# NEGRIL CABINS HOTEL EXPANSION
# BLOODY BAY, JAMAICA

# ENVIRONMENTAL IMPACT ASSESSMENT

Submitted to:

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# 1. INTRODUCTION

## 1.1 PURPOSE AND BACKGROUND

Negril Cabins intend to expand their hotel at Bloody Bay, Negril, by constructing an additional 160 rooms on 2 ha (5 acres) of land on the coastal strip opposite their existing hotel (Figure 1.1). This document sets out the findings and recommendations of an environmental impact assessment (EIA) of the project that has been prepared to meet the requirements of the funding agency as well as those of the National Environment and Planning Agency (NEPA). In the case of the latter, projects involving the construction of hotel/resort complexes of more than 12 rooms may be required to submit an EIA as part of the permitting and licencing process.

The proposed development site is located at Bloody Bay on the sandbar separating the sea from the Great Morass of Negril. It is a green-field site, which is presently used to allow access to the beach for guests staying at Negril Cabins. RIU's Phase I hotel is located on the lot adjacent to, and south of, the proposed development site while the adjacent lot to the north is undeveloped.

The proposed site is relatively flat with slight undulations. Most of the site has elevations ranging between 1.2 and 1.5 m (4 – 5 ft) with maximum elevations being 1.8 m (6 ft) along the eastern boundary of the site. There are poorly defined drainage features on the site and rainfall mainly percolates through the sandy soil. However, during heavy rains, water flows within poorly defined onsite surface drainage features and there is evidence of water ponding in depressed areas.

The length of the beach, at the proposed development site, is about 130 m (426 ft) long and is comprised of fine-grained sands. The bay is reasonably well protected from high wave energy, which helps mitigate against considerable beach erosion. However, the existing beach profile still manages to change cyclically, over time, with the prevailing wave regime.

There are no distinct/established seagrass beds along the shoreline of the Negril Cabins beach although beds of *Thalassia testudinum* and *Syringodium filiforme* are found covering the sea floor towards the center of Bloody Bay. These help bind and stabilize the sediments within the bay. Heavy seagrass bed coverage is found in the northern section of the bay, in the vicinity of the RIU Phase II hotel development site.

Final design details and drawings for the hotel's layout, drainage and sewering systems are expected to incorporate recommendations made by ESL in an initial site assessment report prepared in June 2003 (ESL, 2003). The latter document presented an environmental characterization of the proposed site, identified key environmental matters relevant to the proposed development, and provided environmental guidelines for final project design. It outlined the key environmental considerations relevant to the construction phase of the proposed development and provided an environmentally sensitive framework for the preparation of guidelines for planners, architects, engineers and contractors involved with the physical development of the site.

Completed layout, drainage and sewering plans for the proposed expansion works were not available during the preparation of the environmental impact assessment report.


**Figure 1.1 Negril Cabins hotel expansion EIA – Study area and site location map.**

## 1.2 TERMS OF REFERENCE

The following TORs for the Negril Cabins expansion project were adapted from World Bank and NEPA guidelines and were approved by NEPA.

1. *Introduction – Identify the development project to be assessed and explain the executing arrangements for the environmental assessment.*

2. *Background Information – Briefly describe the major components of the proposed project, the implementing agents, along with a brief history of the project and its current status.*

3. *Study Area – Specify the boundaries of the study area for the assessment as well as any adjacent or remote areas within the area of influence of the project.*

4. *Scope of Work – The following tasks will be undertaken:*

   *Task 1. Description of the Proposed Project – Provide a full description of the project and its existing setting, using plans, maps and graphic aids at appropriate scales. This is to include: location, general layout (size, capacity, etc.), pre-construction and construction activities, operation and maintenance activities, project life span, plans for providing utilities, waste disposal and other necessary services, and the physical, ecological, demographic, socio-cultural and institutional settings of the project. Reference will be made to current development plans for Negril.*

   *Task 2. Description of the Environment – Assemble, evaluate and present baseline data on the relevant environmental characteristics of the study area, including the following:*

   a) *Physical environment: coastal features, geology, topography, soils, climate, hydrology, drainage and storm water runoff, and marine water quality. Existing sources of pollution, and the extent of contamination relevant to the project area, will be identified.*
   b) *Biological environment: flora, fauna, rare or endangered species, sensitive habitats, species of commercial importance, and species with potential to become vectors or nuisances.*
   c) *Socio-cultural environment: present and projected populations, community structures, land use, current development plans, recreation and public health, public and community perceptions and attitudes on the proposed project, and any historical importance of the area.*

   *Task 3. Legislative and Regulatory Considerations – Describe the pertinent regulations and standards governing siting and land use control, environmental quality, health and safety, protection of sensitive areas, protection of endangered species, and tourism.*

   *Task 4. Determination of Potential Impacts – Identify the major issues of environmental concern and indicate their relative importance to the design of the project. Distinguish construction and post-construction phase impacts, significant positive and negative impacts, and direct and indirect impacts. Identify impacts that are cumulative, unavoidable or irreversible. Special attention should be paid to:*

   - *Vegetation clearance and habitat destruction related to construction activities.*
   - *Existing flora, fauna and coastal resources, tree protection, replanting and landscaping.*

- *Modification of existing drainage patterns and surface runoff during construction and post-construction phases, particularly with reference to the hydrography of the Negril Morass.*
- *Water supply and demand.*
- *Waste water treatment, use and management.*
- *Solid waste management during construction and post-construction phases.*
- *Construction impacts including materials sourcing, transport and storage, building construction methods, under-road tunnel, site management, noise, fugitive dust, traffic obstruction, and employment.*
- *Resort operations and maintenance; use of energy saving and resource conservation technology, vehicular traffic generation, and employment.*
- *Socioeconomic conditions, effects on existing users of the coastal areas, infringement on rights of stakeholders, community involvement and public perceptions of the project.*
- *Potential impacts of the development on adjacent property owners.*
- *Impacts on the proposed Negril Marine Park.*

*Reference should be made to the extent and quality of the available data and any information deficiencies and uncertainties associated with the prediction of impacts should be clearly identified.*

*Task 5. Mitigation and Management of Negative Impacts – Recommend feasible and cost-effective measures to prevent or reduce the significant negative impacts to acceptable levels and present an environmental management plan for the construction phase.*

*Task 6. Development of a Monitoring Plan – Prepare a plan for monitoring the implementation of mitigating measures and the impacts of the project during construction.*

*Task 7. Assist in Inter-Agency Coordination and Public/NGO Participation – Assist in co-ordinating the environmental assessment with the government agencies and in obtaining the views of local NGO's and affected groups. Manage and coordinate the public hearing on the EIA findings as required by the NEPA permit approval process.*

5. *Report – The environmental assessment report will be concise and limited to significant environmental issues. The main text will focus on findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data. The environmental assessment report will be organized according to the outline below.*

- *Executive Summary*
- *Policy, Legal and Administrative Framework*
- *Description of Proposed Project*
- *Description of the Environment*
- *Significant Environmental Impacts*
- *Impact Mitigation and Environmental Management Plan*
- *Environmental Monitoring Plan*
- *Inter-Agency and Public/NGO Involvement*
- *List of References*

## 1.3 STUDY TEAM

Environmental Solutions Ltd and Smith Warner International carried out this EIA. The multidisciplinary team engaged to carry out the assessment included local expertise in environmental impact assessment, marine and coastal ecology, coastal engineering, environmental chemistry, socio-economics and tourism planning. The team members were:

*Environmental Solutions Ltd.*

- Mr. Peter Reeson, M.Sc. - EIA Specialist; Environmental Scientist
- Mr. David Narinesingh, M.Sc. – Ecologist; Environmental Scientist

*Smith Warner International*

- Mr. Philip Warner, M.Sc, P. Eng. - Coastal Engineer

## 1.4 METHODOLOGY

### 1.4.1 Terrestrial Survey

A simple 'walk through' terrestrial survey of flora and fauna was conducted on 13 May 2003. Plant species were identified, the presence of rare and endemic plants was determined, and an indication of biodiversity at the site was obtained.

### 1.4.2 Marine Survey

Information and descriptions of the marine environment at Bloody Bay were obtained from recent marine biology surveys conducted by DHV International Limited (1999) and CL Environmental Company Ltd. (2001) during the respective EIAs for the RIU Bloody Bay Phase I and Phase II all-inclusive developments.

Together, these surveys covered the offshore spur-and-groove/patch reef ecosystems outside Bloody Bay, the marine environments and fringing reefs of Little Bloody Bay and Bloody Bay, and the extensive seagrass bed areas of the recently proposed (and shortly to be declared officially) Bloody Bay fish sanctuary. Both surveys involved a series of SCUBA dives, towed-diver transects, and snorkeling exercises.

The information and descriptions obtained from these surveys are summarized and presented in Section 3.6 of this EIA report.

### 1.4.3 Water Quality Survey

Information on marine water quality was obtained from a sampling exercise conducted by CL Environmental Company Ltd. for the RIU Phase II hotel EIA (CL Environmental Company Ltd., 2001).

Physical and biological data were collected from seven (7) stations within the study area in 2001. The locations of these stations are shown on Figure 1.2. Data for twelve parameters were collected. Of these, seven were done *in situ* using a Hydrolab $H_2O$ datalogger. These parameters 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 samples were collected, stored on ice, and transported to the laboratory at the University of the West Indies.

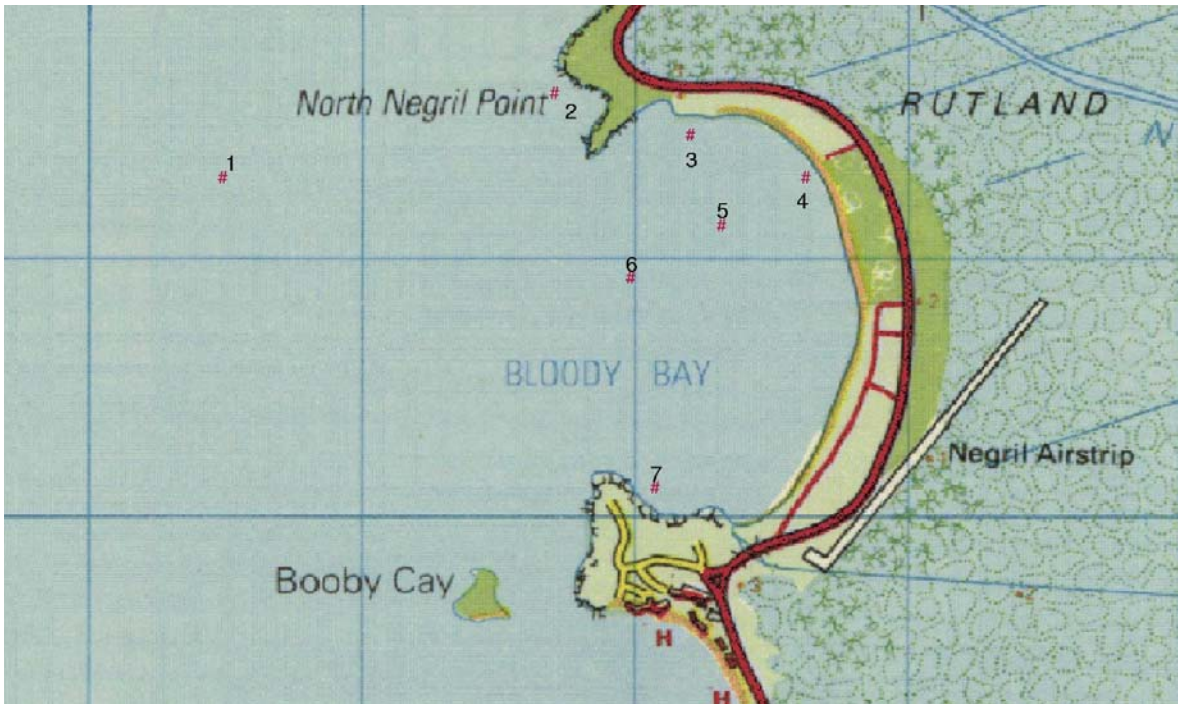


**Figure 1.2 Locations of water quality sampling stations tested by CL Environmental Company Ltd. (2001).**

1.4.4 Bathymetric Survey

A bathymetric survey was conducted on May 29th, 2003 within Bloody Bay to define the nearshore topography. Data was collected using an AutoHelm ST160 depth sounder and a Magellan Pro-Mark X ten-channel GPS receiver. Both instruments logged data points to their internal memories at approximately 1-second intervals. The survey took approximately 2 ¾ hours, collecting almost 5000 positions and corresponding depths. Back in the office, the two data sets were merged to create an ASCII file with X, Y and Z coordinates. A digital elevation model was then constructed using this database. Figure 1.3 shows the locations where water depths were recorded.

**Figure 1.3 Locations of water depth recordings (2003).**

# 2. ENVIRONMENTAL POLICY, LEGISLATION AND REGULATORY FRAMEWORK

The environmental laws and regulations of Jamaica that are relevant to the proposed Negril Cabins expansion project, are listed and commented upon below.

## 2.1 LEGISLATION AND REGULATIONS

Natural Resources Conservation Authority Act (1991)
This is the main environmental legislation that relates to the proposed project. This Act establishes the Natural Resources Conservation Authority (NRCA) with primary responsibility for ensuring sustainable development through the protection and management of the country's natural resources and the control of pollution. This is done mainly through an environmental permit and licence system.

The Act gives the Authority power to:

- issue permits to the person responsible for undertaking any enterprise, construction or development of a prescribed category in a prescribed area [Section 9]. This section, the Prescribed Area Order, designates all of Jamaica as being within the prescribed area;
- issue licences for discharge of trade or sewage effluent or for construction or modification of any works for such discharge [Section 12 (1) (a) and (b)];
- request information or documents as the Authority thinks fit [Section 10 (1) (a)];
- request an environmental impact assessment containing such information as may be prescribed [Section 10 (1) (b)];
- request information on pollution control facilities [Section 17];
- revoke or suspend permits.

The Act also incorporates the earlier Beach Control Act, Wildlife Protection Act and Watersheds Act.

◊ Beach Control Law (1955) and Beach Control Act (1978) (subsequently re-authorized under the NRCA Act and currently under review)
The regulations of 1978 relate to hotels, commercial and public recreational beaches, regulated beach activities, care of beaches and rights of license. The Beach Control Act extends only to the foreshore; while it provides for the designation of protected areas, it does not address the basis for such designation, nor does it deal with the management of coastal resources landward or seaward of the foreshore. The Beach Control Law requires that an application be made for the modification of any beach/coastline and sets out requirements for the posting of public notices.

◊ Wild Life Protection Act (1945)
Prohibits removal, sale or possession of protected animals, use of dynamite, poisons or other noxious material to kill or injure fish, prohibits discharge of trade effluent or industrial waste into harbours, lagoons, estuaries and streams. It authorizes the establishment of Game Sanctuaries and Reserves. Protected under the Wildlife Protection Act are six species of sea turtles.

Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order (1996)
The island of Jamaica and the Territorial Sea of Jamaica has been declared as a Prescribed Area. No person can undertake any enterprise, construction or development of a prescribed description of category except under and in accordance with a permit.

Natural Resources Conservation (Permits and Licenses) Regulations (1996)
These regulations give effect to the provisions of the Prescribed Areas Order. Hotel/resort complexes of more than 12 rooms, as well as sewage treatment facilities, are included on the prescribed list.

Natural Resources Conservation (Sewage Effluent) Regulations (Draft)
These regulations, when brought into effect, will cover the discharge of sewage effluent, the operations, monitoring and reporting mechanism of sewage treatment facilities.

Natural Resources Conservation (Negril Marine Park) (Declaration) Order (????)
The Negril Marine Park was established in 1998. The Order describes the area and includes a map with boundaries and proposed zoning.

Fishing Industry (Fish Sanctuaries) Order (1979)
The Fishing Industry Act of 1975 provides for the regulation of the fishing industry and serves to conserve and manage the fisheries resources by addressing such issues as licensing. Under the 1979 Order fish sanctuaries may be declared by the Minister, in which no fishing is allowed. Such an area has been proposed in the northern part of Bloody Bay.

Water Quality NRCA Act (1990)
The NRCA has primary responsibility for control of pollution in Jamaica's environment, including pollution of water. National standards exist for industrial and sewage effluent discharges to rivers and streams.

Town and Country Planning Act (1958)
Established the Town and Country Planning Authority with responsibility for Development Orders to control both rural and urban land development, ensure proper sanitary conveniences, co-ordinate building of roads and other public services. Planning approvals for the project will have to be obtained from the Town Planning Authority at NEPA.

Quarries Control Act (1983)
This Act repeals the Quarries Act of 1958 and makes provisions for quarry zones and licenses, quarry tax, enforcement and safety. The proposed project should ensure that any earth materials used for the proposed expansion of the Negril Cabins Resort are obtained only from licenced quarries.

## 2.2 POLICIES AND REGULATIONS

National Policy for the Conservation of Seagrasses (1996)
This policy guides the issuing of licenses, or permits for activities such as dredging, disposal of dredged material, beach development and effluent disposal, which directly or indirectly affect seagrass communities. Seagrass meadows occur in Bloody Bay, offshore the shoreline of the

proposed Negril Cabins Hotel site. Note is taken that it is not proposed to remove any seagrasses from in front of the beach at the development site.

Policy for Jamaica's System of Protected Areas (1997)
The System of Protected Areas is an expression Jamaica's commitment to protect the environment and its resources through the protection of parks and protected areas. The policy lists six goals, which include, economic development, environmental conservation, sustainable use of resources, recreation and public education, public participation and financial sustainability. The proposed project is located within the boundaries of the Negril Marine Park.

Mangrove and Coastal Wetlands Protection - Draft Policy and Regulations (April 1996)

A review of the issues affecting wetlands in Jamaica as well as Government's role and responsibility. Five main goals are outlined which include guidelines for wetlands development, cessation of destructive activities, maintenance of natural diversity, maintenance of wetland function and values and integration of wetland functions in planning and development. There are no mangrove or coastal wetlands onsite or within the immediate vicinity of the Negril Cabins site. Extensive mangrove ecosystems are, however, associated with the northern section of Bloody Bay, approximately 2 km NNW of the project site.

Coral Reef Protection and Preservation Policy and Regulation (Draft - 1996)
This document reviews the ecological and socio-economic functions of coral reefs, issues affecting coral reefs and Government's role and responsibility. Five main goals are outlined which include reduction of pollutants, reduction of over-harvesting of reef fish, reduction of physical damage from recreational activities, improving the response capability to oil spills, and control of coastal zone developments. The proposed hotel expansion project must ensure that its activities do not threaten or harm the coral reefs in and around Bloody Bay.

# 3. DESCRIPTION OF PROJECT AREA

## 3.1 PHYSIOGRAPHY

The proposed development site is located at Bloody Bay on the sandbar separating the sea from the Great Morass of Negril; i.e. opposite the existing Negril Cabins Hotel, along the Norman Manley Boulevard between Long Bay (to the south) and Orange Bay (to the north) (Plate 1). The proposed site is a green-field site which is presently used to allow access to the beach for guests staying at Negril Cabins (Plate 2). RIU's Phase I hotel is located on the lot adjacent to, and south of, the proposed development site while the adjacent lot to the north is undeveloped.

Bloody Bay itself is an enclosed bay situated immediately north of the famous Long Bay beach in Negril (Figure 3.1). It is a small, well defined embayment, formed between two rocky promontories: Rutland Point, to the south, and North Negril Point, to the north. The Bloody Bay beach is roughly 2.4 km long and waters in the bay are relatively calm, being sheltered by the promontories and offshore reefs. Two small cays are associated with the bay: Booby Cay, found off Rutland Point, and Pelican Cay, found close to the northern shore of the bay.

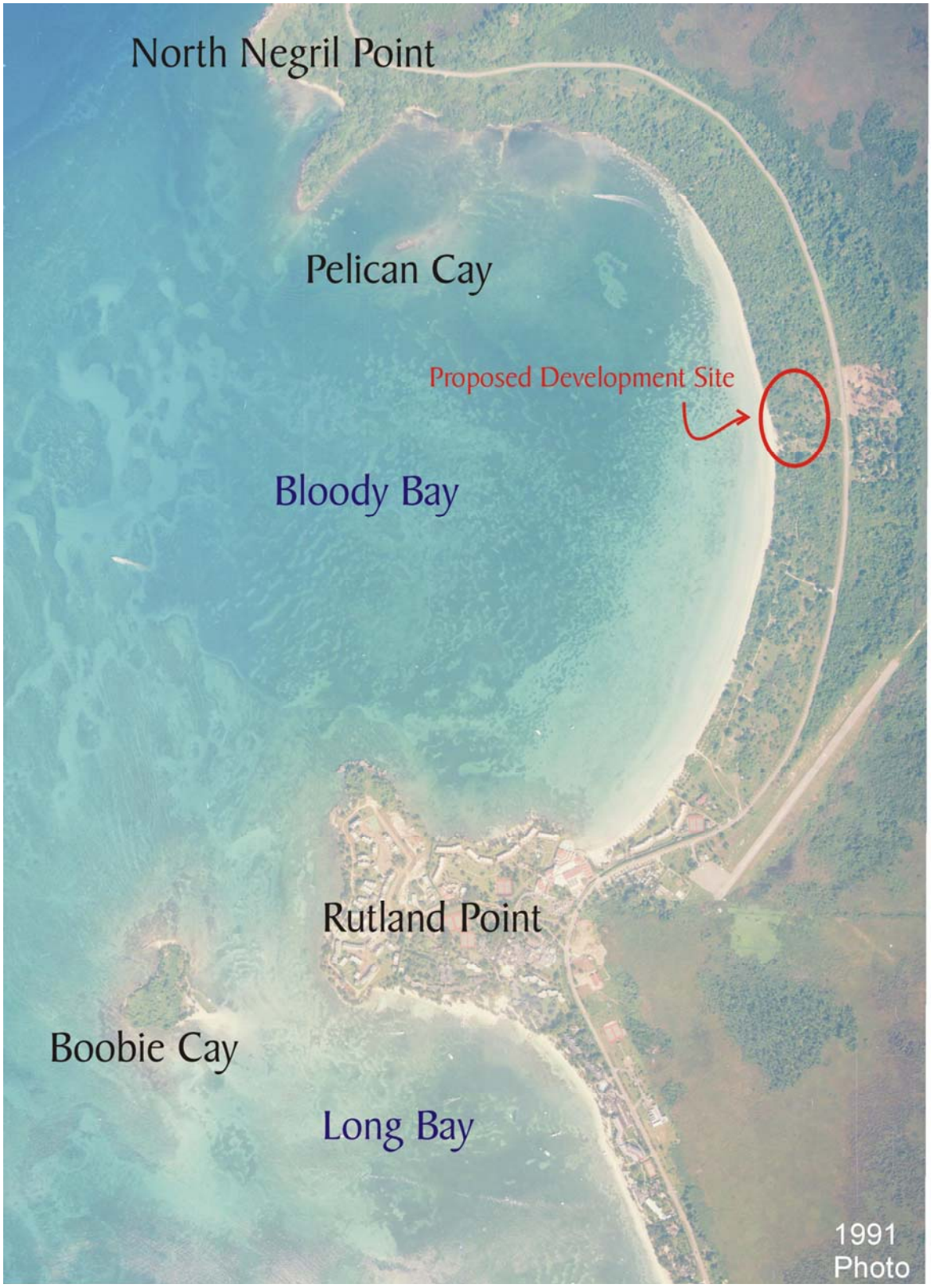


**Figure 3.1 Location of Proposed Development Site**

The proposed development site is relatively flat with slight undulations (Plate 3). Most of the site has elevations ranging between 1.2 and 1.5 m (4 – 5 ft) with maximum elevations being 1.8 m (6 ft) along the eastern boundary of the site. There are poorly defined drainage features on the site and rainfall mainly percolates through the sandy soil. However, during heavy rains, water flows within poorly defined onsite surface drainage features and there is evidence of water ponding in depressed areas (Plate 4).

The length of the beach, at the proposed development site, is about 130 m (426 ft) long and is comprised of fine-grained sands (Hendry, 1982). Fortunately, the bay is reasonably well protected from high wave energy that helps mitigate against considerable beach erosion. However, the existing beach profile still manages to change cyclically, over time, with the prevailing wave regime. Within Bloody Bay itself, the water depths reach a maximum of approximately 6.0 metres in the central portion. The seabed slopes gently up to the shoreline with a slope of approximately 1:75. The slope closer to the shoreline becomes slightly steeper, at approximately 1:40 (see Figure 3.2)

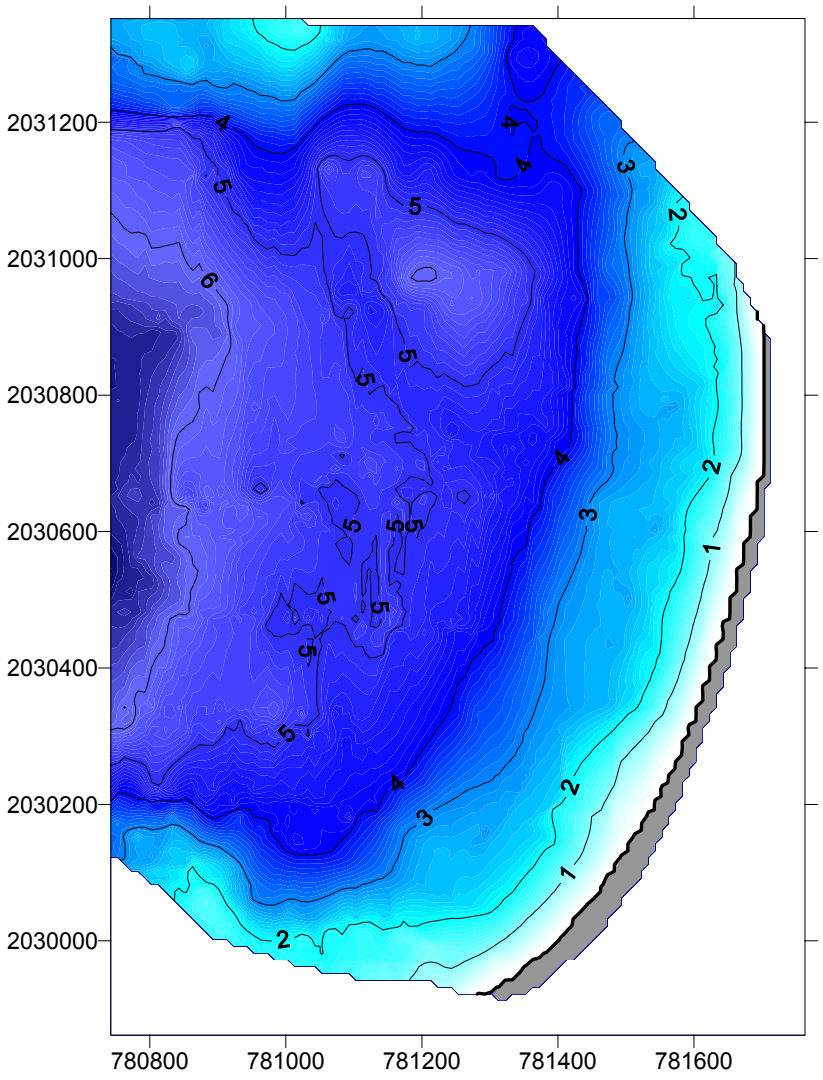


**Figure 3.2 Nearshore Bathymetry, Bloody Bay**

Two coastal shelves, an inner and an outer shelf, characterise the offshore submarine topography off both Long Bay and Bloody Bay. *The inner shelf* is a relatively flat shallow shelf which coincides with the inshore area of Bloody Bay and the offshore region immediately outside Bloody Bay itself. This inner shelf terminates at a submarine patch reef/cliff structure, approximately 1.3 km offshore, beyond which is found *the outer shelf* and deepwater reefs (see Figure 3.1).

The morphology of the bay's marine environments has been extensively surveyed and described by Hendry (1982). The main features of his findings are summarised, in plan view, at Figure 3.3. The distribution of vegetation and other benthos in the bay is shown at Figure 3.4. There are no seagrass beds along the shoreline immediately in front of the Negril Cabins beach. However, beds of *Thalassia testudinum* and *Syringodium filiforme* are found covering the seafloor towards the middle of the bay. These help bind and stabilize the sediments. Dense seagrass beds cover the northern section of the bay (see Figure 3.4), in the vicinity of the RIU Phase II development site.

## 3.2 GEOLOGY AND LITHOLOGY

The bedrock of the Negril area is comprised of Tertiary limestones, principally comprising the Yellow Limestone Group, conformably overlain by the pure limestones of the White Limestone Group. In Bloody Bay, limestone outcrops are evident at North Negril Point and Rutland Point. North Negril Point is characterised by a raised reef of Pleistocene age, which is typically comprised of coral rock and skeletal fragments, whereas at Rutland Point, the outcrop is the micritic limestone and massive corals of the Newport Limestone Formation (part of the White Limestone Group). The bedding of the limestone groups is typically horizontal or only gently dipping, and the described outcrops are due to localised faulting (DHV International Limited, 1999).

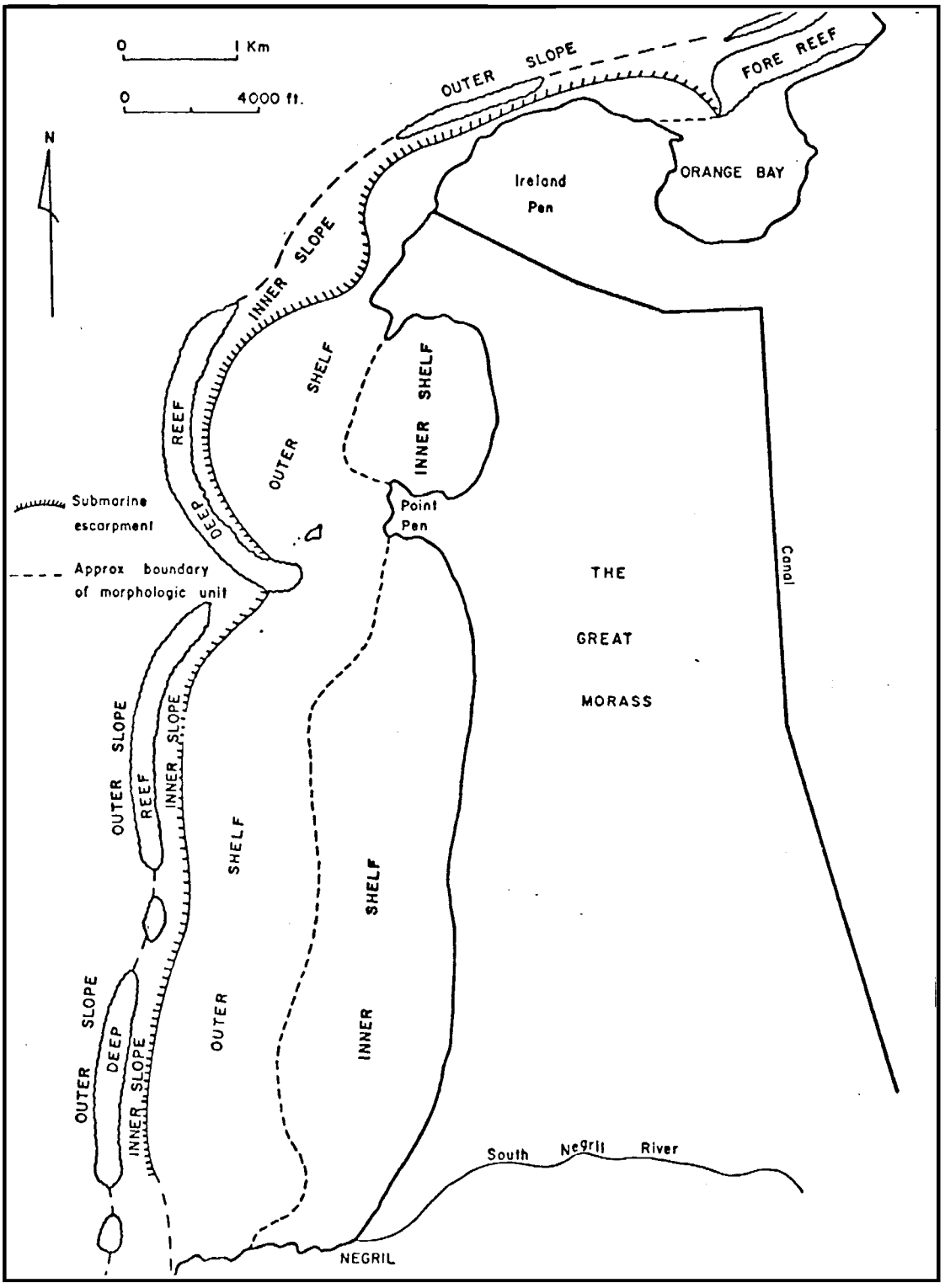


Figure 3.3 Morphology of offshore area at Negril. (Taken from Hendry, 1982.)

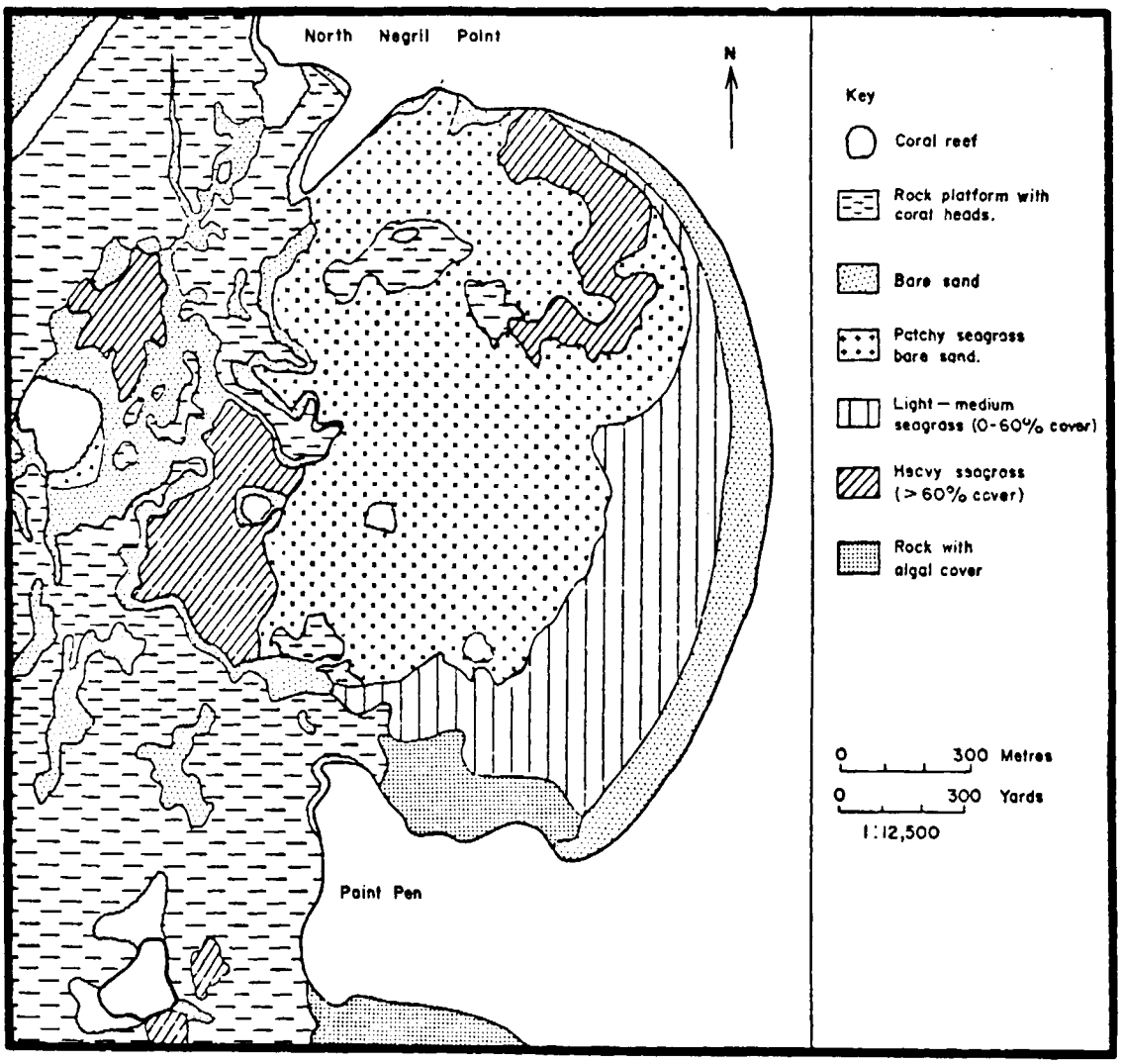


**Figure 3.4 Sedimentary environments of Bloody Bay. (Taken from Hendry, 1982.)**

Along the Bloody Bay coastal strip, superficial carbonate beach sands overlie the limestone rocks. Boreholes drilled along the strip by Hendry (1982) indicate between 6.2 m and 7.6 m of sand deposits, which typically show an upwards-coarsening profile. The interface between the sand and limestone is characterised by a thin layer of clay, which in places also contains peat deposits. The sand soils are also characterised by occasional shells typical of species such as *Chione cancellata*, *Bulla striata*, and *Donax striatus*.

Cores drilled by Jentech Consultants Ltd. in April, 1999 at the adjacent RIU Tropical Bay Phase I site showed a 1 m - 2 m top layer of light brown sand underlain by 3 m - 5 m of creamy brown to grey fine sand on stiff gravelly clay at approximately 8 m below the surface. Some peat intrusions were found. The Jentech boreholes were drilled to depths of 10 m - 11 m and no limestone was found. Fresh water was encountered in nine out of the ten boreholes, occuring at depths between 1 m and 1.5 m, which correlates with an elevation of approximately 0.3 m below sea level (DHV International Limited, 1999).

## 3.3 METEOROLOGY

The Negril area, like the rest of the island, experiences a subtropical climate. Mean daily temperatures are lowest in March (22.9$^{o}$C) and highest in July and August (29.2$^{o}$C and 29.1$^{o}$C, respectively). Relative humidity ranges between 65% and 85% (ESL, 1996).

Rainfall is variable over the 27 km$^2$ catchment area of the Negril Morass. The highest rainfall measured at the Negril Lighthouse occurs between May and October when the average monthly rainfall exceeds 180 mm (CL Environmental Company Ltd., 2001). For the rest of the year the mean monthly rainfall is less than 80 mm.

Wind records collected at Negril Lighthouse (1960 – 1969) and presented in Hendry (1982) reflect the leeward and sheltered position of the area with respect to the predominant easterly trade winds. Calms occurred 39.3% of the time, with the frequency of winds being 22.6% from the NE, 13.7% from the SE, 9.7% from the N, 3.1% from the S, and 7.1% from the E. Winds from the NW and SW accounted for the remaining 4.5% of observations. It is evident that the sea breeze and land breeze system that is evident in other parts of Jamaica is absent at Negril.

## 3.4 HYDROLOGY

The Great Morass of Negril, a 4,500 ha (11,100 acre) wetland, lies east of Long Bay, Bloody Bay and Orange Bay and is separated from them by a narrow sandbar. The thickness of the peat within the Morass varies but is about 8 – 10 m in the middle of the Morass. The hydrology of the swamp has been severely modified by drainage works carried out in the late 1950s. Today, the Eastern Cutoff Canal and the North Negril Canal drain the eastern and northern sections of the Morass. In the south, the South Negril River drains it. The Middle River at Long Bay still flows after heavy rains.

Along the Bloody Bay coastal strip, the high permeability carbonate beach sands described in Section 3.2 influence drainage of surface meteoric waters. Waters infiltrate downwards under gravity until they reach the shallow water table (approximately 1.5 m below ground level). The groundwater table is in hydraulic continuity with the adjacent Morass, the levels of which in turn are determined by the sea. Groundwaters within the immediate vicinity of the development site are of poor quality, due to saline intrusion (DHV International Limited, 1999). The important point to note is that the water table under the Bloody Bay strip (and therefore the proposed project site) is high and is in hydrological continuity with the Morass. It may be found as shallow as 1.5 m below the soil surface, depending on the location. This has implications for the proposal to construct a tunnel under the main road to connect the two sites.

Flooding is not anticipated on or within the vicinity of the site, and the area is not within any designated flood zones (DHV International Limited, 1999). There are no standing waters and no permanently defined surface water drainage features on the site. Although most of the rainfall that falls on the site percolates through the pervious soils, some ponding of water does occur in depressions after long periods of sustained rainfall, resulting in some areas becoming periodically waterlogged. Under more extreme conditions, the flow of surface water cuts across and erodes the face of the beach. The Norman Manley Boulevard, which separates the development site from the existing hotel site on the landward side, has elevations approximating 2 m (7.4 feet). It thus acts as a barrier to surface water flow from the Morass during heavy rainfall.

## 3.5 TERRESTRIAL ECOLOGY

### 3.5.1 Terrestrial Vegetation

Coke *et al* (1982) described the type of vegetation that originally covered the site as 'mixed swamp-margin forest'. In recent years this forest type has largely been destroyed throughout Negril to accommodate coastal resort development. The original forest at the proposed development site has been impacted and cleared over the past two decades to improve accessibility and security, mainly by removal of the understorey and ground cover. Today, only the larger trees remain (Plate 5) and these include *Terminalia catappa* (Almond), *Cocoloba uvifera* (Seagrape), *Calophyllum calaba* (Santa Maria), *Morinda citrifolia* (Hog Apple/Noni), *Haematoxylum campechianum* (Logwood), *Cecropia peltata* (Trumpet Tree), and the endemic palm *Thrinax parviflora.* Most of these trees had diameters at breast height greater than 18cm., they were generally between 6 m – 15 m in height, and they formed semi-closed canopies. The forest floor was devoid of leaf litter and grassed in places; the grounds are maintained by Negril Cabins whose staff regularly cut the grass and rake fallen leaves.

### 3.5.2 Avifauna

Fifteen (15) different species of birds were observed at the site (see Table 3.5.1), i.e. over the course of the site visit and during various *ad hoc* visits to the site (cp. Section 1.4.1). Five (5) species are endemic to Jamaica. These were *Melanerpes radiolatus* (the Jamaican Woodpecker), *Anthracothorax mango* (Jamaican Mango), *Mellisuga minima* (Vervain Hummingbird), *Trochilus polytmus polytmus* (the Red-billed Streamertail Hummingbird) and *Myiarchus barbirostris* (Sad Flycatcher).

Five species of endemics and fifteen species overall is considered to be a moderate to high figure for a given locality. This diversity indicates and underscores the importance of the proposed Negril Cabins development site as a bird habitat. Avifaunal activity was restricted to the canopy of tall trees since the ground and understorey vegetation was virtually absent. Tree cover and the relatively closed forest canopy are extremely important for birds and these should be left as intact and undisturbed as possible.

**Table 3.5.1 Bird species observed and heard at the proposed Negril Cabins hotel site.**

| FAMILY | SPECIES NAME | COMMON NAME | STATUS* |
|---|---|---|---|
| Apodidae | *Streptoprocne zonaris* | White-collared Swift | CR |
| Apodidae | *Tachornis phoenicobia* | Antillean Palm Swift | VCR |
| Columbidae | *Columba leucocephala* | White-crowned Pigeon | CR |
| Columbidae | *Columbina passerina* | Common Ground Dove | VCWR |
| Columbidae | *Zenaida aurita* | Pea Dove | CR |
| Emberizidae | *Coereba flaveola* | Bananaquit | CWR |
| Emberizidae | *Dendroica petechia* | Yellow Warbler | CR |
| Emberizidae | *Mniotilta varia* | Black-and-white Warbler | CWV |
| Emberizidae | *Tiaris bicolor* | Black-faced Grassquit | CR |
| Picidae | *Melanerpes radiolatus*** | Jamaican Woodpecker | CWR |
| Trochilidae | *Anthracothorax mango*** | Jamaican Mango | CR |
| Trochilidae | *Mellisuga minima*** | Vervain Hummingbird | VCR |
| Trochilidae | *Trochilus polytmus polytmus*** | Red-billed Streamertail | CR |
| Tyrannidae | *Myiarchus barbirostris*** | Sad Flycatcher | CR |
| Tyrannidae | *Tyrannus caudifasciatus* | Loggerhead Kingbird | CW |

* Based on Downer & Sutton, 1990
** Endemic species

**STATUS KEY:**

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

### 3.5.3 Other Terrestrial Fauna

Several species of crab were observed in the area of the Riu II project (CL Environmental Company Ltd., 2001) and these species are likely to frequent the proposed hotel site. These include:

i) *Gecarcinus lateralis* (Black Land Crab)
ii) *Ucides cordatus* (Mangrove Land Crab)
iii) *Cardisoma guanhumi* (Great Land Crab)

The two land crab species are hunted seasonally throughout the coastal areas of Jamaica, including at Negril.

Small garden frogs (Genus *Eleutherodactylus*) were heard throughout the area during the CL Environmental Company Ltd. (2001) EIA fieldwork and are likely to be present at the Negril Cabins site. Nineteen (19) species of *Eleutherodactylus* are known to occur in Jamaica, 17 of which are endemic, the remaining two being introduced species. Four species (*E. cundali*, *E. johnsoni*, *E. luteolus* and/or *E. pantoni*) are recorded from Negril (DHV International Limited, 1999).

Four species of tree frog are known to live in Jamaica, including *Osteopilus brunneus*, an endemic and widespread species. *O. brunneus* inhabits and breeds within water trapped within wild tree bromeliads (e.g. 'tank' bromeliads like *Hohenbergia sp.*), often in large numbers. *Hohenbergia sp.* is commonly found within trees in the vicinity of the proposed Negril Cabins site (see DHV International Limited, 1999 and CL Environmental Company Ltd., 2001) and could well be present at the proposed hotel site (cp. Section 3.5.1).

With regards to reptiles, the endemic green lizard *Anolis garmani* is known to inhabit trees within the vicinity of the proposed hotel site (DHV International Limited, 1999; CL Environmental Company Ltd., 2001). 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. Given the small width of the beach and the level of guest activity from RIU Phase I, Negril Cabins and local users, the possibility that nesting turtles use the proposed site 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. ESL (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).

## 3.6 MARINE ECOLOGY

Bloody Bay lies within the boundaries of the Negril Marine Park (see Figure 3.5 following and Section 3.10.4). A fish sanctuary has been proposed for the northern section of the bay and has already been delineated by marker buoys. It encompasses Little Bloody Bay, Pelican Cay, most of the northern section of Bloody Bay and ¾ of the nearshore/inshore area of the RIU Phase II development site.

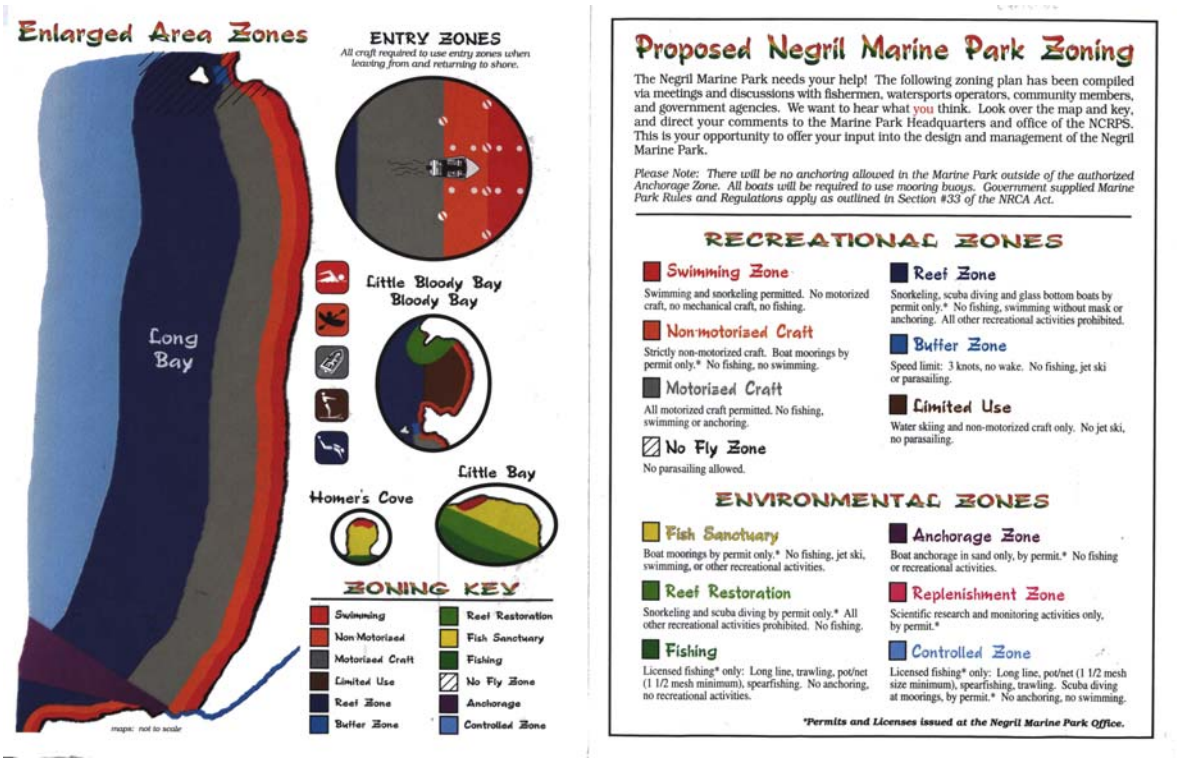


**Figure 3.5 Proposed Negril Marine Park Zoning**

Recent marine biology surveys have been conducted by DHV International Limited (1999) and CL Environmental Company Ltd. (2001), as part of EIA for the RIU Bloody Bay Phase I and Phase II all-inclusive developments. Together these surveys covered the offshore spur-and-groove/patch reef ecosystems outside Bloody Bay, the marine environments and fringing reefs of Little Bloody Bay and Bloody Bay, and the extensive seagrass bed areas of the recently proposed (and shortly to be officially declared) Bloody Bay fish sanctuary. Both surveys involved a series of SCUBA dives, towed-diver transects, and snorkeling exercises. Their findings indicate that there have been no significant changes to the broad physical features and marine ecology within Bloody Bay that were reported and detailed by Hendry, 1982 (see Figure 3.2).

The two EIAs reported that the coral reefs offshore of Bloody Bay were moderately healthy and supported an abundant and diverse benthic invertebrate community of stony corals, soft corals, sea fans, sponges, echinoderms and anemones. However, the reef systems showed signs of stress due to poor/deteriorating offshore marine water quality and heavy use by dive operators. DHV International Limited (1999) further reported that although the fish populations tended to be diverse, fish abundance was low, attributable to pressure from over-fishing.

A summary of the main findings of the ecological surveys carried out by CL Environmental Company Ltd. (2001) at Bloody Bay and Little Bloody Bay are presented in Appendix 1. These areas are the nearest reef environments to the proposed Negril Cabins site and would be the first coral reef ecosystems to be negatively impacted by deteriorating water quality associated with poor construction and operational practices by hotels in the area.

## 3.7 MARINE WATER QUALITY

The results of the water quality sampling exercise carried out by CL Environmental Company Ltd. (2001) are presented in Tables 3.7.1 and 3.7.2.

**Table 3.7.1 Physical and chemical parameters. (Taken from CL Environmental Co. Ltd., 2001.)**

| STN # | TEMP ($^oC$) | SAL (ppt) | DO (mg/l) | pH | PAR ($\mu E/m^2/s$) | TDS (mg/l) | $NO_3$ (µmol/l) | $PO_4$ (µmol/l) |
|---|---|---|---|---|---|---|---|---|
| **1** | 30.30 | 37.50 | 5.93 | 7.64 | 301 | 36.00 | 0.32 | 0.00 |
| **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 | 0.00 |
| **4** | 31.50 | 37.38 | 7.38 | 7.63 | 320 | 35.91 | 1.77 | 0.60 |
| **5** | 31.88 | 37.13 | 6.41 | 7.60 | 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 | 0.30 |

Temperature, salinity, dissolved oxygen (DO), pH, photosynthetically active radiation (PAR) and total dissolved solids (TDS) were within the expected ranges for marine waters. However, pH showed some evidence of fresh water influence since the normal value of pH in marine waters is of the order of eight (8).

Nitrate and phosphate concentrations at the seven stations ranged between 0.32 µmol $l^{-1}$ and 42.23 µmol $l^{-1}$ and 0.00 µmol $l^{-1}$ and 0.74 µmol $l^{-1}$, respectively. Lapointe (1997) and Bell (1992) both suggest that critical levels of nitrates and phosphates are 1 µmol $l^{-1}$ and 0.1 µmol $l^{-1}$ respectively, while Raymont (1980) suggests that low nutrients can be considered as being in the range of 0.2 µmol $l^{-1}$ - 1.75 µmol $l^{-1}$ for nitrates and 0.07 µmol $l^{-1}$ - 0.24 µmol $l^{-1}$ for phosphates. Currently accepted standards for ambient marine water quality are 1.3 µmol $l^{-1}$ for nitrates and 0.5 µmol $l^{-1}1$ for phosphates.

Overall, the nutrient levels within Bloody Bay were higher than their respective ambient marine water quality standard. Nitrate concentrations exceeded 1.3 µmol $l^{-1}$ at all stations except Station 1. Phosphate concentrations also exceeded 0.5 µmol $l^{-1}1$ at Stations 4 and 6.

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 potentially eutrophic waters. The status of a water body is further confirmed by measuring the amount of phytoplankton in the water column. High phytoplankton levels, represented by high chlorophyll *a* values, are indicative of nutrient enriched (i.e. eutrophic) areas (CL Environmental Company Ltd., 2001).

**Table 3.7.2 Biological parameters. (Taken from CL Environmental Co. Ltd., 2001).**

| STN # | CHL a ($mg/m^3$) | $BOD_5$ (mg/l) | FAECAL COLIFORM (MPN/100ml) | TOTAL COLIFORM (MPN/100ml |
|---|---|---|---|---|
| **1** | 0.24 | 1.66 | <2 | 70 |
| **2** | 0.29 | 2.29 | 20 | 500 |
| **3** | 0.27 | 3.43 | 20 | 220 |
| **4** | 0.51 | 0.00 | 40 | 170 |
| **5** | 0.46 | 0.86 | 20 | 110 |
| **6** | 0.36 | 6.00 | 80 | 500 |
| **7** | 0.46 | 0.86 | 80 | 230 |

Total chlorophyll *a* concentrations ranged between 0.24 $mg/m^3$ and 0.51 $mg/m^3$ at the seven stations sampled by CL Environmental Company Ltd. (2001) within Bloody Bay. The southern section of the bay had higher concentrations of chlorophyll *a*, with stations 4, 5, 6 and 7 having the highest values. Webber (1990) suggests that low total chlorophyll *a* concentrations are generally considered to be within the range of 0.28 $mg/m^3$ - 1.03 $mg/m^3$, suggesting that the CL Environmental Company Ltd. (2001) total chlorophyll *a* values, observed within Bloody Bay, were 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 between 0.00 mg/l and 3.43 mg/l. The northern and western sections of the Bloody Bay (i.e. Stations 1, 2 and 3) had the highest concentrations during the CL Environmental Company Ltd. (2001) survey, with Station 3 (3.43 mg/l) exhibiting the highest concentration. Ambient marine water quality standards, for $BOD_5$, range between 0.57 mg/l and 1.16 mg/l.

Faecal coliform levels were within the 100 MPN/100ml standard for ambient marine waters, however, elevated levels were observed towards the southern section of the bay, specifically at Stations 6 and 7. With the exception of Stations 1, 4 and 5 all other stations exceeded the total coliform ambient water quality standard of 200 MPN/100ml.

In summary, the findings of the CL Environmental Ltd. (2001) survey suggest that quality of the marine waters off the proposed Negril Cabins site fluctuates between a pristine and a moderately nutrient-enriched state. There is a history of poor water quality within the southern part of Bloody Bay and regular monitoring of water quality in the bay needs to be carried out to ensure the health and safety of beach users (ESL, 2003).

## 3.8 NOISE

CL Environmental Company Ltd. (2001) reported that noise levels taken in the morning and in the afternoon in the vicinity of the Negril Cabins site ranged between 51 dBA and 56.1 dBA. The NEPA standard for residential areas is 55 dBA

## 3.9 NATURAL HAZARD VULNERABILITY

Negril is prone to hurricane force winds, storm surges, earthquakes and flooding from storm events of varying intensity. Of particular concern to the project area are the hazards of storm surge and flooding from storm events.

A hindcast analysis of storm waves was carried out, using the program HURWave, in order to explore design criteria and storm surge conditions within Bloody Bay. A deep-water location was selected (>200m water depth) with coordinates 18°20' latitude and 78°25' longitude. For this point, the storm tracks that passed within a 400 km radius were extracted from the National Oceanic and Atmospheric Administration (NOAA) historical database of tropical cyclones.

For the 103-year period investigated, 131 storms have come within 400 km of Bloody Bay. Of this number, 54 were classified as hurricanes. The categories are divided according to the Saffir-Simpson Scale, given in Table 1. Almost half of these storms were Category 1 hurricanes and six were Category 4's. One storm, Allen in 1980, was a Category 5, the highest category. Figure 1 shows the distribution of storm intensities over the past 103 years for tropical storms and hurricanes passing within 400 km of Bloody Bay. Figure 2, following, shows the tracks of those storms classified as Category 3 or greater that passed within this 400 km radius between 1900 and 2002.

**Table 3.9.1 Categorization of Tropical storms and hurricanes passing within 400 km of Bloody Bay. (Using the Saffir-Simpson Intensity Scale. 1 minute maximum sustained near surface wind speed)**

| **Storm Category** | | | | | | |
|---|---|---|---|---|---|---|
| | **Tropical Storm** | **Hurricane Categories** | | | | |
| Units | | 1 | 2 | 3 | 4 | 5 |
| Knots | <64 | 64-83 | 84-95 | 96-113 | 114-135 | >135 |
| Km/hr | <119 | 119-154 | 155-178 | 179-210 | 211-250 | >250 |
| m/s | <33 | 33-43 | 44-49 | 50-58 | 59-70 | >70 |
| Number within 400 km of Bloody Bay | 77 | 22 | 13 | 12 | 6 | 1 |

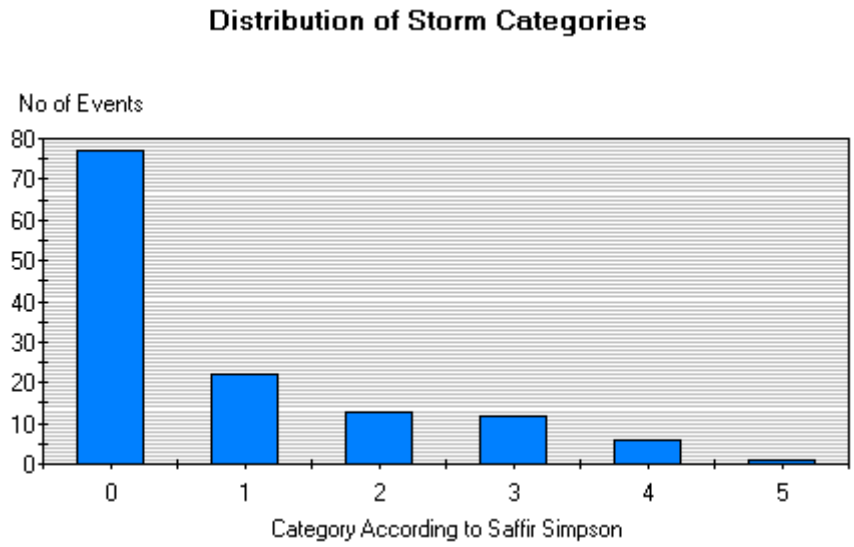


**Figure 3.6: Distribution of Tropical Storms (Category 0) and Hurricanes (Category 1-5) passing within 400km of Bloody Bay 1900-2002.**

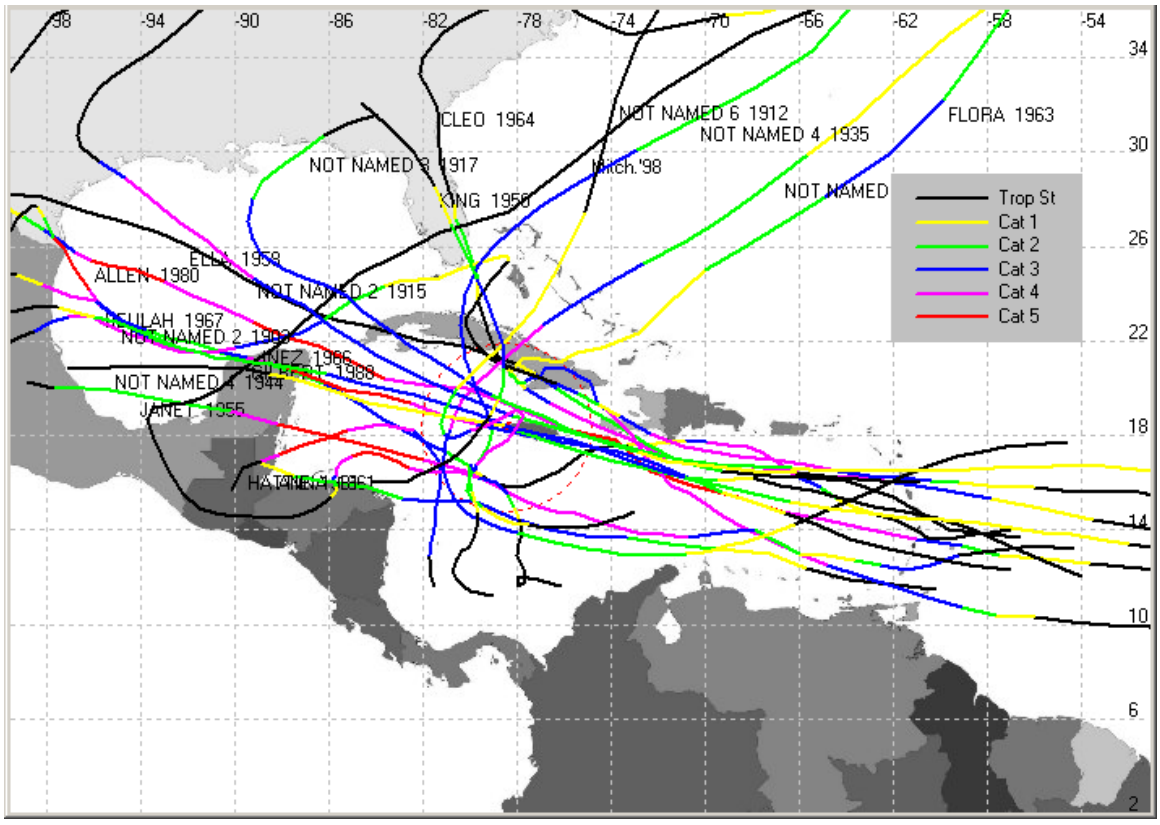


**Figure 3.7: Tracks of intense hurricanes (Categories 3-5) to have passed within 400km of Bloody Bay**

Storm surge consists of the anticipated sea level rise due to the passage of tropical storms and hurricanes, but must also consider the effects of normal tidal variations and any long-term sea level changes.

Tides in Negril were not measured as part of this assignment. Tide measurements were made in Lucea (SWIL, 1996) and showed a typical range of 0.30 metres. The range above MSL would therefore be half of this, or 0.15 metres.

Long-term sea level rise should also be considered in the assessment of storm surge risk. In the absence of local, site specific data, a recommended value of 5mm per year has been proposed by UNEP. For infrastructure works such as a hotel development, a 50-year design horizon should be considered, resulting in an increase in the water level of 0.25 metres.

When defining storm surge, it is usual to select a datum from which to present the results. Existing topographic data for this site is referenced to Mean Sea Level (MSL) datum as is the bathymetric data. The storm surge elevations that have been computed are referenced to the mean sea level. There can be discrepancies between the MSL datum and the actual mean sea level due to a variety of factors, including the effects of global warming.

Storm surge resulting from the passage of a tropical storm consists of several components that are detailed in the Table 3.9.2 following.

**Table 3.9.2 Storm Surge Components**

| Component | Definition | Time scale/Period |
|---|---|---|
| Inverse barometric rise | The low pressure in the "eye" of the hurricane compared with surrounding pressure elevates the water level within the hurricane. | 1 – 4 hours |
| Wind set-up | As the wind pushes water onshore, the water surface becomes tilted to balance the wind stress. | 1 – 4 hours |
| Wave set-up | As waves break nearshore, the forward motion of wave energy halts and is balanced by an increase in the mean sea level. | Duration of high seas |
| Wave Run-up (not part of the quasi-static storm surge) | As waves reach the shoreline the remaining wave energy runs up the shore. | 10-15 seconds |

Inverse barometric rise and the hurricane wave conditions for different wave periods have been computed by the program HURWave.

An analysis of the occurrence of inverse barometric rise was also conducted using HurWAVE. Following a similar procedure to wave heights, the storm surge component caused by the lower atmospheric pressure within the eye of a tropical storm was evaluated on a historical - statistical basis. Figure 3.8 following shows the statistical fit, and Table 3.9.3 shows the resulting IBR values for different return periods.

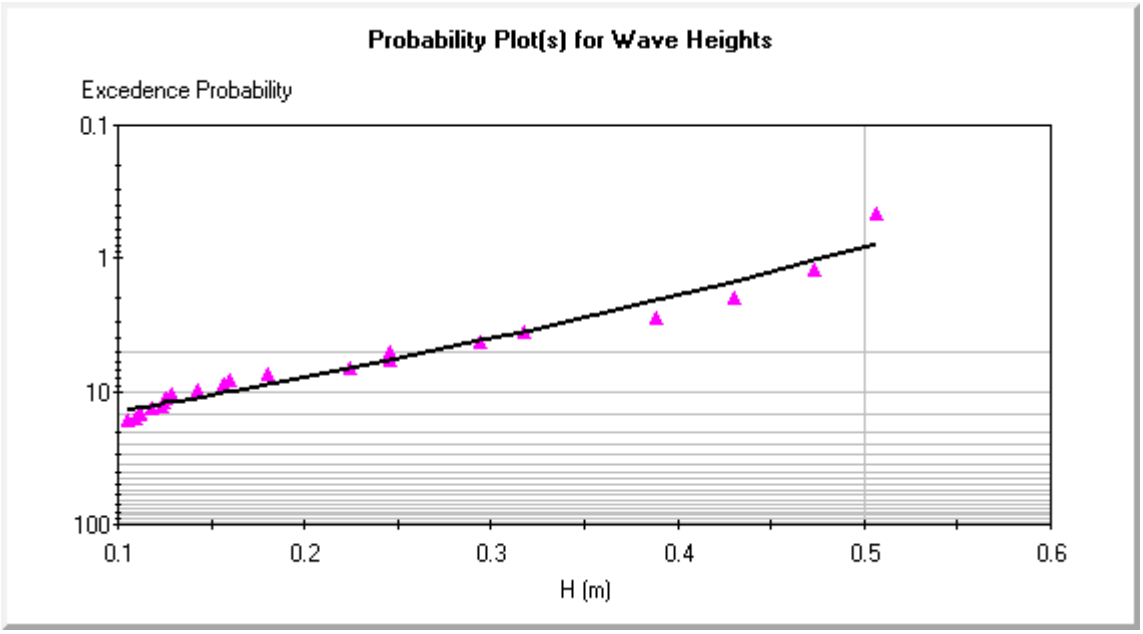


**Figure 3.8 Statistical fit of maximum IBR for tropical storms passing with 400 km of Bloody Bay, JAMAICA**

**Table 3.9.3 Inverse Barometric Rise**

| Return Period (years) | IBR (m) | Standard Deviation (m) | IBR (95$^{th}$ %) | Encounter Probability (%) in 50 years |
|---|---|---|---|---|
| 2 | 0.00 | 0.03 | -0.08 | 100.0 |
| 5 | 0.08 | 0.05 | 0.12 | 100.0 |
| 10 | 0.20 | 0.05 | 0.24 | 99.5 |
| 20 | 0.30 | 0.06 | 0.34 | 92.3 |
| 25 | 0.33 | 0.07 | 0.37 | 87.0 |
| 50 | 0.42 | 0.07 | 0.46 | 63.6 |
| 100 | 0.50 | 0.08 | 0.55 | 39.5 |
| Correlation = 0.936 for Weibull Distribution; K=2.0 | | | | |

The above wave conditions were then combined with the existing seabed information to determine the variation of wave heights from deep water to the shoreline. The complex process of wave shoaling, refraction and breaking requires a computer model. In this case, the most appropriate computer model was found to be sBEACH. The following plot (Figure 3.9) is a typical output from sBEACH and shows the seabed profile and the reduction in wave height as well as the increase in mean water level.

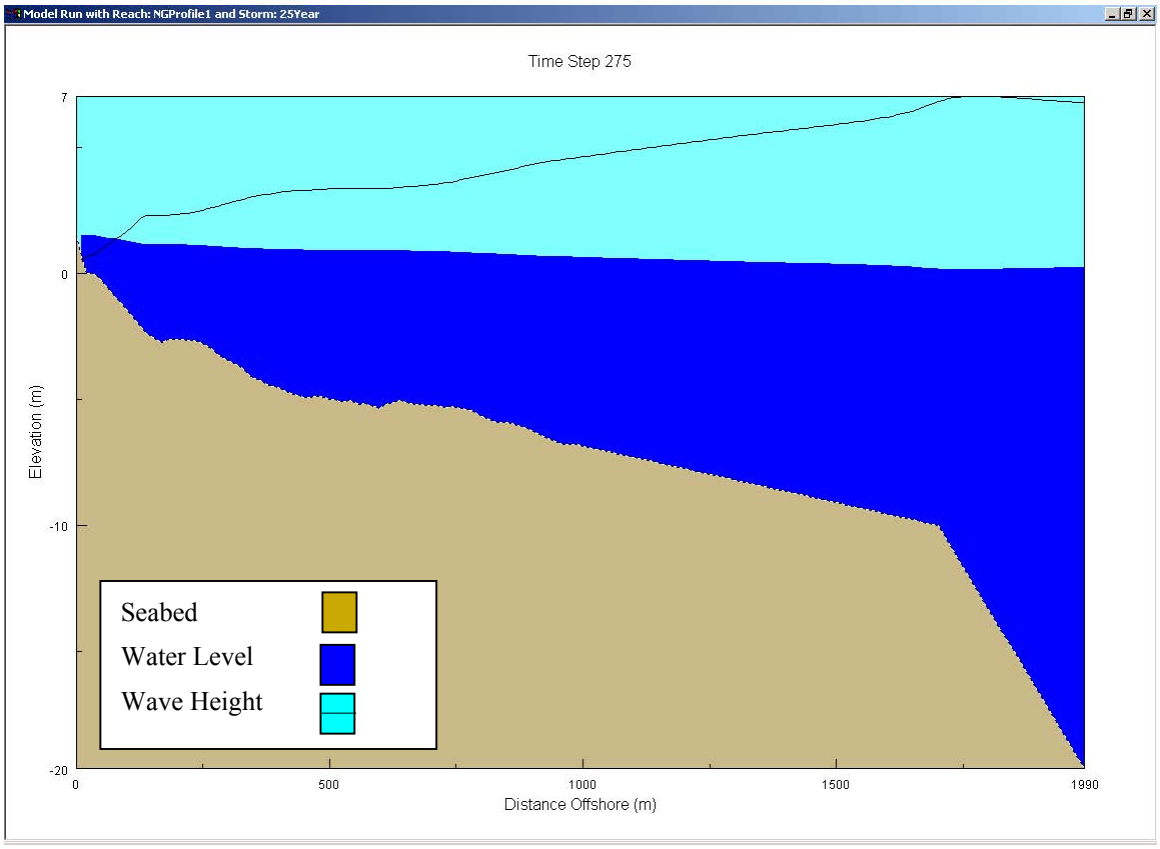


**Figure 3.9 Typical output from sBEACH- Seabed profile**

Tables 3.9.4 and 3.9.5 following outlines the results from this wave transformation procedure and provides the design storm surge levels.

**Table 3.9.4 Storm Surge Levels (relative to MSL), excluding wave run-up**

| Storm Surge Component | Return Period (Years) | | |
|---|---|---|---|
| | **25** | **50** | **100** |
| High tide | 0.15 | **0.15** | 0.15 |
| Global Sea level rise | 0.25 | **0.25** | 0.25 |
| Inverse Barometric | 0.33 | **0.42** | 0.50 |
| Wind and wave set-up | 1.23 | **1.33** | 1.44 |
| **Total** | **1.96** | **2.15** | **2.34** |

**Table 3.9.5 Wave run-up heights (m) and forces (kg/m)**

| Storm Surge Component | Return Period (Years) | | |
|---|---|---|---|
| | **25** | **50** | **100** |
| Nearshore Wave (m) | 0.83 | **0.94** | 1.05 |
| Run-up height (m) above storm surge height | 0.94 | **1.06** | 1.18 |
| Wave Forces (kg/m) with no run-up. | 760 | **970** | 1200 |

For this investigation, the 25-year hurricane event was used to determine the susceptibility to storm-induced beach erosion. A storm duration of 24-hours was used along with the corresponding wave periods and appropriate storm surge components (tide, sea level rise, and IBR). The results of sBEACH suggest that beach erosion would be quite small (less than 5 metres). This is probably due to the very gentle slope of the seabed, which tends to dissipate much of the wave energy before it reaches the beach. However, Figure 3.10 illustrates that the area likely to be affected by wave loading from a 50-year storm, taking into consideration storm surge, wave height and run-up.

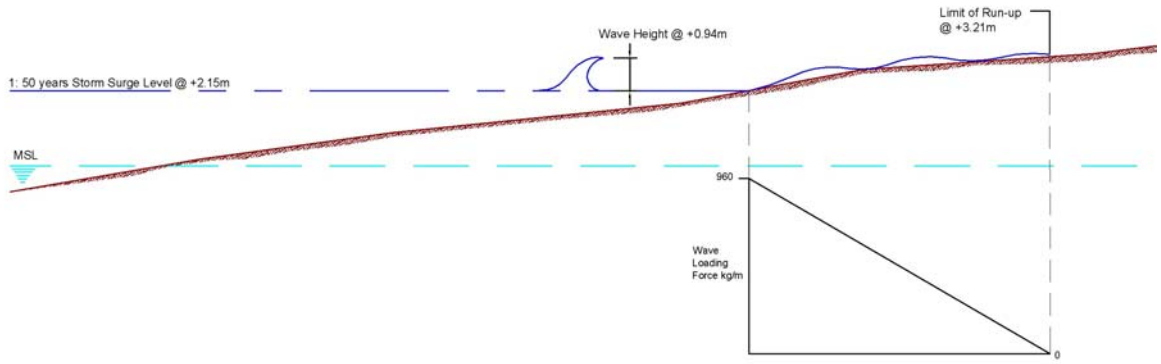


**Figure 3.10 Area of potential impact from 50 year storm waves**

Figure 3.11 following shows the output from sBEACH. The black-line represents the initial profile, and the red, the post-storm profile. Above MSL, erosion is quite small, whereas underwater, a small sand bar is formed, which tends to reduce further erosion by breaking waves offshore.

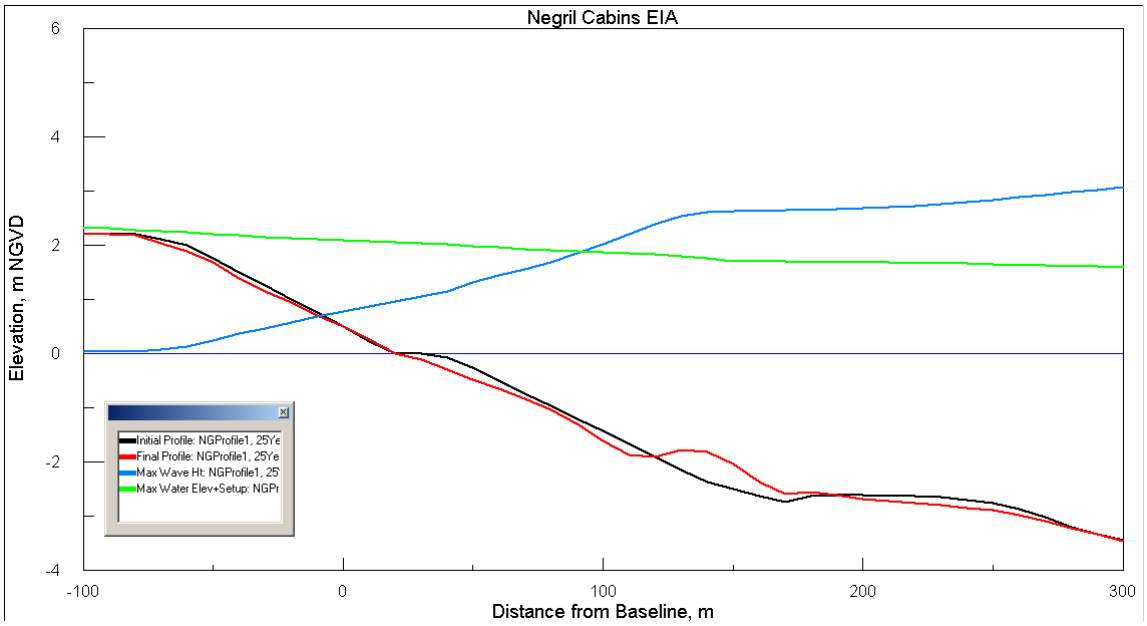


**Figure 3.11 Potential changes in shoreline (erosion) from a storm**

## 3.10 SOCIO-ECONOMIC ENVIRONMENT

### 3.10.1 Land Use

The lack of a broad-based operational plan to guide development has resulted in disorganized mushrooming of various architectural styles and linear sprawl throughout Negril. Existing land use in Negril is mixed and includes tourism, commercial, residential and recreational uses; with tourism facilities being the dominate land use. Small fishing nuclei are found throughout the area. There is an aerodrome located at Bloody Bay and the beaches located at Bloody Bay and Long Bay are used for recreational purposes by tourists and residents within the study area.

The proposed site is currently being used to allow access to the Bloody Bay beach for guests staying at Negril Cabins. It also provides access, i.e. for employees, to the privately operated 'Scuba Caribe' Dive Shop and Watersports facility located on the adjacent RIU (Tropical Bay) Phase I property.

### 3.10.2 Demographics

An outstanding feature of the area is the rapid population growth and high levels of urbanisation that took place in Negril during the period 1970-1991. Internal migration and redistribution of the population in the area have been a major factor accounting for the rapid growth of Negril as a major urban centre. Using 1970, 1982 and 1991 census data, the population of Negril has grown from 1,166 and 2,475 to 3,469 in 1991 respectively (DHV International Limited, 1999).

The general, movement of population between 1982 and 1991 can be summarised as follows:

- The greatest increase in population (80% - 105%) occurred in the enumeration districts which make up Negril and in particular the enumeration districts which include Whitehall property. Squatting in the Whitehall area accounted for a large proportion of this increase.
- Population increases in the order of 50% - 79% took place in the areas of Rutland Pen, Ireland Pen and Orange Bay as a result of tourism and housing development in these areas.
- Other areas of minor population increase (20% - 49%) included the agricultural areas of New Hope, Retreat and Negril Spots along the main road from Sheffield to Negril; of Springfield and Silver Spring along the edge of the morass and the Fish River foothills; and the agricultural communities in the Newfound River Valley.
- Population decrease occurred in the districts of Little Bay and Revival in the Negril Hills, the limestone uplands of Retrieve Mountain and the community of Logwood.

Generally, the areas of greatest population increases are found in Negril Village, Whitehall and Orange Bay. These areas are growing at a much faster rate than the outlying districts of Sheffield and the Fish River Foothills and therefore are expected to account for a greater percentage of the population over time (DHV International Limited, 1999).

Tourism has played an important role in contributing to the growth of population and urbanisation in Negril. During the past decade there has been a significant increase in employment, the number of hotels and the number of beds along the Negril coast. In-migration has been as a result of persons seeking employment in the tourist industry. However population growth is slowing down in line with the rate of growth of tourist development in the small non all-inclusive hotels and guesthouse sectors (DHV International Limited, 1999).

From a socio-demographic study carried out by DHV International (UK) Ltd in the Negril area----through the services of the University of the West Indies (Mona) in 1992----it was found that

overall 61% of the household heads were male and mean family size in the area is 4.08 persons, a little below the national average (DHV International Limited, 1999).

The population is a young one, since over 40% of the total population are less than 16 years old and the age-dependency ratio is 57%. There is an overall but small excess of females over males. However, in the age-group 15 - 45, the surplus of females is a little higher than average. This may be a function of the economic base of the area and may reflect the movement into the area of younger women seeking employment in activities associated with tourism (DHV International Limited, 1999).

### 3.10.3 Household Structure

The mean number of rooms per household was 1.5. Using the average family size of 4.1, this means that, overall, there are about 2.6 persons per room. Assuming that the ideal is 2 persons per room, there is some degree of overcrowding. As expected, the level of overcrowding is higher for squatters than for owners (DHV International Limited, 1999).

About 51% of the households moved to their present address within the last 10 years. About 56% of these recent migrants are squatters. A sizeable fraction of those households who changed their addresses, some 47%, comprised households that had moved within the Negril area and, therefore, represents more a rearranging within Negril than additions to the population (DHV International Limited, 1999).

### 3.10.4 Employment

From the DHV/UWI 1992 demographic study it was found that 41% of the population 14 and over were employed or, put another way, there was roughly a 59% unemployment rate among the labour force (including persons over 65). This apparent unemployment rate is high for a 'boom' area (DHV International Limited, 1999). At least two comments are possible:

- persons involved in illegal activity might have said they are unemployed; and
- as with most boom activities, tourism attracts many more persons than the jobs which are available.

Land owning households contributed 36.7% to the total number of households and 42% to the total number of employed persons, while squatters comprised 42% of households and 44% of employed persons. With respect to the level of employment then, the difference between the two groups was statistically insignificant. Most employed persons are employees but a significant proportion is self-employed, a reflection of the economic base of the area. We11 over 80% of employed persons work full-time. Part-time work accounted for 7% of the population with seasonal and casual work accounting for 2% and 3% respectively (DHV International Limited, 1999).

### 3.10.5 Tourism

In 1992, Negril had a total of 317 hotels, villas, apartments, cottages and guesthouses, approximately 18% of the total number of hotel and non-hotel accommodation on the island and was the third largest resort centre after Ocho Rios and Montego Bay. Visitor accommodation (hotel and non-hotel rooms) in Negril grew by 12.9% in 1992 when compared with 1991. In terms of rooms, Negril had 19.7% of the island's total number of rooms and 19.6% of the total number of beds. There was a 12.8% increase in the number of beds in Negril in 1992 compared with 1991 (DHV International Limited, 1999).

The most recent information, produced by DHV International Limited (1999) and supplied by the JTB-Directors Office shows that the number of 'rooms' available in Negril grew between 1995 and

1997 from 2,110 to 2,823 whilst the number of beds grew from 4,447 to 6,096. The number of nights sold increased for 'rooms' from 520,514 to 632,393 and for 'beds' from 1,041,410 to 1,298,175. The occupancy rates, however, fell from 67.6% to 61.2% for 'rooms' and from 64.2% to 58.2% for 'beds' over the same period (DHV International Limited, 1999).

The prediction for the number of visitors to Negril is an increase from 215,409 (1997) and 222,240 (1998) to 303,980 in the year 2003 (DHV International Limited, 1999).

### 3.10.6 Water Supply

Water supply to the Negril Cabins hotel expansion site will be directly from the bulk supply main running along the western edge of the Norman Manley Boulevard. The Negril water supply is sourced from the Logwood Treatment Plant in Hanover. The plant has a capacity of 6 MGD (Imperial) with only 4 MGD currently being utilized (CL Environmental Company Ltd., 2001). An estimate of the remaining capacity, using a 20% loss to leakage factor, indicates that an estimated additional supply capacity of 1.6 MGD or 7.28 MLPD was available. Taking into account past and estimated future water consumption figures from 1991 to 2026 (Source: CL Environmental Company Ltd., 2001), it is expected that the water demand of the proposed Negril Cabins development is not expected to have any potential negative impact on water supply for the area.

### 3.10.7 Sewage Treatment

A new sewerage system for Negril was completed and commissioned at the end of 1998. The plant has a capacity of more than 3.0 MGPD. Less than 1.5 MGPD is currently reaching the treatment plant and only one series of ponds (out of two) is currently in operation. The plant has excess capacity in the order of 1.5 MGPD (6.825 MLPD). The proposed expansion of the Negril Cabins hotel, generating an additional 36,000 GPD, will therefore be within the capacity of the STP.

NWC personnel cite two issues of concern regarding both the sewerage and the wastewater treatment systems that are of relevance to this project (CL Environmental Company Ltd., 2001). These are:

- Poor location of new development manholes (due to lack of coordination between the NWC and new developments in respect to engineering design and construction). This makes maintenance and NWC assistance difficult during emergencies.
- Odorous sewage, i.e. in the lift stations, and grease on the surface of the waste stabilization ponds; due to poor grease trap sizing and/or maintenance.

More NWC/developer interaction, in both the design as well as the implementation phase, was suggested as a potential remedy for design and operational shortcomings.

### 3.10.8 Solid Waste Management

Solid waste in Negril is derived mainly from commercial activities associated with the tourist industry (i.e. shops, restaurants, hotels, etc.) and the resident population. It is estimated that tourists are responsible for generating approximately 2.3 kg of waste per person per day, 7 days a week. Residential wastes are estimated to be generated at a rate of approximately 0.6 kg per capita per day. Solid waste generated in Negril typically has a high organic content, whilst the levels of metal, glass and paper appear to equate to levels observed elsewhere in the Caribbean. However, there is a trend towards an increase in the volume of wastes being generated, consistent with the growth of tourism and the population in the region (DHV International Limited, 1999).

Responsibility for the collection of solid waste in the Parish of Hanover lies with the Western Parks and Markets Department (WPMD). Waste collection services are provided free of charge to each householder. However, it is understood that the Negril Chamber of Commerce, and the vast

majority of hotel owners, are unhappy with the waste collection services provided and have made their own arrangements for waste removal. Collection from commercial premises is, therefore, carried out at a price negotiated between a waste collection contractor and the owner. The waste is transported to the Retirement dump located in St. James (DHV International Limited, 1999).

The waste from premises is currently collected daily in plastic bags purchased by the owner. General street wastes and litter are collected in a series of oil drums, strategically located throughout the area and emptied approximately every other day. However, the current storage methods prior to collection are unsatisfactory (DHV International Limited, 1999).

Up until about 1994, there were two official dump sites serving the Negril area. These were the Orange Bay and Mount Eagle dump sites. The Orange Bay site, located approximately 9 km from Negril, was closed in the mid 1990s due to significant negative environmental impacts----namely leaching of contaminants into the local hydrological regime. In fact the reefs of Orange Bay and Samuel's Bay are nearly destroyed because of the leaching of nutrients and contaminants from the tip (DHV International Limited, 1999). The Mount Eagle dump is located approximately 30 km from the centre of Negril, a distance which has led to an increase in the occurrence of fly tipping and burning locally; particularly at the mouth of the North and South Negril River and along the Morass access track from Orange Bay to Negril. The Negril Environmental Protection Plan Update (1997) identifies the need to locate a suitable site for waste disposal in the Negril Environmental Protection Area, and to establish and implement clean up and restoration plans for the old Orange Bay site (DHV International Limited, 1999).

#### 3.10.9 Traffic

Motor cars account for the majority of the traffic in the region. It is anticipated that vehicle ownership will continue to grow commensurate with the growth in tourism, leading to an increase in the already high levels of traffic and congestion. Drivers consistently exceed the speed limit along the Norman Manley Boulevard and there is a high risk of severe accidents involving persons attempting to cross the road.

#### 3.10.10 Health Care

Apart from five private practitioners, persons in Negril can obtain health care from the Negril Health Clinic, and the hospitals at Lucea and Savanna-la-mar.

The Negril Health Clinic is approximately 14 km (8 miles) from the proposed site and is the closest facility. It is a Type III clinic offering dental, medical, ante- and post-natal care, family planning, gynecology, psychiatry and food handlers permit. On average, the clinic sees approximately 70 persons per day and people travel from as far as Little London and Hopewell for visits.

The closest hospital to the proposed site is located in Lucea, approximately 30 km (18 miles) from the site. The Savanna-la-mar Hospital is approximately 35 km (22 miles) away.

#### 3.10.11 Fire Station

The closest fire station is located in the town of Negril, some 9 km (6 miles) from the proposed development site. Currently, this station has one fire truck and, if required, backup is received from the headquarters in Savanna-la-mar, which has two fire trucks.

#### 3.10.12 Police Station

The Negril police station is responsible for policing the Bloody Bay area, while highway patrolling is conducted by the Green Island police station. The incidence of major crimes are low with simple

larceny and the small-scale sale of illegal drugs being the main crimes in the area. The police station supports a youth group, the Negril Police Youth Club, that encourages youths to stay away from drugs. Crime is not expected to be a major problem within the region.

3.10.13 Cultural Heritage

Historic sites and buildings in the Negril area are few and poorly documented. Only one building (the Negril Point Lighthouse) is on the National Historic Register. The Negril Environmental Protection Plan Update (November 1997) details seven additional sites which have been recommended for addition to the Register in the 1984 Development Order. None of these sites are in the immediate vicinity of the proposed development site or Bloody Bay. The Negril area is, however, identified as an Area of Arawak - Nature Trail, which is rich in Jamaica's natural heritage (DHV International Limited, 1999).

3.10.14 Negril Marine Park and Bloody Bay Fish Sanctuary

The wetlands/morass, white sand beaches and the offshore coral reefs of Negril were the basis for the establishment of the Negril Marine Park in the mid 1990s. Bloody Bay, and by extension the Negril Cabins project site, falls within the boundaries of the Negril Marine Park.

Under park regulations, there are presently five (5) main zonations within Bloody Bay. These are (i) swimming, (ii) non-motorized sports, (iii) motorized sports, (iv) a replenishment zone and (v) diving. Most of the bay is zoned for motorized craft, however, a moratorium was placed on motorized water sports within the Bay by the Tourism Product Development Company Ltd. (TPDCo) with the support of NEPA. Licenses are no longer being issued to new water sports operators and there are plans afoot to zone the entire bay for non-motorized craft operation only.

The area zoned as the replenishment zone, within the northern section of Bloody Bay, has been proposed as a fish sanctuary. It essentially encompasses Little Bloody Bay, Pelican Cay, most of the northern section of Bloody Bay and ¾ of the nearshore/inshore area of the RIU Phase II development site. Swimming, recreational activities, fishing or jet skiing are not allowed within this zone. There have been recent conflicts between this zoning and recent developments who wish to utilize the nearshore waters of the replenishment zone as swimming areas for their guests.

# 4. PROJECT DESCRIPTION

## 4.1 INTRODUCTION

Final design details and drawings for the hotel's layout, drainage and sewering systems are expected to incorporate recommendations made in an initial site assessment report prepared in June 2003 (ESL, 2003). The latter document presented an environmental characterization of the proposed site, identified key environmental matters relevant to the proposed development, and provided environmental guidelines for final project design. It outlined the key environmental considerations relevant to the construction phase of the proposed development and provided environmental guidelines for use by planners, architects, engineers and contractors involved with the physical development of the site.

This section therefore describes in outline the main features of the development based only on an initial site layout plan, and assumes that the final plans will eventually be submitted to the relevant government agencies for review and approval as they become available.

## 4.2 PROJECT DESCRIPTION

Negril Cabins intends to expand its hotel at Bloody Bay, Negril, by constructing an additional 160 rooms on 2 ha (5 acres) of land on the coastal strip opposite their existing hotel. The proposed development site is located next to the existing RIU Tropical Bay Phase I hotel. The most critical environmental issues and recommendations that were identified and conveyed to the project planning and engineering teams were related to site drainage, construction works management, landscaping, marine resource protection and worker housing were discussed in the site assessment report (ESL, 2003).

Construction will be by conventional block and steel methods. The site layout plan shows a dense development comprised of nine room blocks each three stories high set around a piazza and two large pools. There is also a lobby, back of house, kitchen, and several types of games and sporting facilities. From the drawings, it is estimated that the room blocks closest to the sea have a set back of approximately 40-50 feet from the shoreline. It is difficult to determine precisely from the drawings provided but it appears that the at least 75% - 80% of the site will be covered with impervious surfaces. Site drainage plans have not yet been provided for review and the proposed fate of storm runoff is not known.

A unique feature of the hotel will be a tunnel built under the main road to allow crossing without traffic interference. The location and orientation of this tunnel is shown in Figure 4.1. Details on the excavation and construction methods proposed for constructing the tunnel were still being finalized during the environmental impact assessment and were therefore not available for detailed review during the preparation of the EIA report.

Water will be supplied from existing NWC mains along Norman Manley Boulevard and the additional demand (48,000 gpd or 192 $m^3$/day) should be well within the capacity of the current NWC system. This will be confirmed in writing by NWC.

It is estimated that at full occupancy the new facilities at Negril Cabins will produce an additional 36,000 gpd (144 $m^3$/day) of sewage. This sewage will be discharged to the National Water

Commission's (NWC's) sewage mains along Norman Manley Boulevard for treatment at the Sheffield plant. There will therefore be no on-site disposal of sewage and complete connectivity to the NWC sewage collection and treatment system will be ensured. Issues related to sewage discharges to coastal waters at the site should not arise. Confirmation in writing will be obtained from the NWC that the additional amount of sewage to be added to the system is within the capacity of the treatment plant.

The hotel is expected to continue with its present contracted waste collection arrangements and final disposal of solid waste will therefore be at the Retirement dump. It is expected that garbage management and good housekeeping will be practiced on the site.

Electricity for the hotel will be supplied by the Jamaica Public Service Company (JPSCo.) Ltd. from the existing electrical mains along Norman Manley Boulevard and the additional demand should be well within the capacity of the current system. This will be confirmed in writing by JPSCo. A standby generator is being considered for use during power cuts.

The new owners wish to continue compliance with the Green Globe certification that Negril Cabins Resort currently enjoys and the new development will be operated with the same environmental management procedures.

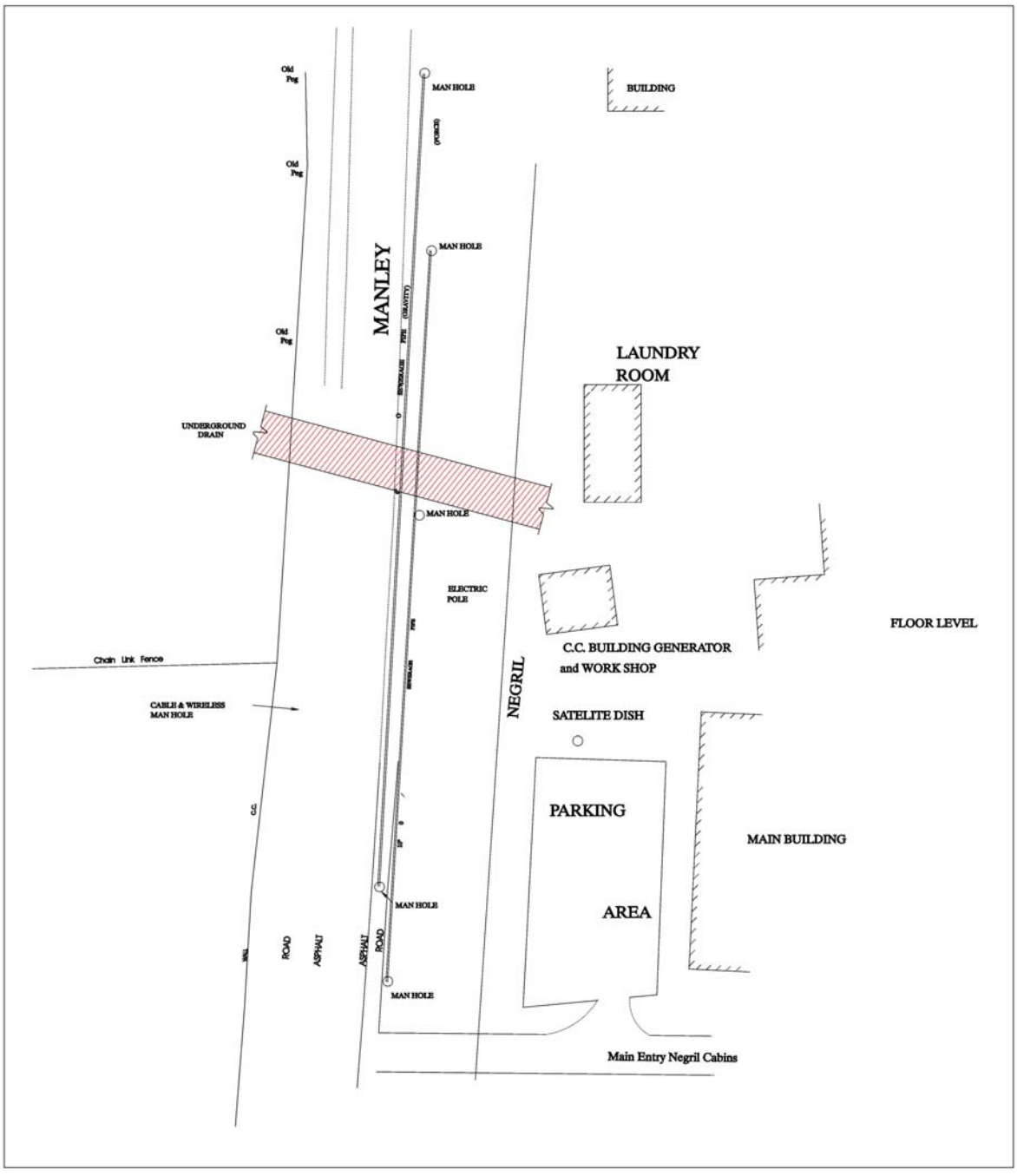


**Figure 4.2 Location and orientation of the proposed under-road tunnel at Negril Cabins.**

# 5. ENVIRONMENTAL IMPACTS AND MITIGATION

Potential positive and adverse environmental impacts, associated with the hotel expansion project, could arise during the construction and the operation phases of the project. These impacts are discussed below under those two major categories of project activities. For ease of discussion and presentation, the corresponding impact mitigation measures are presented after the discussion of each impact. A summary of the impacts is given at Table 5.3.1.

## 5.1 SITE PREPARATION AND CONSTRUCTION IMPACTS

### 5.1.1 Loss of natural habitat

Construction of the hotel will result in the loss of most of the existing trees on the site. This would include the likely loss of specimens of the endemic palm – *Thrinax parviflora*. Noise, vibrations, and intrusive activities related to construction works will scare away any animals remaining on the site after vegetation clearance. The loss of the remaining and disturbed natural habitat is a negative consequence of development of the site in the manner proposed. It is also a cumulative impact in that the development results in further loss of the remaining coastal forest habitat in the Negril region. This is the tradeoff for expansion of the tourism industry.

Landscaping and replanting of trees will be needed to recreate some semblance of the appearance of the site on the other side of the road as is desired by the owners. No details of landscaping plans or planting material are available but it is unlikely that the desired outcome will be achieved given the high density of buildings proposed and the limited areas provided for planting. The plant species selected for replanting will in large part determine which types of birds and other fauna, if any, inhabit the site after construction. (See also Section 5.1.12)

***Mitigation:***
*Impact mitigation is here seeking to retain and restore as much of the original and natural condition of the site as possible.*

- *Finalisation of the site layout plan should be done only after superimposing the proposed building footprints on the tree survey drawing and then realigning the footprints so as to minimize tree removal, taking into account the space needed around buildings for the movement of construction equipment.*
- *Trees to be protected should be clearly marked and indicated on the landscape plan.*
- *Where possible valuable trees should be relocated rather than be destroyed.*
- *The building contractor should be subject to punitive penalties for any breaches of the tree protection plan*
- *Final site layout plan should also seek to maximize areas available for replanting.*
- *The landscape plan should be prepared prior to commencement of site clearance and be subject to careful review and assessment.*
- *The landscape plan should seek to utilize low-maintenance native species tolerant of coastal conditions that are attractive to birds and it should not include imported invasive species.*

### 5.1.2 Loss of land use options

Hotel construction will involve the permanent erection of block and concrete structures on what is essentially a green field site. This will result in a permanent loss of the options for alternative land

use and thus represents an irreversible commitment of land resources. The loss of optional uses for the land in the future is considered to be a negative impact.

***Mitigation:***

***N/A***

### 5.1.3 Coastal erosion and building setback

Based on the gentle slope of the seabed, coastal erosion is not anticipated to be greater than 5m in 24 hours in a 25-year hurricane event. However, flooding is very likely during storm events, and beach scour (a form of erosion) may be a problem associated with flooding. This will have a negative impact on the building developments.

***Mitigation:***

- *Establish a minimum building set-back of 30m (approximately 100ft) from the mean high water mark.*
- *Build a berm in the flood-prone zone, approximately 2m height, to reduce flood and erosion vulnerability, This should be done with consideration for drainage designs.*

### 5.1.4 Modification of surface drainage

Site drainage plans have not been provided for review and thus no assessment can be made related to the potential impacts of the discharge of surface runoff. Given the densely occupied land indicated by the building layout drawing and the relatively large amount of impervious surface to be constructed, it is expected that the site will generate considerable volumes of runoff during the torrential rainfalls typical of Negril. This will negatively impact on the beach if runoff is allowed to run across the beach sufficiently to cause sand erosion, as presently happens. This would not be an irreversible or long-term impact but it would be unsightly. There are no inshore coral reefs in proximity to the site that would be adversely affected by reduced water salinities.

Alternatively, runoff could be drained across the road to the morass although this may be difficult to achieve, especially during those periods when water levels in the swamp are high.

***Mitigation:***

- *Rainfall storage be maximized so as to reduce the volumes of runoff and the water used for irrigation of the grounds.*
- *If and when possible, runoff should be directed into the morass across the road.*
- *If necessary, discharge of runoff should be dissipated at several points rather than being issued at a single location.*

### 5.1.4 Erosion of cleared areas

Vegetation clearance and excavation works related to construction of the hotel will expose soils in the affected areas which could leave them vulnerable to erosion by surface run-off and create the threat of water turbidity and sediment deposition in coastal waters. The flat topography of the site and the pervious nature of the soils would help to reduce erosive surface flows and the potential situation should exist only for the duration of the construction works (approx. 15 months) before landscaping and drainage works would reduce the susceptibility to soil erosion. There are no other significant surface features such as gullies, streams or rivers in close proximity to the site that could be affected by soil erosion.

***Mitigation:***

- *Where possible, phase the site clearance exercise so as to reduce the amount of exposed soil at any given time.*
- *Deliberately re-cover exposed soils with grass and other appropriate species as soon as possible.*
- *Temporarily bund exposed soil and redirect flows from heavy runoff areas that threaten to erode or result in substantial surface runoff to adjacent marine waters.*
- *Monitor areas of exposed soil during periods of heavy rainfall throughout the construction phase of the project*

#### 5.1.5 Earth material sourcing

Earth materials needed for construction (e.g. marl, sand) are normally obtained from quarry and mining operations. Conscious or unwitting purchases of these materials from illegal operations indirectly supports, encourages and promotes environmental degradation at the illegal quarry sites across the island causing medium to long-term negative impacts at source.

***Mitigation:***

- *Earth materials must be obtained from officially licenced and approved quarries and copies of the relevant licences made available for inspection at the site.*

#### 5.1.6 Materials transportation

The various materials required for construction and building (e.g. steel, blocks, lumber, marl, asphalt, etc.) will be obtained from sources elsewhere and transported to the site. Transportation of these materials, typically in over-laden and sometimes uncovered trucks, usually results in undue road wear-and-tear. In the case of fine earth materials, dusting and spillages occur on the roadways between source and site. Dusting degrades local air quality and material spillages worsen road driving conditions and increase the risk of road accidents. These occurrences represent indirect, short-term, reversible, negative impacts on public health and safety related to the project.

Of some concern are the existing levels of traffic on the Norman Manley Boulevard. Heavily-laden and slow-moving construction vehicles, in transit to and from the project site, may cause traffic hold-ups, resulting in commuter frustration and, possibly, in traffic accidents.

***Mitigation:***

- *Earth materials must be obtained from officially licenced and approved quarries and copies of the relevant licences made available for inspection at the site.*
- *All fine earth materials must be covered during transportation to the site to prevent spillage and dusting. Trucks used for that purpose on the project should be fitted with tailgates that close properly and with tarpaulins to cover the materials. The cleanup of spilled earth and construction material on the main roads should be the responsibility of the contractor and should be done in a timely manner (say within 4 hours) so as not to inconvenience or endanger other road users. These requirements should be included as clauses within contracts made with relevant sub-contractors.*
- *The transportation of lubricants and fuel to the site should only be done in the appropriate vehicles and containers, i.e. fuel tankers and sealed drums.*
- *As far as possible, transport of construction materials should be scheduled for off-peak traffic hours. This will reduce the risk of traffic congestion and of road accidents on the access roads to the site.*

- *Appropriate traffic warning signs, informing road users of a construction site entrance ahead and instructing them to reduce speed, should be placed along Norman Manley Boulevard in the vicinity of the entrance to the site.*
- *Flag men should be employed to assist construction vehicles as they attempt to enter and exit the project site.*

5.1.7 Materials storage

The improper siting and storage of sand, gravel, cement, etc., at the project site could lead to fine materials being washed away into the adjacent marine environment during heavy rainfall events. This would not only represent a waste of materials but would also contribute to turbidity and sedimentation with consequent negative impacts on inshore marine water quality and the ecology of shallow marine environments.

Hazardous and flammable materials (e.g. paints, thinner, solvents, lubricants, fuels, etc.), improperly stored and handled onsite, are potential health hazards for construction workers. Improper storage and handling of fuel and oil would inevitably result in spillage during equipment refueling and maintenance exercises. Spilt petrochemicals would have the potential to contaminate soil and inhibit plant growth on the site.

***Mitigation:***

- *The stockpiling of construction materials should be properly managed and controlled. Fine-grained materials (sand, marl, etc.) should be stockpiled away from surface drainage channels and features.*
- *Low berms should be placed around the piles and/or tarpaulin used to cover open piles of stored materials to prevent them from being washed away during rainfall.*
- *Safe storage areas should be identified and retaining structures constructed prior to the arrival of material.*
- *Hazardous chemicals (e.g. fuels) should be properly stored in appropriate containers and these should be safely locked away. Conspicuous warning signs (e.g. 'No Smoking') should also be posted around hazardous waste storage and handling facilities.*
- *Refueling and maintenance of heavy construction vehicles at the site, should be done at specified areas or makeshift "depots" where measures are in place to deal with spillages and temporary storage of oily wastes. Preferably these depots should be located in an area that would ultimately be permanently paved (e.g. parking lots) thereby covering any contaminated soil. The ground at the depot site should be covered with a thick layer of marl to absorb any spillages. Subsequently, this marl layer should be removed for proper disposal. In the event of a large spill, the latter must be cleaned up immediately by excavating the contaminated soil and removing it in a secure vehicle to an approved disposal site.*
- *In order to reduce ground contamination, an impervious sump or container should also be placed under the spigots of fuel drums to collect drippings.*

5.1.8 Air contamination

It can be anticipated that a certain amount of air borne particulate matter (dust) will be generated by the movement of heavy equipment and by earth moving activities, particularly if marl is imported to the site for land filling purposes, etc. This situation will be worse during the dry season and during the afternoons when the winds are most prevalent. Air borne particulates may pose a hazard to persons in the vicinity of the construction site that suffer from upper respiratory tract problems. Otherwise it may be a nuisance. The impact of dusting is short-term, lasting for the duration of the

construction works, but it may be severe if it causes significant health problems, a matter of particular concern given the nature of the hospitality industry.

***Mitigation:***
- *Access roads and exposed ground should be regularly wetted in a manner that effectively keeps down the dust.*
- *Stockpiles of fine materials (e.g. marl) should be wetted or covered with tarp during windy conditions.*
- *The dispersal of dust beyond the construction site will be reduced somewhat if a fence is erected around the site.*
- *Workers on the site should be issued with dust masks during dry and windy conditions.*

#### 5.1.9 Noise

The use of heavy equipment during site preparation and construction works, particularly for the piling of foundations, will inevitably generate noise, which may cause a nuisance to hotel guests and nearby residents. Albeit annoying, this negative impact will be short-term (limited to the construction phase of the project) and is not considered to be a significant threat to the health or well being of guests at the adjacent hotel blocks.

***Mitigation:***
- *Construction activities that will generate disturbing sounds should be restricted to normal working hours.*
- *Local residents and hotel guests should be given notice of intended noisy activities so as to reduce annoyances.*
- *Workers operating equipment that generates noise should be equipped with noise protection gear. Workers operating equipment generating noise levels greater than 80 dBA continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels of 70 - 80 dBA should wear earplugs.*

#### 5.1.10 Sewage and litter management

Inadequate provision of toilets for use by workers can lead to ad hoc defaecation in secluded areas on the site, thus creating of unsanitary conditions and sources of fly infestation. Improper disposal of food cartons and other domestic forms of construction camp garbage could lead to littering of the site and pollution of adjacent coastal waters.

***Mitigation:***
- *Proper solid waste receptacles and storage containers should be provided, particularly for the disposal of lunch and drink boxes so as to prevent littering of the site.*
- *Arrangements should be made for the regular collection of litter and for its disposal only at the Retirement dump site.*

#### 5.1.11 Construction waste disposal

Solid waste generated during site preparation and construction work would include cut vegetation and typical construction waste (e.g. wasted concrete, steel, wooden scaffolding and forms, bags, waste earth materials, etc.). This waste would negatively impact the site and surrounding environment if not properly managed and ultimately disposed of at an approved dumpsite. Cleared vegetation, if burnt onsite, would generate smoke, negatively impacting ambient air quality (with reciprocal negative impacts upon human health). Vegetation and solid waste, if allowed to accumulate in sensitive areas, may cause localised ponding and flooding. Furthermore, the ponding

of water would create conditions conducive to the breeding of nuisance and health-threatening pests such as mosquitos.

***Mitigation:***

- *A site waste management plan should be prepared prior to project commencement. This should include designation of appropriate waste storage areas, collection and removal schedule, identification of approved disposal site, and system for supervision and monitoring. Preparation and implementation of the plan must be made the responsibility of the building contractor with the system being monitored independently.*
- *Special attention should be given to minimizing and reducing the quantities of solid waste produced during site preparation and construction. To reduce organic waste, softer vegetation may be composted onsite and used for soil amendment during landscaping.*
- *Vegetation and combustible waste must not be burned on the site.*
- *Reusable inorganic waste (e.g. excavated sand) should be stockpiled away from drainage features and used for in-filling where necessary.*
- *Unusable construction waste, such as damaged pipes, formwork and other construction material, must be disposed of at an approved dumpsite.*

5.1.12 Replanting and landscaping

In addition to enhancing the aesthetic appeal of the project site, landscaping provides the means for partially restoring the site's natural elements and ecological habitats. It is therefore a significant mitigation activity with a positive impact.

The landscaping plan should seek to avoid the use of non-native and potentially invasive species. It should include low-maintenance, salt-tolerant coastal species and the types of trees and shrubs used for feeding by local bird species. The landscape design should seek to encourage bird life, maximize shade and windbreak effect, as well as to hide the roofline of the hotel. Such species should include trees found locally such as *Bucida buceras* (Black Olive), *Calophyllum calaba* (Santa Maria), *Conocarpus erectus* (Buttonwood Mangrove), *Thespesia populnea* (Seaside Mahoe), *Lignum vitae, Phyllanthus acuminatu*s and palms like endemic *Roystonea princeps* (Swamp Cabbage).

***Mitigation:***

**N/A**

5.1.13 Employment/Income Generation

It is estimated that 350 workers will be employed on the site during the construction phase. The expansion project is expected to augment current employment levels by about 100 persons. These levels of short-term and long-term employment will have a positive impact on the local economy and on regional unemployment.

***Mitigation:***

**N/A**

5.1.14 Worker housing demand

Tourism resort development in Negril, as is the case elsewhere in Jamaica, has not been matched by the corresponding development and construction of housing and the social infrastructure to meet the demand from resort facility workers, etc. Therefore, squatting and informal settlements despoil

the town and worsen social tensions. This is viewed as an indirect, cumulative, long-term, reversible negative impact. The present project may add to this settlement problem.

***Mitigation:***
- *Negril Cabins Resort must seek, in some appropriate manner, to alleviate the problems of housing shortage for the increased workforce induced by the expansion project.*

5.1.15 Under-road tunnel

An under-road tunnel has been proposed to connect the existing and proposed Negril Cabins developments to facilitate safe road crossings. As indicated under Sections 3.2 and 3.4 above, the presence of a high water table (-1.5 m) along the Bloody Bay coastal strip means that the tunnel would be completely submerged. It would therefore have to be watertight and its construction poses a number of challenges, which could result in significant short-term negative impacts if not properly handled and managed. Furthermore, stand-by pumps would have to be installed to ensure that the tunnel is not flooded while persons are within.

Depending upon the manner and duration of the excavation works, these negative impacts could include interference with the flow of traffic on Norman Manley Boulevard by excavation and construction works. A considerable amount of water-saturated earth would be excavated and stored, the drainings from which could cause local flooding and inundations as well as flows of turbid water. Furthermore, tunnel construction would require constant de-watering of the excavation site and thus the generation of a constant flow of turbid water for the duration of the construction works. This effluent would cause localized and unsightly turbidity at whatever site to which it was discharged but would be particularly problematic if it reached the sea or spread over the hotel site.

*Mitigation:*
- *A cheaper and less logistically challenging alternative to a tunnel should be considered. Negril Cabins and the other larger properties along the main road employ traffic wardens to stop traffic and ensure safe road crossings by hotel guests. This method appears to be effective and should be considered.*
- *If the tunnel alternative is deemed unavoidable, detailed plans for excavation site management must be prepared by the contractor and submitted to NEPA for approval, particularly with respect to equipment use, traffic control and effluent discharge.*

## 5.2 OPERATIONAL IMPACTS

5.2.1 Water Supply

As indicated under Section 3.10.6, the Logwood plant has the capacity to meet any additional water demands generated by the new development. This fact will be confirmed in writing by NWC. The demand for water by the expanded Negril Cabins hotel is, therefore, not expected to have any negative impacts on the water supply network in the area.

***Mitigation:***

***N/A***

5.2.2 Sewage Disposal

Sewage generated by the hotel will be collected and treated at the Shefield plant. The increased volumes generated by the expansion project are not expected to exceed the treatment capacity of the STP. Issues of concern have been identified and discussed at Section 3.10.7 about (i) location and design of manholes, and (ii) greases in the treatment plant's stabilization ponds.

***Mitigation:***

- *The design engineers should collaborate with NWC in the design and location of manholes at the project site.*
- *Adequate numbers of wastewater grease traps must be suitably installed at the site.*
- *Grease traps must be properly maintained on a regular basis during the operational phase of the project. This task should be formally assigned to a person/s held responsible for ensuring it is carried out. This task, and its procedure, should also formally be incorporated into the weekly housekeeping and ground maintenance schedules and procedures for the new hotel.*

5.2.3 Depletion of water resources

If the expansion of the hotel results in a net increase in the number of foreign visitors to Jamaica it will also imply an increase in the pressure on local water resources. Negril Cabins, as part of its commitment to Green Globe certification, should put the following water conservation devices or technologies in place at the new hotel.

***Mitigation:***

- *Install aerators/flow restrictors*
- *Install low flush toilets.*
- *Install water meters at key usage points to monitor water usage*
- *Collect grey-water separately from sewage effluent and use for irrigation.*
- *Collect rainwater be from roofs and store for grounds irrigation.*

5.2.4 Solid waste disposal

Poor solid waste disposal practices would not arise if the hotel continues with its contracted waste collection arrangements and with final disposal of wastes at the Retirement dump. It is expected that garbage management and good housekeeping will be practiced on the site and problems arising from the improper storage of solid waste will therefore be avoided.

***Mitigation:***

***N/A***

Recommended that a waste compactor be installed at the hotel to reduce the volume of solid waste.

5.2.5 Use of electricity

JPSCo Ltd. will supply power for the expanded facilities from the existing mains running along Norman Manley Boulevard. The incremental demand will be within the capacity of the system and this will be confirmed in writing by the utility. The expansion should therefore not cause any supply shortages to the rest of the system.

However, this increased demand will commensurately increase the utility's use of fossil fuel to generate that electricity, and thus the project will indirectly incur negative impacts associated with greenhouse emissions.

***Mitigation:***
***Mitigation measures relate to improving energy management and conservation practices.***

- *Sub-meters and real-time energy monitoring equipment, timers, photoelectric cells, thermostats, etc. should be installed at the hotel.*
- *Translucent shades, phosphorescent lighting and key/card switches be installed and used in guest rooms.*
- *Pipe insulation, tank lagging (not asbestos!) and heat recovery systems be installed in the hotel's laundry and throughout the hotel, wherever it is practical to do so.*

5.2.6 Use of stand-by generator

In the event of a power failure, a standby generator will be used. The associated potential negative impacts include fuel oil spills, exhaust emissions, noise disturbances, and vibration.

***Mitigation:***

- *The standby electricity generator should be located downwind of guestrooms and insulated against noise and vibration.*
- *Contingency plans should be formulated to deal with the containment of spills of stored fuel oil.*
- *The fuel storage tank should be placed within a bund that can contain the contents of the tank in the event of leakage or spillage.*

## 5.3 SUMMARY OF IMPACTS

The impacts and environmental issues discussed above are summarised in Table 5.3.1.

**Table 5.3.1 Summary Environmental Impact Matrix.**

| ENVIRONMENTAL IMPACT | IMPACT TYPE | | | | | | | | MITIGATION | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Positive | | Negative | | | | | | | | |
| | Significant | Not significant | Significant | Not significant | Short Term | Long Term | Irreversible | Cumulative | No Mitigation Required | Mitigation Required | Reference to Mitigation Section |
| **SITE PREPARATION AND CONSTRUCTION PHASE** | | | | | | | | | | | |
| • Loss of natural habitat | | | × | | | × | × | × | | × | 5.1.1 |
| • Loss of land use options | | | × | | | × | × | × | × | | |
| • Modification of surface drainage | | | | × | | × | × | | | × | 5.1.3 |
| • Erosion of cleared areas | | | | × | × | | | | | × | 5.1.4 |
| • Earth material sourcing | | | | × | × | | | | | × | 5.1.5 |
| • Materials transportation | | | | × | × | | | | | × | 5.1.6 |
| • Material storage | | | × | | × | | | | | × | 5.1.7 |
| • Air contamination | | | × | | × | | | | | × | 5.1.8 |
| • Noise | | | × | | × | | | | | × | 5.1.9 |
| • Sewage and litter management | | | × | | × | | | | | × | 5.1.10 |
| • Construction waste disposal | | | × | | × | | | | | × | 5.1.11 |
| • Replanting and landscaping | × | | | | | × | | | × | | |
| • Employment/income generation | × | | | | | × | | | × | | |
| • Worker housing demand | | | × | | | × | | × | | × | 5.1.14 |
| • Under-road tunnel | | | × | | × | | | | | × | 5.1.15 |
| **OPERATIONAL PHASE** | | | | | | | | | | | |
| • Water supply | | | | × | | × | | | × | | |
| • Sewage disposal | | | | × | | × | | | × | | 5.2.2 |
| • Depletion of water resources | | | | × | | × | | | | × | 5.2.3 |
| • Solid waste disposal | | | | × | | × | | | × | | |
| • Use of electricty | | | | × | | × | | | | × | 5.2.5 |
| • Use of stand-by generator | | | | × | | × | | | | × | 5.2.6 |

# 6. OUTLINE ENVIRONMENTAL MONITORING PLAN

Prior to site preparation and construction activities, the main contractor should present an environmental management plan (including, *inter alia*, location of labour camp and toilet facilities, location of material storage areas, solid waste management plan, dust control measures, activity schedule, etc.) for review and approval by NEPA, the environmental monitor and the supervising engineer. The developer should present a landscape plan and the trees/vegetation earmarked for protection should be flagged and hoarded by the contractor. The entity selected to carry out environmental monitoring of the construction works should then prepare an environmental monitoring programme based on the above, the requirements of the EIA, and conditions of the development permit.

The major elements of the environmental impact monitoring programme to be implemented during the construction phase of the project are as follows:

- Site clearance to ensure that trees marked for protection are left untouched and that large areas of soil are not left exposed and uncovered for extended periods of time.
- Site drainage and surface runoff, especially during and shortly after major rainfall events, to ensure there is no flooding, ponding and runoff of surface water across the beach.
- Compliance of construction works with site management and landscape plans.
- Inspection of quarry licences to ensure earth materials are obtained only from licensed operators.
- Transportation of earth materials is done by covered trucks.
- Stockpiles of fine materials are placed away from drainage features and are not washed into the marine environment.
- The contractor must immediately and completely clean up spills of materials in public areas.
- Solid waste disposal practices to ensure appropriate on-site management and final disposal at approved dump.
- The labour camp to ensure installation of VIP toilets and the proper disposal of sewage and labour camp solid waste.
- Marine water quality to ensure that the construction works are not impacting negatively on coastal water quality. The parameters to be monitored should include salinity, dissolved oxygen, BOD, nitrates, phosphates, turbidity, faecal and total coliforms.

# 7. SUMMARY AND CONCLUSIONS

- The proposed Negril Cabins hotel expansion project site is covered by a remnant of swamp margin forest that has been greatly disturbed in recent decades.
- The EIA has not identified any significant negative impacts that cannot be mitigated.
- Due to the absence of information on the proposed drainage of the site at the time the assessment was made it has not been possible to determine the impacts related to discharge of surface runoff. This is expected to be significant given the building density.
- As a normal part of the EIA review process, detailed plans of the proposed site drainage system must be submitted to NEPA for review and approval before the permit for construction will be issued. These should describe in detail any planned modification of existing drainage patterns at the site and demonstrate the adequacy of the proposed system to effectively handle surface runoff from the new hotel site without discharging it to sea directly across the beach.

- The most critical environmental issues identified during the assessment, apart from site drainage, were construction works management, landscaping, marine resources protection, worker housing and construction of the under-road tunnel.
- Positive impacts of implementing the proposed project include:
  - Expansion of tourism product and the generation of foreign exchange that will help to improve the Jamaican economy;
  - increased employment in the region;
- Letters verifying the satisfactory delivery of services are required from JPSCo and NWC.

# 8. APPENDICES

## 8.1 The seagrass environment offshore of north Bloody Bay (and within the fish sanctuary)

Figure 3.2 summarises marine flora and benthic-type distribution within Bloody Bay, as reported by Hendry (1982). The findings of the DHV International Limited (1999) and CL Environmental Company Ltd. (2001) EIAs indicate that there have been no significant changes to the broad physical features, or marine ecology, within Bloody Bay----shown in Figure 3.2.

There are no distinct/established seagrass beds along the shoreline of the Negril Cabins beach. However, beds of *Thalassia testudinum* and *Syringodium filiforme* may be found covering the seafloor towards the center of the bay. These play an important role in helping to bind and stabilize the sediments within Bloody Bay. Heavy seagrass bed coverage is found in the northern section of the bay, in the vicinity of the RIU Phase II development site.

Associated with the seagrass beds found within the proposed fish sanctuary are echinoderms such as *Diadema antillarum*, *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.

Algal species observed during the CL Environmental Company Ltd. (2001) snorkel surveys are listed in Table 8.1.1. Two high nutrient indicating algal species (i.e. *Chaetomorpha linum* and *Dictyosphaeria cavernosa*) were observed during the survey, suggesting that there may already be periodic eutrophic conditions within the waters of the fish sanctuary. Water clarity within this section of Bloody Bay, however, was exceptionally good (i.e. horizontal visibility was approximately 30 - 40 m) (CL Environmental Company Ltd., 2001).

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. 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 (CL Environmental Company Ltd., 2001).

**Table 8.1.1 Marine algal species observed within the seagrass/coral bed community of the fish sanctuary, immediately offshore of the RIU II hotel site.**

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

Species marked by * are high nutrient indicating species.

The Moon Jelly (*Aurelia aurita*) was observed in the surface waters above the *T. testudinum* beds. 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 (CL Environmental Company Ltd., 2001).

In addition, at least three different species of stingray are known to frequent and inhabit the extensive seagrass meadows of the proposed fish sanctuary. These are the Yellow Stingray (*Urolophus jamaicensis*), the Southern Stingray (*Dasyatis americana*) and the Spotted Eagle Ray (*Aetobatus narinari*); and were all observed during the recent 2003 RIU II seagrass relocation exercise, and during subsequent post-relocation monitoring exercises. Barracuda (*Sphyraena barracuda*) are also a common occurrence in the waters of the fish sanctuary (where they prey on schools of smaller fish) and a pair of squid (*Sepioteuthis sepioidea*) were observed during one of the RIU post-relocation monitoring exercises.

## 8.2 The fringing reef ecosystem at Little Bloody Bay

A shallow protective fringing reef (with a back reef lagoon) is located northwest of the proposed Negril Cabins hotel site (within the proposed fish sanctuary), at the mouth of Little Bloody Bay---- outside Bloody Bay. This fringing reef is 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 8.2.1, and algal species observed during the SCUBA surveys are listed in Table 8.2.2 (CL Environmental Company Ltd., 2001).

**Table 8.2.1 Summary of substrate composition at the Little Bloody Bay fringing reef and 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 8.2.2 Marine algal species observed on the Little Bloody Bay fringing reef.**

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

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.)

Massive Starlet Coral (*Siderastrea siderea*) and Symmetrical Brain Coral (*Diplora strigosa*) were the dominant stony coral species in the fore reef environment; 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. Turf and macrophytic algae accounted for 20% of substrate cover and was dominantly interspersed in and around coral heads and the observed living and dead coral colonies and rubble (CL Environmental Company Ltd., 2001).

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 (CL Environmental Company Ltd., 2001).

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

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.

## 8.3 Deep Water Wave Climate

The definition of a deep water wave climate typically involves establishing both day-to-day conditions and extreme wave heights. Day-to-day conditions for Negril are effectively calm and result in limited beach response. More extreme wave conditions arise during the so called "Northers", which occur between 5 and 8 times every winter season. The characteristics of these northers are not well known, but their occurrence coincides with the passage of cold fronts moving across the United States. Typically, these waves range between 1.0 and 3.0 metres in height and have wave periods between 9.5 and 11 seconds. In deep water, the wave angle is typically from the northwest.

Even more extreme wave conditions arise during the passage of tropical storms and hurricanes. A long database of tropical storm tracks exists and can be used to determine the characteristics of resulting wave conditions.

A hindcast analysis of storm waves was carried out, using the program HURWave, in order to explore design criteria and storm surge conditions within Bloody Bay. A deep-water location was selected (>200m water depth) with coordinates 18°20' latitude and 78°25' longitude. For this point, the storm tracks that passed within a 400 km radius were extracted from the National Oceanic and Atmospheric Administration (NOAA) historical database of tropical cyclones.

For the 103-year period investigated, 131 storms have come within 400 km of Bloody Bay. Of this number, 54 were classified as hurricanes. The categories are divided according to the Saffir-Simpson Scale, given in Table 1. Almost half of these storms were Category 1 hurricanes and six were Category 4's. One storm, Allen in 1980, was a Category 5, the highest category.

A parametric hurricane wave prediction model developed by Cooper [1] (1985) was employed to develop a series of historical extreme wave conditions from 1900 to 2002. The Cooper model computes hurricane wave heights and periods using certain characteristic components of the storm (central pressure, maximum wind speeds, forward speed and radius to the maximum winds). The wave heights can be computed anywhere within the hurricane wind field.

In order to represent the sheltering effect that the landmass of Jamaica could have on hurricane conditions, waves with an approach angle of between 45 and 135 degrees were screened from the database.
After this first-stage analysis, extremal statistical analyses were performed on the maximum wave heights that were predicted for each storm track. These maxima of wave heights were then fitted to various statistical distributions. The best-fit distribution function was selected on the basis of its correlation with the data as well as its fit with the highest waves in the distribution. These extremal methods that were applied are based on work published by Yoshima Goda in 1988[2] for statistically analyzing extreme events such as hurricane waves. The design wave heights were determined for a number of return periods.

[1] Cooper.
[2] Goda, Y., 1988. "*On the Methodology of Selecting Design Wave Height*," Proc. 21st Int. Conf. On Coastal Engineering, June, pp. 899-913.

The following figure (Figure 8.1) shows the statistical fit of the wave height series to the Weibull distribution. A portion of the data set was censored to omit the lowest values in order to achieve a better fit to the higher values in the data set. The return wave heights and periods and their encounter probabilities for a 50-year design life are presented in the Table 8.3.1 that follow. The 95th percentile confidence levels and the standard deviations are also shown.

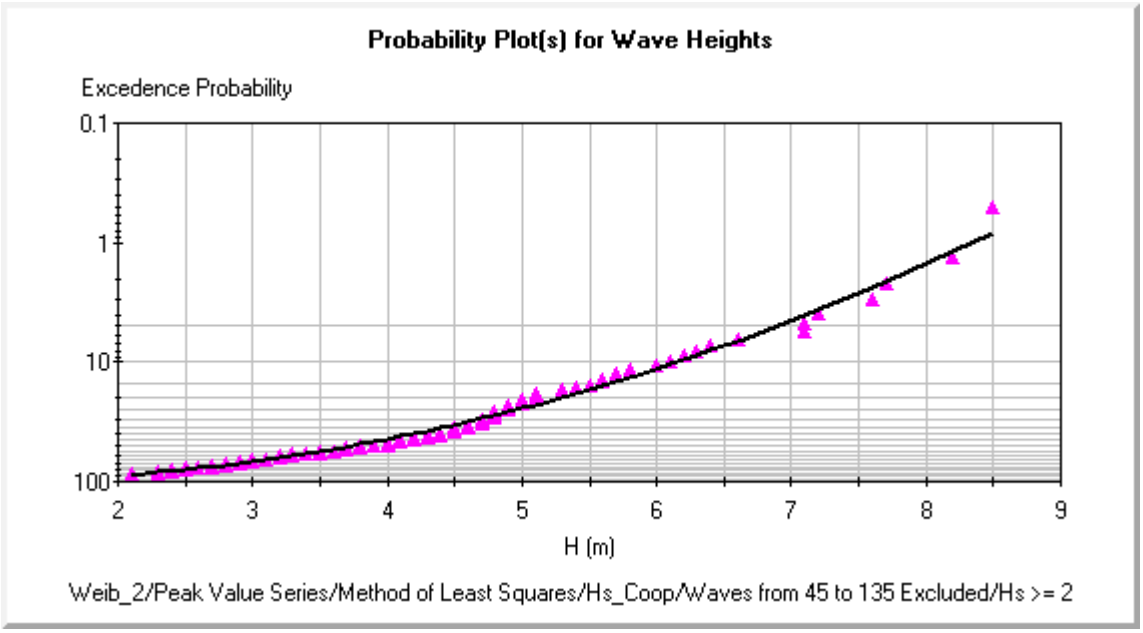


**Figure 8.1: Statistical fit of maximum wave heights for tropical storms passing with 400 km of Bloody Bay (Directional Filtering 45 – 135 deg. Excluded)**

**Table 8.3.1: Design Wave Conditions – including directional filtering**

| Return Period (years) | Significant Wave Height (m) | Standard Deviation (m) | Hs (95th %) | Encounter Probability (%) in 50 years | Wave Period (s) |
|---|---|---|---|---|---|
| 2 | 4.02 | 0.17 | 4.25 | 100.0 | 7.93 |
| 5 | 5.46 | 0.22 | 5.69 | 100.0 | 9.61 |
| 10 | 6.30 | 0.27 | 6.53 | 99.5 | 10.52 |
| 20 | 7.03 | 0.31 | 7.26 | 92.3 | 11.27 |
| 25 | 7.24 | 0.32 | 7.48 | 87.0 | 11.49 |
| 50 | 7.87 | 0.35 | 8.11 | 63.6 | 12.11 |
| 100 | 8.45 | 0.38 | 8.68 | 39.5 | 12.66 |

Correlation = 0.991 for Weibull Distribution; K=2.0

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# 10. PLATES

**Plate 1.**

**Plate 2.**

**Plate 3.**

**Plate 4.**

**Plate 5.**