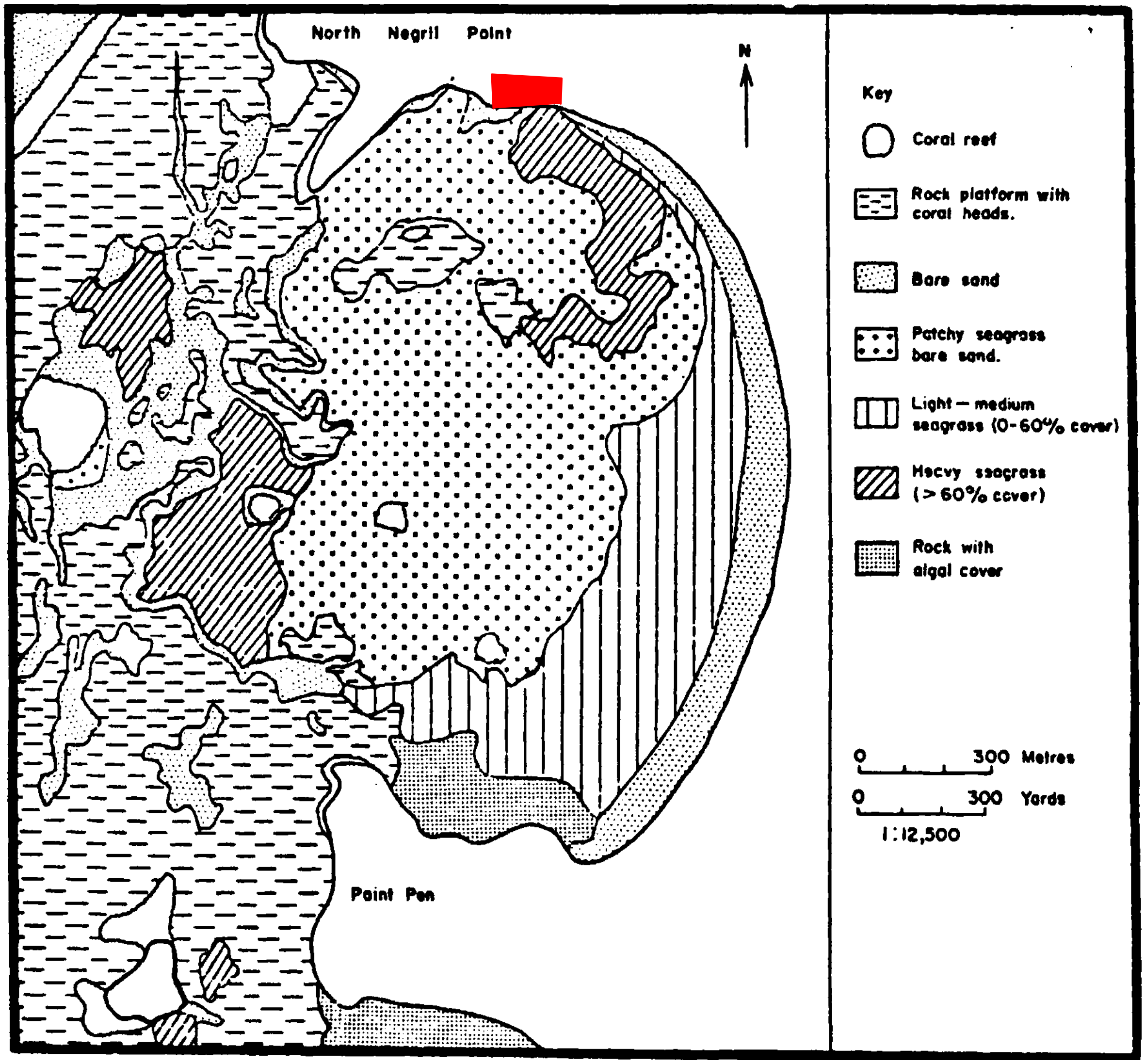

Figure 4.5 : Shows the vegetation, benthic-type distribution within Bloody Bay and proposed site

Overall, DHV International Limited (1999) observed a combined total of 37 different species of fish and 20 different species of stony coral. Their findings indicate that there were no significant changes to the broad physical features, or marine ecology, within Bloody Bay reported and detailed by Hendry (1982) and shown in Figure 4.5.

In summary, DHV International Limited (1999) reported that the coral reefs, offshore of Bloody Bay, were moderately healthy and support an abundant and diverse benthic invertebrate community of stony corals, soft corals, sea fans, sponges, echinoderms and anemones. However, the reef systems themselves were showing signs of stress due to poor/deteriorating offshore marine water quality and heavy use by dive operators.

DHV International Limited (1999) further report that the observed fish populations were also diverse, but low in abundance attributable to pressure from over-fishing.

During the boat patrolling (bathymetry) survey of the current EIA, no significant changes were observed in the overall extent of the benthic communities shown in Figure 4.5 and mapped by Hendry (1982) and DHV International Limited (1999). As reported by DHV International Limited (1999), Bloody Bay was found to be characterised by extensive beds of seagrass, interspersed with patches of sand. The dominant form of seagrass was turtle grass (*Thalassia testudinum*), with manatee grass (*Syringodium filiforme*) being found interspersed throughout. Boat patrolling during the present EIA revealed a mosaic of seagrass communities, intermixed with sand patches. A few coral heads were noted along the rocky coastlines of Rutlands Point and North Negril Point.

Finally, specific to the present EIA, the seagrass beds immediately offshore of the project site, along with the fringing coral reef ecosystem of Little Bloody Bay (both of which lie within the proposed fish sanctuary and were not surveyed in detail by DHV) were surveyed and photographed during consecutive SCUBA dives and snorkelling exercises, conducted on

September 14 and 15, 2001. These two areas are characteristic representatives of the present-day conditions and main ecosystems found within the proposed fish sanctuary. They would also, in turn, be the primary marine and established coral reef ecosystems to be negatively impacted by deteriorating water quality associated with poor wastewater disposal practices at the proposed site and declining ground and marine water quality within the northern sections of Bloody Bay. A detailed account and discussion of the findings of the surveys of these two areas is discussed in the following two subsections. In summary, comparison with the DHV survey, a combined total of 24 different species of fish and 10 different species of stony coral were observed during the present survey (i.e. offshore of the project site and at Little Bloody Bay). Of the 37 different species of fish and 20 different species of stony coral observed by DHV International Limited in 1999, 18 fish and 5 stony coral species were observed during the present survey.

4.3.3 The Seagrass Environment Immediately Offshore of the Proposed Site (and Within the Fish Sanctuary)

The benthos immediately offshore of the proposed RIU hotel site was comprised of coralline sediment which supports a moderately thick *Thalassia testudinum* community of 70% - 80% ground coverage. Average water depths, within this region, are generally less than 2 m.

The *T. testudinum* (turtle grass) beds become fairly extensive, with 100% bottom coverage, approximately 20 m immediately offshore. Associated with the seagrass beds are echinoderms such as *Diadema antillarum* (Plate 4.1), *Tripneustes ventricosus* and *Oreaster reticulatus*, along with holothurians and calcareous algae such as *Halimeda monile* and *Amphiroa sp*. Manatee grass (*Syringodium filiforme*) was observed interspersed throughout the turtle grass bed community and *Halodule wrightii* seagrass beds were observed close to shoreline in the northern and northeastern sections of Bloody Bay.

Plate 4.1: ***Photo of* Diadema antillarum**

Algal species observed during the snorkel surveys are listed in Table 4.6 and exhaustive lists of the observed coral, fish and invertebrate species are presented within Appendix 9.

Table 4.6 Marine algal species observed within the seagrass/coral bed community of the fish sanctuary, immediately offshore of the proposed RIU hotel site.

	Classification		
	Green Algae (*Chlorophyta*)	Brown Algae (*Phaeophyta*)	Red Algae (*Rhodophyta*)
Species	*Chaetomorpha linum** *Dictyosphaeria cavernosa** *Codium isthmocladum* *Avrainvillea nigricans* *Penicillus pyriformis* *Halimeda monile*	-	*Amphiroa sp.*

*Species marked by * are high nutrient indicating species.*
*Species marked by ** are reef building, red encrusting algal species.*

Two high nutrient indicating algal species (i.e. *Chaetomorpha linum* and *Dictyosphaeria cavernosa*) were observed during the survey, suggesting that there are already eutrophic waters within the fish sanctuary and offshore of the proposed RIU hotel site. Water clarity within this section of Bloody Bay, however, was exceptionally good (i.e. horizontal visibility was approximately 30 - 40 m).

Observed fish species were diverse and abundant, however, mainly concentrated around patches of coral heads found east of Pelican Cay and interspersed throughout the seagrass beds (see Appendix 9). Observed coral species were primarily the Starlet Corals (*Siderastrea radians* and *Siderastrea siderea*). The Rock-boring Urchin (*Echinometra lucunter*) was also observed within these coral head communities, breaking down coral rubble.

A single Moon Jelly (*Aurelia aurita*) was photographed in the surface waters above the T. *testudinum* beds (Plate 4.2). This species is mildly toxic to humans and can sting bare sensitive skin causing a slight itchy rash. Similarly mildly toxic species, also observed with the *T. testudinum* beds, include the Upsidedown Jelly (*Cassiopea frondosa*) and the fire worm *Hermodice carunculata*. Blade Fire Coral (*Millepora complanata*) was observed in conjunction with the coral head communities scattered throughout the seagrass bed east of Pelican Cay. This species produces minor rashes/welts upon contact with bare skin.

Plate 4.2: A Moon Jelly (*Aurelia aurita*)

A shallow protective fringing reef (with a back reef lagoon) is located west of the proposed RIU hotel site (within the proposed fish sanctuary), at the mouth of Little Bloody Bay. This fringing reef the closest defined coral reef to the project site and would probably be the first established reef ecosystem to be negatively impacted by deteriorating water quality associated with poor wastewater practices at the site and declining ground and marine water quality within the northern sections of Bloody Bay.

The fringing reef is approximately 400 m long with maximum water depths of 8 m, 1 m and 3 m (respectively) on the fore reef, the reef crest and within the back reef lagoon. Overall, substrate composition on the reef and within its back reef lagoon is summarised within Table 4.7, and algal species observed during the SCUBA surveys are listed in Table 4.8.

Table 4.7 Summary of substrate composition, on the Little Bloody Bay fringing reef and within its corresponding back reef lagoon.

Substrate Type*	% Composition	
	Fringing Reef	Back Reef Lagoon
SEAGRASS	0	70
ALGAE	20	5
CORAL (LIVING)	20	0
MACRO FAUNA	3	0
SPONGE	7	0
BASE SUBSTRATE	50	25

SUBSTRATE TYPE CODE:

SEAGRASS - 'r' species or climax communities
ALGAE - turf or macrophytic
CORAL - branching, boulder or encrusting
MACRO FAUNA - other cnidarians; e.g. gorgonians, anemones or zoanthids
SPONGE - fleshy, boring or encrusting
BASE SUBSTRATE - bare rock, rubble, sand or mud

Table 4.8 Marine algal species observed on the Little Bloody Bay fringing reef.

	Classification		
	Green Algae (*Chlorophyta*)	Brown Algae (*Phaeophyta*)	Red Algae (*Rhodophyta*)
Species	*Cladophora prolifera* *Caulerpa sertularioides* *Caulerpa serrulata* *Caulerpa cupressoides* *Ventricaria ventricosa* *Cladocephalus luteofuscus* *Penicillus dumetosus* *Halimeda tuna* *Halimeda opuntia*	*Dictyota linearis* *Sargassum hystrix*	*Gracilaria tikvahiae*

*Species marked by * are high nutrient indicating species.*
*Species marked by ** are reef building, red encrusting algal species.*

No high nutrient indicating algal species were observed on the Little Bloody Bay fringing reef or within the back reef lagoon; however, the observed genus *Caulerpa* is considered to be a low to moderate nutrient indicator species, by some authors. Three different species of *Caulerpa* were observed during the surveys.

Exhaustive lists of the coral, fish and invertebrate species, observed on the fore reef and within the back reef lagoon, are presented in Appendix 10. Massive Starlet Coral (*Siderastrea siderea*) and Symmetrical Brain Coral (*Diplora strigosa*) were the dominant stony coral species in the fore reef environment (Plates 4.3 and 4.4); whilst colonies of Blade Fire Coral (*Millepora complanata*), Sea Plumes (*Pseudopterogorgia sp.*) and Slit-pore Sea Rods (*Plexaurella sp.*) were the frequent and dominant soft coral species on the reef (Plates 4.5 and 4.6). Turf and macrophytic algae accounted for 20% of the substrate cover and was dominantly interspersed in and around coral heads and the observed living and dead coral colonies and rubble (Plate 4.7).

Plate 4.3: ***Massive Starlet Coral (*****Siderastrea siderea*****)***

Plate 4.4: ***Symmetrical Brain Coral (*****Diplora strigosa*****)***

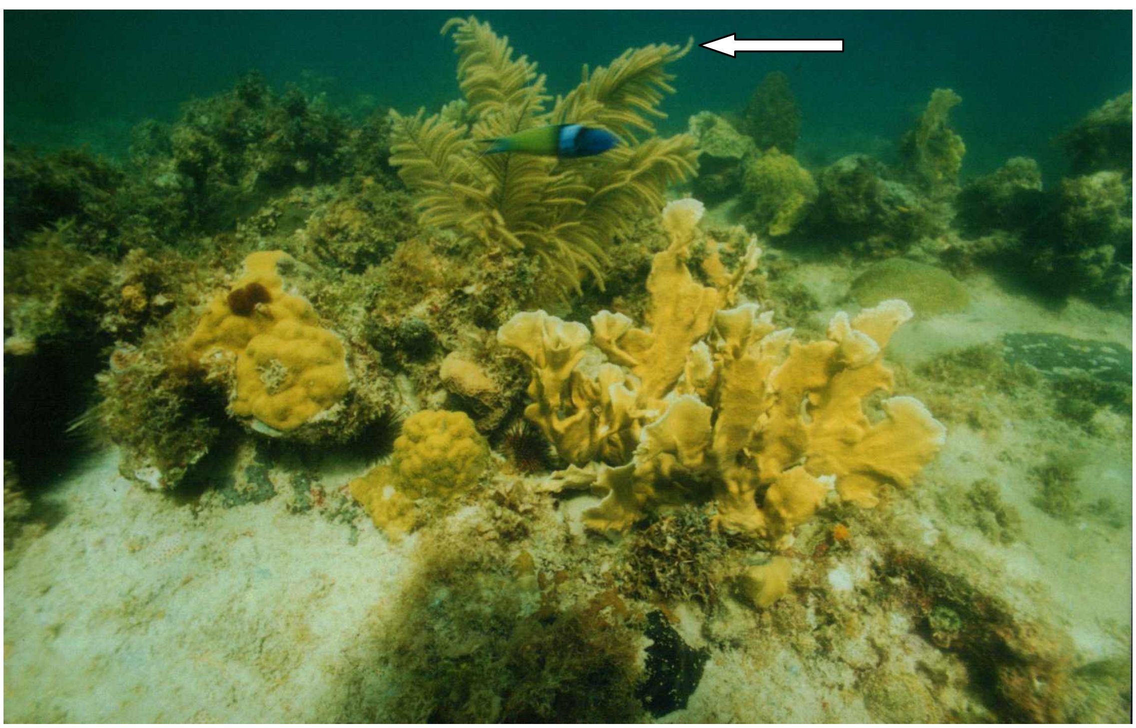

Plate 4.5: ***Photo showing Sea Plumes (*****Pseudopterogorgia sp.*****)***

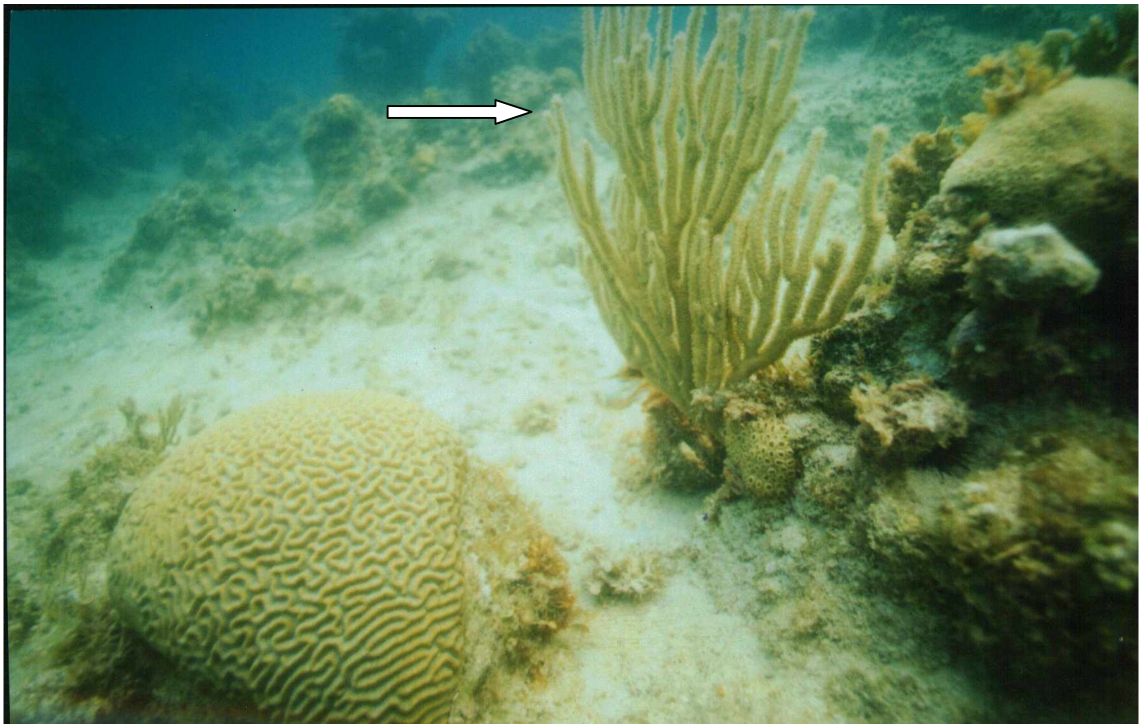

Plate 4.6: ***Photo showing Slit-pore Sea Rods (*Plexaurella sp.)**

Plate 4.7: ***Photo showing turf macrophytic algae interspersed between coral heads***

Staghorn coral (*Acropora cervicornis*) and living Elkhorn coral (*Acropora palmata*) were conspicuously absent, although dead coral skeletons of Elkhorn coral (*A. palmata*) were observed and photographed on what may be described as the reef crest of the reef (Plate 4.8).

No sea turtles or sea lobsters were observed during the surveys, however, a Yellow Stingray (*Urolophus jamaicensis*) was seen and photographed on both dives (Plate 4.9).

With regards to the back reef lagoon, the latter was approximately 100 m wide (from the shoreline to the reef crest) and protected from high wave energy by a partial reef crest. T. testudinum dominated seagrass cover within this lagoon and accounted for 60 - 70 % of benthic cover. Bare coralline sand, dead coral colonies, coral rubble and algae accounted for the remaining 30 - 40 % of ground coverage.

Plate 4.8: ***Photo showing dead coral skeletons of Elkhorn coral (*****A. palmata*****)on reef crest***

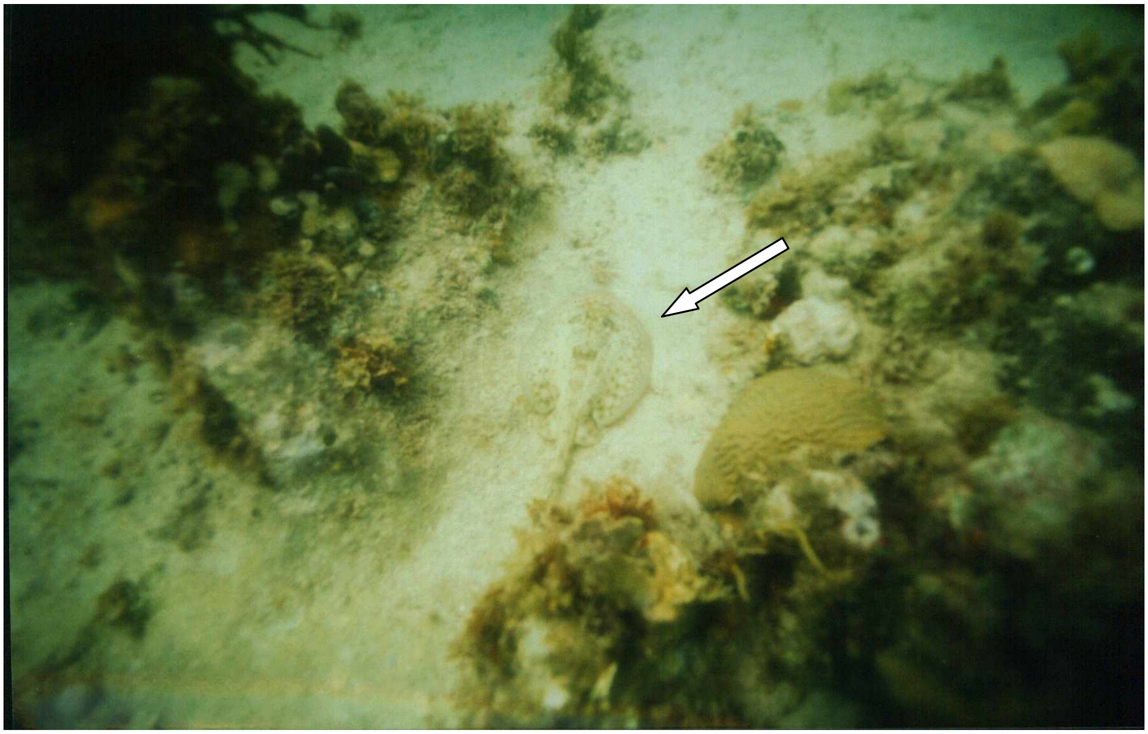

Plate 4.9: A Yellow Stingray (*Urolophus jamaicensis*)

4.4 Bathymetry

Background Data

A search for existing bathymetric data for the Negril revealed that there is only one very course 1:325,000 British Admiralty chart for the area.

A very detailed topographic drawing of the proposed site area was available from the developer. The topographic drawing was contoured to a 0.25 m interval. Trees with preliminary identification were also represented.

A 1:50,000 scanned and geo-referenced topographic map of the region was also available in the Jamaica Grid System

A vertical coloured photograph of the area was also available from NEPA.

In summary, no detailed bathymetric chart existed for the area. However, there was sufficient detailed shoreline and background photograph data to allow for the preparation of a bathymetric chart after fieldwork.

Data Collection and Chart Preparation

A bathymetric survey was conducted on September 8, 2001, between the hours of 10:30 am to 2:00 pm local time. The data collection exercise involved traversing the near shore (between the shoreline and 5m) and collecting simultaneous GPS and depth sounder data using a GARMIN 168 Map Sounder.

The data was reduced from the instrument and error checked for spurious low depth readings. The data was then transformed to the Jamaica Meter Grid system (projection) and Clarke 1884 (Ellipsoid) from UTM coordinates system and WGS84 Ellipsoid. The bathymetric data was then supplemented with topographic data to allow for a reasonable shoreline representation. The data was then put in a grid using a Linear Triangulation algorithm and surface contoured.

A background image consisting of the site layout, topographic map and aerial photograph was prepared. This involved geo-referencing the images using the north-eastern corner of the site as a reference (N=108807.896, E=189433.1538), in an AutoCAD© environment. The photograph was scaled and oriented by measuring the distance between similar objects in both the 1:50,000 topographic map and the photograph. See figures 4.6 and 4.7

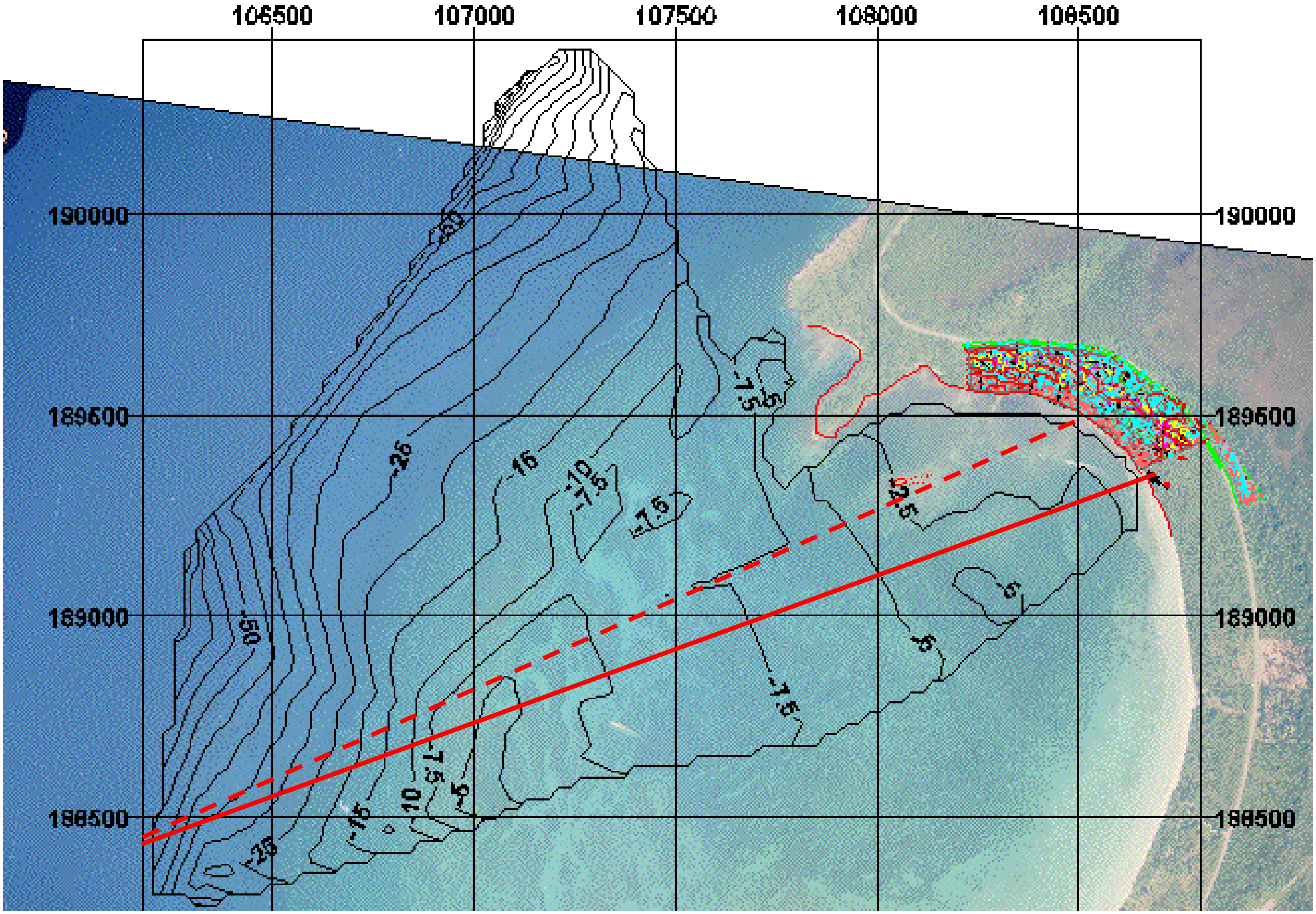

Figure 4.6 - Bathymetric chart of part Bloody Bay, showing RIU -II site and alignment of profiles for middle of site (Red dashed line) and southern end of site (red solid line)

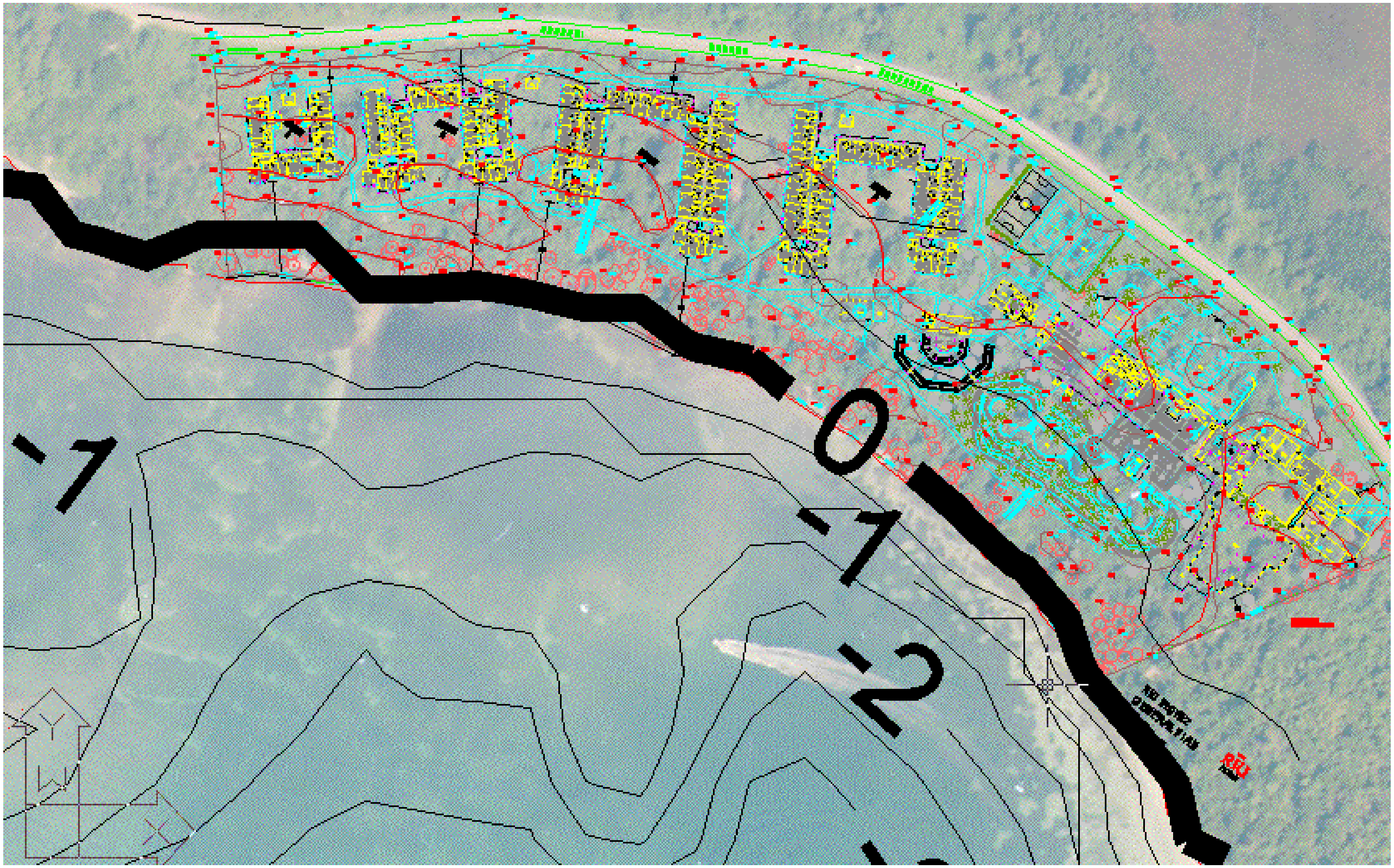

Figure 4.7 - Nearshore bathymetry showing sit layout and contours

4.4.1 Shoreline Sediment

Data Collection

Three sediment samples were collected on the beach face along the proposed site's shoreline. The sediments were dried in an oven and sieved from the 1 mm to the 0.125 mm opening size. The balance was collected in a pan below the rack of sieves.

Grain Size Characterization

Data from the laboratory sieve analysis was analysed to determine the median grain size. The results are summarized in Table 4.9 and shown in Figure 4.8. The results indicate that the sample to the southern end of the site, which is also more exposed to wave action, is some 50% coarser than the sediment samples in the centre of the beach and on the northern end. It must also be noted that the median grain size of 0.42 mm on the eastern end of the beach could reasonably be defined as medium grain sand. Where as the other sediment samples could be referred to as fine grain sand samples.

Table 4.9 - Results of sediment grain size analysis

	BB1 (North)	**BB2 (Centre)**	**BB3 (South)**
Size (mm)	**% Finer**	**% Finer**	**% Finer**
1	98.00	87.98	82.85
0.5	95.26	74.02	64.00
0.355	89.50	68.41	39.30
0.25	69.61	61.58	13.25
0.18	39.02	49.69	3.66
0.125	13.09	16.70	1.30
0	0.01	0.01	0.01
Median	**0.21**	**0.18**	**0.42**

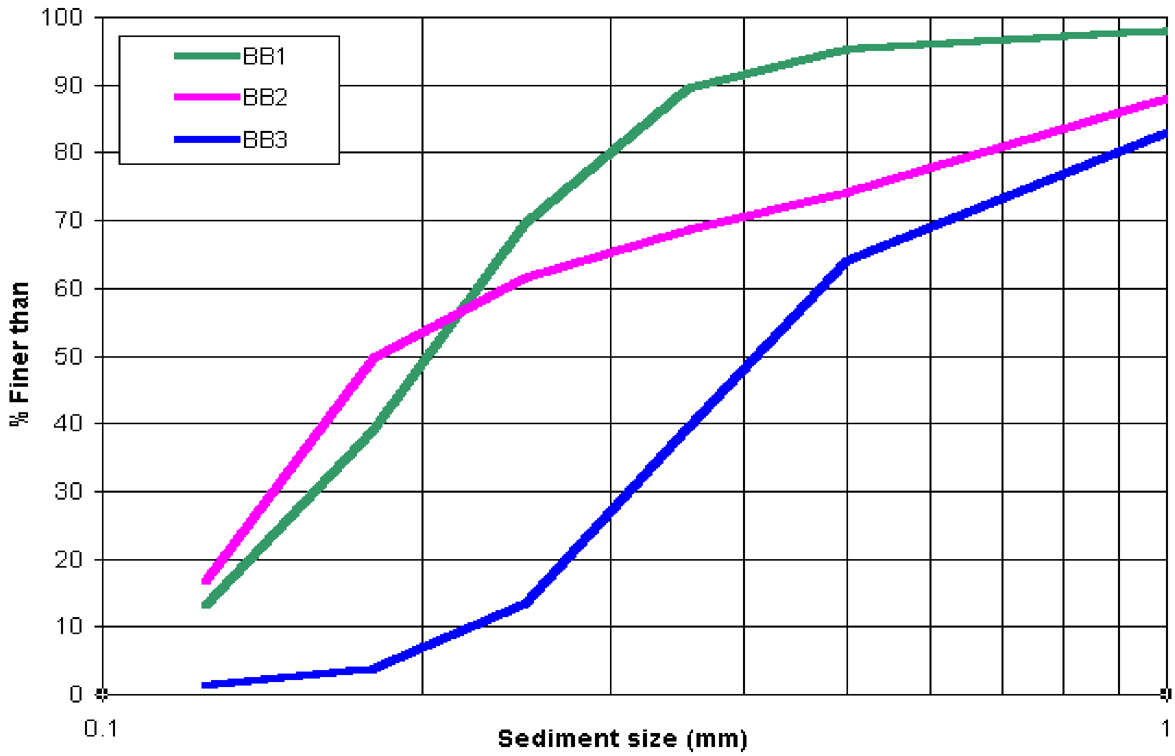

Figure 4.8 - Grain size analysis for proposed hotel shoreline sediment samples

4.4.2 Hurricane Environment

The Caribbean is exposed to yearly occurrences of tropical storms and hurricanes, which often generate waves that have damaging impacts on coastal areas. The coastlines of Jamaica have not been excluded from these occurrences and we must therefore study the probable hurricane conditions at the site. This was done by carrying out a hindcast analysis.

Hurricane Occurrences in relation to Negril

Given the high frequency of hurricane activity and the availability of hurricane data in the Caribbean Sea, we were able to carry out a thorough statistical analysis to determine the hurricane wind and wave conditions at a deep-water location for the site. A database of hurricanes, dating back to 1886, was searched for storms that passed within a 300km radius from the site. Table 4.10 shows the list of storms.

Table 4.10 - Results of search for hurricanes that came within 300km of Negril in the last 100 years

1	ALLEN.'80	**11**	JANET.'55	**21**	NUMBER18.'33	**31**	NUMBER4.'05	**41**	NUMBER8.'06
2	BEULAH.'67	**12**	KATRINA.'81	**22**	NUMBER19.'33	**32**	NUMBER4.'15	**42**	NUMBER9.'09
3	CARMEN.'74	**13**	KING.'50	**23**	NUMBER2.'03	**33**	NUMBER4.'16		
4	CHARLIE.'51	**14**	Lenny.'99	**24**	NUMBER2.'10	**34**	NUMBER4.'35		
5	CLEO.'64	**15**	Mitch.'98	**25**	NUMBER2.'15	**35**	NUMBER4.'44		
6	ELLA.'58	**16**	NUMBER10.'32	**26**	NUMBER2.'33	**36**	NUMBER5.'09		
7	FIFI.'74	**17**	NUMBER11.'44	**27**	NUMBER2.'38	**37**	NUMBER5.'15		
8	FLORA.'63	**18**	NUMBER11.'45	**28**	NUMBER2.'42	**38**	NUMBER5.'39		
9	GILBERT.'88	**19**	NUMBER13.'16	**29**	NUMBER3.'17	**39**	NUMBER6.'12		
10	HILDA.'55	**20**	NUMBER15.'33	**30**	NUMBER3.'38	**40**	NUMBER6.'16		

Wave Hindcasting and Extremal Analysis

The hurricane track records in the database gives the tracked points, maximum wind speed, radius to maximum winds and central pressure of the hurricane at 6 hour intervals. For this analysis, each track was further segmented into 2-hour intervals to get a better representation of a hurricane's effect while in proximity to the project area.

A parametric hurricane model was then used to develop a database of hurricane wind and wave heights at each point along each track. The model used was Cooper (1988), which estimates the wind speed from a parametric representation of a hurricane wind field. The parametric form is given as a function of the hurricane's central pressure, forward speed, maximum sustained wind speed and radius to this maximum wind speed. The model then approximates the wave height from the wind speed.

Following this, an Extremal statistical analysis was carried out on the wave heights. The waves were grouped in descending order and fitted to several Extremal distributions. The best fitting distribution was selected and the return values computed for several periods. Figure 4.9 shows the best-fit plot for the wave heights. This was the Weibull distribution with a shape factor of 1.4. The correlation with the data is 0.972.

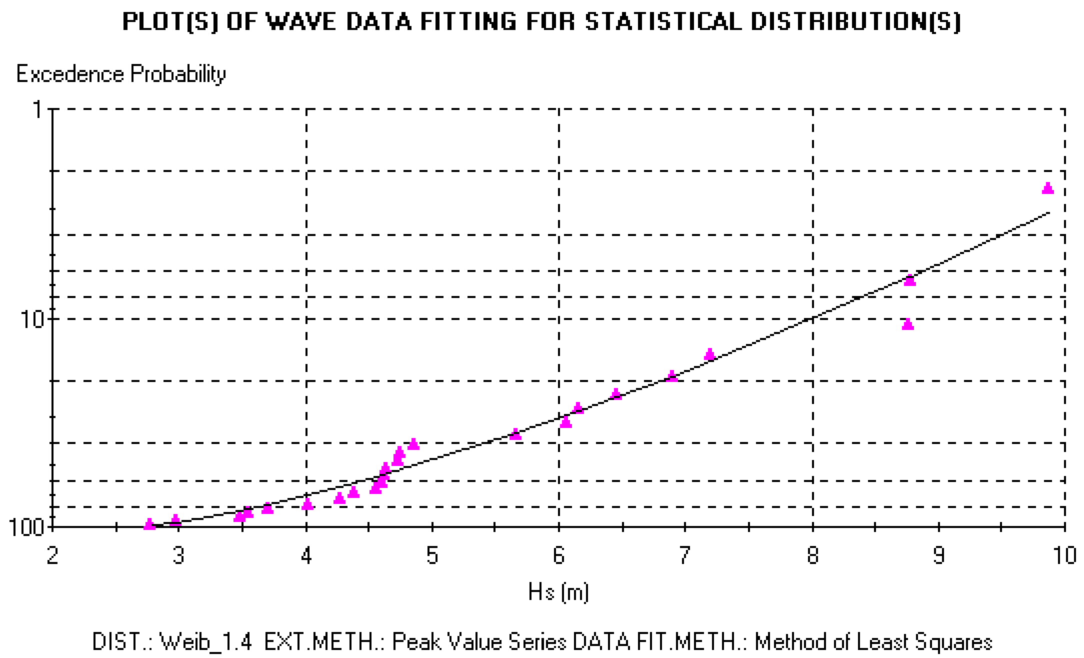

Figure 4.9 - Extremal Analysis for the wave hindcast results for Deep water offshore Negril

Table 4.11 below shows the results for several return periods. The equivalent wave periods were derived by assuming a 1/25 wave steepness for hurricane waves and the equivalent wind speeds were computed by using the model of Cooper (1988).

Table 4.11 - Extremal Analysis results FOR deep-water Wave heights

Return Period, Rp (yr)	Significant Wave Height, Hs (m)	Return Wave Period, Tp (s)	Return Local Wind Speed, V (m/s)
5	6.4	10.1	25.6
10	7.7	11.1	30.8
25	9.2	12.1	36.8
50	10.2	12.8	40.8
100	11.2	13.4	44.0

Phenomena Considered for Storm Surge

Hurricanes often cause inundation in coastal areas. This inundation is referred to as a storm surge which is simply the increase in sea level during a storm. This increase in water level is caused by several components. These include:

1. Inverse barometric pressure rise, which is due to the low-pressure system surrounding a hurricane.
2. Wind setup caused by the high winds associated with hurricanes
3. Wave setup caused from breaking of the hurricane generated waves.

These are the three main components will be analyzed here in order to compute the potential for flooding during a storm. However, sea level change over a long-term period is also due to global sea level rise (GSLR). Short-term (<6 hours) changes also occur due to tides. Researchers have predicted a 0.125 increase in global sea level for the next 100 years for GSLR for the Caribbean. The tidal range is approximately 0.4m. As such, we will add a further (0.125+0.2=) 0.325m to represent the effects of global sea level rise and high tide.

Given these potential increases, we then computed the increase in sea water level by the Inverse Barometric Pressure Rise (IBR). The IBR caused by each hurricane in the database was computed. This was done with the following model:

$IBR = 0.01(Pn - Pc)(1 - e^{\frac{-R\max}{r}})$; where r is the storm distance from the site, Rmax is the radius to maximum winds, Pn (in mbars) is the ambient pressure and Pc (in mbars) is the central pressure. A statistical analysis was then conducted on these values and the return values derived.

One profile to the east end of the site was investigated as far as storm surge was concerned. See figure 4.6.

A one-dimensional non-linear model to compute the total storm surge. This model is called SBEACH (Storm-induced BEAch CHange) and it simulates cross-shore beach, berm, and dune erosion produced by storm waves and water levels. The input parameters were the wave conditions, sediment sizes and the increase in water level due to IBR. Each hurricane return period event was investigated by running approximately 10 hours of hurricane waves.

Storm Surge Results

Storm surge predictions from SBEACH were extracted and plotted for the 10, 25, 50 and 100-year events. In addition to storm surge, the wave heights at the shoreline were also computed. These results are summarized in Table 4.12 and Figure 4.10. The results indicate that the storm surge for the 10 to 100 Year Return Period Event can be expected to range from 2.59 to 3.56 m above Mean Sea Level. These levels will inundate the site, given the existing topographic information.

Table 4.12 - Storm Surge Analysis Results for RIU-II

Return Period	**Storm Surge (m)**	***GSL+ Tides (m)***	**Total Design Surge (m)**	**Wave Height at shoreline (m)**
10	2.26	0.325	**2.59**	**0.93**
25	2.83	0.325	**3.15**	**1.25**
50	3.23	0.325	**3.55**	**1.50**
100	3.23	0.325	**3.56**	**1.56**

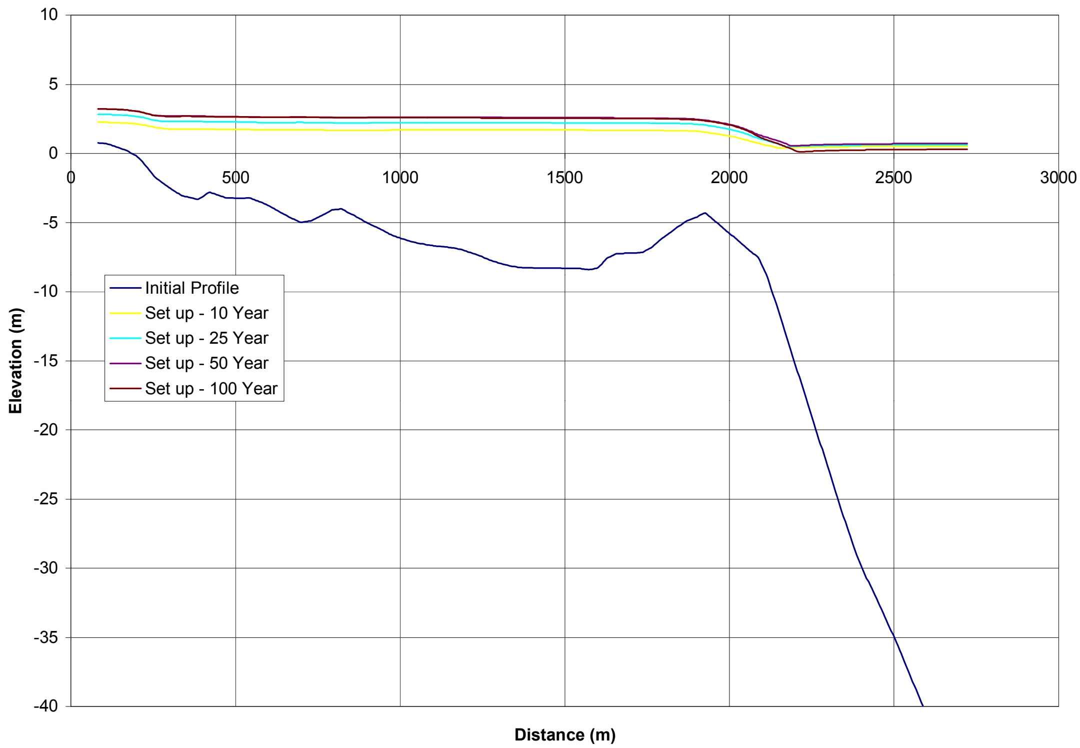

Figure 4.10 - Storm Surge Results for RIU-II

<u>Storm Event Erosion Analysis Methodology</u>

Two profiles were initially investigated as shown in Figure 4.6. Detailed analysis for the middle profile was not conducted. Initial investigations revealed that regardless of the relatively fine sand that was present at this location, the beach was stable due to the presence of the submerged and emergent reef structure. This structure provides a critical sheltering effect for portion of the shoreline between the middle of the site and the western end of the site.

Detailed analysis of the southern portion of the site involved using the sand size determined from the sieve analysis (0.18 to 0.42 mm). The main sediment transport parameters in the SBEACH model: Transport rate coefficient, (ranging from 2.5e-07 to 2.5e-06) K; and Coefficient for slope-dependent term, Eps (ranging from 0.001 to 0.005) are calibration parameters for the sediment transport calculations. Larger K values produce greater sand transport and more prominent bar features, and larger values of Eps produce a more subdued bar. The entire range for these parameters was investigated. Hence, two scenarios were investigated. These were a low transport regime and high transport regime scenario.

Ideally, the model results should be calibrated with anecdotal and measurements of erosion after significant storm events. Checks with NEPA (Mr. Ainsley Henry) and the Negril Coral Reef Protection Society (Mr. Carl Hansen) revealed that there was very limited anecdotal information in the Bloody Bay area. This is more than likely due to the limited development, until lately (<10 years) in this area and hence limited presence or interest of observers after storm events.

The strategy adopted for the estimation of storm event erosion was to investigate the range that was likely for this stretch of shoreline after storm events. Thus, parameters values that gave the highest likely transport (such as smallest particle size and lowest K and Eps values) as well as parameters that gave the lowest likely transport were investigated.

Erosion Analysis Results

The results for the 10, 25, 50 and 100-year event final profile were extracted from the model. The change in distance between the initial shoreline and final was determined. These results are summarized for the Low and High Transport regime in Table 4.13.

The analysis essentially indicates that the southern shoreline could be prone to 25 m of horizontal erosion of the shoreline after extreme storm events. This preliminary results must however, be tempered by the fact that there was no anecdotal information with which to verify the predictions.

Table 4.13 - Erosion Analysis Results for the Proposed Hotel Site

Return Period	**Maximum Horizon Erosion of SWL (m)**	**Minimum Horizon Erosion of SWL (m)**
10	**20**	**~0.0**
25	**25**	**~0.0**
50	**25**	**~0.0**
100	**25**	**~0.0**

4.5 Water Quality

4.5.1 Methodology

Physical and biological data were collected from seven (7) stations within the study area on one occasion. Data for twelve parameters were collected. Of these twelve, seven were done *in situ* using a Hydrolab H_2O datalogger. The parameters that were measured *in situ* were; temperature, salinity, dissolved oxygen, pH, photosynthetically active radiation (PAR), total dissolved solids and nitrates.

Chlorophyll a, biochemical oxygen demand, phosphates, faecal and total coliform were obtained from water samples that were stored on ice and transported to the laboratory at the University of the West Indies.

4.5.2 Results

Coastal water quality is important in island states. Jamaica is no exception. Being dependent on tourism demands that coastal water quality be of a high standard. Water quality monitoring was conducted at seven stations within Bloody Bay. Data for twelve parameters were collected. The results of which are outlined in Tables 4.14 and 4.15

Water quality samples were taken at seven stations within Bloody Bay (see Figure 4.11).

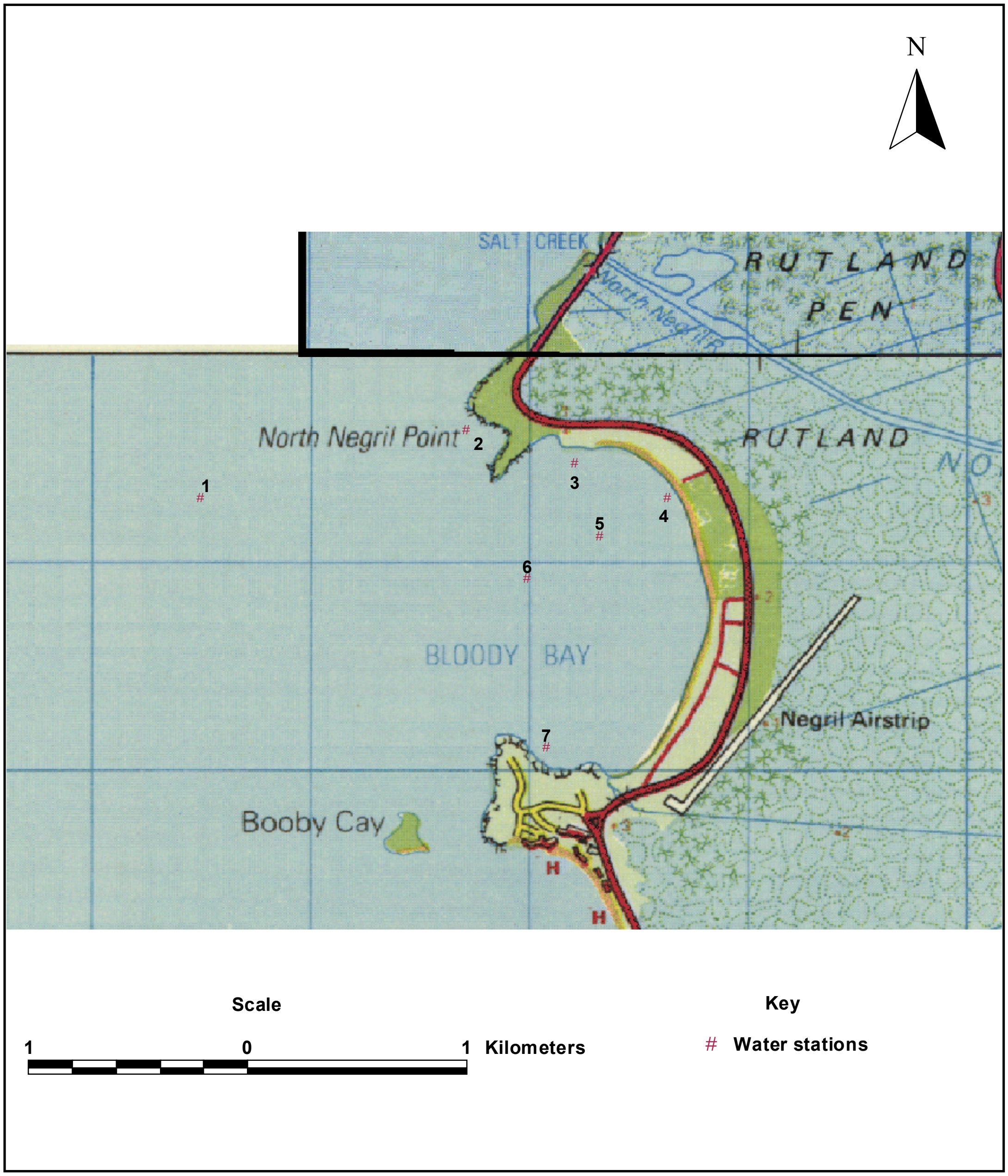

Figure 4.11 Map Showing Water Quality Stations

Table 4.14 Physical and Chemical Parameters

STN #	TEMP (^oC)	SAL (‰)	DO (mg/l)	pH	PAR ($\mu E/m^2$ /s)	TDS (mg/l)	NO_3 (µmol/l)	PO_4 (µmol/l)
1	30.3	37.5	5.93	7.64	301	36	0.32	0
2	30.47	37.45	5.31	7.25	1813	36.03	49.35	0.06
3	30.96	37.35	5.67	7.54	450	35.92	24.52	0
4	31.5	37.38	7.38	7.63	320	35.91	1.77	0.6
5	31.88	37.13	6.41	7.6	504	35.73	42.23	0.14
6	30.89	37.62	6.77	7.19	2285	36.25	28.87	0.74
7	30.95	37.55	6.17	7.49	335	36.01	38.06	0.3

KEY:

TEMP = Temperature (°C)
SAL = Salinity
DO = Dissolved Oxygen
PAR = Photosynthetically Active Radiation
TDS = Total Dissolved Solids
NO_3 = Nitrates
PO_4 = Phosphates

Table 4.15 Biological parameters

STN #	CHL a (mg/m^3)	BOD_5 (mg/l)	F. COLI (MPN/100 ml)	TOT. COLI (MPN100 ml)
1	0.24	1.66	<2	70
2	0.29	2.29	20	500
3	0.27	3.43	20	220
4	0.51	0	40	170
5	0.46	0.86	20	110
6	0.36	6	80	500
7	0.46	0.86	80	230

KEY:

CHL a = Total Chlorophyll a
BOD = Biochemical Oxygen Demand
F. COLI = Faecal Coliform
TOT. COLI = Total Coliform

The interpretation of the data must be cognizant of the fact that the parameters were collected after a period of rain. Therefore, the results obtained may reflect values that are elevated when compared to what occurs normally.

Temperature, salinity, dissolved oxygen, pH, photosynthetically active radiation (PAR) and total dissolved solids were within the expected range of marine water. However, pH showed some evidence of fresh water influence as normal marine water pH is of the order of eight (8).

Nitrate and phosphate concentrations at the seven stations ranged from (0.23-42.23 µmol l^{-1}) and (0-0.74 µmol l^{-1}) respectively. Lapointe (1997) and Bell (1992) both suggested that critical nutrient levels (nitrates and phosphates) are 1 µmol l^{-1} and 0.1 µmol l^{-1} respectively. Raymont (1980) suggested that low nutrients were (0.2 -1.75 µmol l^{-1} nitrates) and 0.07-0.24 µmol l^{-1} respectively. Ambient marine water quality standards for nitrates and phosphates are 1.3µmol l^{-1} and 0.005 µmol l^{-1} respectively.

As expected, nutrient levels within Bloody Bay were higher than ambient marine water quality standards. Nitrate concentrations were elevated at all stations except station 1. Phosphate concentrations were elevated at stations 4, 6 and 7. Hoegh-Gulbers *et al* (1997) said that coral calcification and growth inhibition occurred when nitrogen concentration is 15µmol l^{-1} and phosphorus concentration is 0.4 µmol l^{-1}. Only station 6 met that criterion.

Nitrates and phosphates are important to the growth of phytoplankton and together with chlorophyll *a* can be used to determine the state of the water quality within Bloody Bay. Elevated nutrients (nitrates and phosphates) give an indication of eutrophic or potential eutrophic waters. The status of a water body is further confirmed with the use of phytoplankton (chlorophyll *a*), with elevated values indicating nutrient enriched areas (eutrophic).

Phytoplankton are the best aquatic indicators of eutrophication and water quality assessment as they display a rapid response to immediate, short term and long term changes in aquatic systems (Webber, 1990). The value of phytoplankton being used as indicators of water quality is evidenced by the fact that a sharp increase in nutrients produces immediate phytoplankton increases, while rapid disappearance of nutrients only slowly reduces phytoplankton populations (Satsmadjis, 1985).

Total chlorophyll *a* concentration ranged from 0.24-0.51 mg/m^3 at the seven stations within the Bay. The southern section of the Bay had higher concentrations of Chl *a*, with stations 4, 5, 6 and 7 having the highest concentrations. Webber (1990) suggested that the low total chlorophyll *a* concentration ranged from 0.28 –1.03 mg/m^3. This suggests that the total chlorophyll *a* concentration within the Bay was low.

Biochemical oxygen demand (BOD) is indicative of the amount of organic matter present in the environment. Hence, it is indicative of inputs to the environment from sewage and other organic effluent. The BOD at the seven stations ranged from 0 –3.43 mg/l. The northern and western sections of the Bay (stations 1, 2 and 3) having the highest concentrations. Station 3 (3.43 mg/l) exhibited the highest concentration. Ambient marine water quality standard for BOD_5 range from 0.57 –1.16 mg/l. It is proposed that BOD concentrations for coastal waters should range between 0.7 - 1.7 mg/l. The northern and western sections of the bay shows some evidence of be influenced by organic effluent, quite possible from the North Negril River.

Faecal coliform levels were within the standard 100 MPN/100ml, however, elevated levels were observed towards the southern section of the Bay, specifically stations 6 and 7. The presence of faecal coliform can be used as an indicator of sewage contamination. Faecal coliform are found in the bowels of mammals. Total coliform include other bacteria and viruses with faecal coliform. With the exception of stations 1, 4 and 5 all other stations exceeded the 200 MPN/100ml standard.

General nutrient levels within the Bay were elevated, however, not to the limit to be considered eutrophic. Nitrate concentrations were higher than was observed in the previous environmental impact assessment (June 1999) and the Environmental Solutions Study (January 1996). Phosphate concentrations were lower than observed in the previous two studies.

The fact that total Chl *a* concentrations were low further supports the point that the Bay is not eutrophic. It is also important to note that the station with the second lowest nitrate concentration had the highest Chl *a* concentration suggesting that the phytoplankton was utilizing the nitrogen. This station also had the second highest phosphate concentration.

It can be deduced from the data, that Bloody Bay is not totally pristine (oligotrophic). It is oligotrophic but has the tendency to become mesotrophic (moderately nutrient enriched). This is evidenced by the fact that results of coliform suggest that the southern section of the Bay is being influenced by sewage contamination and the Bay generally had elevated levels of bacteria and viruses. The elevated BOD concentration at the northern and western sections of the Bay suggests that the Bay also influenced being from inputs from the North Negril River. The Bay appears to be phosphate limited, therefore any development occurring there should ensure that in addition to not increasing the nitrate concentration within the Bay, special and concerted efforts must be made to prevent an increase in the phosphate loading to the Bay. If there were to be an increase in the phosphate loading then there would be the potential to increase the algal within the Bay.

The proposed development has the potential to have a negative impact on the water quality within the Bay.

4.6 Noise

4.6.1 Methodology

One off noise readings were taken at points within the proposed development area. The readings were taken in the morning (7-8 am) and in the afternoon (5-6 pm).

Noise level readings were taken by using a Quest 2700 Sound Level Meter. The noise meter was calibrated with a Quest QC - 10 sound calibrator. The meter was turned on and the response was set to slow, the weighting to A and the mode to SPL. The calibrator was turned on for approximately 10 seconds to allow it to stabilise. The decibel range (dB) was set at 60 - 120 and the calibrator placed over the microphone. The meter was calibrated each time they were turned off.

The reading on the noise meter should be 114 dB. If not, adjustment of the calibration potentiometer was done as necessary. A windscreen (sponge) was placed over the microphone to prevent measurement errors due to noise caused by wind blowing across the microphone.

The meter was pointed in the direction of the noise source (towards the Norman Manley Boulevard) at approximately chest height and 0 - 40 degrees from the body. The dB range was set at the lowest level without the over the limit (OL) signal coming on. If the OL signal came up during a reading then the range level was increased. Records of the high and low dBA readings and the level at which it rests at most were noted.

4.6.2 Results

The average noise level was 53.8 dBA and actual readings ranged from a low of 51 dBA to a high of 56.1 dBA. In the afternoon the average noise levels was 46.3 dBA and actual readings ranged from a low of 46.3 dBA to a high of 58.2 dBA. The higher levels in the afternoon can be attributed to a higher volume of vehicular traffic.

These levels fall within the recommended zone limit (55 dBA - 7 am – 10 pm) for a residential zone proposed by the National Environment and Planning Agency. Noise levels above or equal to 55 dBA may cause a noise nuisance as stated by the World Health Organization (WHO).

The proposed development has the potential to cause a noise nuisance during its construction.

4.7 Air Quality

Actual ambient air quality readings were not conducted, however, due to the nature of the site (vegetated) and the fact that other areas in proximity such as other properties are adequately covered and the main road is properly paved, dust is not considered a problem at the site.

The proposed development has the potential to negatively impact the ambient air quality on the proposed site and areas in proximity.