Environmental Impact Assessment for the Paradise Found Development, Barbuda

BASELINE CONDITIONS REPORT

Submitted to: Mr Darren Flanagan
For Paradise Found LLC

24 January 2023

Submitted by: Smith Warner International Limited
Unit 13, Seymour Park, 2 Seymour Avenue
Kingston 10, Jamaica, WI

Contents

1 Introduction

Smith Warner International Limited (SWIL) was contracted by the proponents of the Paradise Found Development to prepare an environmental and social impact assessment (ESIA) for the establishment of a resort development on the south-east coast of Barbuda. This report was prepared in accordance with the Terms of Reference for an EIA as provided by the Department of Environment, Antigua & Barbuda, and presents the Environmental and Social and Environmental Impact Assessment (ESIA).

In 2016 SWI was contracted to investigate coastal setbacks and a drainage master plan for the Paradise Found Development in Barbuda. In 2017 a major hurricane directly hit the island leading to widespread devastation and migration. As a result, the Paradise Found Development was also halted. In 2022 SWI was contracted to investigate how baseline conditions would have changed from the previous contract and to carry out a full environmental impact assessment.

The project site is located on the leeward side of the island to the north of Princess Diana beach. The property will have multiple phases starting with the construction of a hotel at the south end of the property. Following the hotel construction, future ponds will be created that will act as retention ponds on the property and provide fill material.

The project site is very remote and this factor, coupled with the requirement for importation of materials, became major drivers of the concept development. Due to a lack of connectivity to utilities the property developers have included the following systems in their master plan:

- Reverse Osmosis Plant;
- Wastewater Treatment Plant; and
- Solar Farm.

The remoteness of the site also factors into the design of coastal and drainage features. The guiding principles of the design phase were to use the material on the land in the most efficient way possible to reduce importation and equipment costs. In a previous report, SWI provided a detailed description of the baseline conditions and their implications on the design. In Chapter 7 of this report, options for concepts are presented for the coastal and drainage works, with a final option being highlighted after an abbreviated multi-criteria analysis.

The Project Application number and name are given as *G10-2021 Paradise Found Resort Development in Barbuda*. The site identified for the resort development is contained within approximately 391 acres, which have been (long-) leased to the developer to facilitate hotel and villa development. The application describes the project as a resort mixed-use property.[1]

The development is to be located at the site of the former K Club Development on the southeast coast of Barbuda (Figure 1.1). The terrain of the area is characteristic of Barbuda. The site is low-lying, and

[1] Review of Plan Application #G10-2021 (Paradise Found), Department of the Environment April 28, 2021. Department of the Environment, Ministry of Health Wellness and the Environment

many wetland ecosystems and hydraulic features are present. The development is within an area zoned for tourism development.

The Plan application submitted for the development is for 39 individual guest villas (each with a private pool) located in a staggered formation along the beachfront, as well as a signature Nobu Restaurant, beach club and bar, spa and wellness centre, tennis pavilion and kids club. The resort property will also have a small farm and plant nursery, private homes and a back of house area with housing and amenities for staff.

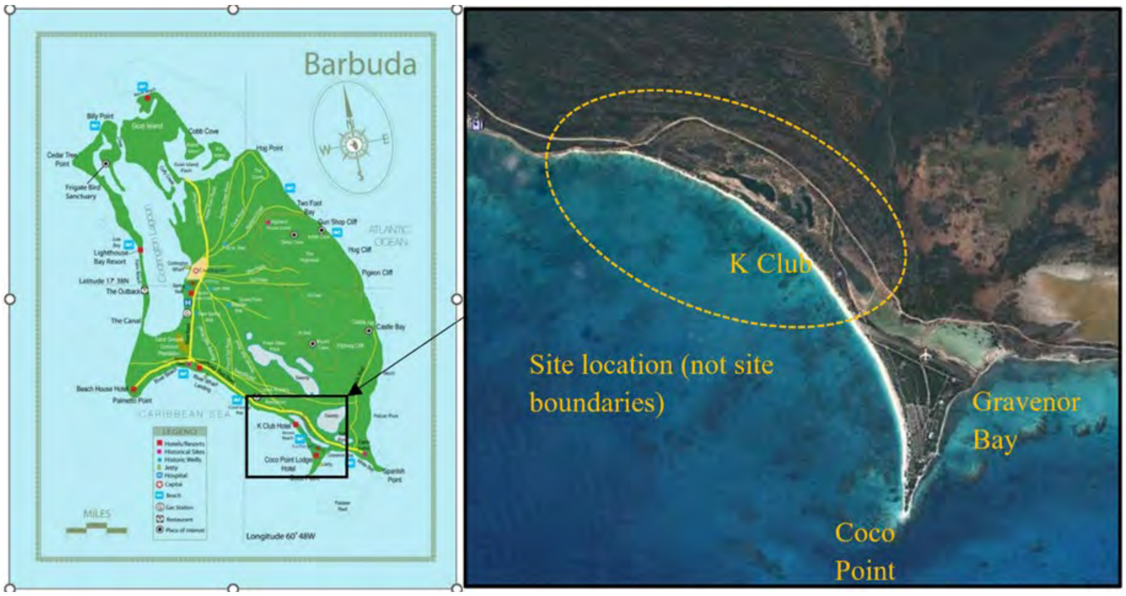

Figure 1.1 Map of Barbuda (left) with inset showing project location

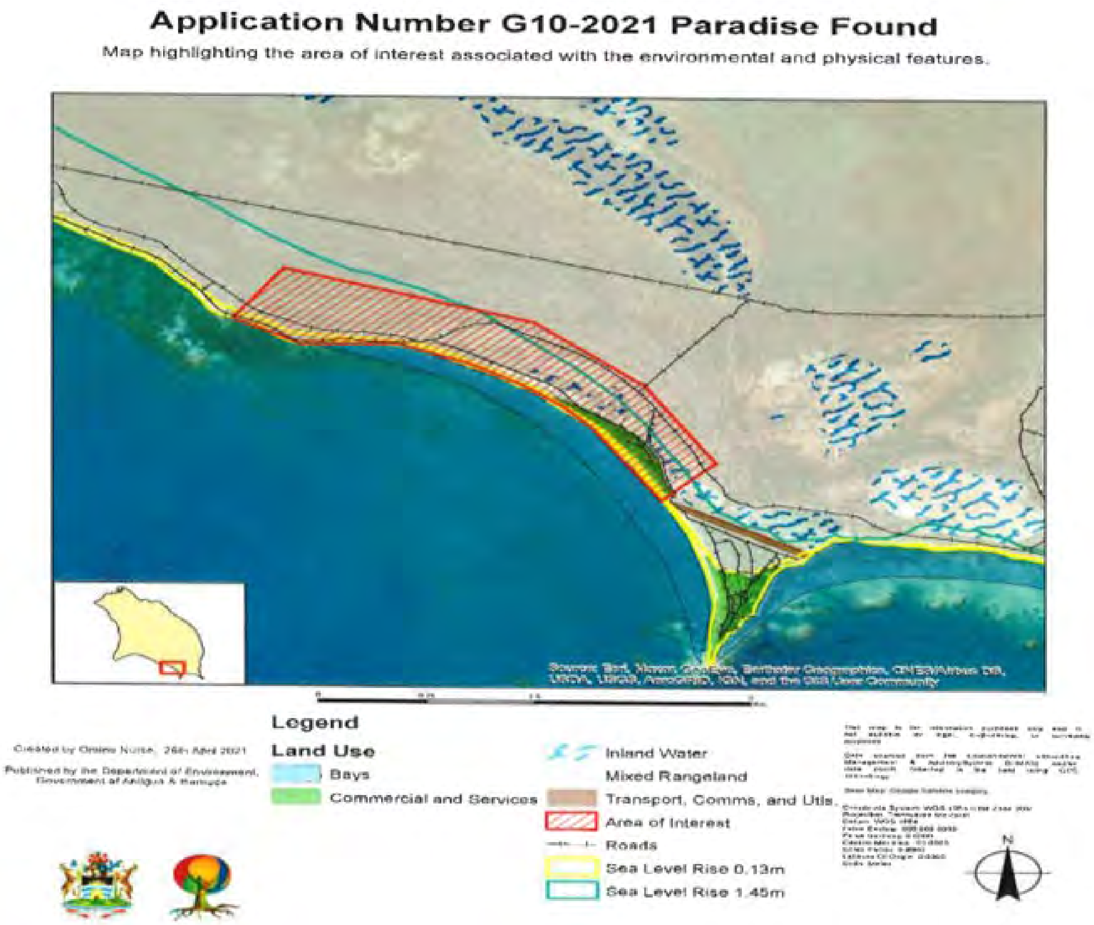

Figure 1.2 Paradise Found development property (in red hatch)

2 Project Description

This project description provides information on the proposed Paradise Found Development, to facilitate the identification of potential benefits and impacts for this ESIA.

2.1 Project Location

The proposed Paradise Found Development will be situated on the southeast coast of the island of Barbuda, in the vicinity of Gravenor's Bay, Coco Point and Princess Diana Beach (see Figure 2.1).

Figure 2.1 Location map

2.2 Options for Project Facilities, Services and Utilities

As shown in Figure 2.2 this development will include the following facilities:

- Nobu Beach Inn Clubhouse
- Guest Villas
- Arrival Area
- Beach Bar
- Nobu Restaurant / Satellite Restaurant
- Sales Village
- Spa
- Tennis and Kids Club
- Farm and Nursery
- Logistics and Staff Center, and
- Home Sites.

Figure 2.2 Development Plan

Due to the remote location of the project and the current lack of infrastructure on the island of Barbuda, the project must develop much of its own infrastructure and support facilities. The ambition of the project is that it should ultimately be as independent as possible in food, water, and energy. The development will therefore include a road network, a drainage system, water supply, electricity supply and its own wastewater treatment plant.

The following sub-sections provide information on these elements of the development, under the following headings:

- Built Facilities
- Farm and Nursery
- Road Network
- Drainage System
- Water Supply
- Electricity Supply, and
- Wastewater Treatment Plant.

2.2.1 Built Facilities

The term "built facilities" is used here to include all the facilities listed above except the farm and nursery. The proposed numbers of accommodation units within the development are shown in Table 2-1.

Table 2-1 Number of accommodation units

Facility type	Number of units
Hotel	17
Hotel Villas	10
Hotel Estates	53
Inland Lots	27
Custom Lots	43

Detailed designs have not yet been prepared for these built facilities, but the buildings are expected to be a combination of reinforced concrete and timber construction. Similarly, a decision has not yet been made whether the tennis courts will be grass courts or hard courts. One important feature vis-à-vis project risk is that LPG cylinders will be installed both at the new restaurant and at individual homes. Based on present practice, the cylinders at the new restaurant are expected to be 100-pound cylinders, while those at the individual homes are expected to be 20-pound cylinders.

2.2.2 Farm and Nursery

A farm / nursery will be established to grow plants for use in landscaping the development. A small nursery already exists on site with palms, succulents, and cacti (see Photograph 1 series below).

Photograph 1 Plants at the existing nursery

2.2.3 Road Network

Roads will be constructed within the site to service the various elements of the development. The roads will be left in a natural state, with select paved areas (approximately 80% natural and 20% paved). In addition, in their Land Lease, Paradise Found was granted the right to re-route the existing boundary road that runs through this property. The road realignment project will be completed in two phases (see Figure 2.3). Phase 1 of the road project will involve re-routing the road towards the perimeter of the property at the north end of the property boundary (adjacent to Barbuda Cottages) and following the perimeter boundary to the location at the center of the property where the existing road crosses to the outside of the property line (see Figure 2.4). The rest of the road location (which is existing and currently in use) would stay the same and follow the outside boundary fence until it reaches the old salt pond road at the south end of the property.

Phase 2 of the road realignment will involve improving and rehabilitating the old existing road that crosses the salt pond at the south end of the property (see Figure 2.5). Currently neglected and dilapidated, this road previously provided access to Coco Point and Princess Diana Beach, and the new road realignment will maintain access to Gravenor's Bay, Coco Point and Princess Diana Beach. The road in this area has existing pipes and culverts underneath that have been damaged because the pipes were uncovered and vulnerable to the elements. In recent years, this road section has been a dump site for construction waste and other debris to stabilize the roadway (see Photographs 2 to 6). Paradise Found intends to remove all the construction waste and rubbish from the location, re-establish the road, add littoral shelves for planting mangroves and install culverts to assist with the flow of water in and out of the salt pond.

Photograph 2 Old road route

Photograph 3 Typical "natural" road

Photograph 4 Old culvert

Photograph 5 Concrete rubble

Photograph 6 Concrete rubble

On July 6, 2020 the Department of Environment reviewed an application from Paradise Found to realign the road in the Phase 2 area and concluded that a road should not traverse a flash area (an area where the mangrove habitually overflows). It is clear upon further investigation that the location to which the Department of Environment refers is an existing road that pre-dates the Paradise Found development, not an untouched section of virgin land. Paradise Found intends to restore the existing road while prioritizing the drainage and flow of water to the mangroves, thereby improving the ecological health and stability of the mangrove area.

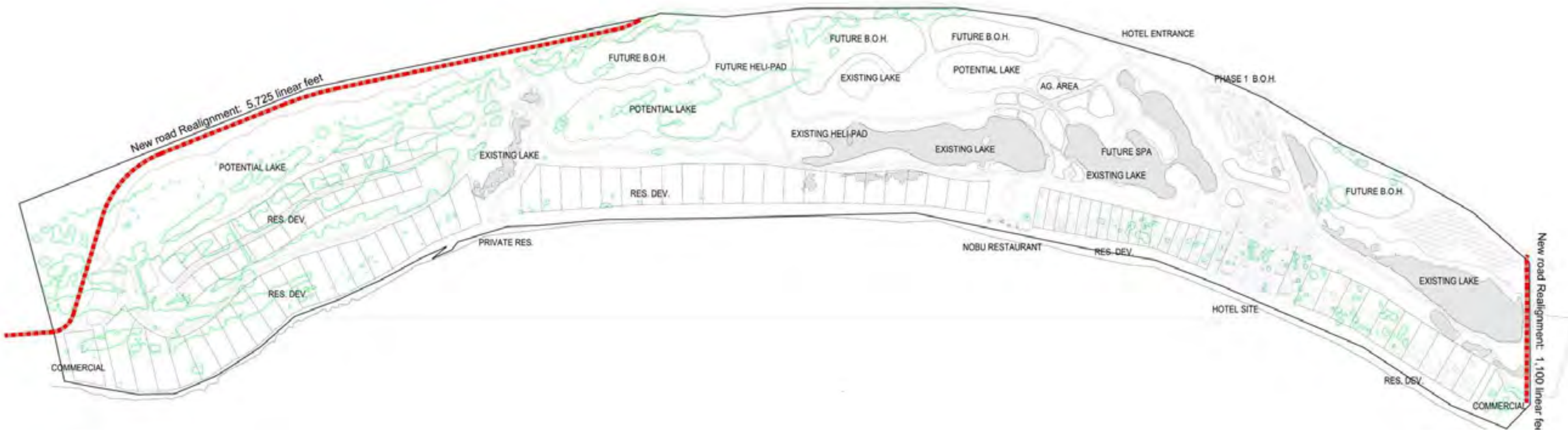

Figure 2.3 Road Realignments 1 and 2

Figure 2.4 Road Realignment 1

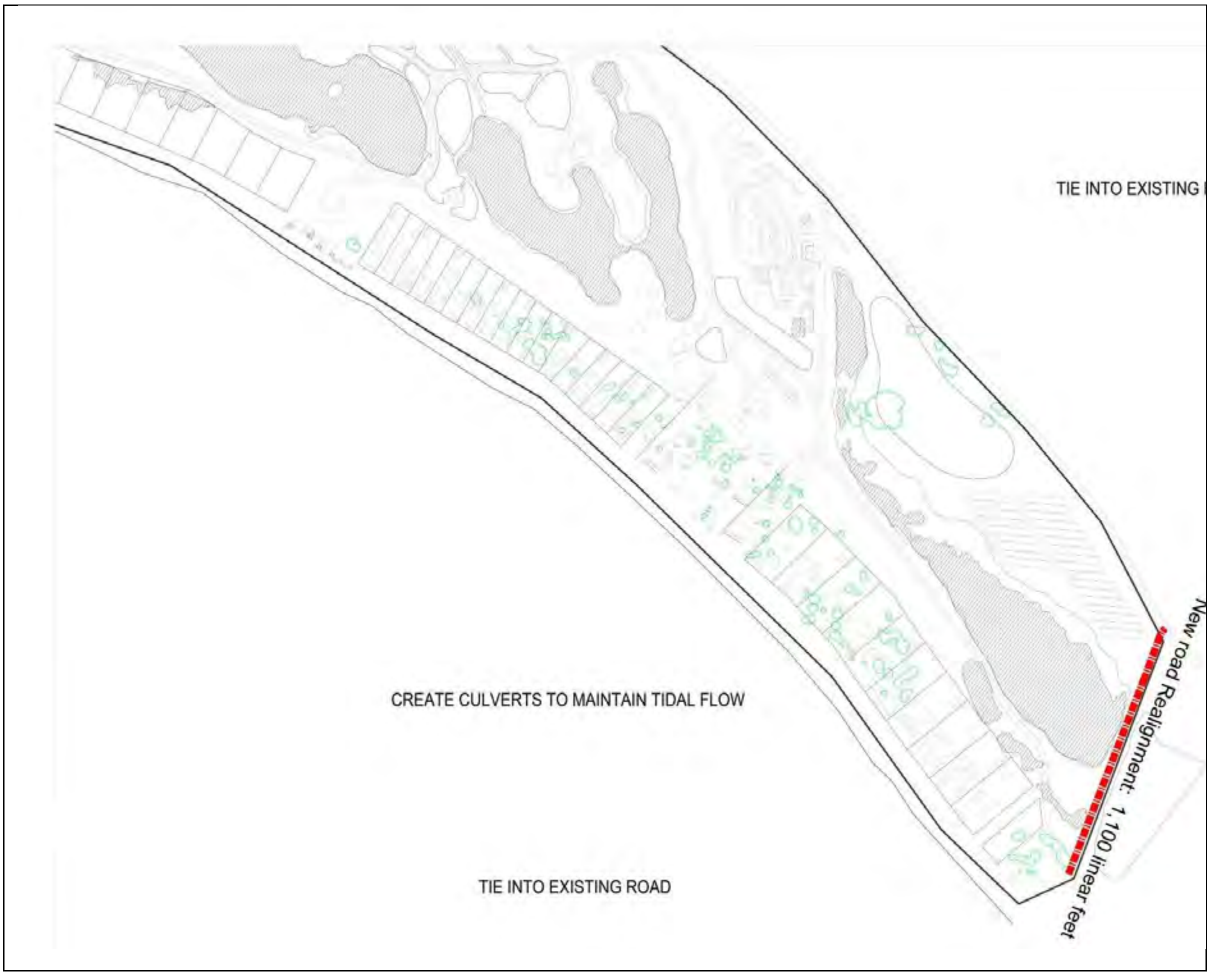

Figure 2.5 Road Realignment 2

2.2.4 Drainage System

As the development is constructed, consideration will be given to catchment zones in each phase, collection of water, transportation or delivery of water, and disposal of water for both surface runoff and closed gravity pipe networks. Using the Rational Method of design, the use of closed pipe networks will be minimized as much as possible and reserved only for situations where the disposal of water is rapidly required, such as in and around buildings and associated hard-standing areas, decks, pathways, and parking zones. The collected water will be conveyed in a closed pipe or open channel system to a point of disposal such as a bio-swale, soak-away, detention pond, or a well. Hydraulic gradients, cover levels, and invert levels will be provided. The sizing of pipes, culverts, and disposal capacities will be determined by time of concentration and peak flow calculations using IDF curves to determine design rainfall intensities.

The remaining areas of the development site will be addressed in a more holistic and non-disruptive way. Rainfall will be handled more naturally, incorporating surface runoff and subsurface runoff, with the understanding that the existing natural ground facilitates good percolation and subsurface runoff that conveys the water to the existing ponds and low-lying areas, filtering water as it travels. Storm water drainage designs will coordinate with architectural, utility, and landscaping designs as they pertain to manholes, trenches, and site grading, to ensure each discipline does not clash with the other. Rainwater harvesting systems can also be employed in this development, which will also assist in the management of stormwater runoff.

2.2.5 Pollution of Wetlands

The development intends to use structural, vegetative, and managerial solutions to treat, prevent, and reduce water pollution caused by stormwater runoff. Both primary drainage solutions (open channels and/or closed pipe networks) will consider areas of potential contamination such as petrochemical or grease deposits, and interceptors will be located as necessary. Erosion issues are not considered to be significant as hydraulic gradients will likely be small. Still, any final grading or drainage solution will carefully look at that potential and adopt soil stabilization solutions if required. Conversely, gradients will be examined to ensure that siltation issues do not become problematic. Protection of the existing pond ecology will be of paramount importance in any final storm drainage management solution.

Hurricane Irma in 2017 caused significant damage to the salt pond at the southern end of the property. Although Irma was an abnormally large and destructive storm, Paradise Found intends to bolster the strength and health of the mangroves surrounding the salt pond area to protect the pond and the adjacent regions from future storms of all sizes. Paradise Found intends to transplant mangrove plants where possible and restore the mangrove's health by ensuring that its tidal and freshwater hydrology is functioning normally, so that the mangroves can repair themselves over time.

2.2.6 Water Supply

During the operational phases (Phases 1 and 2), the projected demand for potable water for the development is expected to be 150,000 gallons per day (usgpd). Accounting for the scarcity of fresh water, this demand will be managed by employing water conservation techniques such as rainwater harvesting, installing water-efficient appliances, and using drought-tolerant landscape plants and turfgrass. The development plans to incorporate rainwater harvesting into as many community buildings as possible. Residential homes will also be encouraged to capture rainwater in individual cisterns for later use on landscape irrigation. These rainwater collection systems will reduce the demand for potable water and hence the need for imported water.

Potable water for the hotel and private residences will predominantly be supplied by Flowtronex on-site seawater reverse osmosis desalination plants (SWRO). There is currently a small SWRO unit (2500-gal capacity) and a well on the development site. To accommodate the new construction, additional wells and larger SWRO units will be required, which will be specified with Energy Recovery Devices (ERDs). The brine water from the current SWRO unit is discharged into the hypersaline salt pond on site. The additional SWRO units will be discharged into an injection well to be located on the property. A test well is scheduled to be carried out in February 2023. Absorption rates for the development will be verified from this test dig.

It is proposed that the SWRO plant be incorporated over three phases, with Phase 1 incorporating 2 x 36,000 gpd plants thereby providing 100% redundancy. Phase 2 will allow for a further 100,000 gpd production allowing for an uninterrupted water supply. Phase 3 is still to be determined as it will be heavily reliant on landscape requirements. At this stage, a further 100,000 gpd is being planned for.

A minimum of ten days storage supply is planned for the development. Water from these storage tanks will be piped to individual facilities through a system of buried distribution pipelines, fitted with valves as required. It is envisaged that this flow will be largely by gravity, but pumps will be installed where gravity flow will not be effective.

2.2.7 Electricity Supply

When fully built out, the projected electrical load demand for the development will be 1.5MVA. Due to a lack of existing infrastructure on the island, the electrical power demand will initially be met using diesel generators. To fuel these generators, diesel fuel will be stored on site in 9.1m^3 volume (2,000 Imperial gallons / 2,400 US gallons) tanks. Over time, the reliance on generators will be phased out in favor of more sustainable options, including photovoltaic systems and battery storage. The development will eventually seek to be energy self-sufficient from these sustainable energy sources, while maintaining generators on-site for redundancy.

On developments of this type, overhead electricity cables are aesthetic unappealing, so the electricity distribution system within the development is likely to consist of buried cables installed within PVC pipes. Manholes will be constructed in this system to facilitate the installation of cables and to allow access to the cables for maintenance or repair.

2.2.8 Wastewater Treatment Plant

During the operation phase, the projected wastewater treatment demand for the development is 15,000 US gallons per day (gpd) for the Back-of-House (BOH) and Phase 1 and 2 of the Hotel Component only. As no municipal wastewater treatment option is available on Barbuda, the Paradise Found development will construct a private facility to treat wastewater produced from the resort, while individual beachfront villas will be connected to their own WWTPs. The selected WWTP for the hotel is a Bionest system, which is an aerobic treatment unit that removes wastewater contaminants with the help of biomass that grows on ribbon-shaped plastic supports. These systems will collect toilet waste as well as grey water. The systems for individual villas will likely be smaller Bionest systems if subsurface characteristics are suitable, or simple mechanical treatment systems if they are not.

The extended aeration fixed film reactor of the Bionest system minimizes biological sludge production and results in a high-quality level of discharge water where 100% of the treated water can be reused. Bionest technology has been tested and verified by third-party entities against protocols recognized in Canada (ETV), the United States (NSF), and Europe (CE Mark) and consistently met and surpassed those standards. The treatment quality of the final effluent will always equal or exceed NSF Standard 40 Class 1. Design effluent quality reported on the Bionest website is summarized in Table 2-2.

Treated effluent will be further disinfected with UV or chlorine and pumped out for landscape irrigation. Excess activated sludge (biosolids) will periodically be pumped out by a sewage truck and safely disposed of. All wastewater from the commercial kitchens will pass through a grease trap to remove fats, oil, and grease to minimum levels.

The major advantages of the Bionest system are:

- High level of treatment,
- Clear and odorless effluent,
- Organic and hydraulic shock resistant,
- Small footprint, buried and usually no need for technical building,
- Media never need to be replaced,
- Reliable and long-lasting components, and
- Low operation and maintenance costs.

Table 2-2 Bionest design effluent quality

Parameter	Effluent concentration
pH	6.6 to 7.8
Total Suspended Solids	<2 mg/L
BOD5	<2 mg/L
COD	<25 mg/L
Total Nitrogen	<12.5 mg/L
Faecal Coliform (after Chlorine Disinfection)	0 CFU/100 mL
Dissolved Oxygen	>3.2 mg/L
Chlorine Residual (after 30 min Contact Time)	>0.5 mg/L

Given the arrangement of wastewater treatment at individual buildings, there will be no need to provide central sewerage throughout the development. Instead, toilet water and gray water will be routed to the wastewater treatment plants through relatively short lengths of buried sewers. Manholes will also be provided where required to facilitate flow or to permit inspection and clearing of chokes.

2.3 Construction Methods

This section describes methods that are likely to be used in constructing the Paradise Found Development. These are presented solely to facilitate the identification and understanding of potential benefits and adverse impacts of the development. They are not binding on the contractor(s) who will be engaged to undertake the construction works. Instead, each contractor will independently determine the most appropriate construction methods when construction works begin.

The following sub-sections describe likely methods for:

- Clearing and grubbing,
- Earthworks,
- Construction of roads,
- Construction of drainage system,
- Installation of utilities and sewers,
- Reinforced concrete construction,
- Timber construction,
- Finishing of buildings, and
- Installation of wastewater treatment plants.

2.3.1 Clearing and Grubbing

Clearing of vegetation will be required to facilitate the construction of roads, drainage, utilities and facilities, and topsoil containing roots must also be removed (grubbing). This will likely be done using the following methods:

- Mangrove trees will be cut using chain saws only after necessary approvals have been obtained from the relevant divisions of the Ministry of Agriculture, Lands, Fisheries and Barbuda.
- Smaller bushes and grass will either be cut manually or removed using bulldozers.
- Cleared vegetation will be removed from the site in dump trucks to a location where they can be composted, or to the landfill for disposal.
- Grubbing will be done using bulldozers. Grubbed topsoil will be temporarily stockpiled on site for use in landscaping.

2.3.2 Earthworks

Earthworks will be required in areas where the existing ground elevation must be adjusted upward or downward to facilitate construction work, likely using the following methods:

- Excavation to lower the existing ground elevation will likely be done using bulldozers or road graders. Surplus material from such excavation will either be reused on site or removed from site for beneficial reuse elsewhere.
- It is preferable to balance excavation and filling in the design so that all fill material will come from the site itself. If this is not possible, fill material will have to be brought from offsite in dump trucks.
- Regardless of source, fill material will be spread in layers using bulldozers, road graders or front-end loaders and compacted using sheepsfoot rollers or smooth face rollers to achieve the required density and degree of compaction. Successive layers will then be spread and compacted until the target elevation is reached.

2.3.3 Construction of Roads

The cross-section of a typical road is shown in Figure 2.6. To construct this, the roadbed must be compacted using sheepsfoot or smooth rollers until the required density is achieved. Gravel will be brought to the site in dump trucks and spread and compacted in layers as described for filling in Section 2.3.2. If the road is to be paved with asphalt, this will be brought to the site in dump trucks, spread using asphalt spreaders and compacted using smooth face rollers. If the road is to be paved with concrete, the likely method will be as described below in Section 2.3.6.

Culverts will be required to facilitate drainage across specific roads, and the likely construction method for these is described below in Section 2.3.4

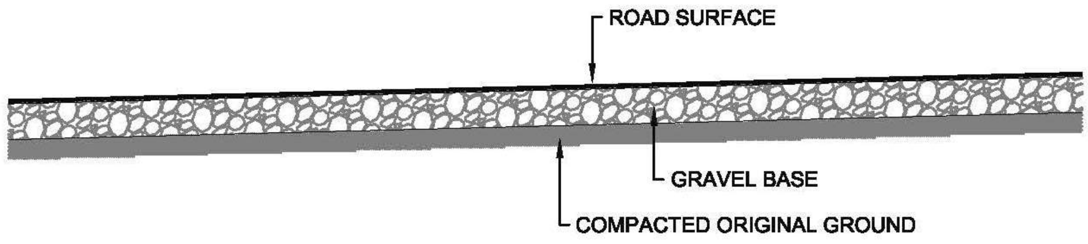

Figure 2.6 Cross-section of a typical road

2.3.4 Construction of Drainage System

This sub-section describes the likely construction methods for earthen drains, paved drains, buried pipe drains and culverts. For earthen drains (Figure 2.7) the alignment will be prepared by clearing and grubbing (see Section 2.3.1) and excavation or filling (see Section 2.3.2). The drain itself will then be trenched using a backhoe or an excavator. Surplus material from trenching will be managed as described in Section 2.3.2. Paved drains (Figure 2.8) will be prepared and trenched as for earthen drains, and then lined with concrete using methods described in Section 2.3.6. Alternatively, precast concrete drain sections may be brought to site on flatbed trucks and lowered into the trenches using HIAB units on the trucks or by hand.

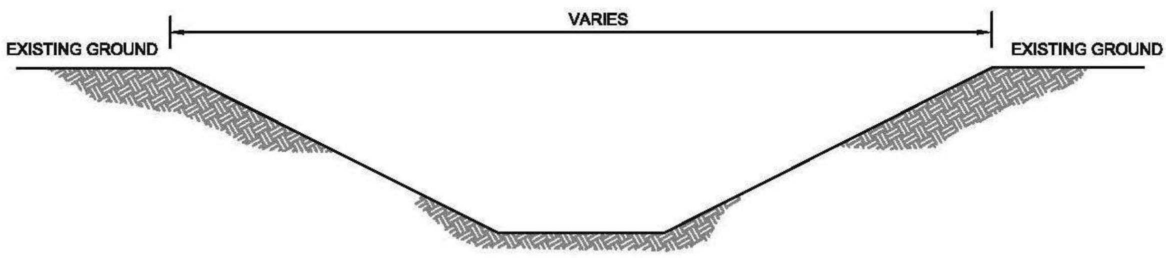

Figure 2.7 Cross-section of an earthen drain

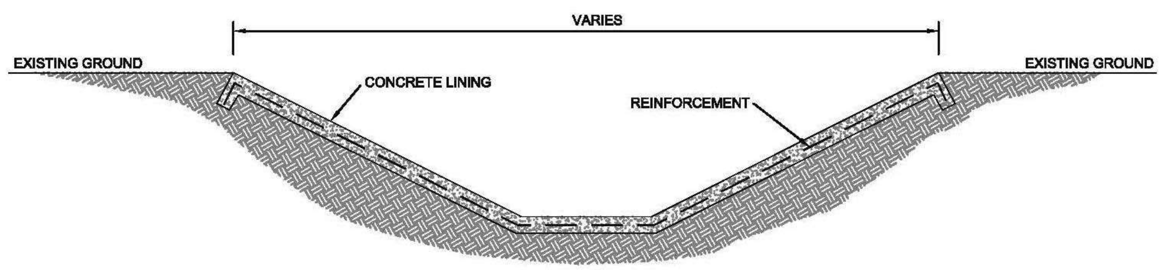

Figure 2.8 Cross-section of a paved drain

For buried pipe drains (Figure 2.9) the precast concrete or PVC pipes must be imported to the site by ship and brought to the site on flatbed trucks. Trenches will be dug along the design alignments using backhoes or excavators, and the pipes lowered into the trenches using HIAB units (concrete pipes) or by hand (PVC pipes). Backfill will then be placed to the sides and over the pipes in layers, with each layer being compacted to the required density using whackers.

Buried drainpipes will be pressure tested in place after they are installed. Given the size and type of the pipes on this development, it is unlikely that chemical treatment of the hydrostatic test water will be required. As a result, the water will not be significantly contaminated after use and can be disposed directly to surface drains. However, if chemicals (such as anti-rusting agents) are mixed into the hydrostatic test water, it will be considered contaminated and cannot be discharged directly to surface drains after use.

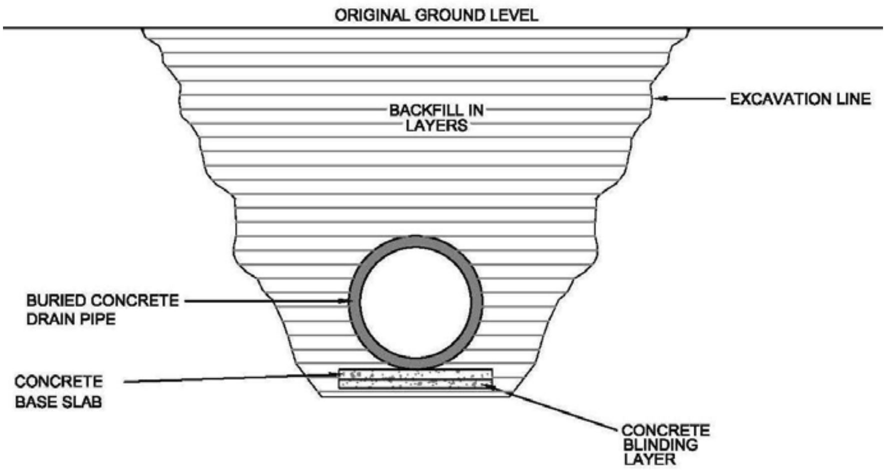

Figure 2.9 Cross-section of a buried concrete pipe drain

Culverts will be constructed of precast concrete pipes and installed using the same methods as just described for buried pipe drains. In addition, a head wall with wing walls and apron (Figure 2.10) will be constructed at each end of each culvert using methods as described in Section 2.3.6. Since water flows through culverts by gravity rather than under pressure, there is no need for hydrostatic testing when construction is complete.

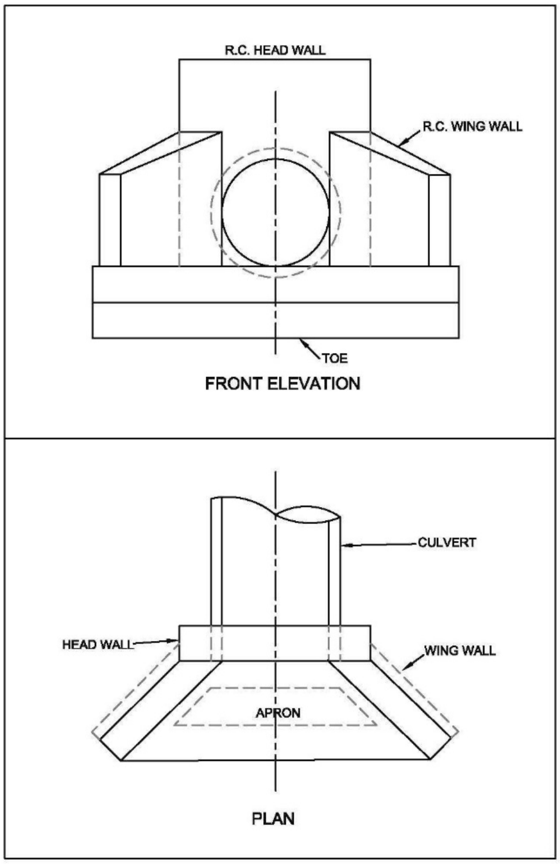

Figure 2.10 Front elevation and plan of the end of a culvert

2.3.5 Installation of Utilities and Sewers

Water pipes, electricity cables and sewers will all be buried on this development, with manholes provided in each case. Likely construction methods will be as follows:

- PVC water pipes will be imported to the island by ship, either in shipping containers or as bulk cargo. These pipes will be brought to the site either in shipping containers or on flatbed trucks. Trenches will be dug, the pipes lowered into the trenches and glued together, and the trenches backfilled, using methods as described for buried pipe drains in Section 2.3.4.
- Electricity cables and PVC pipes will be imported and transported to the site as described above for PVC water pipes. Once the PVC pipes have been installed into the trenches and the manholes constructed, the electricity cables will be unspooled and pulled through the PVC pipes. The cables will then be connected to the electricity system at each end.
- Sewers will be installed as described above for water pipes.
- Manholes will be constructed of reinforced concrete, as described in Section 2.3.6, below.
- As with buried drains, other buried pipes must also be hydrostatically tested (see Section 2.3.4). The comments pertaining to disposal of this water after use in that section are also relevant here.

2.3.6 Reinforced Concrete Construction

Reinforced concrete structures on this development will include building foundations and floor slabs, manholes and head walls on culverts. These may be constructed of premixed concrete or mixed-on-site concrete. In either case, formwork and reinforcing steel will be brought to the site in flatbed trucks. Reinforcing steel will be cut and bent to the required lengths and shapes. Formwork will be installed to receive the concrete and reinforcing steel placed within the formwork. Concrete will then be placed into the formwork and compacted using vibrators.

Where premixed concrete is used, this will be mixed offsite at a batch plant and brought to the site in mixer trucks. Where concrete is mixed on site, the mixers must be brought to site on flatbed trucks and assembled at the selected locations. Sand and gravel will be brought to the site in dump trucks and water brought to the site in tankers. Cement will be imported to the island in ships, most likely in shipping containers. These containers will then be brought to the site by road. Concrete can then be batched on site in mixers using these materials.

After any concrete work, the equipment (including the mixer trucks and concrete mixers) and tools must be washed to avoid the concrete hardening on them. Throughout the West Indies, improper disposal of this wash water has created a contamination problem in receiving surface water bodies. To avoid this, the wash water and any surplus concrete must be placed in a plastic-lined area and allowed to evaporate or harden. It can then be disposed of as a relatively inert solid.

2.3.7 Timber Construction

The design of the villas and some of the hotel buildings may include significant structural timber construction above the foundations and floor slabs. Wooden posts, beams and planks will be imported to the island in ships either in shipping containers or as bulk cargo. This timber will be transported to the site by road either in shipping containers or on flatbed trucks. Carpentry will then be done on site to install the timbers.

2.3.8 Finishing of Buildings

This involves the construction of external and internal walls and the roof, as well as the installation of plumbing and electricals. The material required for this work includes bricks, eaves and roofing sheets, water pipes and plumbing fixtures and electricity wiring and electrical features. All these items will be imported to the island in ships, most likely in shipping containers. They will be transported to the site by road in containers, and installed by masons, carpenters, plumbers, and electricians.

2.3.9 Installation of Wastewater Treatment Plants

Wastewater treatment plants of this type are shipped to site in shipping containers, completely assembled for smaller units and in parts for larger units. The units will be formed from poured concrete and will be sized to treat the anticipated wastewater volumes from the development. Units are to be located completely underground, allowing landscaping (i.e., native grass, plants, etc.) or parking atop. The units will be transported to the site by road. Smaller units will be ready to install and connect to the incoming plumbing. Larger units will require some on-site assembly. Tanks and piping on these units are normally pressure tested at the factory before shipping, so in the case of fully assembled units there is no need for repeat hydrostatic testing on site. However, for units that are assembled on site it will be necessary to conduct hydrostatic testing after assembly. The volume of water required for hydrostatic testing of wastewater treatment plants will be significantly more than what is required for testing of piping, and the comments on potential contamination of surface water in Section 2.3.4 are also relevant here.

3 Regulatory Framework

There are several pieces of legislation, new and existing regulations, and local, regional, and international guidelines which together provide a framework that informs the environmental and social impact assessment and its outcomes on the island of Barbuda in the State of Antigua and Barbuda. The following subsections present the most relevant of these and the succinct points within each.

3.1 Antigua and Barbuda Act No. 6 of 2003

This Act makes provision:

- for the orderly and progressive development of land and the preservation and improvement of the amenities thereof;
- for the grant of permission to develop land and for other powers of control over the use of the land;
- for the regulation of the construction of buildings and other related matters;
- for the conferring of additional powers in respect of the acquisition and development of land for planning; and
- for purposes connected with the matters aforesaid.

Additionally, the Director of the Department of Environment may also require, in consultation with the Chief Town and Country Planner, that any matter that is likely to cause any serious social impact, or harm to the environment or to human health to be subject to an environmental impact assessment. The third schedule of the Act (Section 23) notes matters for which environmental impact assessment shall be required includes (number 10) “a hotel or resort complex”.

As a general rule any proposed developments, undertakings and other activities, which are likely to cause an adverse impact on human health, society or the environment, should be subject to the EIA process, including *inter alia:*

- *Proposals that could harm or destroy important cultural resources including archaeological sites, cemeteries, historic sites, and landmarks; and*

- *Proposals that would challenge or contravene customary controls over the use of environmental resources.*

3.2 Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean (Escazu Agreement 2018)

Article 1 sets out the Objective of the Agreement as follows:

“The objective of the present Agreement is to guarantee the full and effective implementation in Latin America and the Caribbean of the rights of access to environmental information, public participation in the environmental decision-making process and access to justice in environmental matters, and the creation and strengthening of capacities and cooperation, contributing to the protection of the right of every person of present and future generations to live in a healthy environment and to sustainable development.”

Article 6, Generation and Dissemination of Environmental Information, notes that "Each Party shall promote access to environmental information contained in concessions, contracts, agreements, or authorizations granted, which involve the use of public goods, services or resources, in accordance with domestic legislation.

Article 7 indicates that "Each Party shall ensure the public's right to participation and, for that purpose, commits to implement open and inclusive participation in environmental decision-making processes based on domestic and international normative frameworks."

The Government of Antigua and Barbuda is a signatory to this Agreement.

3.3 Medium-Term Development Strategy 2016 to 2020

The Medium-Term Development Strategy (MTDS) represents a set of strategies and actions to be undertaken by Antigua and Barbuda over the Medium-Term (2016 to 2020) in moving the country towards its long-term goals. Within such a framework, Antigua and Barbuda will strive to become a developed country within fifteen to twenty years, guided by the vision of "A harmonious, prosperous and modern Antigua and Barbuda founded on the principles of sustainability and inclusive growth; where equality of opportunity, peace, and justice prevail for all citizens and residents". The attainment of this vision must be guided by a sustainable development approach in which we treat our public sector machinery as a single system working towards a singular, overarching goal, which is "To improve the quality of life for all Antiguans and Barbudans and their posterity".

Flagship Priority Three: Transform Barbuda into a Green, Low Density, High-End Tourism Destination. Barbuda is a natural paradise with unique pink sand beaches, lagoons, salt ponds and unique flora and fauna species, including one of the world's largest bird sanctuaries. Barbuda is virtually untouched with significant growth potential which, if exploited in a sustainable manner, can substantially transform the way of life for Barbudans while at the same time, protecting and preserving its natural beauty.

3.4 IUCN Environmental and Social management System (ESM) Standard on Cultural Heritage (Version 2.1 – December 2019)[2]

The purpose of the Standard on Cultural heritage is to assure that projects:

I. Anticipate and avoid negative impacts on cultural resources or, if avoidance is not possible, minimise and compensate for such impacts.
II. Avoid restrictions of people's ability to legitimately use and/or access cultural resources.
III. Assure a fair and equitable sharing of benefits if existing and new uses of cultural resources generate economic, cultural, and social benefits.

For this Standard, cultural heritage refers to:

[2] This standard is consistent with internationally accepted social safeguard standards related to cultural heritage, notably International Finance Corporation's Performance Standard 8 on Cultural Heritage and the World Bank's Operational Manual section on Physical Cultural Resources, among others.

i. A tangible, moveable or immovable cultural resource or site with paleontological, archaeological, historical, cultural, artistic, religious, spiritual, or symbolic value for a nation, people, or community; or

ii. A natural feature or resource with cultural, religious, spiritual, or symbolic significance for a nation, people or community associated with that feature.

Examples of the first category are burial sites, monuments, buildings, groups of buildings, urban areas, and cultural landscapes. Examples of the second are sacred mountains, forests, trees, or landscapes.

For the People of Barbuda their island has historic, cultural, spiritual, and symbolic value for its people.

4 Baseline Conditions

4.1 Physical Environment

4.1.1 Climate Change

Barbuda has a tropical marine climate and maintains a generally dry environment. Forty years of historical rainfall data show that Barbuda has low rainfall frequency with most months registering under 100mm of rainfall. Climate change projections indicate that Barbuda will experience longer dry periods, with January to March slated to be the driest. Extreme rainfall events such as those that occur during tropical storms and hurricanes are likely to become more intense, with larger peak wind speeds and heavier precipitation.

Rainfall trend graphs were plotted using available long-term precipitation data (Figure 4.1 and Figure 4.2). Barbuda has a dry season from January to April and a primary wet season from August through to November. The wet season coincides with peak tropical storm activity. The largest recorded value for the Coco Point station was in November 1999 where 483mm of rainfall was recorded. This was due to Hurricane Lenny passing south of the island.

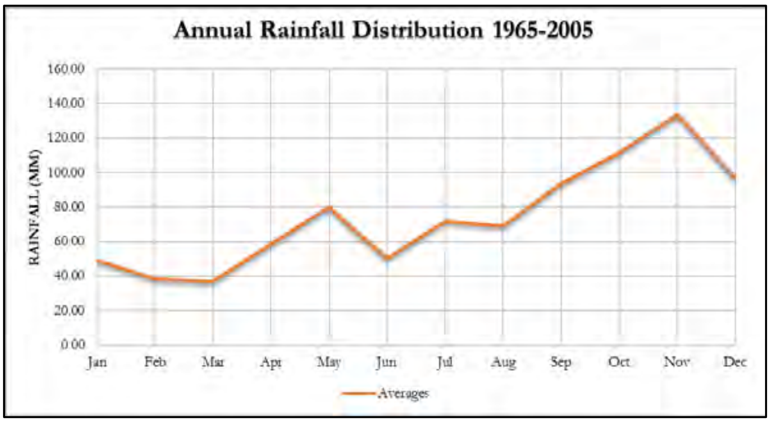

Figure 4.1 Annual rainfall distribution for the period 1965-2005

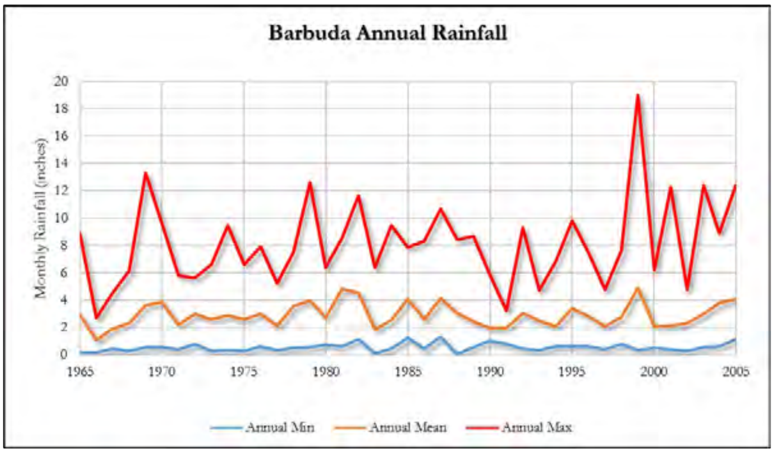

Figure 4.2 Annual minimum, mean and maximum for the period 1965 to 2005

Barbuda does not experience high rainfall, but rather is characterised by many periods of drought. As a result, rainfall values are much lower there than for other Caribbean nations. Rainfall values computed for return periods varying from 2 years to 100 years, are shown in Table 4-1.

Table 4-1 Rainfall levels for varying return period events

Return Period (years)	**Rainfall**	
	(mm)	(in)
T2	142	5.6
T5	19	7.6
T10	223	8.8
T25	240	9.4
T50	330	13
T100	533	21

4.1.2 Hydrogeology

The hydro-stratigraphic units of Barbuda, their stratigraphic sequence, subsurface relationships, and hydraulic character have been described by previous investigators. These were examined in the field for this EIA and found to be generally accurate. However, wells recently drilled through the Palmetto Sand Aquifer in the Palmetto Point headland at the southwest end of Barbuda, indicated that the Central Plains Limestone Aquiclude was absent, requiring a possible re-interpretation of the stratigraphic sequence in that area, and the depositional history of Barbuda.

The determination of well head elevations for data points in the Highland Limestone Aquifer, the Central Plains Limestone Aquiclude and the Palmetto Sand Aquifer could allow computation of the water table elevation in the respective hydro-stratigraphic units and a better understanding of the hydraulic relationship between them.

Field determinations of Specific Conductance (i.e., Electrical Conductivity) allowed characterisation of the water quality in the water table sections of the Highland Limestone Aquifer, Central Plains Limestone Aquiclude and the Palmetto Sand Aquifer. The fresh groundwater in the Palmetto Sand Aquifer reported by previous investigators up to 1992, no longer existed but was now moderately saline, believed to result from the extensive mining of the sand and the exposure of the water table to direct evaporation.

4.1.3 Air Quality

Ambient air quality was monitored to:

- Establish baseline air quality conditions within the study area for the proposed Paradise Found Development; and
- Compare baseline air quality results with air quality guidelines developed by the World Health Organization/ World Bank.

The air quality parameter monitored was Particulate Matter, which refers to a mixture of solid particles and liquid droplets found in the air. These include:

- **PM_{10}**: particles with diameters that are generally 10 micrometers and smaller and
- **$PM_{2.5}$**: particles, with diameters that are generally 2.5 micrometers and smaller.

These particles are so small they can be inhaled and cause serious health issues, such as aggravated asthma, lung disease and heart complications. Particulate matter such as dust can also be a public nuisance. At high concentrations, dust can also affect plants by coating the leaves and impeding photosynthesis. PM_{10} and $PM_{2.5}$ are emitted directly from sources such as unpaved roads or construction sites. Therefore, since this is a construction project, these parameters were monitored at strategic locations within the study area to establish the baseline. The four monitoring locations are shown in Figure 4.3 below.

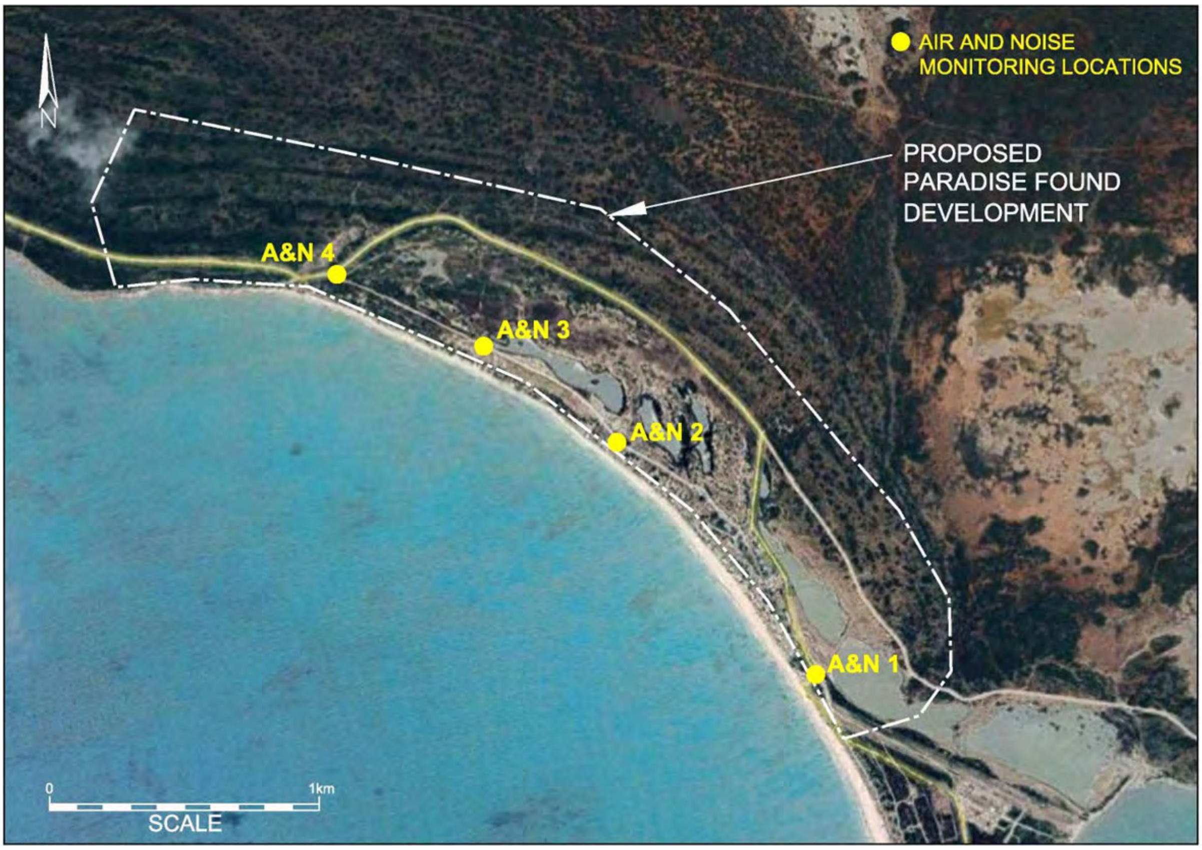

Figure 4.3 Air monitoring locations

These locations were selected based on the site boundaries and existing and proposed activities within the area. A&N 1 and A&N 4 respectively are representative of the northern and southern boundaries of the site and A&N 2 is representative of the nearest sensitive receptor, which in this case was a house with occupants who could be affected by particulate matter. A&N 3 was also selected, as construction works were on-going near this area.

A DustTrak II aerosol monitor (Model 8530) was used to measure Particulate matter ($PM_{2.5}$ and PM_{10}) at each of the four monitoring locations. For each monitoring event, the DustTrak II was zero calibrated, placed in an enclosure (to protect from rainfall) and mounted onto a surveyor's tripod. Each parameter was monitored at all locations for a 1-hour period and at a one (1) minute logging interval. Following the field monitoring, data was downloaded to a laptop and 24-hour concentrations of $PM_{2.5}$ and PM_{10} at each location were calculated.

In the absence of national laws for air quality, World Health Organization (WHO) and World Bank (WB) Guidelines were used for comparison purposes.

The WHO guidelines present recommended key air pollutant limits (both outdoors and inside buildings) based on global scientific evidence and for which concentrations greater than these are considered to be harmful to human health. Relevant parameters and their respective WHO Guidelines are presented in Table 4-2.

Table 4-2 WHO air quality guidelines

Parameter		**Averaging Period**	**Guideline (µg/m³)**
Particulate Matter	PM_{10}	24-hour	50
	$PM_{2.5}$	24-hour	25

The main sources of air emissions identified within the study area were due to: (i) the road network (vehicular exhaust and the kick-up of dust from trucks transporting material); and (ii) dust from construction sites.

Since monitoring of each parameter was only conducted for 1 hour at each location, the Time Weighted Average (TWA) was used to calculate estimated concentrations of $PM_{2.5}$ and PM_{10} for a 24-hour period at each location.

Based on the results obtained, the following was determined:

- The main sources of air emissions identified within the study area were from the road network (vehicular exhaust and the kick-up of dust from trucks transporting material), and dust from construction sites.
- Concentrations of both $PM_{2.5}$ and PM_{10} were highest at A&N1.
- However, estimated 24-hour concentrations of $PM_{2.5}$ and PM_{10} at all four monitoring locations were less than the respective WHO Guidelines for a 24-hour averaging period.
- None of the sources of air emissions identified appear to significantly impact the ambient concentrations of $PM_{2.5}$ and PM_{10} within the study area.
- Given that the proposed project site is situated on the coast and vegetation is sparsely distributed, the site experiences good dispersion characteristics.

4.1.4 Ambient Noise

Ambient noise monitoring was carried out to:

- Establish baseline noise conditions within the study area for the proposed Paradise Found Development and
- Compare baseline noise results with noise guidelines developed by the World Health Organization/ World Bank Group.

Noise monitoring was conducted for one (1) hour during the daytime and one (1) hour during the nighttime at the same four (4) locations within the study area as for the air quality. A SoundPro sound meter manufactured by Quest Technologies (DL Series) was used to monitor noise levels at each of the four monitoring locations. For each monitoring event, the sound meter was calibrated, mounted onto a tripod, and set to record equivalent continuous sound pressure level (L_{eq}) for a one (1) hour period at one (1) minute logging interval.

After field monitoring, data was downloaded onto a laptop and compared to the World Bank Group's *Environmental Noise Management Guidelines*.

In the absence of national laws for noise, limits listed in the World Bank Group-*Environmental Health and Safety Guidelines-Environmental Noise Management Guidelines* were used for comparison purposes. The EHS Guidelines state that noise impacts should not exceed the levels presented in Table 4-3 below or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

Table 4-3 World Bank Group noise guidelines

Receptor	**One (1) hour L_{eq} (dBA)**	
	Daytime (7:00 a.m.-22:00 p.m.)	*Nighttime (22:00 p.m.-7:00 a.m.)*
Residential; Institutional; Educational	55	45
Industrial; Commercial	70	70

The study area has been zoned for tourism, but currently commercial activity in the area is sparse. Further, residential homes are few and far between. However, it should be noted that the nearest sensitive receptor was a house located at A&N 2.

Given the presence of both residential and commercial buildings within the study area, the results of this noise monitoring exercise were compared to the guidelines for commercial areas as well as residential areas.

Table 4-4 lists the sources of noise identified at each monitoring location.

Figure 4.4 compares the daytime L_{eq} values recorded at each monitoring location to the World Bank Group's Noise Guidelines. The figure indicates that daytime L_{eq} values recorded at the four monitoring locations were below the daytime limit for commercial areas. However, L_{eq} values recorded at A&N1, A&N3 and A&N4 were at, or slightly above, the daytime limit for residential areas.

Table 4-4 Sources of noise within the study area

Monitoring Location	Sources of Noise	
	Daytime	***Nighttime***
A&N1	• Vehicles traversing roadway (mainly trucks) • Wind • Birds Chirping	• Vehicles traversing roadway • Insects • Crab catchers
A&N2	• Birds Chirping • Vehicles • Persons Chatting • Heavy Equipment working in the distance	• Vehicle • Wind
A&N3	• Music • Construction work (on Helipad) • Birds chirping	• Music in the distance • Vehicle
A&N4	• Vehicles traversing roadway • Truck horns • Wind • Birds chirping	• Music in the distance • Vehicles traversing roadway

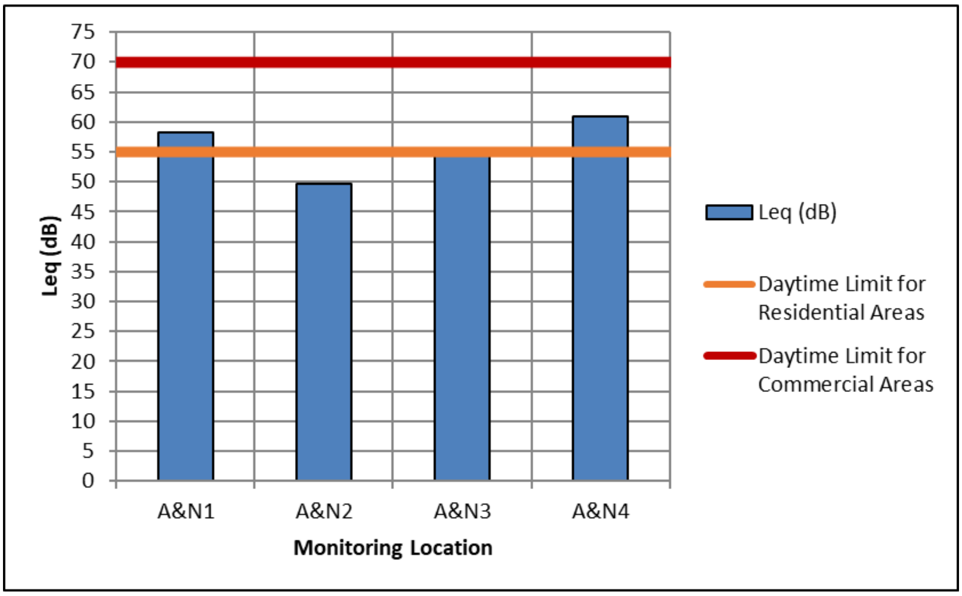

Figure 4.4 Ambient noise monitoring results & comparison to recommended daytime limits

Figure 4.5 compares the nighttime L_{eq} values recorded at each monitoring location to the World Bank Group's Noise Guidelines. Similar to the daytime, nighttime L_{eq} values recorded at all four monitoring locations were also below the limit for commercial areas. However, L_{eq} values recorded at A&N1, A&N2 and A&N4 were slightly above the nighttime limit for residential areas.

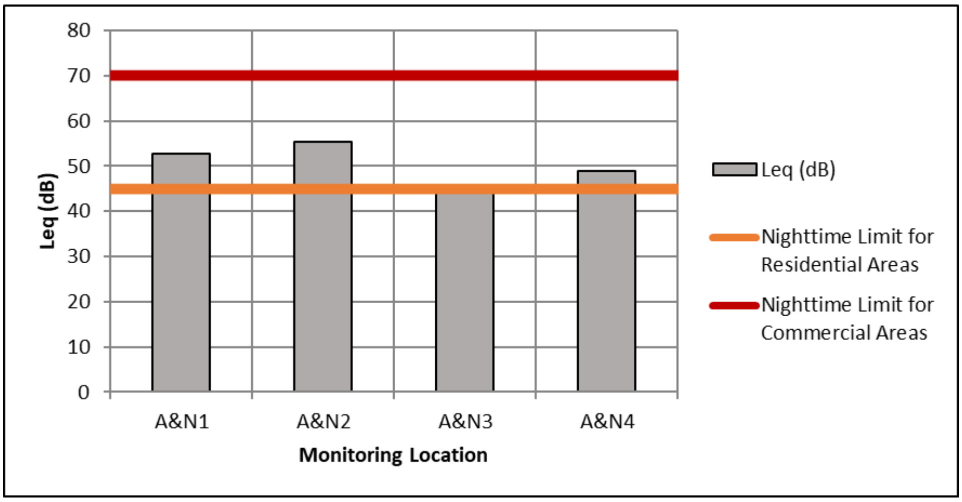

Figure 4.5 Ambient noise monitoring results & comparison to recommended nighttime limits

Based on the results of the noise monitoring, the following can be concluded:

- Equivalent continuous sound pressure levels (L_{eq}) were higher during the daytime than the nighttime at all monitoring locations except A&N2.
- Daytime L_{eq} values recorded at the four monitoring locations were below the daytime limit for commercial areas. However, L_{eq} values recorded at A&N1, A&N3 and A&N4 were slightly above the daytime limit for residential areas.
- Similar to the daytime, nighttime L_{eq} values recorded at all four monitoring locations were also below the limit for commercial areas. However, L_{eq} values recorded at A&N1, A&N2 and A&N4 were slightly above the daytime limit for residential areas.
- These results provide an envelope of noise ranges during the day and night, which will be used to assess the impacts of the proposed development on the noise regime.

4.1.5 Metocean and Coastal Parameters

Baseline coastal zone modelling is required to gain an understanding of the baseline coastal processes acting along the shoreline of the project site. Waves, currents, and sediments all interact to affect shoreline morphology, resulting in actions such as erosion or accretion. This section of the report describes the additional work that was done to enhance the 2016 study.

Especially when considering climate change and projected sea level rise (of particular relevance to coastal developments in small island states such as Barbuda), the vulnerability of the proposed development is a function of its setback from the shoreline. The vulnerabilities typically include:

- Increased storm surge and coastal erosion from more frequent Category 3, 4 and 5 hurricane activity.
- Long term shoreline erosion from higher waves due to higher sea levels.
- Natural trends of shoreline change.
- Exacerbating coastal erosion by building too close to the sea, or by the destruction of natural dunes and coastal vegetation

The text in this chapter provides an assessment of the site's exposure to these risks and provides recommendations to reduce its vulnerability. Specifically, appropriate setback limits are derived. The horizontal setback is the distance from the high-water mark or line of permanent vegetation to the location of the development. The vertical step-up refers to the floor level above high-water mark that should be maintained to reduce vulnerability. This analysis also includes projected climate change impacts on sea level rise.

Background

Coastal setback is a buffer zone defined by a calculated minimum distance from the shoreline's mean high-water mark within which permanent construction is to be prohibited. Coastal setbacks are implemented as a coastal management and planning tool to protect the ecology of the land and to reduce the impact of natural hazards on a development. Setbacks vary based on the location, topography and wave climate and planning legislation and guidelines. They also affect where construction may begin and guides the vertical elevation of floor levels. Guidelines usually require that all development falls behind the coastal setback line.

A regulatory value for coastal setback was difficult to justify as current legislation does not specifically state what this value should be. Nevertheless, the Department of Environment (DOE) specifies in an undated "brochure for developers", stamped as "Draft Policy", that beachfront developments should be 100 feet from the first vegetation line[3]. The DOE also provided as reference "*Model OECS Coastal Development Setback Guidelines – with specific recommendations for Antigua and Barbuda"* from January 12, 2016, which provides recommendations for determining setback limits on a site-specific basis. This approach considers the projected coastal change (i.e., recession) from expected rising sea level. The document also references the setback guidelines developed by Cambers (1998) which requires 100 to 130 feet setback for the line of permanent vegetation for sandy beaches.

Approach

A site-specific approach to develop the setback limits for the Paradise Found Development similar to that recommended in the OECS guidelines was carried out. Setbacks were developed for 25, 50 and 100-year storm return period conditions and were compared to the standard DOE draft policy guideline of 100ft from first line of vegetation. The approach involved the following:

a) Understanding the daily and seasonal wave conditions for the site since they relate to potential shoreline erosion.

b) Understanding the general trends of sand transport along the shoreline to assess potential for coastal erosion or growth of the shoreline.

c) Assessment of the potential for storm surge inundation from hurricanes for i) the existing site; and ii) the proposed development masterplan with surge risk reduction recommendations measures in place with a higher sea level from climate change accounted for.

d) Evaluation of potential long term and storm surge erosion due to sea level rise and its associated impacts such as higher waves at the shoreline on a day-to-day basis and during hurricanes.

---

[3] Investor's Brochure, Department of Environment

These coastal investigations required data collection, historical hurricane analysis and numerical modelling. The site topography and nearshore bathymetry data was the baseline data used to set up a model domain for MIKE 21, a hydrodynamic modelling software developed by the Danish Hydraulic Institute.

Shoreline Change (Longer-Term)

Historical shoreline change for the project site was analysed to determine the long-term observed changes in beach width along the site's coast. Aerial imagery was obtained from Google Earth and georeferenced using to the UTM 20 system. Fixed reference points were established at road intersections and reference lines drawn to show relative change. The years retrieved were 2003, 2005, 2009 and 2013, 2016, 2019 and 2020. These shorelines were overlaid on the current site imagery.

Figure 4.6 to Figure 4.10 shows that the shoreline fluctuates. Between 2003 and 2005 the shoreline eroded 15-20m but then accreted almost to the 2003 shoreline by 2009. There was again erosion between 2009 and 2013 and the 2016 shoreline seems to enjoy a wider beach than the 2013 shoreline. Between 2016 and 2020 the shoreline shows signs of erosion of 45m to 47m. This is likely because of recent hurricanes (Irma and Jose 2017) and tropical storms that passed within 300km of the site. It should be noted that the fluctuations observed might have been just from seasonal variations rather than over a period of years as just a single point in time for a year is being observed. It would require a longer period of imagery to determine a long-term trend in shoreline change and to say whether the erosion seen between 2003 and present is an ongoing trend. This analysis, however, illustrates that the beach does vary by up to 45m seasonally or annually.

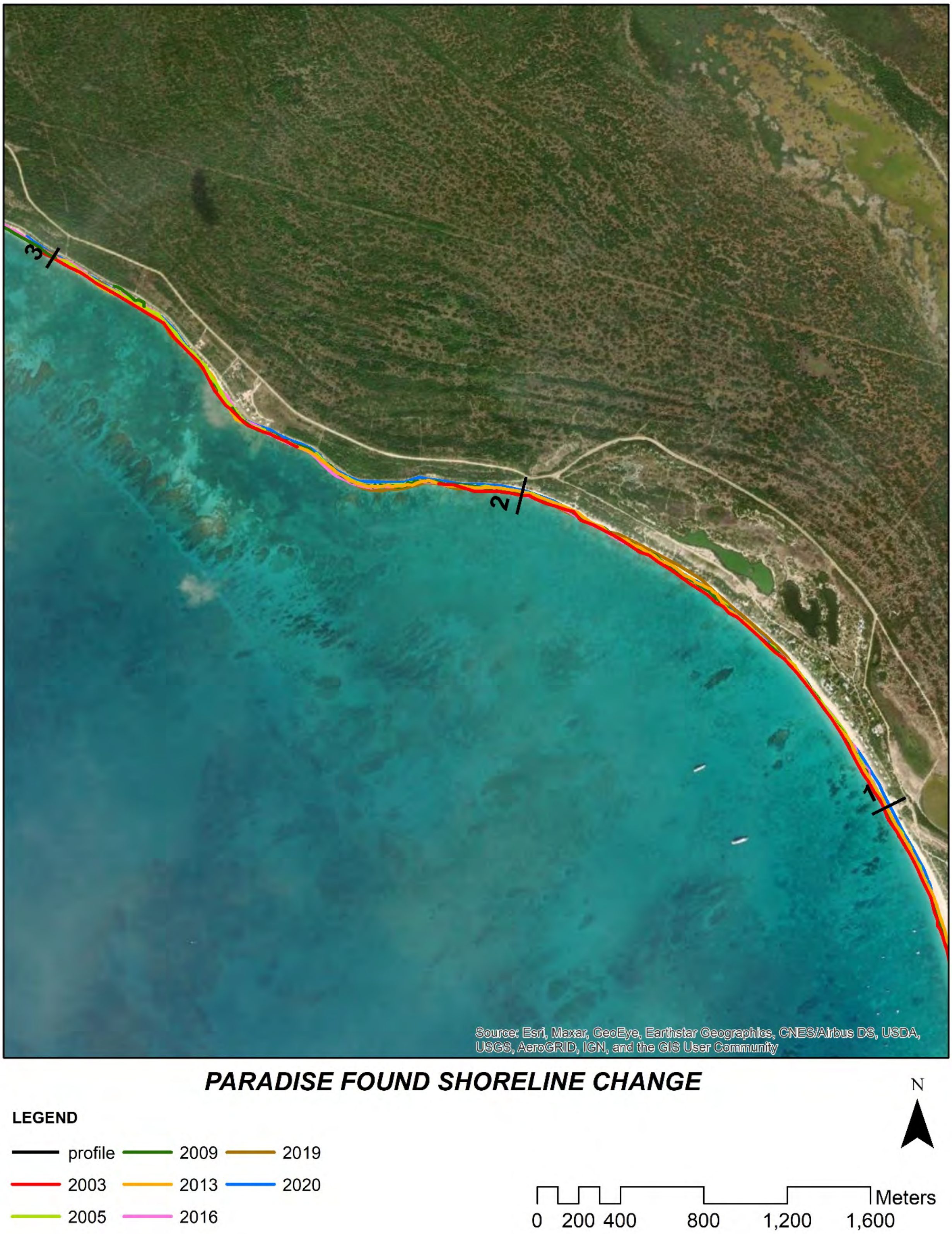

Figure 4.6 Paradise Found shoreline change

Figure 4.7 Paradise Found shoreline change profile 1

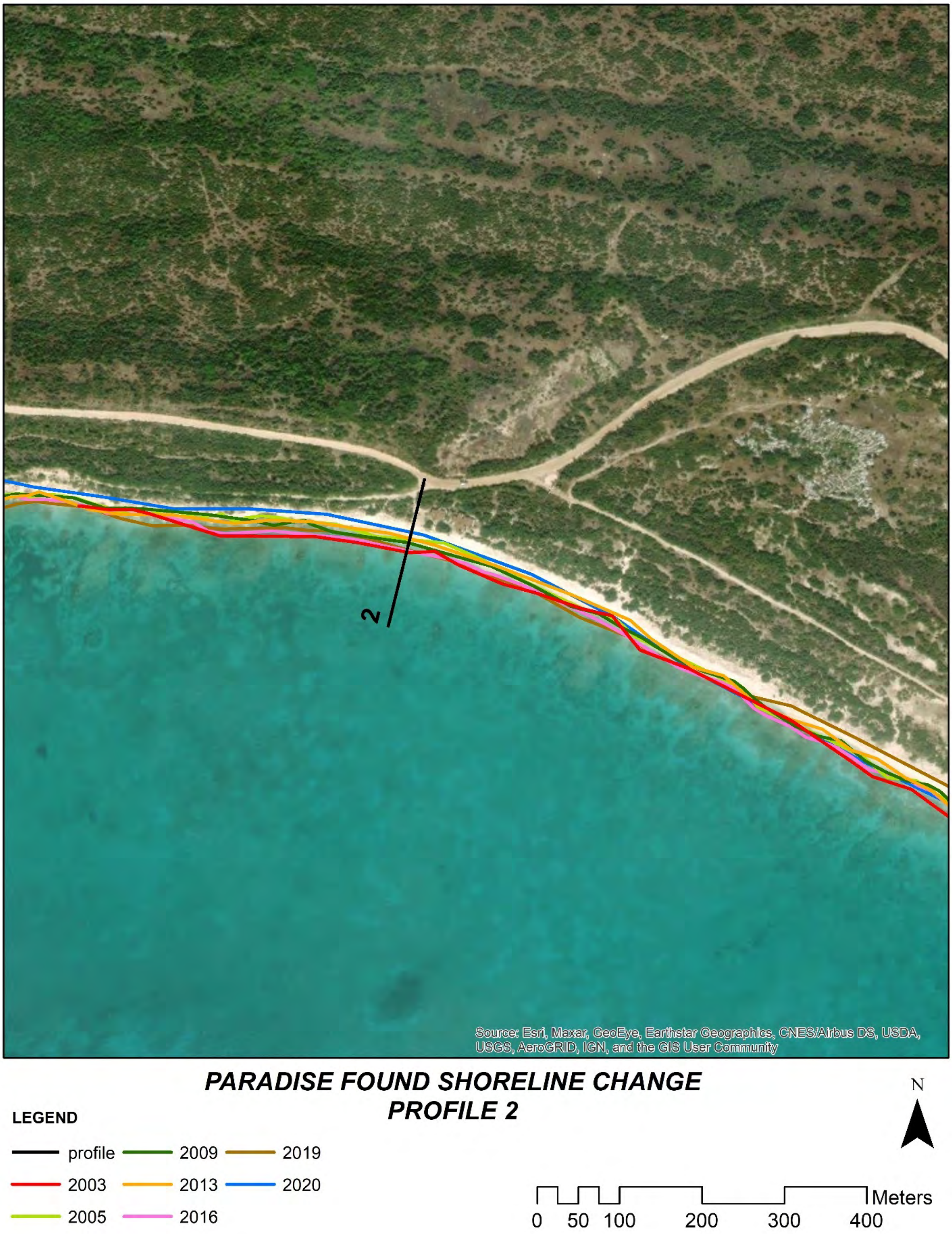

Figure 4.8 Paradise Found shoreline change profile 2

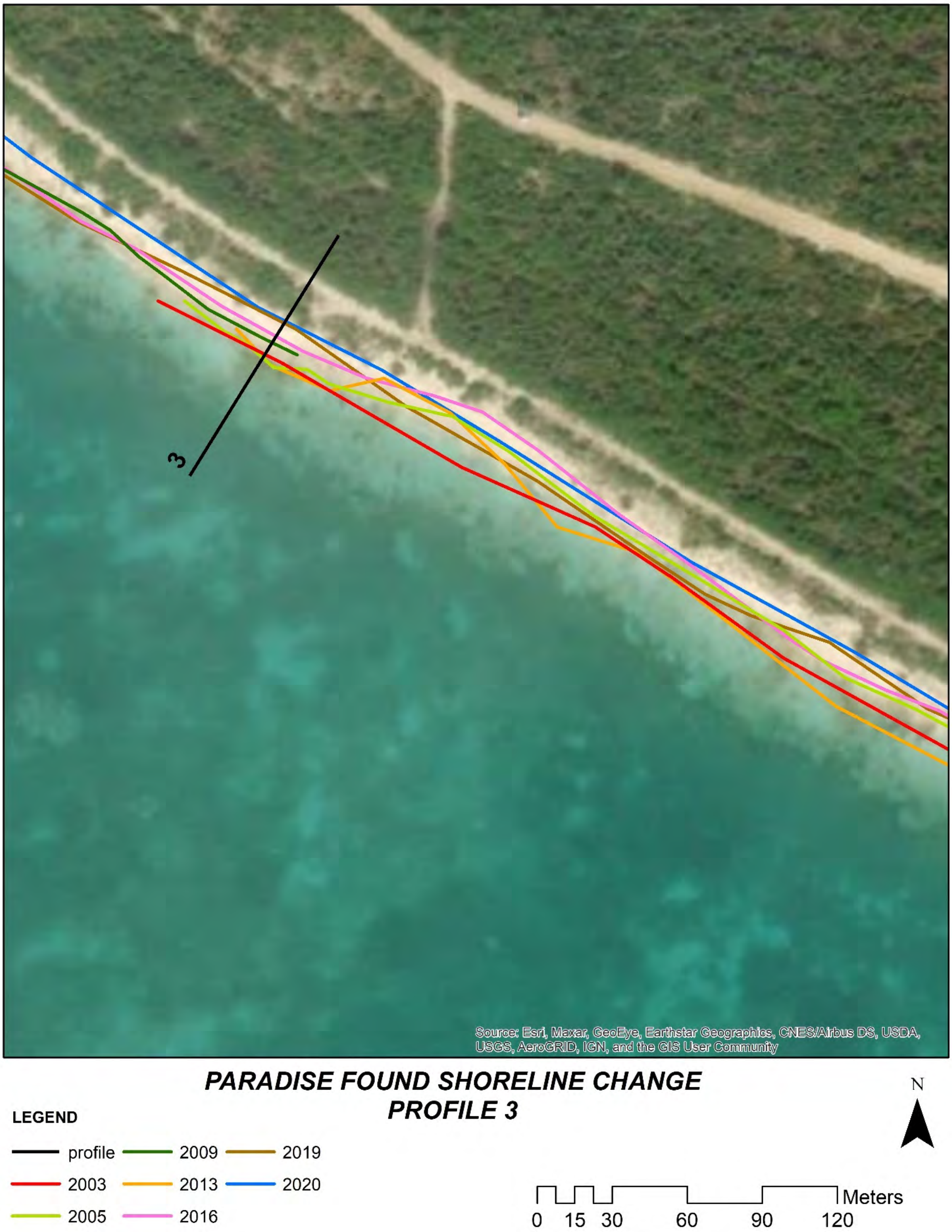

Figure 4.9 Paradise Found shoreline change profile 3

Sand Movement

A general understanding of the patterns of sand movement along the shoreline is essential to understanding vulnerabilities of the beach. The previous section illustrated that the beach undergoes significant variations in profile and width, seasonally or annually. A preliminary analysis was carried out to gather a general insight into the patterns of sediment movement around the southwest coast of Barbuda.

Waves propagate towards the coastline at an angle and this action drives currents that transport sediment in the cross-shore or alongshore direction. Barbuda's coastline has two main wave climates: (i) higher energy waves from the Atlantic Ocean affect the eastern side, while (ii) the western side is calmer. The proposed site is sheltered by both Coco Point to the southeast and Palmetto Point to the northwest. Simulation of sediment movement around Barbuda can help in understanding the long-term behavior of the Paradise Found shoreline.

Sediment transport modelling was done using the Sand Transport Module of the DHI MIKE21 Software Suite. This module incorporates hydrodynamics and the annual statistical wave conditions for each defined direction. The output from the run showed the maximum load and the direction of transport. The output received was post-processed using a weighted average algorithm that provided the mean annual transport for the sea floor. The final plot showed total load magnitude and direction of transport.

The plot shows that the potential for sand transport is most prevalent on the east side of Barbuda given the more energetic wave climate that prevails there. There is a general westerly movement of sand into Gravenor Bay, which would explain why this bay has a sandy beach that blocks the outlet of the salt pond to the sea. A large sediment flow also moves towards and around Coco Point. A portion of these sediments would move onto the beach at Coco Point, explaining why this end of the bay has a wider and gentler slope. A portion of the sand that drops onto Coco Point beach and the nearshore area is expected, however, be transported northwards to the Paradise Found beach. The sediment flow seems to bypass the northern end of the Paradise Found property, which explains why there is not a sandy beach in this area.

As such, the supply of sand, as expected, is from the south. Any structure across the beach south of the Paradise Found property that would interrupt this sediment flow would have an adverse impact on the Paradise Found beach. Further, if the Paradise Found beach is to be extended northwards along the property, artificial interventions would have to be implemented to achieve this objective.

Storm Erosion

Storm surge inundation also causes beach erosion. This recession of the shoreline increases the ingress of surge inland. As such, determining the potential erosion during a storm is critical to determine setback limits. Shoreline erosion may also occur over the long-term due to projected sea level rise. Increased sea level means the water line is farther inland and larger waves are able to reach the beach, contributing to progressive coastal erosion. This vulnerability is evaluated in this section.

Shoreline recession was quantified based on three categories: sea level rise, beach erosion from storms and long-term recession. Sea level rise will result in a narrowing beach. The narrowing observed is a function of the slope of the beach. Beach slopes were extracted along the length of the shoreline and the maximum horizontal recession for each profile calculated.

Nearshore wave conditions were extracted from the selected MIKE 21 plots and used to assess beach erosion for each storm event. Five profile lines were chosen for analysis with four being on the sandy section of the site and one on the rock coast. The numerical model tool, sBEACH, which simulates cross-shore beach change was used.

Long-term recession was calculated using the Bruun Rule for coastal retreat. The Bruun model was applicable as is relevant to sandy coastlines. For the application of this model, the wave climate from the previous analysis was applied to measured beach profiles and estimate coastal retreat for the 25-year, 50-year and 100-year return periods. Table 4-5, Figure 4.10 and Figure 4.11 show the results of this analysis.

Table 4-5 Components of setback

Setback						
Coast Type	Return Period	Bruun Recession (m)	Storm Erosion (m)	SLR Component (m)	Total Setback	
					(m)	(ft)
Beach	25	5.1	31.0	4.4	41	133
	50	5.4	41.8	4.4	52	169
	100	6.3	59.8	4.4	70	231
Rock	25	5.3	16.0	1.0	22	73
	50	6.1	18.5	1.0	26	84
	100	6.9	23.5	1.0	31	103

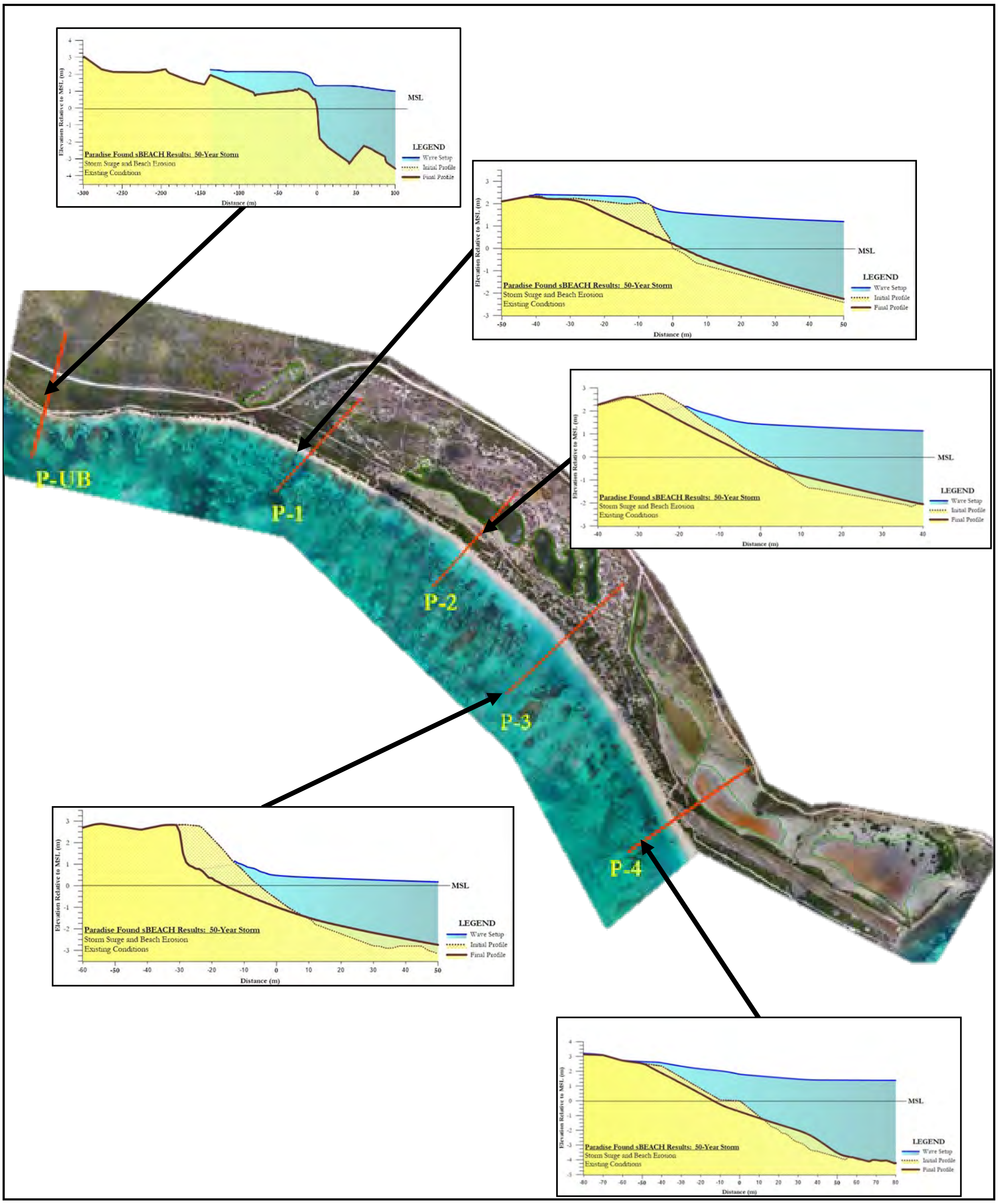

Figure 4.10 Plan with profile lines and beach erosion for a 50-year event

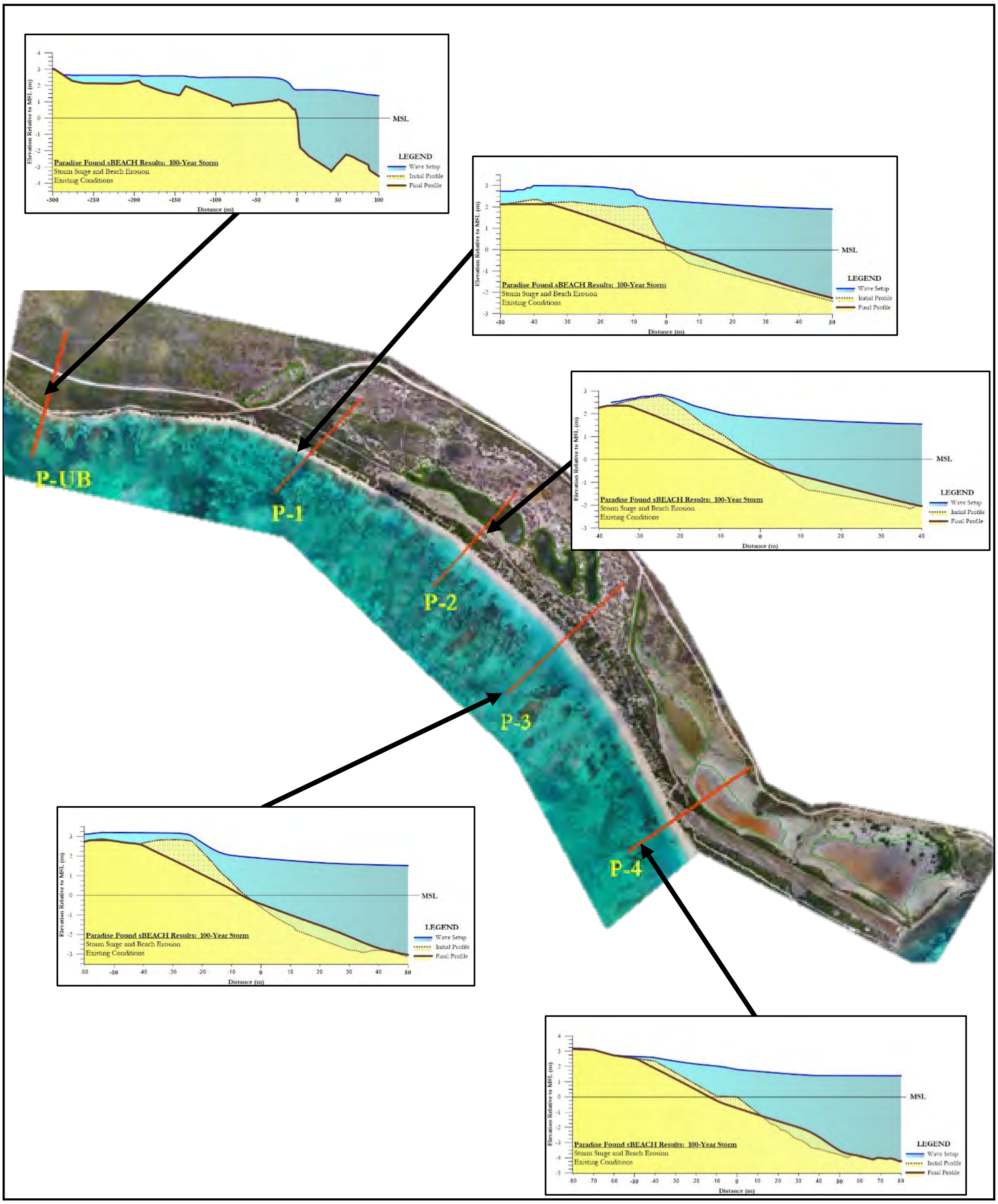

Figure 4.11 Plan with profile lines and beach erosion for a 100-year event

Summary of Key Findings

A review of historical hurricane data showed that hurricanes have typically approached from the east or southeast. The eastern side of the island experiences higher water levels and wave heights during these hurricane events. Hurricane conditions from the south were found to produce the highest storm surge elevations, and this direction was used in further modelling of impacts. Storm surge was mainly observed by the outlet at Gravenor Bay and the break in the berm near the roadway to the north.

Figure 4.12 below shows the 50-year storm event pre- and post-development. The proposed master plan would introduce a dyke behind Pond 1 and then raise the berms; modelling has shown this would prevent inundation on site from storm surge.

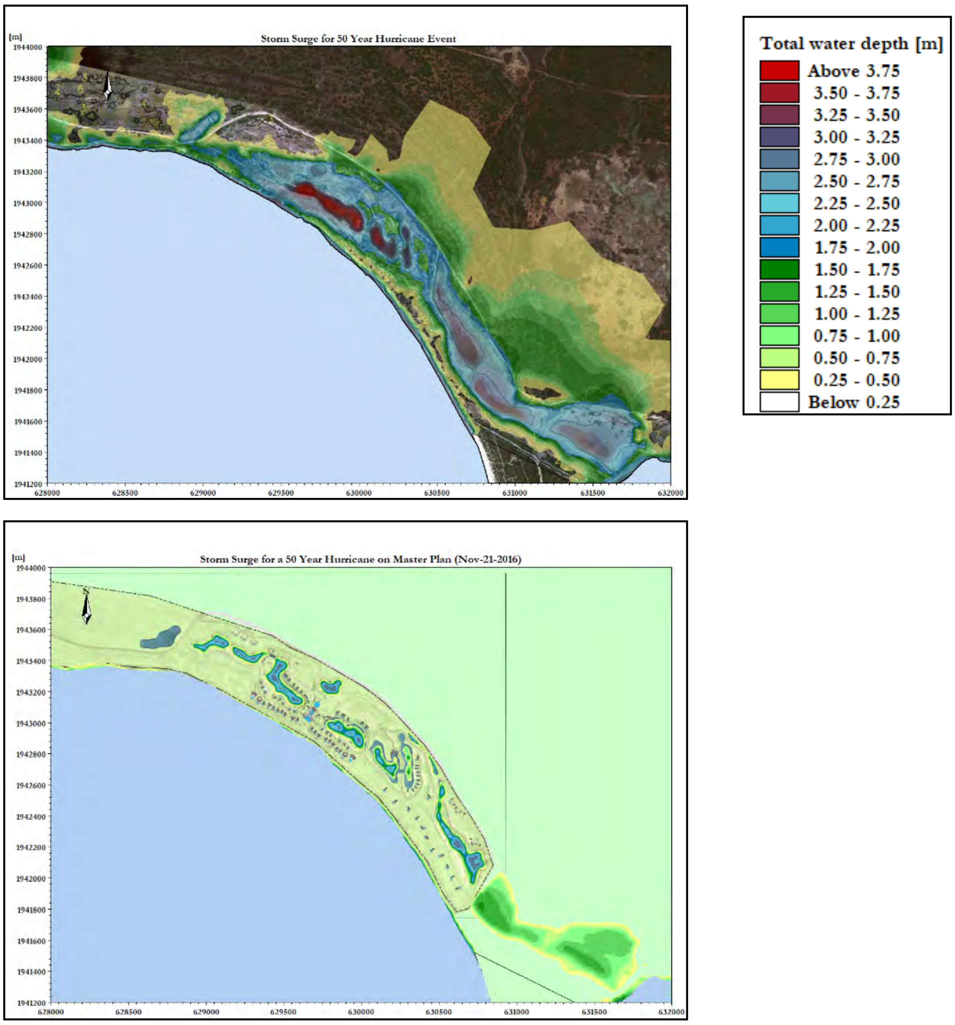

Figure 4.12 Storm surge comparison pre-development (top) and post-development (bottom) for the 50yr storm

The dunes along the coastline will be inundated during extreme storms. It is therefore necessary to enforce a setback limit for development along the shoreline.

Setback Distances and Step-Up Elevations

The mean high water mark was used as the horizontal datum for the calculated 25-year, 50-year and 100-year setback lines. Analysis of tide data from long-term tidal records (19 years) produced a mean high-water level at +0.09m and tidal range of 0.3m. The high-water mark was plotted by using the point data from the Digital Elevation Model (DEM) to trace an accurate 0.09m contour line, and the line was checked against the drone image. The calculated setback values were then offset from the high-water mark to specify the setback lines.

Calculated setback lines were compared with the Department of Environment regulations. This was done by assessing the historical vegetation lines to determine the furthest that vegetation has been from the coast. That line was offset by 30m to define the vegetation setback line.

Sandy coastlines were differentiated from rocky coastlines due to the predominant factors in their reach that would affect setback values. Sandy coastlines experienced mainly beach erosion while rocky coastlines experienced large values of wave run-up. The final computed setback values are shown in Table 4-6 and Table 4-7.

Table 4-6 Horizontal setback values based on long-term sea level rise, beach type and incorporating predicted hurricane erosion

Return Period	**Beach Setback**		**Rock Setback**	
	(m)	(ft)	(m)	(ft)
25	41	133	22	73
50	52	169	26	84
100	70	231	31	103

Table 4-7 Vertical step-up values for development along beach

Return Period	**Minimum Building Floor Level**	
	(m)	(ft)
25	2.6	8.5
50	2.9	9.5
100	4.1	13.5

Outcomes and Implications

The regulatory vegetation setback line mainly coincides with the 50-year setback line and does not exceed the 100-year setback line. Figure 4.13 shows the recommended distances for each return period.

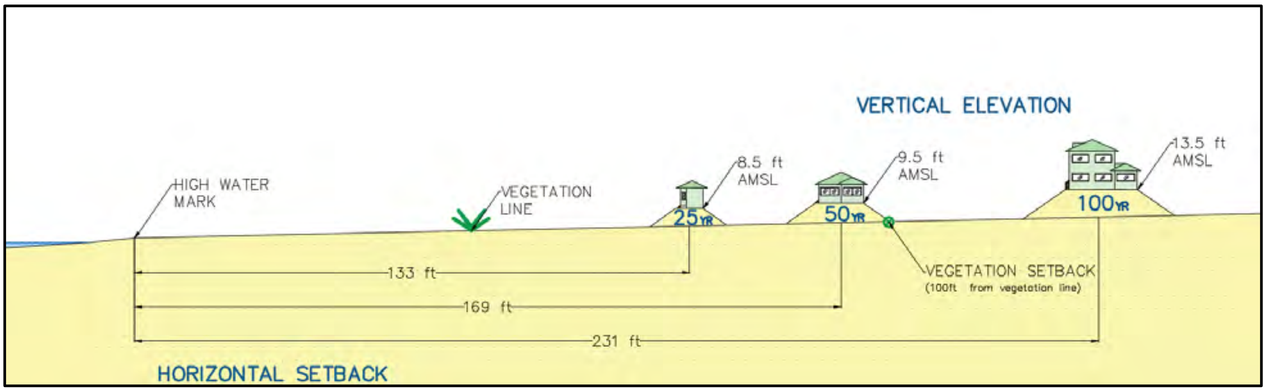

Figure 4.13 Final setback values relative to the vegetation setback line

Storm surge is inundation from the sea caused by storm events. During tropical storms and hurricanes, the sea level rises because of the low-pressure centre surrounding the system. The high winds generate unusually high waves, which run up farther inland. As these large waves collapse, they further push up the water level. The combination of these phenomena contributes to what is known as storm surge.

The Paradise Found property, being relatively low and flat, is vulnerable to storm surge. The site is exposed to storm surge from two points: along the beach and from Gravenor Bay across the salt ponds. Anecdotal reports suggest that Hurricane Luis (1995), Hurricane Irma, and Jose (both 2017) did not cause significant storm surge from the beach. This provides an opportunity to validate the storm surge assessment.

Assessing the vulnerability of the project to storm surge involved the following key steps:

- Historical assessment carried out for all tropical storms and hurricanes to have passed within 300km of the project site since 1852. The storm track data from the National Hurricane Centre was used within our in-house software, HURWave. This included a total of 209 storms.
- The waves and water levels generated by each of these storms just offshore of the site were parametrically determined.
- The waves that would have a direct or near-direct approach to the Paradise Found site were filtered. The highest hurricane waves for Barbuda are from the east but the worst-case waves for the site are from the south. A statistical analysis was carried out on these wave and water level conditions. This produced the 25yr, 50yr and 100yr conditions.
- These hydrodynamic conditions were simulated in the model domain of MIKE21, which was set up for the south of Barbuda using collected bathymetry and topography as the baseline data for the model. The model provided the storm surge levels for the project site based on the selected input conditions. This process was completed for the existing site conditions, thereby providing storm surge plots for the 25yr, 50yr and 100yr storm conditions.
- The full track of hurricane Luis (1995) was simulated in MIKE21 and an inundation map for the project site was developed to evaluate if the predicted results validate the anecdotal reports of limited inundation from the sea for that event.
- The above simulations were repeated for all the storms for the scenario with the development in place and taking future projected sea level rise into consideration. The sea level rise considerations were incorporated by using the Inter-Governmental Panel on Climate Change (IPCC) projections for mean global sea level change. The IPCC RCP8.5 scenario was chosen as it represents the highest level of radiative forcing by the year 2100 (least responsive societal reaction to GHG emissions). The global mean increase in sea level is projected to be 0.69m. This additional water level was added to the model domain in the simulation of the 25yr, 50yr and 100yr conditions for the scenario with the development masterplan in place.

The simulations for the various return periods were done assuming the event happens during a high-tide situation. The simulation of Hurricane Luis was done with the actual tide conditions during the storm. Based on the statistical analysis, the waves from Luis were slightly higher than from the 25-year event, however the simulated water level (storm surge) was less. Luis therefore showed storm surge levels even less than the 25-year hurricane. The plots below show storm surge for Luis as well as the pre- and post-development scenarios for the modelled 25-year event.

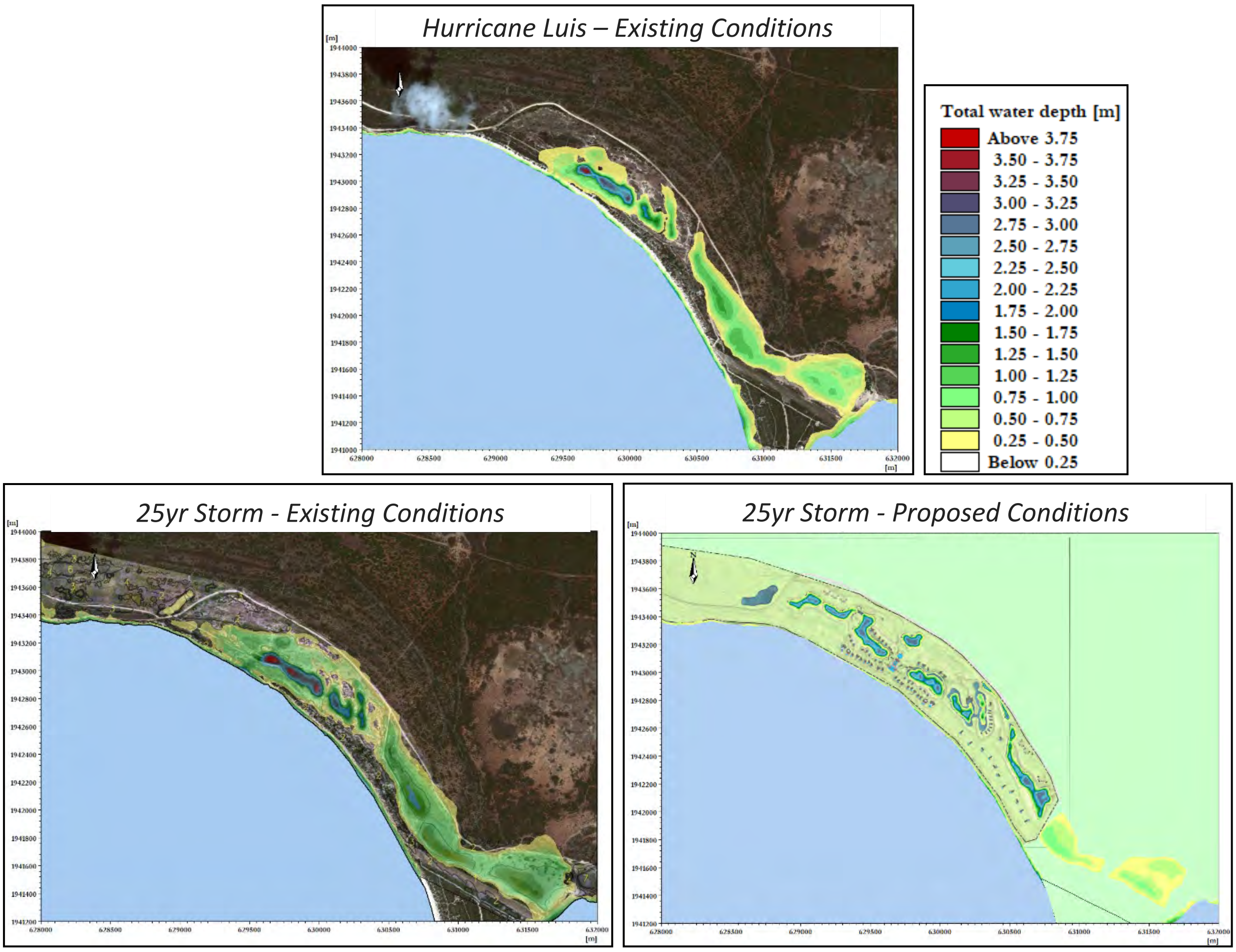

Figure 4.14 Storm surge comparison for Hurricane Luis (top) and 25-year event (pre-development (bottom-left) and post-development (bottom-right))

For the pre-development scenario, the water elevation is shown above existing ground level, whereas for the post-development case, it is shown as being above the proposed finished ground levels. The following are key observations from the analysis:

- Hurricane Luis did not produce significant inundation from the beach, and this finding concurs with the anecdotal reports. Rather, inundation was observed to come in from an influx of water from Gravenor Bay, which increased the height of the water in the salt ponds. The low-pressure center of the hurricane affected the height of the water in the ponds and the winds from the hurricane pushed the water, causing inundation of the low areas around the pond. These low areas typically flood in any case when there are heavy rainfall events.
- All simulated events caused some level of inundation along the shoreline as waves run-up across the beach and into the dune area. This inundation level carries farther inland for higher return periods. There is a single low area between Pond 3 and the beach where there is a consistent breach of waves causing additional inundation around this pond. The post-

development scenario, however, raises the elevation of this area thereby getting rid of this impact.

- Gravenor Bay represents the most significant path for inundation of the site. Waves breach this bay and carry water across the salt ponds and on to the property. A dyke built to an elevation of +3m is proposed along this eastern property boundary, which eliminates this impact for the post-development scenario. This, however, might cause increased water levels in adjacent areas. This impact will require further and more detailed consideration.
- In the 100-year event, water levels are as high as 2.9m (approx. 9ft) above existing ground at the site shoreline. The 100-year event inundates most of the existing property. The high areas of the site where the K Club cottages were built and towards the raised areas at the north-western end of the property had lower depths of 0.2-0.4m.
- With the dyke along the eastern property boundary in place, low areas around the ponds raised, and the waterfront properties appropriately setback from the shoreline, the proposed development will not be at high risk from storm surge inundation for events up to the 100-year return period.

4.1.6 Surface Drainage

The natural existing drainage features and ponds on the Paradise Found site become inundated with flood water easily during moderate rainfall conditions. Further, the offsite drainage run-off has a significant impact by infiltrating the Paradise Found site. The existing flooding situation onsite demonstrates the need for an assessment of current drainage features and existing site conditions along with a need for the design of a new comprehensive drainage strategy and drainage system.

Despite efforts to elevate areas of the site and construct a golf course by previous developers, the site still floods quite easily and significantly as indicated in the hydrology models. The hydrology model identifies the areas of concern that needs to be addressed. Low lying areas of the site will require significant filling and drainage works to provide flood management solutions. There are cost implications and, as a result, various solutions have been investigated and optimized.

To ensure that the model was properly defined, validation tests using the 2-year rainfall statistics were done and compared to a recent rainfall event. After validation was achieved the 5yr, 10yr, 25yr, 50yr and 100yr rainfall events were run on the existing site. Flood modelling was done for all master plans submitted (September 2016, November 2016, and December 2016).

The images below (Figure 4.15 and Figure 4.16) illustrate the existing and post development scenarios for the 2yr and then the 10yr rainfall events. The master plan presented was the latest version at the time of this report. This version had been modified from previous versions to reduce fill and allow non-critical areas of the site to flood. As shown, in the 2yr flood event most of the site is without floodwater, but flooding occurs during the 10yr flood event. The aerial extent of flooding increases with greater return periods in those noncritical areas.

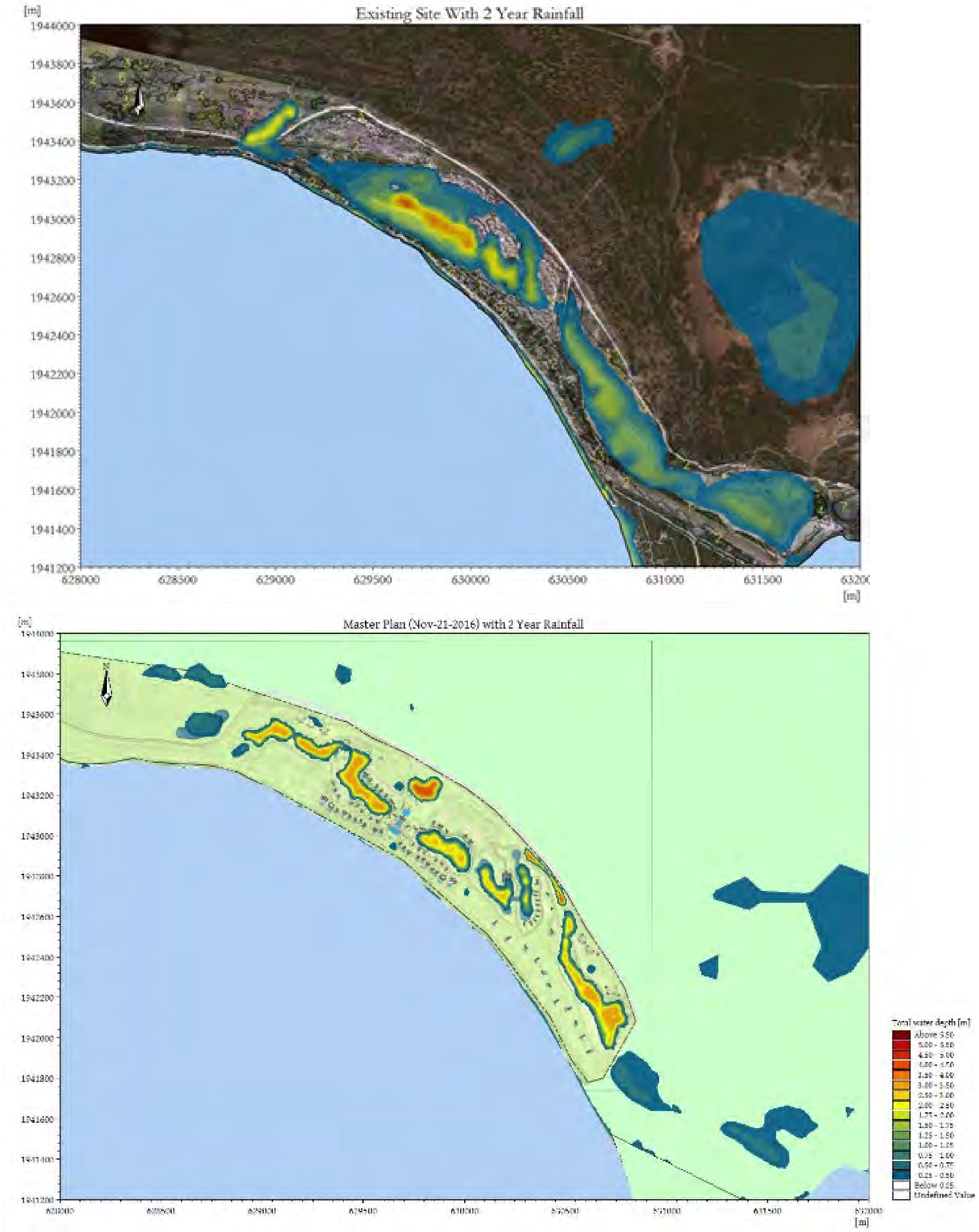

Figure 4.15 2yr Flood map for existing and post-development scenarios

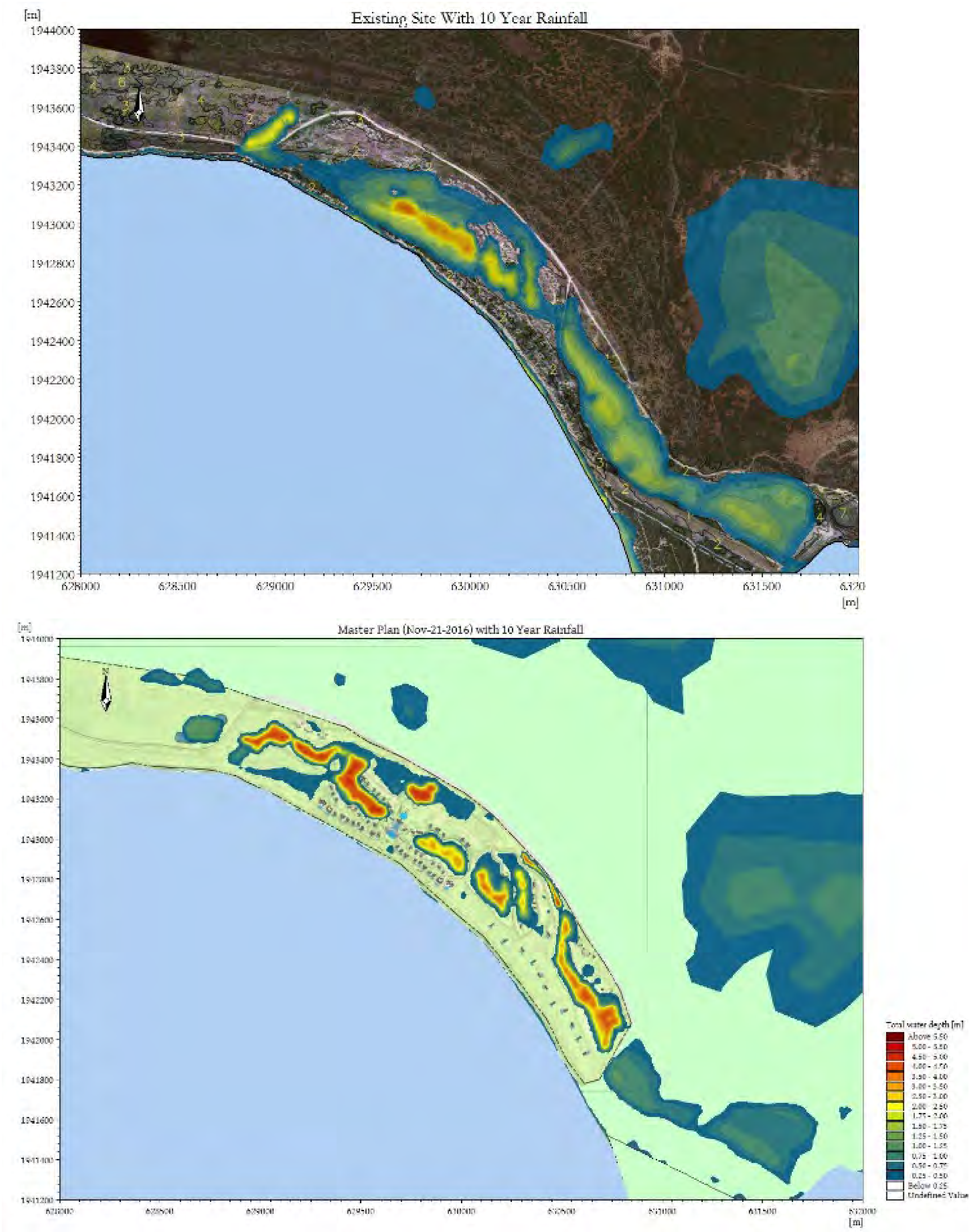

Figure 4.16 10yr flood map for existing and post-development scenarios

New ponds have been designed with regards to master planning requirements, aesthetics, drainage requirements, cut and fill requirements, as well as ecological considerations and geophysical requirements. A three-dimensional model has been set up and used to optimize the drainage system, the various drainage elements, and components of the preliminary design system. With this model, further iterations can be easily reviewed and investigated. A cost effective, balanced cut/fill solution has been achieved and can be improved upon in advancing towards a final design. As previously stated, the revised master plan allows areas to be flooded during events less frequent than 1 in 5yrs. This approach significantly reduced the cut and fill requirements from previous masterplan versions.

The site conditions have been effectively reviewed and a grading strategy has been developed with the team to optimize the grading levels around the ponds and low-lying zones resulting in a cost-effective approach to the fill and grading of the site. Most of the cut material extracted from the site can be used for effective filling material. However, some of the cut material will require treatment that will involve mixing and crushing. The geological report identified various soil components on the site and the new ponds provide a good source of reliable fill material.

The material volume calculations were executed for the Master Planning models. In the latest design, the cut and fill requirements closely match each other using onsite cut resources. The latest calculations at the time of this report revealed a total cut quantity of just under 670,000 cubic yards of material which balances with the fill requirements. This is an important consideration as imported material costs are twice as much as site sourced material. For a project of this magnitude, this sustainable and balanced approach can offer significant savings.

For the site to have proper drainage it must have a clear definition of flow off the site. This is to be achieved by grading the land so that surface runoff does not stay in the development for long. The offsite discharge coming from the north must be diverted so that it does not interfere with infrastructure. Lastly, the ponds should add to the drainage capacity of the site by allowing for small retention in the ponds.

It must be clearly understood by the developers that this effort to reduce fill requirements can result in flooding of areas of the site for events exceeding the 1 in 5yr event. These areas include the private beachfront lots, northwest of the hotel cottages, the depression zones of the recreational and nursery areas, areas around the spa village and the restaurant village north of Pond 1.

Table 4-8 documents the various objectives of the drainage analysis and their anticipated outcomes and implications.

Table 4-8 Drainage Related Tasks with Anticipated Outcomes & Implications

Drainage Objectives	Proposed Outcomes & Implications for Drainage
Assess qualitatively the existing natural drainage and flooding characteristics of the site as well as the impact of offsite runoff.	The natural existing drainage features and ponds on the Paradise Found site become inundated with flood water fairly easily in moderate rainstorm conditions. Furthermore, the offsite drainage run off has a significant impact by infiltrating the Paradise Found site. The existing flooding situation onsite demonstrates the need for an assessment of current drainage features and existing site conditions along with a need for the design of a new comprehensive drainage strategy and drainage system.
Investigate the extent of site flood conditions via hydrology model	Despite efforts to elevate areas of the site and construct a golf course by the previous developers, the site still floods quite easily and quite significantly as indicated in the hydrology models. The hydrology model identifies the areas of concern that needs to be addressed. Low lying areas of the site will require significant filling and drainage works in order to provide flood management solutions. There are cost implications as a result, various solutions have been investigated and optimized.
Identify, quantify and delineate the Storm Water Catchment Areas which will help to define the site drainage requirements.	The current existing ponds are quite large in size relative to the catchment areas. The new ponds are also significant in size relative to their catchment zones. Therefore, there must be a reasonable link between catchment zones, ponds, and drainage features. Comprehensive site drainage requirements have been identified and optimized resulting in an effective preliminary design solution.
Design new retention ponds with respect to the site wide required drainage capacity and within the natural ecological boundaries.	New ponds have been designed with regards to master planning requirements, aesthetics, drainage requirements, cut and fill requirements, as well as ecological considerations and geophysical requirements.
Establish a computerized drainage model of the area using HydroCAD.	An effective computer model has been established resulting in the optimization of the drainage system, the various drainage elements, and components of the preliminary design system. Via the establishment of the computer model, further iterations can be easily reviewed and investigated. A cost effective, balanced solution has been achieved and can be improved upon in advancing towards a final design.
Simulate storm conditions, analyze flood routing and runoff via the ponds and identify the overall storm water drainage system performance during storm conditions.	The simulation of storm conditions that analyzes the flood routing and runoff via the ponds has been executed in accordance with the suggested design criteria and site model. This simulation has assisted in successfully identifying an effective preliminary storm water drainage design system.

4.2 Biological Environment

The site footprint occurs at a derelict former development site, with manmade ponds, modified soils and elevations and hard structures. The site includes the original K Club resort footprint, inclusive of the golf course, which was abandoned in 2004. As such, the area is not an undeveloped site but one that had previously undergone extensive modification.

Several types of habitat / ecosystems were identified within the site and immediate surrounding study area. The main ecosystem types found at the Paradise Found site were mangroves, dry forest, ponds, sand dunes and rocky shore. The western end of the property is occupied by shrub/scrub type ecosystems with xerophytic vegetation. Various species of cacti dominate the area. Rocky shores exist along sections of the shoreline, sand dunes occur in the middle sections of the property and there are mangrove stands on the landward side, however, not to the easternmost limits. The eastern section of the property is characterised by dry limestone forest, with large areas occupied by invasive wild cotton species along the roadway. A large proportion of the site is bare soil.

To determine the dominance of species in the various floral assemblages on the site, a series of observation points were established across the site to make note of the dominant vegetation. The output of the surveys was an update of the list of species, description of the ecological assemblages, habitats and overall ecosystems collated from the 2016 report (included in the October 2022 Baseline Report).

A total of 30 species were encountered on the site across the various habitats identified. Four species were listed as endemic (Locustberry, Dagger Plant, Wild Frangipani and Lignum vitae); one species was listed as near threatened (Lignum vitae); and one species was listed as threatened (Black Mangrove) by the IUCN Red List of Threatened Species. All other species are listed as being of “least concern”.

Fixed point bird counts were undertaken to describe the avifauna within the site. Based on factors such as access, vegetation type and cover, four bird count locations were established on the site, and these were recorded using a hand-held GPS unit. A total of 20 bird species were observed on the site either during the bird counts or opportunistically. Of these species, the West Indian Whistling Duck and Caribbean Coot are considered near threatened and the Barbuda Warbler is listed as vulnerable. All other species are listed as being of “least concern”.

Other fauna, including donkeys and iguanas were observed but are listed as being of “least concern”. The only vulnerable species listed was the Red-footed Tortoise.

Detailed descriptions of the ecological surveys are available in the *Baseline Conditions Report* (SWI, 2022).

4.3 Social / Cultural Environment

4.3.1 Overview

This section of the report presents information that facilitates an understanding of the population and the potential social and economic impacts of the proposed project on the population. The issues of employment and livelihoods, health and well-being, and awareness of the population about the project activities, vulnerabilities of the aged, children, youth and those with differing abilities are explored and presented.

A gender analysis of the data collected is presented where possible.

The cultural norms, practices of the population, and assets that have potential for being affected, are also presented. The analyses seek to strengthen the investor's focus on the social components, especially in cases where the local communities affected may be dependent on the same natural resources as the investor.

The literature of this Social Impact Assessment (SIA) is situated around three main theoretical issues: The concept of the 'social licence'; the human rights-based approach; and the importance of the non-technical risks or the social risks.

The Social Licence to Operate, according to Vanclay *et al* (2015), refers to the level of acceptance or approval of the activities of an organization by its stakeholders, especially locally impacted communities. The theory contends that leading corporations accept that they need to meet more than just the regulatory requirements. It argues that corporations also need to consider, if not meet, the expectations of a wide range of stakeholders, including international NGOs and local communities. The consequences of ignoring the expectations of this wide array of stakeholders could put corporations at risk not only of their reputational position but also at the risk of being subject to negative action and the financial consequences of those actions.

Vanclay *et al* (2015) note that in some countries, 'social licence' has become an established element of the language of business, influencing and driving the business strategy of many companies. They conclude that a social licence has become part of the governance landscape.

The human rights-based approach refers to a conceptual and procedural framework which seeks to ensure the promotion and protection of human rights in policies, programs, plans and projects. Such an approach seeks to: (1) position human rights and its principles as the core element of actions; (2) demand accountability and transparency by duty-bearers towards rights-holders; (3) foster empowerment and capacity building of rights-holders to, *inter alia*, hold duty-bearers to account; (4) ensure that the meaningful participation of rights-holders in development processes and planned interventions is recognised as an intrinsic right, not simply as best practice; and (5) ensure the non-discriminatory engagement of rights-holders and the prioritization of especially-vulnerable or marginalized individuals or groups (e.g. women, elderly, children and youth, minorities and indigenous peoples).

Last but by no mease least is the notion of non-technical or social risks, which refers to those risks such as the managerial, legal, social, and political issues faced by a project, in contrast to the technical risks (i.e., the physical, structural, engineering, and environmental risks). Often due to the technocratic focus of many project staff, the technical risks are usually fully considered whereas the non-technical risks are under-considered or ignored altogether. The World Bank defines social risk as "the possibility that the intervention would create, reinforce or deepen inequity and/or social conflict, or that the attitudes and actions of key stakeholders may subvert the achievement of the development objective, or that the development objective, or means to achieve it, lack ownership among key stakeholders". For the World Bank, social risk is both a risk (threat) to the success of the project, and also risk (social issues) created by the project, which in turn becomes a threat to the project.

4.3.2 Methodology

The SIA uses a mixed applied research approach. The methodology includes desk review of relevant literature; community engagement of stakeholders, utilising an in-depth semi structured questionnaire; consultations with key policy makers; and collection and analysis, including a gender analysis, of data about the Directly Affected Community (DAC). Such an approach ensures a full understanding of the baseline conditions which the project encounters.

Stakeholder groups were identified as follows: elders who knew the history of the island well; fisherfolk; farmers; people who own and run guest houses; persons who transport tourists (tour guides); persons who are engaged in any way with the tourism industry (e.g., cooking food for tourists); and those in the health sector. In addition, policy makers were identified for in-depth interviews such as the Chair of the Barbuda Council, the Member of Parliament for Barbuda, the CEO (Ag) of the Barbuda Council, key officers in the Division of Statistics, Ministry of Finance, the Gender Affairs Department of the Ministry of Social Transformation, officials from the Ministry of Health, Wellness (both in Barbuda and Antigua) and the Climate Assessment and Information Officer, Department of Environment.

The key ethical issue that may arise in this assessment surrounds the question regarding for whom the SIA assessor works - the community or the project proponent? The report emphasises to all parties that the assessment is being conducted to the highest ethical standards and it adopts an independent stance. Such a stance allows the SIA to make relevant community interests explicit in the assessment and should the assessor "perceive risks beyond those identified in the preliminary assessment conducted by the DOE, the assessor is obligated to investigate such".[4] Through such an approach the Assessor seeks to lay bare opportunities for building a balanced, just, and harmonious relation between community and project proponent.

The governance arrangements for the conduct of the SIA are derived from the Review of Plan Application #G10-2021 (Paradise Found), by the Director of the Department of Environment of the Ministry of Health, Wellness and Environment of the Government of Antigua and Barbuda. That review called for an EIA to be undertaken, which in Section Five (5) *inter alia,* requested a Socio Economic & Health Environment Baseline.

In section 5.5 the request noted that (the)

> "Baseline data should include the demography, nearest settlements, and existing infrastructure facilities in the proposed area. Present employment and livelihood of these populations and awareness of the population about the proposed activity should also be included. Vulnerable groups and gender analysis may also be included if applicable. If there are cultural practices or norms which may affect the environment or be affected by the environment it should also be mentioned".

This Report is situated within the conceptual understanding of the notions of livelihoods as defined by Chambers and Conway (1991). A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

To better understand how persons in the DAC of Barbuda, develop and maintain livelihoods, the Sustainable Livelihoods Framework (SLF) was applied[5]. This framework is an analysis tool, useful for

---

[4] DOE April 2021

[5] DFID's Sustainable Livelihoods Approach and its Framework. https://efaidnbmnnnibpcajpcglclefindmkaj/http://www.glopp.ch/B7/en/multimedia/B7_1_pdf2.pdf

understanding the many factors that affect a person's livelihood and how those factors interact with each other. The SLF views livelihoods as systems and provides a way to understand:

1. The assets people draw upon.
2. The strategies they develop to make a living.
3. The context within which a livelihood is developed.
4. Those factors that make a livelihood more or less vulnerable to shocks and stresses.

How people access and use these assets, within the social, economic, political, and environmental contexts, form a livelihood strategy. The range and diversity of livelihood strategies are enormous. The SLF acknowledges that an individual may take on several activities to meet his/her needs. One or many individuals may engage in activities that contribute to a collective livelihood strategy.

The diverse livelihood strategies of the DAC of Barbuda will be presented as part of the Community Profile.

One limitation of the applied methodology which the assessor encountered was data driven, as social statistics are not as current or readily available across the Caribbean, and the situation in Antigua and Barbuda was found to be no different. Another was that the COVID-19 pandemic acted as a constraint to consultations, as some people were unavailable because of the exigencies of the Pandemic.

Yet still another issue identified as a limitation of the Assessment, was the fact that multiple development projects are currently taking place on the island, with members of the DAC being unable to distinguish between which development and its impacts belong to which developer or project. This lack of clarity results in the social impact analysis having to consider all on-going effects and impacts. In the assessment methodology, such a situation is often referred to as a multiple hazard environment resulting in complex impacts and requiring solutions that engage enhanced application of the tools of integrated development planning. [6]

4.3.3 Community Profile and Social Baseline

Barbuda with a land area of 176 km^2, is located some 40 km north of Antigua and has a land mass size of approximately 39% that of Antigua and Barbuda, which together comprises some 456 km^2. Antigua, the bigger sister island, has a land area of 280 km^2. The estimated population in 2022 for Antigua and Barbuda was 100,722 and of those 52% are female and 48% male. Some 97% of the population resides in Antigua.

Barbuda has an estimated population of 1,935, of whom 52% are female and 47.8% male, with details being obtained from the Statistics Division.[7] Some 28 % of the population are 19 and under and 10% of the population comprise persons 65 to 80 and over.

Together, these islands comprise the state of Antigua and Barbuda and have similar characteristics of small island developing states (SIDS) in the Caribbean. Both islands are low-lying with 70% of the

---

[6] Integrated Development Planning is an approach to planning that involves the entire geographic area and its citizens in finding the best solutions to achieve good long-term development. https://www.etu.org.za/toolbox/docs/localgov/webidp.html

[7] This estimate has been produced by the Statistics Division (as of July 2022) in support of this Assessment. It should be noted that all stakeholders have concerns about the accuracy of the projected population as numbers have been affected by the movement of people following the Hurricanes of 2017, the return of population groups, the arrival of workers from Antigua and wider Caribbean.

land in Antigua less than 30m above mean sea level and most of Barbuda only 3m above mean sea level. The country's economy is heavily dependent on natural resources, low-lying coastal zones, and favourable climate conditions to support the tourism sector, which accounts for about 80% of output gross domestic product (GDP), about 70% of direct and indirect employment and 85% of foreign exchange earnings. [8]

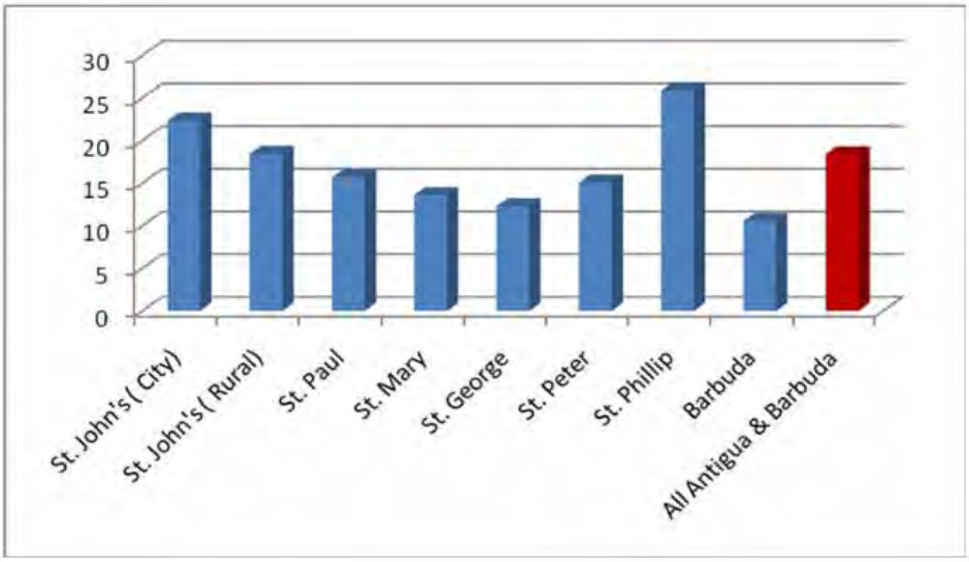

Figure 4.17 Proportion poor in Antigua and Barbuda by Parish
Source: 1. Survey of Living Conditions, Antigua and Barbuda: Poverty in a Services Economy in Transition 2007.

Despite a high-income ranking, according to the latest data available, approximately 18% of the total population falls below the national poverty line; 3.7% indigent (food poor); and 10% vulnerable to poverty in the event of a significant socio-economic shock or natural hazard. When considering the proportion of the population that is at risk of falling into poverty if there is a shock to the economy, the percentage rises to 28%.

Interestingly Barbuda had the lowest proportion of poor (10.6%) when compared to other Parishes of Antigua and Barbuda. See Figure 4.17.

Education Sector

There are two schools in Barbuda, the Holy Trinity Public Primary School, and the Sir Mc Chesney George Public Secondary School, which together provide education for the school age population, and which accounts for about 21% of the Barbuda population, or 409 children. Early Childhood Education centres include Toddlers' Paradise Day-care centre and the kindergarten, Cody Kelly Preschool, both of which, along with the Primary and Secondary school, suffered damage and required renovation and repair following the devastating hurricane season of 2017. Presently, most children can be seen walking to and from school.

---

[8] Antigua and Barbuda Updated Nationally Determined Contribution, (NDC) for the period 2020 to 2030, communicated to the UNFCCC on 2nd September 2021. Government of Antigua and Barbuda, Department of Environment Ministry of Health, Wellness, and the Environment.

Health

The health systems in Antigua and Barbuda are mainly financed and operated by Government. Health services are delivered at primary, secondary, and tertiary levels and at the primary level, there is a network of 25 public health clinics, with clinics located within 3.2 km of every major community. Secondary and tertiary health services are provided at the Mount St. John's Medical Centre, a 186-bed facility in Antigua, commissioned in 2009. There is one clinic and hospital in Barbuda, the Hannah Thomas Hospital, which was formally handed over to the Barbuda Council by the Government of Antigua and Barbuda, after its rehabilitation from the devastation in 2017.

The country is undergoing epidemiological transition with non- communicable diseases accounting for 85% of deaths, and most patient visits to primary health care facilities, and an ageing population (12% over 60 years, nationally and 15% in Barbuda). The three leading causes of death were cancer, heart disease, and diabetes. The government is implementing cost effective prevention activities focusing on obesity, exercise, and reduction in tobacco and alcohol use.

Communicable diseases, including HIV/AIDS, accidental and intentional injuries are among the ten leading causes of mortality.

About 70 % of infant deaths occur during the neonatal period, with main causes being birth asphyxia, prematurity, and injuries. Major focus is on reducing the neonatal deaths to meet the SDG's.

From 2011 to 2016 Antigua and Barbuda experienced increased cases of Vector borne diseases of Dengue, Chikungunya and Zika. Implementation is continuing of the integrated management strategy for control and prevention of vector-borne diseases.

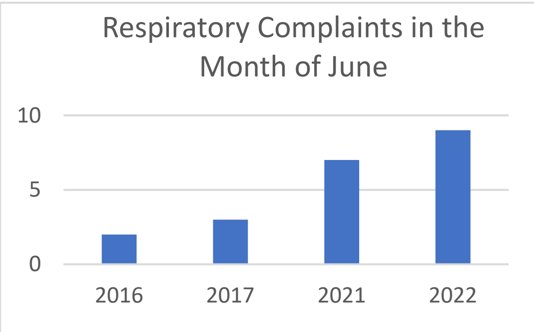

Figure 4.18 Number of children seen with respiratory complaints at the Hanna Thomas Hospital (June)

In Barbuda, health concerns have been expressed by key informants and stakeholders emerging from the concentrated levels of dust, oil and diesel which have overtaken the environment of Codrington Village since development projects have gotten underway. Community members speak of elders having to live like shut-ins to avoid the dust, children suffering from increased respiratory complaints and all villagers experience the need to scamper off the roadways from oncoming trucks who use the roadways as well as pedestrians. There are little or no sidewalks to be found in Codrington.

Two sets of data were collected at the Hanna Thomas Hospital to investigate the concerns of the DAC for children 18 and under, male and female. Data, as presented in Figure 4.18, was collected for the month of June for the years 2016 and 2017, before development projects got underway and before the devastation of the hurricanes of 2017. They were collected again for the same month in 2021 and 2022.

The data suggests a marked increase in the observed number of cases of respiratory illnesses ranging from difficulty breathing, to bronchitis, acute bronchitis, asthma, and acute asthma for the second period (June 2021 and June 2022) compared to the first period (June 2016 and June 2017).

Employment and Livelihoods

According to the Labour Force Survey (LFS) of 2017, the working age population of Barbuda comprises 1,341 persons or 69% of the population. The labour force participation rate was 70.9%. It was higher among men than among women. Of the working age male population, 73.9% participated in the labour force, compared with 68.5% of their female counterparts. There are two interesting facts about the LFS when the data for Barbuda and other Parishes in Antigua were compared. For one, the highest *labour force participation rate* was observed in the Parish of Barbuda, 88.9%, while the lowest was in the Parish of St. George, 72.3%.

The second was that the unemployment rate for Antigua and Barbuda stood at 13.7% based on the 2015 LFS. When the unemployment rate was examined by Parish, a significant amount of variation in unemployment rates was observed. Barbuda was found to have the lowest unemployment rate among the Parishes with only 7.4% of the labour force population being unemployed, while in the Parish of St Paul (in Antigua) the unemployment rate was reported at 20.6%, almost three times higher. Figure 4.19 below is taken from the preliminary release of the 2015 Labour Force Survey. It illustrates the variations in the unemployment rate by Parish and by Sex.

The data suggests that a significant proportion of the active labour force in Barbuda is employed in various forms of income earning activity.[9]

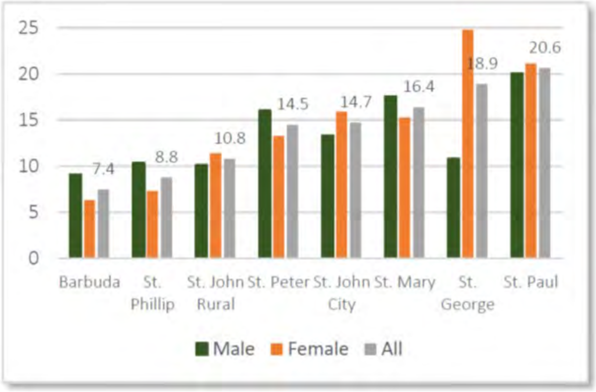

Figure 4.19. Unemployment by Sex and Parish
Source: 2 Preliminary LFS 2017

Data gathered through consultations with stakeholders suggest that income earners in Barbuda are engaged in multiple livelihood activities which constitute their livelihood strategy. Livelihood strategies display a rich knowledge of the local environment and a strong commitment to sustainable development practices.[10] Barbudans work in the formal and informal sectors of the labour market. In the formal labour market, an examination of employment by occupation and sex indicate that the largest segment of the labour force is found among the elementary occupations, and these were predominantly women (Figure 4.19).

Skilled agricultural and fishery workers were all male, and craft and related trades workers were predominantly male, with females comprising approximately 22% of this occupation. Income earning activities in the informal sector include agricultural production on 'family grounds', fishing and free diving for lobster and conch when in season, 'picking salt' or salt mining, tour guides - providing day trips to tourists for snorkelling, bird watching and exploring caves and other attractions on the island such as the pink sand beaches and salt and freshwater ponds. Guest houses have been established for short stay visitors and many female micro entrepreneurs have established facilities that cater for meal preparation and sales across the Village to visitors and workers alike.

[9] See preliminary data from Labour force survey 2015 in Appendix

[10] There was a period when sand mining had been the main industry in Barbuda (2015 and 2016), but because of the potential impact on the environment, it was significantly curtailed. Currently there is a complete halt to sand mining on Barbuda. The last time that the Barbuda Council had received revenues amounting to some $600,000.00 from sand mining was in the 2nd quarter of 2017.

The unemployment rate for youths in Antigua and Barbuda according to the LFS 2015, aged 15 to 24 was 33.9%, more than three times the rate for adults aged 25 to 54. Unemployment was higher among young women (37.3%) than among young men (30.4%).[11]

	Male	Female	Total
Employment by occupational category (Main job)			
Armed Forces	-	-	-
Managers	-	-	-
Professionals	-	-	-
Technical and associate professionals	41	74	115
Clerical support workers	55	27	82
Service and sale workers	84	101	185
Skilled agricultural, forestry and fishery workers	20	-	20
Craft and related trades workers	50	14	64
Plant and machine operators, and assemblers	31	-	31
Elementary occupations	-	202	202
Total	**281**	**418**	**699**

Source: Statistics Division, Ministry of Finance and Corporate Governance
Date: 30th September, 2017

Figure 4.19 Barbuda: Employment by Occupation and Sex

Two examples should suffice to suggest that Barbudans are able to earn incomes that could support a good quality of life that would be significantly disrupted if development is not managed as key informants have cautioned.

The Lobster trade which is conducted from the Lagoon generates from about 9 to 11 thousand pounds of lobsters which are sold to exporters (many of whom are Antiguans and who conduct a brisk wholesale and retail business). The market price is $20 per pound and the open season is for approximately 10 months.[12] Fisher folk are extremely worried about pollution damage to the Lagoon by new developments, that would result in the destruction of the Lobster trade, and also the conch trade.

Another area of brisk earnings can be found in that of the tour guides operated both in the high and low season. Tour guides enjoyed a brisk trade taking 'day trippers' on whole day tours across Barbuda, including caves, frigate birds, lagoon, historical sites, etc. For such activity they were paid US100.00 per day, per person. Their costs included, fuel, boat maintenance and meals provided to tourists. Even at a conservative estimate of 200 workdays per year for ten tour guides who service 32 customers per day, income before expenses could be as high as US$640,000 per year.

Stakeholders expressed concerns that developers were attempting to take control of the 'tour guide' trade by bringing in their own guides and boats to the exclusion of the Barbudan guides. In addition, there was the fear of Barbudans being excluded from access to certain areas such as the pink sand beaches.

Cultural Norms, Practices and Assets

The Antigua and Barbuda Medium-Term Development Strategy, 2016 to 2020 described Barbuda as, "a natural paradise with unique pink sand beaches, lagoons, salt ponds and unique flora and fauna species, including one of the world's largest bird sanctuaries." When asked about the cultural assets, a Barbudan replied," …it is traditional for us to hunt, it is traditional for us to fish, to farm and so forth, so that in itself is a cultural resource… The camp sites, that is a tradition that has been around for ages…now you are saying that all of these could be lost because you want to give it to someone else our cultural traditions don't matter?"

Although the planned development may be some 13.8 Kilometres away from the Codrington Village, stakeholders expressed a sense of much intrusion and exclusion. Most stakeholders felt they had no

[11] Antigua and Barbuda LFS 2015
[12] The Council receives a small fee of approximately $1,600 to $1,800 per month.

information about developments taking place, could not distinguish between one developer and the other, and often thought that Paradise Found and PLH was one and the same development.

One stakeholder expressed it in this way, “I am not certain if they (Paradise Found) are associated with the PLH because the area where they supposed to develop now PLH is developing, so I am uncertain if there is a collaboration or anything of the sort”.

Most reiterated that they had not been consulted.[13] Some community members do remember a very early consultation meeting in 2015 (or thereabouts) but nothing since then and no news as to any new or changed plans and no idea how they, the people of Barbuda would benefit from the observed development.

There was much worry and consternation expressed about impending destruction of natural resources (draining of ponds, allowing chemicals to seep into the Lagoon, the mismanagement of human waste that could enter the waters, the destruction of near shore fishing areas, etc). Another stakeholder asked: “are we compromising our safety and the safety of our livelihoods for money? For persons to feel like, ok, we can make a few million dollars for a few years before all these (assets) gets destroyed and then we just find someplace else to go” … “you see the same company that left Abaco is the same company that is here doing the exact same thing”.

Community stakeholders took umbrage to the low-level jobs being offered to Barbudans and the exclusion of Barbudans to parts of the natural resources to which they have been accustomed.

Included among cultural assets are their access to the rich natural resources found on the island - from beaches to camp sites - which they frequent to pass on to the next generation, traditional knowledge about the value of the flora and fauna and indigenous animals. The Lagoon for Barbudans is a rich cultural asset, not only as it spawns the lobsters which forms part of their livelihoods but is part of their historic landscape.

Among the cultural assets which the Barbudans hold dear is the social capital which supports their ability to “never lock a door or window”. So strong is the social capital that fear of theft or assault does not exist. The new workforce on the development sites brings new people into the village with new behaviours, including the use of drugs and sexual grooming of young girls.

Stakeholders expressed satisfaction and considered it a ‘good turn of events” that some young people who previously had no jobs were getting jobs as labourers. But they want more for them, training, certification and opportunities for advancement.

[13] Barbudan Council Members were the key exception to this rule who noted that they had been spoken to by the Developers some time ago.

5 Impact Assessment and Mitigation Measures

5.1 Physical Environment

The following sections describe the potential impacts and proposed mitigation measures for the various activities associated with both the construction and operational phases of the Paradise Found resort.

5.1.1 Turbidity

Nature of Concern

During the placement of sand nourishment to the required the grade there is potential for turbidity and sedimentation of the area offshore the site.

Mitigation Measures

Turbidity barriers will be used around all works in the sea to minimize leakage of silty material to sensitive areas. Turbidity will also be monitored daily at two locations of each work area in the sea where there is construction in the sea. A further measure is to ensure that the sand used for nourishment has a low silt content (ideally less than 0.5%).

5.1.2 Oil Pollution

Nature of Concern

There is the potential for fuel leaks or spills from equipment used for the construction, excavation and/or sand nourishment during refuelling or operation. Refuelling of the boat and sea-based equipment should only be done at anchor out at sea if the sea conditions are calm, otherwise, all refuelling should be done when docked at land. Appropriate refuelling equipment (such as funnels) and techniques should always be used.

Mitigation Measures

Appropriate minor spill response equipment (for containment and clean-up) must be kept on site, including oil absorbent pads and disposal bags.

5.1.3 Dune Extension

Nature of Concern

Once the appropriate slope into the water has been attained through grading, the dune will be nourished with appropriately sized sediment. The sand will then be mechanically placed on the beach to match the lines and grades of the design and finally smoothed manually by labourers.

Mitigation Measures

Marine sand will be required for the beach nourishment exercise. The materials will be brought to the site from a certified/approved source. All acquired sediment will be placed on the proposed beach and shaped accordingly. The silt content should be low, ideally less than 0.5%, and great care should be taken when spreading to minimize loss of material.

5.1.4 Impaired Air Quality (Dust) during Construction Phase

Nature of Concern

Dust is the primary air quality concern arising from cleared areas, excavation works and the movement of construction vehicles and equipment and also from stockpiles of aggregate. The main sources of air emissions identified within the study area were:

- the road network (vehicular exhaust and the kick-up of dust from trucks transporting material); and

- dust from construction sites.

It is important to note that calculated 24-hour concentrations of $PM_{2.5}$ and PM_{10} at all four monitoring locations were less than the respective WHO Guidelines for a 24-hour averaging period.

Dust is released into the air from the contact of tires and working parts with the ground, particularly when equipment and vehicles travel over unpaved areas, thereby contributing to the 'kick-up' of dust into the air.

Dust is a nuisance causing discomfort among persons affected and could also exacerbate illnesses such as asthma and bronchitis. Discussions with Dr. Deazle of the Hannah Thomas Hospital (HTH) revealed that there has been an increase incidence of intense asthma due to dust. Medical records at HTH clearly show this increase in areas through which trucks carrying construction material are routed.

At high concentrations, dust can also affect plants by coating the leaves and impeding photosynthesis. The potential concern of dust on air quality is most pronounced in the dry season when winds are also highest.

Mitigation Measures

The following mitigation measures can be employed for the control of dust emissions during construction:

- Clear only the area needed for construction, leaving vegetation in other areas intact as far as practical, thereby reducing the area from which dust can be formed.
- Install dust screens close to sensitive receptors to reduce the amount of dust leaving the construction area.
- Designate a Community Relations Officer to deal with complaints from affected persons in the project area.
- Notify residents of schedule for significant truck movements.
- Vegetate or pave cleared areas as early as practical.
- Keep stockpiles to a minimum and use as soon as practical, thereby reducing a source of dust.
- Cover smaller stockpiles, or store fine aggregates in bins or silos. This prevents exposure of material to the wind.
- During earthworks (including excavation) implement dust control measures at source, including frequently wetting bare surfaces and access ways.
- Cover the tray of all transport vehicles (with tarpaulins, etc.) while moving materials and fill to and from the site to prevent material/ fill flying up from the load into the air as dust.
- Implement a speed limit for trucks transporting materials to and from the construction site. This should be done in conjunction with the Police Service.

While this impact is expected to be temporary, it is expected to extend beyond the project area and have significant effects on social groups. Once the mitigation measures listed above are effectively implemented, this impact is expected to be medium intensity.

Cumulative Impact

Dust from the other construction projects ongoing in the vicinity of the Paradise Found project site will represent a cumulative impact with the dust generated from the Paradise Found development. This will result from the transport of material along the existing roadways. As previously noted, the impact of dust has already resulted in an increase in respiratory illnesses treated at the HTH. This cumulative impact is expected to be significant.

5.1.5 Impaired Air Quality (Exhaust Emissions) during Construction Phase

Nature of Concern

The main source of exhaust emissions in the study area are vehicles travelling along the roads. The engines of vehicles and powered equipment emit carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen oxides, volatile organic compounds and soot (dust); all of which are harmful to people, animals and plants at sufficiently high concentrations. However, experience in other jurisdictions in the Caribbean suggests that such emissions dissipate to very low concentrations in a relatively small distance from source (typically less than 20 m). The impact of exhaust emissions is expected to be less significant than the impact of dust as discussed in Section 1.1.1, above.

Mitigation Measures

The following mitigation measures can be employed for the control of exhaust emissions during construction:

- Only use vehicles with a valid inspection certificate from the Transport Board.
- Properly service all vehicles and equipment to ensure that there are no visible sooty emissions.
- Remove defective vehicles from the fleet until they are repaired.
- Optimize trips bringing material and/or transporting waste from the site by ensuring that the use of part-filled trucks is minimized (to the extent practical).
- Designate a Community Relations Officer to deal with complaints from affected persons in the project area.
- Notify residents of schedule for significant truck movements.

Exhaust emissions from the passage and operation of vehicles and equipment is expected to be temporary, extend beyond the project site and have marked effects on individuals. Once the mitigation measures listed above are effectively implemented, this impact is expected to be low intensity.

Cumulative Impact

Exhaust emission from construction vehicles associated with the other construction projects ongoing in the vicinity of the Paradise Found project site will represent a cumulative impact with the emissions generated from the Paradise Found development. This will result from the transport of material along the existing roadways. This cumulative impact is expected to be moderate.

5.1.6 Impaired Air Quality (Emissions from Generators) during Operational Phase

Nature of Concern

As noted previously, due to a lack of existing infrastructure on the island, the electrical power demand will initially be met using diesel generators. To fuel these generators, diesel fuel will be stored on site in 9.1 m^3 volume (2.000 imperial gallons / 2,400 US gallons) tanks. Given the size and the need to continually use these generators, these emissions are expected to be significant.

Mitigation Measures

The following mitigation measures can be employed for the control of diesel emissions during operation:

- Phase out the reliance on generators in favor of more sustainable options, including photovoltaic systems and battery storage. The development will eventually seek to be energy self-sufficient from these sustainable energy sources, while maintaining generators on-site for redundancy.
- Site the generators downwind from the development (as far as practical) to reduce the impact of emissions on residents.
- Conduct regular maintenance of the generators to reduce the potential for excessive dark smoke.
- Include diesel generators with air pollution control devices. These can achieve considerable emissions reductions.

Once the mitigation measures listed above are effectively implemented, this impact is expected to be low intensity.

Cumulative Impact

Impaired air emissions from use of generators are not expected to be cumulative with other developments in the vicinity of Paradise Found.

5.1.7 Impaired Air Quality (Odours from the WWTPs) during Operational Phase

As no municipal wastewater treatment option is available on Barbuda, the Paradise Found development will construct a private WWTP to treat wastewater produced from the resort, while individual beachfront villas will be connected to their own WWTPs.

The proposed sewage treatment plants are of a type known not to emit foul odours during normal operation. Odour problems would develop only if there is a failure of the sewage treatment plants (see Risk Assessment). In order to minimize the incidence of such failures, preventative maintenance of the STP should be scheduled. Should a failure still occur, the appropriate mitigation measure would be to repair the system as quickly as possible. In this case, it would be in the interest of the Developer to do so, as the first persons to suffer from these odours would be guests and homeowners within the development. In addition, the location of the STP in an enclosed building within the services area should also help in mitigating odour.

Once the mitigation measures listed above are effectively implemented, this impact is expected to be low intensity.

Cumulative Impact

Odours from non-functioning WWTPs are not expected to be cumulative with other developments in the vicinity of Paradise Found.

5.1.8 Noise (Construction Phase)

Nature of Concern

Sources of noise at all monitored locations in the project vicinity included a combination of movement of trucks and birds chirping. Baseline noise measured on the site showed that equivalent continuous sound pressure levels (Leq) were generally higher during the daytime than the nighttime. Daytime Leq values recorded at the four monitoring locations were below the World Bank's daytime limit for commercial areas but at three locations the Leq were slightly above the daytime limit for residential areas.

In addition to vehicles traversing the area such as light motor vehicles and heavy motor vehicles, construction vehicles and equipment will also emit noise from their engines, exhaust, horns and alarms. Noise levels emitted by equipment will vary depending on factors such as the type of equipment used, the operation being performed and the condition of the equipment. Therefore, noise generated due to the project would be dependent upon the selected method of construction and the manner in which materials and equipment are moved within the project area (Society of Automotive Engineers, 1976). The equivalent sound level (Leq) of the construction or operation activity also depends on the fraction of time that the equipment is operated over the period. Construction noise can affect persons and structures in nearby communities at and around the project site.

Mitigation Measures

The following mitigation measures can be employed for the control of noise:

- Only use vehicles with a valid inspection certificate from the Transport Board.
- Ensure that noise-generating equipment are routinely maintained and inspected to reduce unnecessary increases in noise levels;
- Ensure that existing acoustic controls on all noise-generating equipment are functional.
- Designate a Community Relations Officer to deal with complaints from affected persons in the project area.
- Schedule construction activities for the period 7:00 am to 7:00 pm to the extent practical. If night work is necessary, inform the relevant authorities of the proposed schedule for this activity.
- Inform surrounding communities and other stakeholders of construction activities ahead of the start of works.

Noise generated by clearing, grading and other construction activity will be temporary, lasting for the duration of these activities. Noise is likely to be audible at the nearest residences but is expected to last only as long the construction phase lasts but may have significant effects on the functioning of social groups.

Once the mitigation measures listed above are effectively implemented, this impact is expected to be low intensity.

Cumulative Impact

Noise from the movement of existing construction vehicles will represent a cumulative impact with the noise generated from the Paradise Found development. This will result from the transport of material along the existing roadways. This cumulative impact is not expected to be significant in the immediate vicinity of the development but will have a more significant impact in Codrington where there are more residents.

5.1.9 Noise (Operational Phase)

Nature of Concern

The major source of noise during the operation phase is from the use of generators to power the diesel generators. Experience during a visit to the site to collect baseline data, is that the noise of the generator is very noticeable once outside.

Mitigation Measures

Measures to mitigate this impact include:

- Include noise levels specification when ordering new equipment.
- Place the generator in a plant room with thick walls, sound adsorption materials, sound-proof door and silencers for air inlets/outlets.
- Isolate the machine from the building structure by use of inertia blocks and vibration isolators.
- Provide flexible connectors between the machine and associated pipework to avoid structural vibration transmission.
- Use vibration isolators for attaching pipes to walls, ceilings or floors.
- Conduct regular maintenance, check alignment and quickly replace worn-out components.

Once the mitigation measures listed above are effectively implemented, this impact is expected to be low intensity.

Cumulative Impact

Noise from use of generators during the operation phase is not expected to result in a cumulative impact.

5.2 Biological Environment

5.2.1 Clearing of Vegetation (Loss of Habitat)

Nature of Concern

The habitats identified on the proposed project site include dry forest, ephemeral zones, xerophytic shrubland, salt pond and coastal fringe. In addition, there are brackish ponds that were created (Pond 1, Pond 2 and Pond 3) during the former development.

The clearing of vegetation during site preparation and construction works will result in loss of terrestrial habitat. Clearing of vegetation will be required to facilitate the construction of roads, drainage, utilities and facilities, and topsoil containing roots must also be removed (grubbing).

A total of 30 plant species were encountered on the site across the various habitats identified. Four species were listed as endemic (Locustberry, Dagger Plant, Wild Frangipani and Lignum vitae), one species was listed as near threatened (Lignum vitae) and one species was listed as threatened (Black Mangrove) by the IUCN Red List of Threatened Species. All other species are listed as least concern. Additionally, mangroves, native palms and cacti are protected species in Barbuda.

The removal of vegetation is associated with the loss of habitat for birds and other fauna supported by the system. It is expected that displaced fauna will be able to inhabit similar contiguous areas and their functioning may only be impaired for a short period until they re-establish themselves in adjacent suitable habitats.

Mitigation Measures

Although clearing of vegetation will be an unavoidable activity and impact during the construction phase, the following measures are also recommended to mitigate this impact:

- Minimize the areas to be cleared, to the extent practicable especially in areas where there are environmentally sensitive species such as the mangrove communities surrounding the ponds.
- If mangrove is to be cleared, approval will be required from the Fisheries Division and the Department of Environment.
- Allow for the re-vegetation of areas where possible, either naturally or by replanting, using same or like species, to the extent practical.
- Revegetating will be facilitated by use of the onsite nursery that already exists on site.

As noted above clearing of trees for the development will be a permanent and unavoidable impact of this development.

Cumulative Impact

Loss of habitat is expected to be cumulative impact since vegetation to be cleared for the Paradise Found development are representative of the same habitats cleared for the nearby PLH development. This cumulative impact is expected to be significant.

5.2.2 Disturbance to Terrestrial Species during Construction Phase

Nature of Concern

The construction of the Paradise Found development is expected to create noise and light conditions that have the potential to impact terrestrial fauna. This is separate from the concerns related to clearing of vegetation and loss of terrestrial habitat discussed above. Heavy transport vehicles and equipment used during the construction activities are expected to generate noise, which may result in mobile animals temporarily leaving the area during site clearing and construction activities. Artificial light may be required during the night to supplement existing lighting for site safety and security. Artificial lighting has the potential to impact the behaviour of nocturnal animals, which may include these animals avoiding areas with increased lighting. Additionally, the influx of workers in the area during site preparation and construction may result in unauthorized hunting of animals.

Twenty bird species were observed on the site. Of these, the West Indian Whistling Duck and Caribbean Coot are considered near threatened and the Barbuda Warbler is listed as vulnerable. All other species are listed as least concern.

Noise impacts on wildlife must be considered in two categories: impacts on wildlife on the site; and impacts on wildlife in adjacent areas. With regard to wildlife on site, noise is considered a significant concern because of the fragmented nature of the habitats on the site. Where possible the wildlife will leave the site due to the clearing of vegetation or take refuge in areas of the site which will not be cleared. Since it is not anticipated that perceptible noise increases will be experienced more than 200m from the site, noise impacts on wildlife in adjacent areas will be minimal. Noise impacts during site preparation and construction are expected to be transitory, lasting only while noise-intensive activities are in progress on the site.

The potential impacts associated with artificial lighting on nocturnal species will be of medium term duration as it may last beyond the construction phase into the operation phase but not by more than two years. Of the species observed on site, the West Indian Whistling Duck is considered nocturnal and would therefore be impacted by the introduction of artificial lights.

Mitigation Measures

In addition to the mitigation measures recommended for noise, the following mitigation measures are recommended to address this concern:

- Limit construction works to daylight hours to the extent practical;
- If night work is to occur, shield light from the vegetation and avoid use of bare and upturned bulbs;
- The minimum light intensity that can be used to ensure safety should be employed for night work; and
- Prohibit hunting or harassing of animals by workers on the construction site.

Noise impacts during site preparation and construction are expected to be transitory, lasting only while noise-intensive activities are in progress on the site. Similarly, the potential impacts associated with artificial lighting on nocturnal species will be of medium duration as it may last beyond the construction phase into the operation phase. Once the mitigation measures listed above are effectively implemented, this impact is expected to be of medium intensity.

Cumulative Impact

Noise and artificial light impacts to terrestrial species are not expected to be cumulative since construction noise and light from nearby projects will not extend to the Paradise Found site.

5.2.1 Disturbance to Terrestrial Ecology during Operational Phase

Nature of Concern

During the operational phase there is the potential for impacts to the mangroves that fringe on site ponds as a result of a failure of one of the many WWTPs proposed for the site. This can lead to the release of untreated or poorly treated sewage into surface drains that discharge into the salt ponds on site leading to eutrophication. Eutrophication describes the process by which excessive plant and algal growth occurs due to the increased availability of one or more limiting growth factors needed for photosynthesis, such as nutrient fertilizers. Untreated sewage is rich in nitrogen and phosphorus, and so it is a contributor to eutrophication. Eutrophication creates dense blooms of noxious, foul-smelling phytoplankton that reduce water clarity, limiting light penetration, reducing growth and causing die-offs of plants. Although mangroves will initially benefit from the enhanced nutrient availability. Nutrient enrichment favours growth of shoots relative to roots, thus enhancing growth rates but increasing vulnerability to environmental stresses (Lovelock CE, Ball MC, Martin KC, C. Feller I, 2009).

Mitigation Measures

Measures that can be implemented to mitigate these impacts are as follows:

- Select wastewater treatment systems that are adequately sized to receive the combination of toilet waste and grey water from the hotel, villas and houses;
- Carefully choose the types of chemicals used in toilets, sinks and bathrooms and for laundering at the hotel, villas and houses so that they are not incompatible with the aeration of aerobic wastewater treatment systems.
- Maintain and repair all of the wastewater treatment systems in strict accordance with the manufacturer's recommendations.
- Educate residents on the most appropriate types of chemicals that can be used in toilets, sinks and bathrooms and for laundering.

Once the mitigation measures listed above are effectively implemented, this impact is expected to be low intensity.

Cumulative Impact

There is no cumulative impact on terrestrial ecology as a result of a failure of onsite WWTPs.

5.2.2 Impacts of Artificial Light on Fauna during Operational Phase

Nature of Concern

During the operational phase, lights from artificial sources will be used for various purposes including, lighting paths, security, etc. Since some of the site is expected to remain under vegetative cover and there will be replanting of areas cleared for construction, there is the potential for impacts to fauna in these habitats.

Mitigation Measures

- The lighting design must incorporate light levels that match usage, zone, time, and traffic.
- Lights should be shielded from the vegetation and the use of bare and upturned bulbs should be avoided.
- The minimum light intensity that can be used to ensure safety should be employed.

Once the mitigation measures listed above are effectively implemented, this impact is expected to be low intensity.

Cumulative Impact

There is no cumulative impact associated with artificial light.

5.3 Social and Cultural Environment

5.3.1 Methodology of the Social Impact Assessment

The social impact assessment (SIA) has a specific objective, which is to identify, analyse and assess the negative, positive, or neutral social impacts of a project. Such a process enables the management and monitoring of the direct and indirect impacts that affect the well-being of the people and their communities at all stages of the project's lifecycle.

To ascertain the extent of influence which the project may have on these factors, the methodology involves:

- The collection and analysis of a socio-economic baseline to establish existing characteristics of the directly affected community (DAC);
- An assessment of the potential positive and negative impacts that could result from implementation of the Project, and
- Propose measures to mitigate and monitor any potential negative impacts.

The SIA methodology has been completed in accordance with both national and international requirements.

The key aspects considered in detail in this SIA have been determined from the Terms of Reference and the outcome of the Baseline Conditions Report. As a result, the following issues are considered in this SIA:

- Impact on the demographics, social fabric, and social capital

- Impact on the health and well-being of children
- Impact on the elderly
- Impact on young women
- Impact on young men
- Impact on livelihoods
- Impact on cultural assets, norms, and practices

These have been examined during both the construction and operational phases of the project.

5.3.2 Identification of Impacts

The social impact assessment predicts and assesses the likely positive, negative, or neutral impacts of the project. Each impact is also subject to a gender assessment to make clear the differential impact on males and females. The assessment is based on the examination of scenarios with stakeholder consultation. Scenarios have been defined as "logical-imaginations based on construction of hypothetical futures" (UN Centre for Good Governance, 2006), regarding the assumptions about the SIA variables in question. Such consultations, which include local experts, local authorities, and knowledgeable citizens, allows local knowledge to play a part in determining the likely impacts. This allows the assessor to better rank the impacts in order of priority.

The significance determination, or the magnitude criteria for Socio-Economic Impact Assessment is then based upon social norms or values, professional judgement, and is dependent on the social factors under consideration. An impact significance assessment is an analysis of the extent to which potentially impacted communities and stakeholders may be affected, whether positively or negatively. Considerations are to be given to the probability, duration, scale, and intensity of the impact, as well as the characteristics of the community or stakeholders which may be affected. Where a potential impact is found to be significant, a residual significance assessment (extent of impact after management measures have been applied) is also undertaken (Queensland Government, 2018).

There are two orders of impacts to be considered, direct and indirect impacts. Direct impacts arise out of the effect of a social factor, while an indirect impact is a consequence of a direct impact.

The generic criteria for the definition of magnitude of impacts is summarised in the section following.

5.3.3 Impact Magnitude Criteria

The social assessment of impact magnitude is undertaken by first categorising identified impacts of the project as 'beneficial' or 'adverse'. Then impacts are categorised as 'major', 'moderate', 'minor' or 'negligible' based on consideration of parameters such as:

- **Duration** of the impact – ranging from beyond the life of the project to very short lived.
- **Spatial extent** of the impact – for instance, within the site boundary, within the region or nationally.
- **Social spread of the impact** – ranging from among a few workers or community persons to a broad cross section of the population/ local benefit sharing.

- **Reversibility** – ranging from 'permanent thus requiring significant intervention to return to baseline' to 'no change'.
- **Likelihood** – ranging from highly likely to potentially.

Table 5-1 presents generic criteria for determining impact magnitude (for adverse impacts). Each detailed assessment will define impact magnitude in relation to its environmental or social aspect.

Table 5-1 Criteria for determining social and gender impacts

Magnitude (beneficial or adverse)	Definition (considers likelihood, duration, number of people affected, spatial extent and local benefit sharing)
Major Adverse	A highly likely impact that would have implications beyond the Project's life. It would negatively affect the wellbeing of many people across a broad cross-section of the population. The affects would be felt across various segments of the local communities, or workers and increase their susceptibility to the negative effects of climate change.
Moderate	A likely impact that continues throughout the Project's life. It would affect the wellbeing of specific groups of people and specific segments of the local communities, or workers and increase their susceptibility to the negative effects of climate change.
Minor	A potential impact that occurs periodically or over the short term throughout the life of the Project. It would affect the wellbeing of a small number of people with little effect on the local communities, or workers. There would be little change to the susceptibility to the negative effects of climate change by those affected.
Negligible	A potential impact that is very short lived so that the socio-economic baseline remains relatively unchanged and there is no detectable effect on the wellbeing of people or the local communities or workers, or on their resilience to the negative effects of climate change.
Beneficial	A highly likely impact that would have potential benefits during and beyond the life of the project to the wellbeing of a section of the population and affecting various segments of the local community or workers. It should build resilience to the negative effects of climate change.
Highly Beneficial	A highly likely impact that would have potential benefits during and beyond the life of the project. It would affect positively the wellbeing of many people across a broad cross section of the population. It would affect positively various segments of the local community or workers and strengthen their resilience to the ill effects of climate change.

Source: Dominica Geothermal Development – Environmental and Social Impact Assessment. NZ Ministry of Foreign Affairs and Trade.

The duration of the impact has also been considered as this will play a key role in how the impact affects the community on a social level. The impacts were considered to either be short-term, medium- or long-term impacts, as defined by Table 5-2.

Table 5-2 Definition of duration of impacts

Duration of Impact	Definition
Short	Impacts restricted to the duration of the construction phase of the works
Medium	Impacts expected to terminate, or become negligible, within six months of the construction completion date
Long	Impacts expected to remain significant for a period greater than six months after the construction completion date.

The level of significance is then determined using the matrix presented in Table 5-3. The sensitivity of potential receptors is assumed to be of medium sensitivity for all social impacts. If the impact is negative then the effect is adverse, if the impact is positive then the effect is beneficial.

Table 5-3 Levels of significance

Magnitude of Impact	Sensitivity of Receptors			
	Negligible	**Low**	**Medium**	**High**
Negligible	Insignificant	Insignificant	Insignificant	Insignificant
Minor	Insignificant	Insignificant	Minor	Minor
Moderate	Insignificant	Minor	Moderate	Moderate
Major	Insignificant	Minor	Moderate	Major

5.3.4 Mitigation

Mitigation measures are actions that if taken can lessen or limit the adverse social impacts of an event. The mitigation hierarchy suggests that measures should involve avoidance, reduction, repair, in kind compensation and/or compensation by any other means. Mitigation measures have been identified and will be implemented to reduce significance impacts to an acceptable level.

5.3.5 Monitoring

Monitoring allows for the measuring of the effectiveness of mitigation measures. Monitoring and follow-up actions should be completed to:

- Continue the collection of data throughout the construction and operation phases.
- Evaluate the success of mitigation measures, or compliance with project standards or requirements.
- Assess whether there are impacts occurring that were not previously predicted.
- Where it is appropriate, involve local communities in monitoring efforts through participatory monitoring. In all cases, the collection of monitoring data and the dissemination of monitoring results should be transparent and made available to interested project stakeholders.

5.3.6 Residual and Cumulative Impacts

Those impacts that remain once the measures to address mitigation have been put in place are described as residual impacts. Those that occur as a combination of multiple impacts are considered cumulative impacts.

Both residual and cumulative impacts are to be assessed as part of the SIA.

5.3.7 Assessment Details – Introduction

There are potential positive and negative social impacts related to both the construction activities and the future operation/use of the new development.

A significant number of the potential negative impacts relate to construction works. As such, it is important to understand these before construction and to manage those construction activities to reduce or mitigate any negative impacts on the community. Upon completion, the project is expected to have both potential positive and negative impacts on the community. Interventions are to be considered to mitigate the negative impacts and to support or amplify the beneficial impacts.

The social impacts have been categorised under five headings: Socio Demographic; Employment; Livelihoods; Health and Well-being; and Cultural Heritage and access to cultural assets. The impacts are presented in two areas – construction impacts and operational impacts.

The impacts are felt both in Codrington Village but also in the island of Barbuda as a whole, particularly with regard to cultural heritage assets, norms, and cultural practices.

Construction Phase

5.3.8 Socio-Demographic

There is concern of impacts to the general population of the Barbudan Community, which is a delicate, micro community consisting of just under 2,000 persons. There is concern that during the construction phase, with many new workers seeking opportunities on the island, the population will expand. This may, however, be for a short period. Issues of changing personal safety, cultural practices and disruption of the norms and practices, resulting in a reduced quality of life usually enjoyed by the Villagers, is of concern as new **short-term** workers arrive. This impact is considered to be potentially **adverse**.

5.3.9 Employment

The development of the Paradise Found Resort is expected to increase employment opportunities for young men from the Codrington Village. The probability of this impact occurring is high and will occur in the **short term** and is not expected to last after the construction phase has been completed. It is expected to have **a beneficial impact,** which is expected to be of a medium **significance** as it’s not anticipated to go beyond the construction phase of the project. There is little expectation that young men will receive long term jobs at the Resort.

5.3.10 Livelihoods

The construction phase is expected to have a beneficial impact on the livelihoods of some groups and an adverse effect on the livelihoods of others. Women who prepare food for tourists and workers have the potential to experience a **beneficial effect** during the construction phase as a brisk trade in their services should take place. The impact on the fishing and lobster trade is expected to be **negligible** during the construction period, as there may only be minor impact on the lagoon or coastal areas. The impact on tour guides and boat and tour operators who provide tour services to 'day trippers' who disembark from cruise ships and stay over tourists from Antigua is expected to be of **minimal** effect. There is also the impact on those who engage in salt mining who may be excluded from those areas during the construction phase. This group may suffer an **adverse impact**.

5.3.11 Health and Well-Being

A potential **adverse** effect on the health and well-being of children from the Village of Codrington is expected during the construction phase. There is an increase in dust from the trucks working on the construction site and moving through the village, leaving clouds of dust everywhere. The impact is **significant** and although the cause may cease at the end of the construction (that is the movement of trucks through the village during the construction phase), the impact **may have long term** consequences on the respiratory condition of the children.

There is the potential for an **adverse impact** on the elderly because of noise and air pollution during the construction phase. Trucks traverse the village roads, drivers can be seen undertaking servicing of their vehicles on the roadside, leaving oil and diesel residue. Trucks move at a very high speed through the village where the elderly walk to carry out their routine leisure and business activities. Sidewalks are nearly non-existent in Codrington.

There is the potential of an **adverse impact** on young women by the influx of mainly young male workers who may engage in sexual grooming of the young girls who are out of school, unemployed and without opportunities for income earing or personal advancement.

5.3.12 Cultural Heritage Assets, Norms and Practices

There is the potential **adverse impact** to the population and their special relationship to the island involving their norms and cultural practices and the cultural assets which they share. The probability of this occurring is medium to high due to the possibility of exclusion from salt mining ponds, traditional camping sites, traditional fishing, and farming sites, etc., during the construction phase.

Table 5-4 following presents the impact assessment summary during the construction phase of the project.

Table 5-4 Impacts during construction phase

Theme	Area Impact	Impact	Probability of this Impact to occur	Type (Beneficial or Adverse)	Intensity	Magnitude	Impact Significance	Direct/Indirect	Duration (Short, Medium or Long Term)	Avoidable?	Reversible?
Employment	Codrington Village	Increase in employment opportunities for young men	High	Beneficial	High	Medium	Medium	Direct	Short to Medium		
Impact on Livelihoods	Island of barbuda	Impact on Tour Guides;	Medium	Adverse	High	Moderate	Moderate	Indirect	Short	No	Yes
	Codrington Village	Impact on women who cook for touists and workmen	Medium	Adverse	High	Moderate	Moderate	Indirect	Short	No	Yes
	Island of barbuda	Impact on boat and tour operators	Medium	Adverse	High	Moderate	Moderate	Indirect	Short	No	Yes
	Island of barbuda	Impact on fishing and lobster trade	Low	Negligible	low	low	low	direct	short		
Impact on Health and Well being of Children	Codrington Village	Increase in air and noise pollution from construction plant and transport	High	Adverse	High	High	High	Direct	Short		Yes
Impact on the elderly	Codrington Village	Increase in air and noise pollution from construction plant and transport	High	Adverse	High	High	High	Direct	Short		Yes
Impact on young women	Codrington Village	Sexual grooming/loss of possibility of completing education/ teenage pregnancy	High	Adverse	High	High		Direct/Indirect	Short/Long term	Yes	
Impact on Cultural Heritage assets, norms and practices	Island of Barbuda	Disruption of villagers way of life (fishing, salt mining, camping, hunting)	High	Adverse	Medium	Moderate	Moderate	Indirect	Short	Yes	Yes
Impact on Socio Demographic	Island of Barbuda	Potential for increase in the population from residents at the Resort	High	Adverse	Medium	Moderate	Moderate	Direct	Short	No	Yes

Operational Phase

5.3.13 Socio-Demographic

During the operational phase of the project, there is expected to be a population increase of possibly a longer duration, from those who purchase homes or are involved in long term rentals. Villagers are not clear what that population increase will look like, and they are concerned about what new practices will come to the Villagers for which they are not prepared. They perceive the impact to be **adverse** as they do not wish to be viewed or treated as second class citizens in their own homeland.

5.3.14 Employment

Only a small proportion of Barbudan male youth are unemployed. During the operational phase of the Resort, there is the potential for an **adverse impact** on employment if young Barbudans are put to work at purely elementary levels of work on the resort.

5.3.15 Livelihoods

There is the potential for **adverse impact** on livelihoods in Barbuda for a number of reasons: (a) if the Lagoon suffers from pollution or careless management of waste disposal. The impact on the Lobster trade would be significant; (b) if the tour boat operators are not allowed to continue their trade in preference to resort operators; (c) if local tour guides are unable to ply their trade over foreign tour guides; (d) if resorts become exclusive areas and tourists do not come to receive the services of women who cook in the Codrington Village.

5.3.16 Health and Well Being

Unbridled tourism has the potential to involve young girls in behaviours that reduce their chances at fulfilling their true potential. There is a medium probability that the resort once completed may expose young girls to the unsavoury side of the tourism sector, resulting in an **adverse impact** on the young women of Codrington Village.

5.3.17 Cultural Heritage, Assets, Norms and Practices

The development has the potential to exclude Barbudans from the cultural assets found in their environment to which they have enjoyed the use traditionally. Should the villagers find themselves excluded from ponds, fishing grounds, and salt ponds, camp sites and improper waste disposal technologies result in the destruction of the lagoon which supports the lobster trade, the impact would be **adverse** and have long term implications. The significance level would be high, and information suggests that such action would **not be easily reversible**.

Table 5-5 presents the potential impact during the operational phase of the project.

Table 5-5 Operational impacts

Theme	Area Impact	Impact	Probability of this Impact to occur	Type (Beneficial or Adverse)	Sensitivity	Magnitude	Impact Significance	Direct/Indirect	Duration (Short, Medium or Long Term)	Avoidable?	Reversible?
Employment	Resort	Small number of persons may be hired at the elementary level to work at the Resort; no evidence of consideration of local technical staff	High	Adverse	High	high	high	Direct/indire	Medium	Yes	Yes
Impact on Livelihoods	Island barbuda	Impact on Tour Guides;	High	Adverse	High	high	high	Indirect	Long term	Yes	Yes
	Codrington Village	Impact on women who cook for touists	Medium	Adverse	Medium	Medium	Medium	Indirect	Long term	Yes	Yes
	Codrington Village	Impact on boat and tour operators	High	Adverse	High	high	high	Indirect	Long term	Yes	Yes
	Island of Barbuda	Impact on fishing and lobster trade	High	Adverse	High	high	high	Indirect	Long term	Yes	no
Impact on young women	Codrington Village	Tourists culture may seek to involve young girls in inappropriate behaviour that dampens personal development	Medium	Adverse	High	Medium	Medium	indrect	Long term	yes	yes
Impact on Cultural Heritage assets, norms and practices	Island of Barbuda	Exclusion from cultural assests; camp sites; ponds, fishing sites;damage to lobster breed grounds - the lagoon	high	adverse	High	high	high	direct/indirect	Long term	yes	no
Socio Demographic	Codrington village	Influx of new persons into the village for work or on the island as residents on the resort may change the culture of the population	Medium	Adverse	Medium	High	High	Indirect	Long Term	Yes	No

5.3.18 Mitigation Measures and Monitoring

Table 5-6 presents the mitigation measures recommended to address the potential impacts both for the construction and operational phases of the project. Many of the mitigation measures required during the construction phase of operation can be undertaken by simple setting of policy guidelines and ensuring regulations are adhered to. These can be supported by the Ministry of the Environment and the Barbuda Council. Other measures require information sharing with the Directly Affected Communities (DAC) so as to reduce the spread of misinformation and increase understanding regarding the actual work of the project. These should emanate from the project proponents and be disseminated with the support of the Barbuda Council. Measures that address training should be undertaken in conjunction with the Ministries of Labour and Education (and where women are the special target group, the Department of Gender Affairs) by the project proponents.

With regard to monitoring, it is important to measure all likely impacts and any issues that may be of concern to the various stakeholders and the DAC over time. This is done through the monitoring process.

Based on the data provided in the baseline conditions report, appropriate indicators can be selected that will allow the potential impacts to be tracked and monitored, such as the number of young men trained and employed on the job site.

In addition to the tracking of the implementation of the mitigation measures, the concerns of the various vulnerable groups such as the children, the elderly and young women should be monitored.

Having a mechanism to monitor for the unexpected is also needed. By regular monitoring of the effectiveness of the proposed mitigation measures, corrective action can be taken if necessary. Also, where any unanticipated issues arise, they can be addressed quickly.

Indicators also need to be considered to measure potential cumulative impacts.

The Project proponent, the Ministry of the Environment, Ministry of labour, the Department of Gender Affairs and the Barbuda Council all have their part to play in the monitoring activities.

Table 5-6 Proposed mitigation measures

Theme	Area Impact	Impact on Construction phase	Mitigation interventions	Impact during operation	Mitigation interventions
Employment	Codrington Village	Increase in employment opportunities for young men	Ensure that job oportunities are advertised where young men can be reached: recreation centres and sporting grounds; eating places and pubs; Develop a programme of on-the-job training that offers practical skills training and work with certification as an end product.	Small number of persons may be hired at the elementary level to work at the Resort; no evidence of consideration of local technical staff	Offer upskilling and retraining programmes including apprenticeship programmes with possibility for certification a the end of the planned programme.
Impact on Livelihoods	Island of Barbuda	Impact on Tour Guides;	Develop a policy that ensures local tour guides are used unless local guides are unavailable	Impact on Tour Guides;	Enusre that local tour guides receive a fair trading opportunity at services to be provided
	Codrington Village	Impact on women who cook for touists and workmen	n/a	Impact on women who cook for touists	Ensure that tourists have the option and are offerred the opportunity to vist the villages and participated in the loal food
	Island of Barbuda	Impact on boat and tour operators	Develop a policy that ensures local tour guides are used unless local guides are unavailable	Impact on boat and tour operators	Enusre that local boat operators and tour guides receive a fair trading opportunity at services to be provided
	Island of barbuda	Impact on fishing and lobster trade	n/a	Impact on fishing and lobster trade	Safeguard the Lagoon
Impact on Health and Well being of Children	Codrington Village	Increase in air and noise pollution from construction plant and transport	Regulate trucks use of roads in the village. This willreduce th dust which affects children; and assign a area for parking outside of viallage where service operations can take place.	Neutral impact expected	none required
Impact on the elderly	Codrington Village	Increase in air and noise pollution from construction plant and transport	Regulate trucks use of roads in the village. This willreduce th dust which affects children; and assign a area for parking outside of viallage where service operations can take place.	Neutral impact expected	none required
Impact on young women	Codrington Village	Sexual grooming/loss of possibility of completing education/ teenage pregnancy	Increase job training opporotunities for young women theus reducing their susceptibility to the groom prospects of male workers. Provide sexual harrassment in the workplace traing for young male construction and transport workers on site.	Tourists culture may seek to involve young girls in inappropriate behaviour that dampens personal development	Ensure opportunities exist on island for furthering education and skills development for young women
Impact on Cultural Heritage assets, norms and practices	Island of Barbuda	Disruption of villagers way of life (fishing, salt mining, camping, hunting)	Share information explaining the short term nature of the disruptions and work through methods with the DAC as to how to limit and mitigate the disruptions during the construction period	Exclusion from cultural assests; camp sites; ponds, fishing sites;damage to lobster breed grounds - the lagoon	Share information widely on the development proposals with the DAC ; allow locals to share views; arrive at concensus
Impact on Socio Demographic	Island of Barbuda	Potential for increase in the population from residents at the Resort		Influx of new persons into the village for work or on the island as residents on the resort may change the culture of the population	Encourage orientation sessions for resort owners to learn something of the history and culture of the island

6 Comparison of Alternatives

Smith Warner International Ltd. (SWI) was contracted to design an improved beach along with a surface water drainage plan for the Paradise Found development. Within this contract newly collected data from external contractors were used to develop a new drainage master plan and coastal inundation defence for the property. This information will also be used as input for overall Environmental Impact Assessment (EIA) of the proposed works by showing how the concept will interfere (if at all) with baseline conditions.

A major concern for this project is the potential for coastal and overland flooding, which was highlighted in the *Baseline Conditions Report – October 12, 2022*. A summary of the findings from that analysis is presented in Figure 6.1. The baseline conditions show that coastal flooding is a threat from three low points on the property, the greatest of which is the low salt ponds to the south. These ponds act as an avenue for storm surge from the south-east to progress onto the project property. Statistically, wave conditions from this sector were higher than what would be experienced on the property's beach. These surge levels and extents were therefore used to guide the finished elevations of the roadways, beach dunes and property that are proposed.

Across the property, computer model results showed that there are many low areas where water pools during heavy rainfall. The locations of these areas were the focus of either filling or grading activities when developing the drainage master plan. Grading efforts intended to use the existing ponds as much as was practical to hold storm water during heavy rainfall.

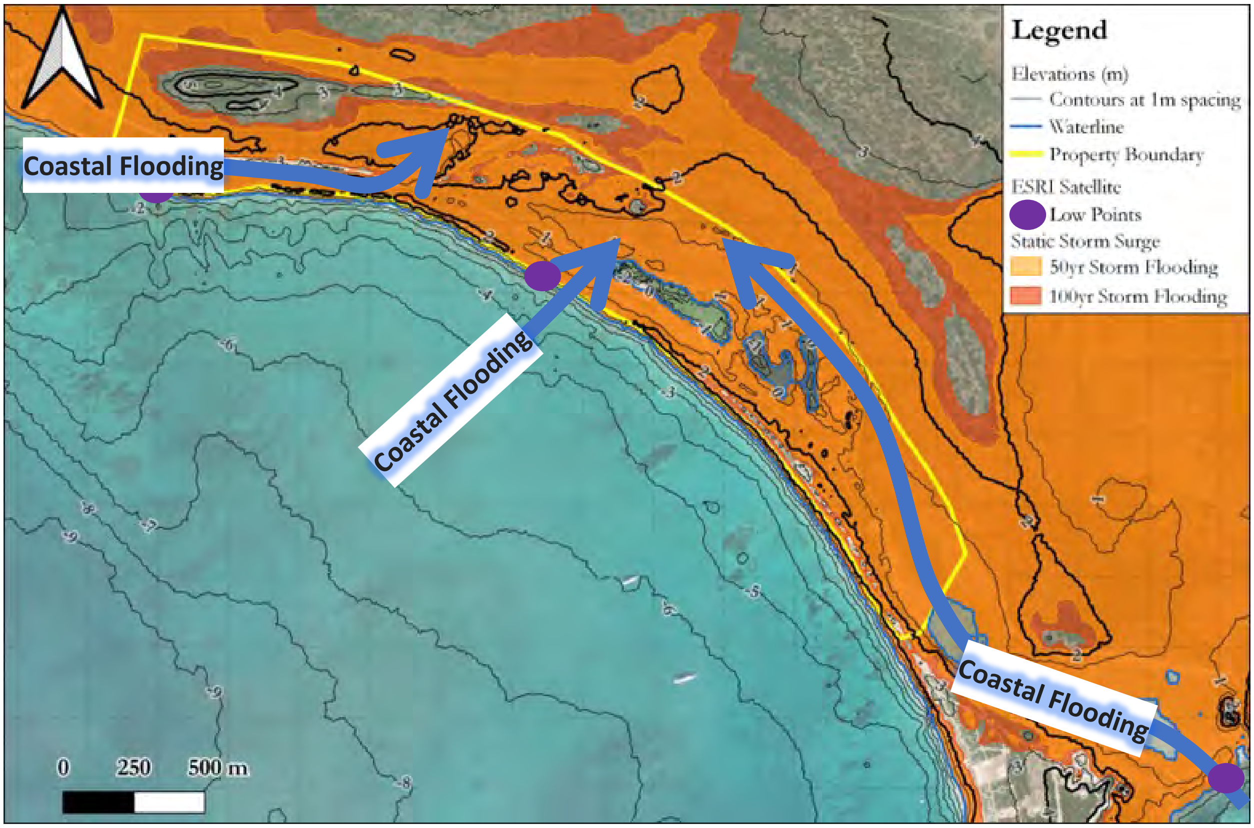

Figure 6.1 Main conclusions from the baseline study which guide coastal and drainage design

6.1 Concept Development

Coastal intervention is typically either soft (such as beach nourishment) or hard (such as stone structures). The design philosophy on the property is guided by using what is readily available on the island. From early in the design phase the client indicated that the property should maintain its natural beauty with few imported obstructions. Therefore, the coastal defences were mainly soft. In this case two possible options were developed and compared to the do-nothing option.

From the topography collected in the baseline conditions report, the south-eastern section of the property had a high sand dune which stopped the inundation of the land behind. This dune was used as a model for the lower beach sections to the north. Based on the 99th percentile waves and 50-year storm waves two dune cross-sections were developed. The section is shown below in Figure 6.2.

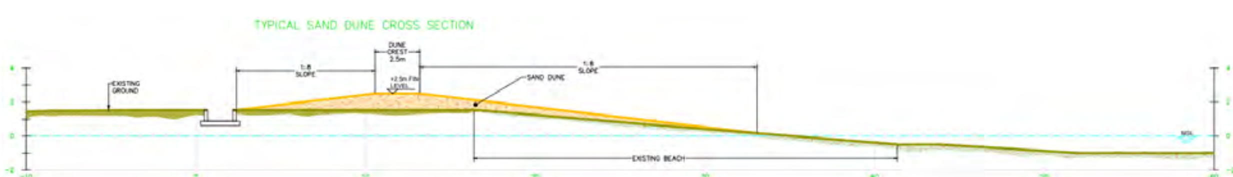

Figure 6.2 Dune section sketches compared to the existing grade

The dune construction could include sand filled geotubes to limit the erosion potential during high energy events. Above the geotubes would be a 0.3m thickness of sand which corresponds to the scour experienced during high energy events.

The sand dune will be located along the phase-two private lots. Although it would be most desirable to have all coastal elements implemented at the same time, the nature of construction costs typically encourage the use of phasing. Since the lot will be developed in the second phase of the construction, it is anticipated that the bulk of the dune construction works will occur during the second development phase.

This section of the report presents considerations and calculations in the design of the structures. Boundary conditions used for the calculations are presented first, then nourishment specifications are shown.

6.1.1 Design Parameters

For the design of the structures, the maximum wave heights incident on each structure for a different wave forcing condition were extracted from the MIKE21 model. For this design, we must consider the wave conditions on the structures under:

1. Average daily wave conditions;
2. 99.86th percentile waves to represent a swell event; and
3. Hurricane conditions.

The use of a return period or design event such as the 1 in 50-year or 1 in 100-year essentially defines the kind of design conditions that will, on average, occur or be exceeded once every 50 years or every 100 years. It is important to understand risk and consider the chance of occurrence of a particular storm condition during the lifetime of a structure so that the associated risk of damage can be understood.

Table 6-1 gives the exposure risk (probability) over a project lifespan for different return period events. For example, a project lifespan of 50 years (Design Life = 50) has a 99% chance of a 1:10-year event occurring, a 64% chance of a 1:50-year event occurring and a 39% chance of a 1:100-year storm event occurring.

Table 6-1 ***Probability of occurrence for various return periods and design life***

Storm Event Return Period (years)	Design Life (years)			
	25	50	100	200
10	93%	99%	100%	100%
25	64%	87%	98%	100%
50	40%	64%	87%	98%
100	22%	39%	63%	87%
200	12%	22%	39%	63%
500	5%	10%	18%	33%

6.1.2 Design Overview

The proposed shoreline enhance**ment plan** includes the extension of an existing dune to provide protection during swell events. To protect against a hurricane would require a dune with a crest elevation up to 3.5m above mean sea level, which would significantly increase the cost of the coastal works. To provide a more cost-effective design, the dune was lowered to +2.5m above MSL, which would protect lots against inundation in swell events. During the 50-year storm it is anticipated that the beach will be inundated, however the dune will reduce the depths of inundation further inland as highlighted in the following section.

The design features that will protect against coastal surge are:

1. *Beach nourishment*: The northern section of the shoreline is presently very low with elevations between 1m and 1.5m above MSL. Using the existing features as inspiration, the dune is to be extended to meet the northern boundary up to 2.5m above MSL. This would be an average increase of 1m. To further reduce the cost of the of dune, it recommended that geotubes be used up to an elevation of 2.2m above MSL which would then be covered by 0.3m of sand.
2. *Perimeter Road:* The property shoulders a main road for residents on the island which leads directly to some important facilities such as the seaport and airport. A critical component of the design was to have the road be accessible in a 50-year storm and to have it merge well with the existing marl road.

Updated Coastal Setback

A key outcome of the 2016 study was the prescription of coastal setback distances and elevations. These elevations were based on typical beach profiles at the southern shores. These levels included a consideration for hurricane surge levels. With the passage of ferocious storms in 2017, it was determined that the levels should be updated to include the hurricanes that passed in the time since the prior study. Additionally, climate change projections have changed since 2016, the Intergovernmental Panel on Climate Change (IPCC) Sixth Annual Report (AR6) was used to update the projected sea level rise. With these new formulations, the proposed setback and elevations were calculated (summarised in Table 6-2).

Table 6-2 Coastal setback and floor elevations calculated for dune areas

Design Scenario	Coastal Setback (m inland from high waterline)	Floor Elevations (m above mean sea level)
50-year storm	52	3.7
100-year storm	70	4.5

The final levels also include water increases related to high tide, sea level rise and a freeboard of 0.3m (1'). The freeboard was added to provide a buffer between possible surge and the base of structures.

The design narrative for this property shows that there is a focus on enhancing the property while being cognizant of typical building practices. On Barbuda, many homes are built atop stilts. This is expected to be utilized in the plan as it would reduce the amount of fill needed on the lots. The land will be graded the existing (and future) ponds to allow for proper drainage of the site.

Perimeter Road Elevation

A critical objective of the proposed concept was to reduce coastal flooding on the property and recommend safe elevations for an emergency roadway along the perimeter of the property boundary.

The elevation of this roadway was set based on the 50-year storm wave conditions. Once the static surge was computed, further investigations into the wind setup and wave runup were done to properly estimate a maximum elevation of water. Following this an allowance for the thickness of the road and freeboard were added. The final elevation was 3.0m above MSL. This road elevation is maintained from the southern boundary to the eastern boundary. The road elevation changes to meet existing grade at the northeast boundary where elevations are up to 6m.

Figure 6.3 shows the model results for a profile that runs through the road to determine if the road is overtopped. The results indicate that the elevation of the road would be satisfactory in a 50-year storm.

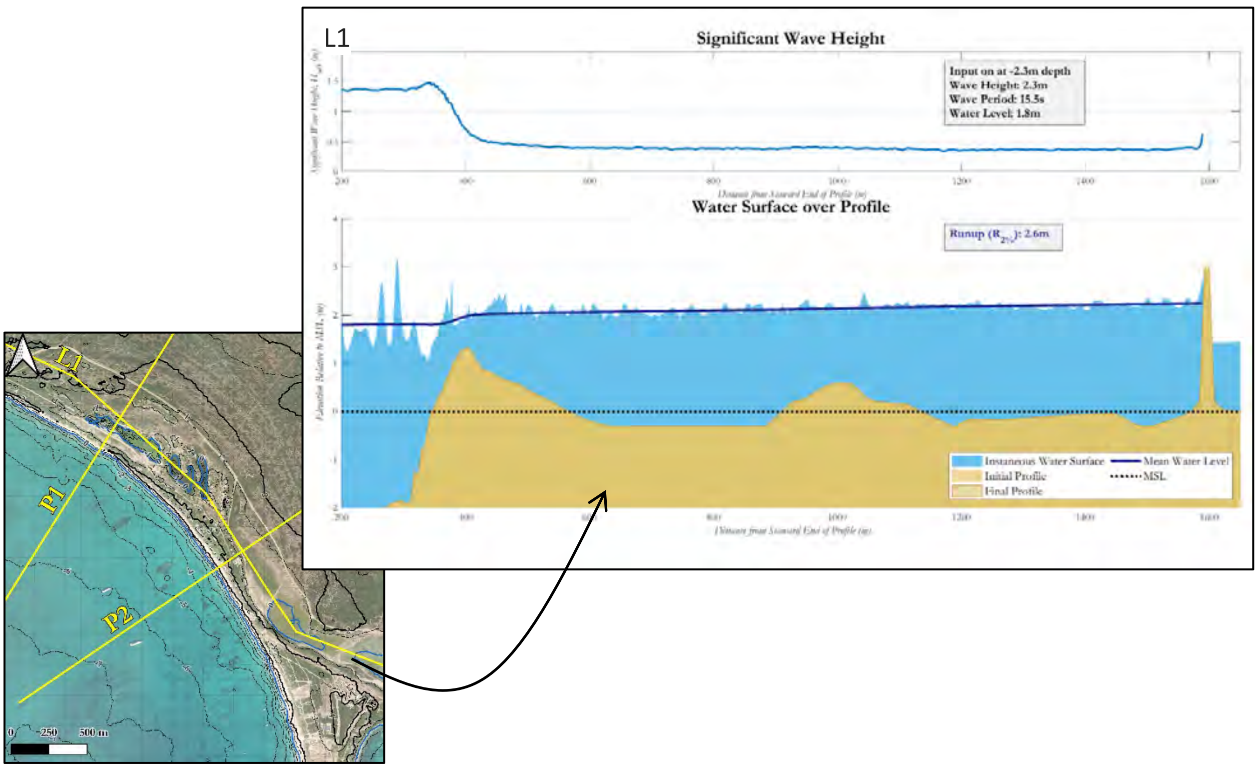

Figure 6.3 Model results for wave run-up and wind setup at the southern boundary with the concept in place

Sand Characteristics for Beach Nourishment

To further predict the behaviour of the beach with the extended dune in place, the formula developed by Ahrens and Hands[14] was used. Their research describes the use of nonlinear wave theory to predict cross-shore sediment movement under waves in shallow water. This synthesis of wave theory and sediment movement initiation criteria allows much of the present understanding of cross-shore sediment movement to be determined.

[14] Ahrens, J.P., Hands, E. B. (1998). Parameterizing Beach Erosion/Accretion Conditions. International Conference on Coastal Engineering 1998, Paper #75, Pages 2382 – 2394.

The beach stability is determined by looking at all the possible ranges of wave height and periods extracted along the proposed beach slope/toe and by varying the mean grain size diameter. The variation of parameters will cause the beach to either accrete, be transitional, or erode. Where the beach is in accretionary mode it can be concluded that the beach is adequately sheltered, and the grain size is ideal. Where the beach is in transitional mode it can be anticipated that the beach will fluctuate throughout the year and the shoreline may reshape. Although the structure layout is acceptable, adopting a coarser grain size could be recommended to limit beach fluctuations. Where the beach is in erosion mode it would be recommended to adopt a coarser grain size for nourishment.

The wave parameters during swell events are represented by wave conditions exceeding 12 hours per year (99.86th percentile), and these were used to assess the stability of the beach. These wave conditions were up to a wave height of 0.75m and wave period of 15.0s at the toe of the beach nourishment. The tendency for the beach to accrete, erode, or be in a transitionary zone under the input conditions, is illustrated in Figure 6.4.

The critical conditions show that the beach fluctuates naturally under existing conditions. The *in-situ* beach sediment is fine with a mean grain size of 0.25mm. Material that is used to nourish the beach should have a similar grain size distribution and have a low silt content (less than 0.5%). Higher silt content will result in cloudy water as the waves gradually clean the sand and can create a hardened surface over time. Other characteristics, such as carbonate content and colour are generally aesthetic, and are subject to preference. From tests done, the minimum grain size to keep the beach in at least a transient state is 0.15mm. If a fine sediment is place on the beach, there is likely a high probability of erosion. In summary, a D50 grain size of 0.25mm is recommended to keep the beach in an accretion zone.

Beach Erosion / Accretion					
Parameters	Units	Max Daily Existing	Max Daily Proposed	Min Daily Existing	Min Daily Proposed
Hso	m	0.80	0.75	0.14	0.14
Tp	s	15.0	15.0	4.5	4.5
d50	mm	0.25	0.15	0.25	0.25
p sand	kg/m^3	1922	1922	1922	1922
p water	kg/m^3	1025	1025	1025	1025
rel pho		0.88	0.88	0.88	0.88
Lo	m	351	351	32	32
Hso/Lo		**0.0023**	**0.0021**	**0.0044**	**0.0043**
Hb	m	2.02	1.93	0.29	0.29
db		2.6	2.5	0.4	0.4
Ns (Ahrens)		**9240**	**14700**	**1342**	**1308**
Ns - Upper Transition		15330	16175	8878	9144
Ns - Middle Transition		11469	12102	6643	6841
Ns - Lower Transition		5689	6002	3295	3393

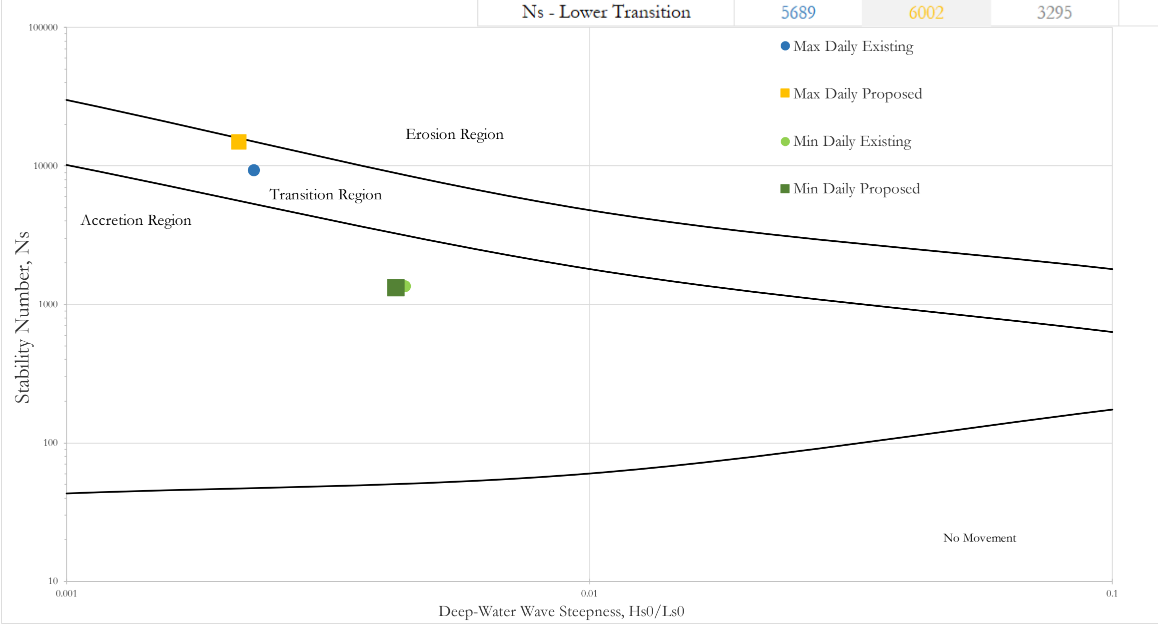

Figure 6.4 Sediment erosion and accretion zones as developed by Ahrens and Hands (accompanying spreadsheet shown in inset)

6.2 Coastal Design Impacts

The proposed shoreline concepts were developed from several model iterations to find the most economically feasible solutions. Another objective was to ensure that the concepts proposed provided coastal defence in the design conditions of the 99th percentile and 50-year storm. Most importantly, the proposed concept should not adversely impact the surrounding coastal area. Fortunately, the proposed coastal intervention is primarily land-based, which would reduce the impact zone of the works.

To test possible changes in the wave climate in the area, conditions before and after the proposed concept were tested. Analyses were carried out primarily with the numerical modelling suite MIKE 21. General beach response modelling was performed using various wave conditions and sediment sizes to determine the stability of the proposed sediment.

Further, MIKE 21 was used to evaluate the impacts of operational waves (both sea and swell) and hydrodynamics for both the existing condition ("do nothing" scenario) and the proposed dune concept described above. The modelling results were used to indicate what could happen in the short and long term if the proposed solution was implemented.

Short term impacts from erosion were simulated using the XBeach model in a profile mode. This model is well adapted for the modelling of beach and particularly dune changes in storms (Roelvink, 2009).

The results of all tests are plotted side by side to easily compare the conditions for each test case. They are presented in the following sections.

6.2.1 Long-term Impacts on Operational Waves

The design philosophy for Paradise Found is in keeping with softer approaches to beach stability. Stability is related to the long-term patterns of erosion and accretion on a beach as determined by the operational wave climate. The waves generate currents which then move sediments towards or away from a beach. In the case of Paradise Found, the impact of the development was checked by comparing the wave climate with and without the concept in place.

The process of determining the operational waves along the project site were presented in prior reports. The main conclusions were that waves typically propagate from the south with a magnitude of 0.3m in the nearshore. The southern section of the property was more sheltered and thus had smaller wave heights of about 0.2m.

Figure 6.5 depicts a comparison of mean annual wave heights under existing and proposed conditions. Figure 6.6 shows the wave results for conditions exceeded 12hrs out of the year to represent a swell condition. Overall, the findings indicate that:

- There is no appreciable change in operational waves between the existing and proposed conditions. This is due to all works being confined on land within the property boundaries. Under operational conditions, the concept plan would provide an additional dune to the northern section of the property, which is more exposed to waves.
- In the more extreme condition of the 99.86th percentile waves, the wave heights range from 1m to 1.2m at the shoreline. As with the operational waves, the northern section of the beach is exposed to higher waves. These wave conditions may generate significant scour on the sandy beach, and this is addressed in the following section.

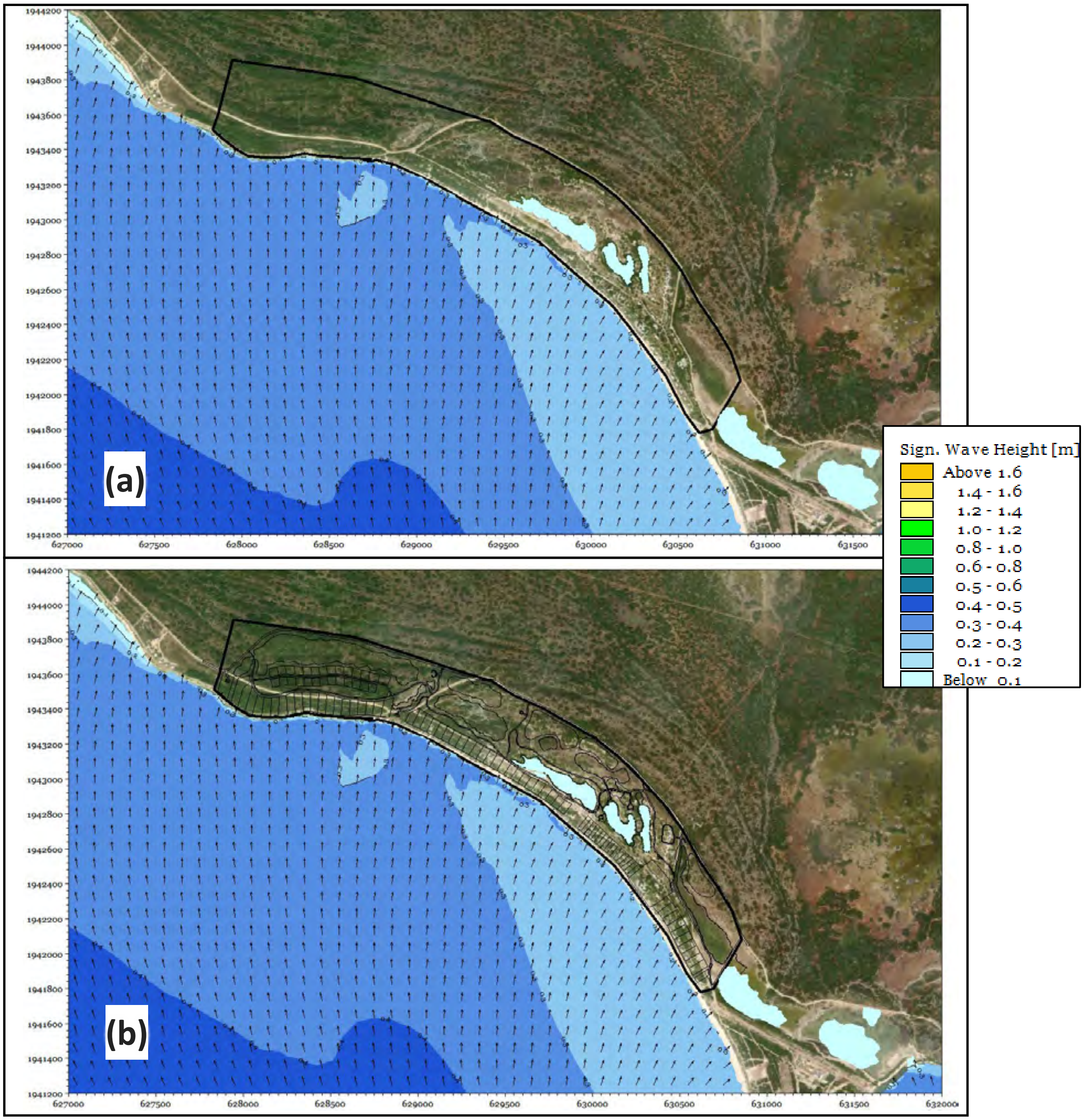

Figure 6.5 Comparison of mean annual waves results (a) under existing conditions and (b) with the plan in place

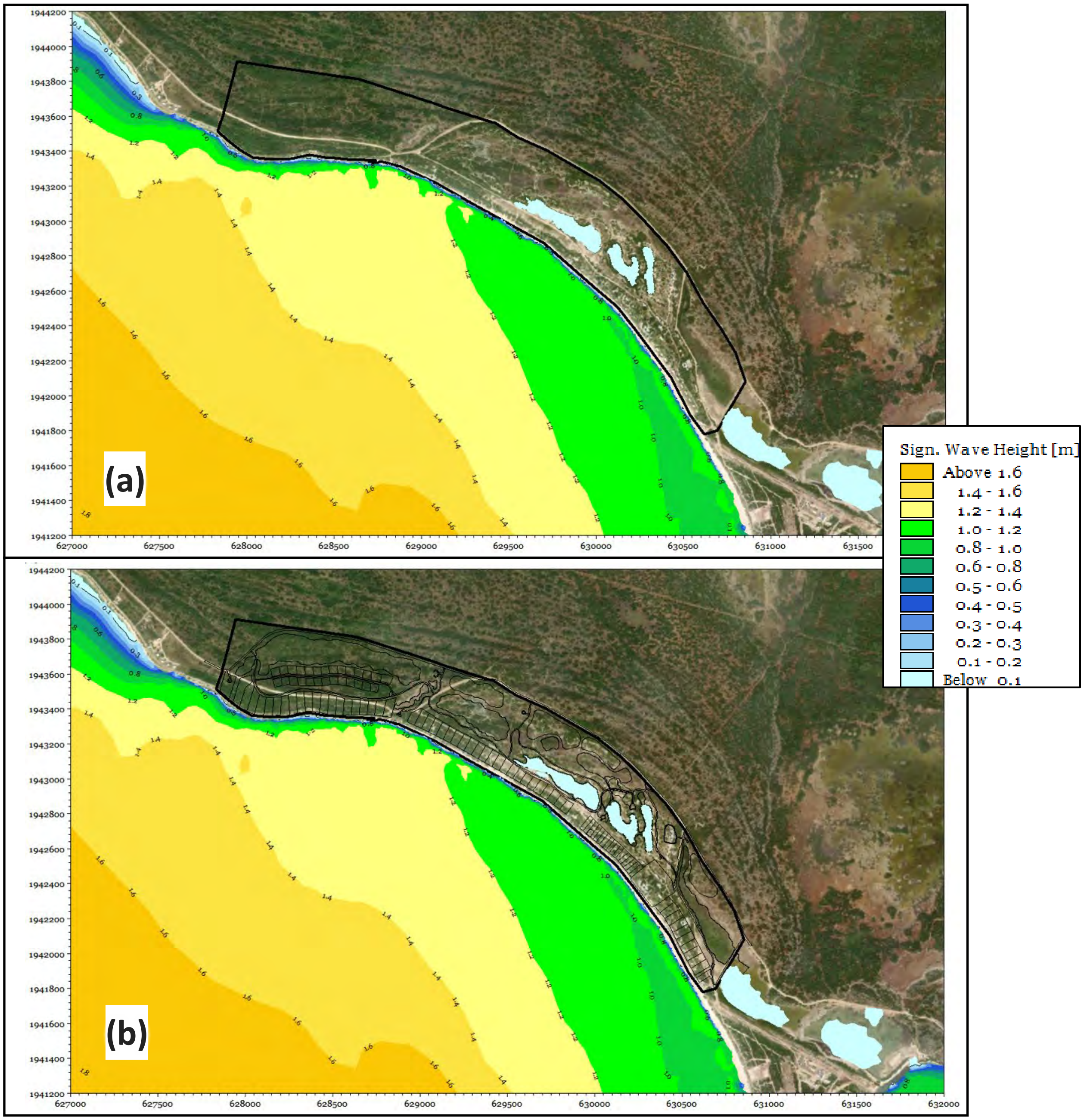

Figure 6.6 Comparison of wave heights statistically exceeded 12hrs per year (a) under existing conditions and (b) with the plan in place

6.2.2 Short-term Impacts from Swell Waves

High energy swell waves cause significant erosion on sandy shores. To capture the effects of a swell wave, forty-two years of wave data was assessed using exceedance statistics. A wave condition that is exceeded for only twelve hours per year was chosen and simulated at high tide. To account for possible climate change impacts, sea level rise was added to the simulation, and this was found to be 0.74m. Key results were plotted along a profile in the low vulnerable area to the north.

In the existing case, there was up to 0.3m of scour along the beach profile (Figure 6.7). The face of the dune was eroded and deposited around the waterline, which led to a temporary widening of the beach. In proposed conditions, there was less scour of around 0.2m on the dune face. The eroded sediment from the dune was deposited by the waterline. Erosion/accretion zones were reduced for the proposed conditions from 75m to about 50m.

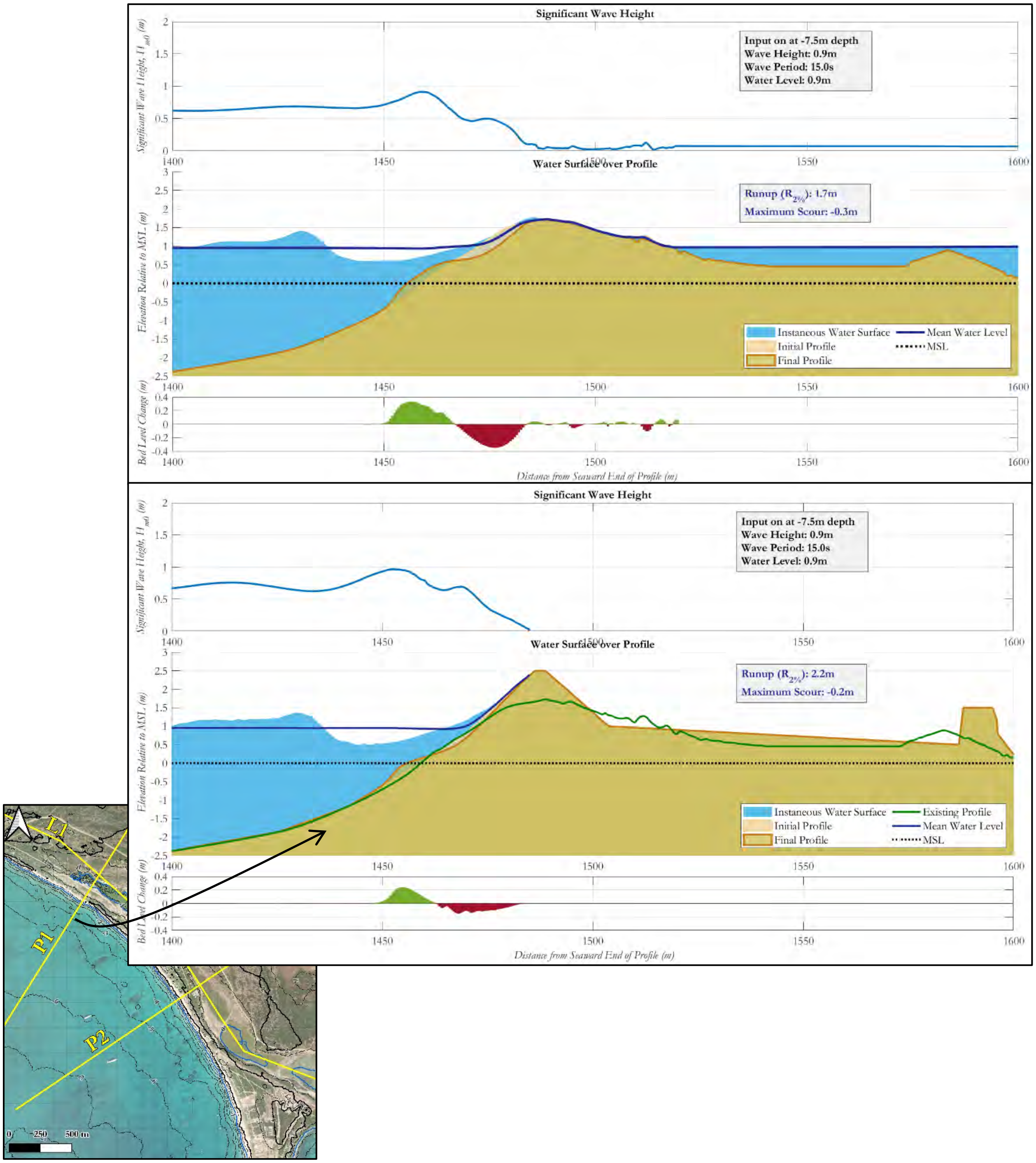

Figure 6.7 Comparison of erosion scour during 99.86th percentile wave conditions

6.2.3 Short-term Impacts from Hurricane Waves

The island of Barbuda has experienced significant damage and loss of environment associated with the passage of hurricanes. As shown in prior reports, the combination of strong waves and high surges creates a major flooding issue for the low site. Under existing conditions, the land would be under 1-2m of water during the 50-year hurricane event. However, by extending the dune and raising the perimeter road (also to facilitate drainage) the development is protected from hurricane-related flooding as shown in Figure 6.8, Figure 6.9 and Figure 6.10.

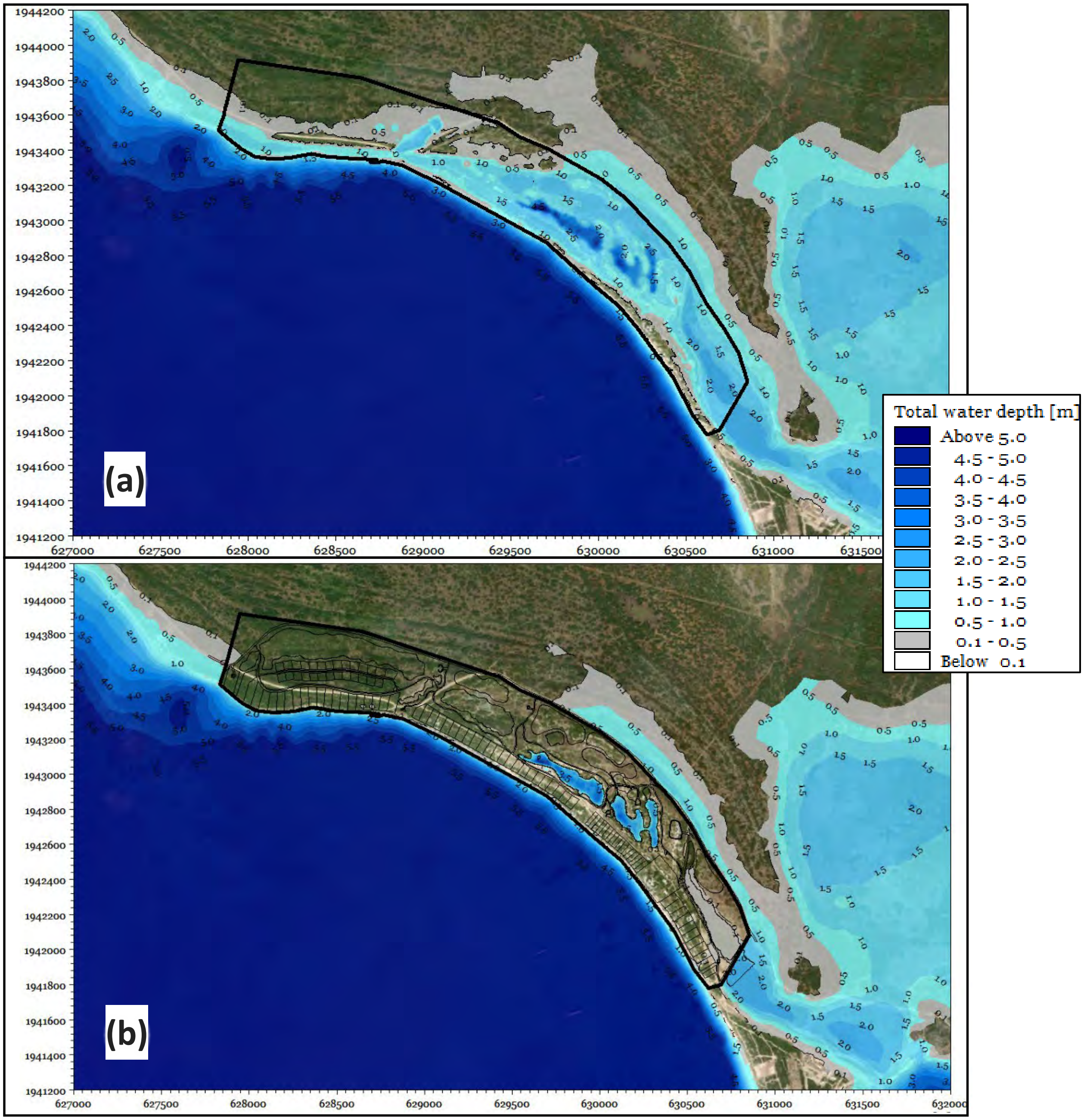

Figure 6.8 Comparison of 50-year storm simulation results for water depths (a) under existing conditions and (b) with the plan in place

Inundation results are shown in Figure 6.8 as water depths across the area. In existing condition almost all areas slated for housing would be inundated with up to 1.5m of water. In proposed conditions the surge is blocked by the extended dune and perimeter road. Inundation outside of the property is similar in both existing and proposed conditions.

Storm surge extents and elevations are compared in Figure 6.9. As with the inundation mapping, the site was not flooded by static storm surge. The conditions outside of the property were not worsened by the perimeter structures.

Finally, the storm waves are plotted in Figure 6.10. Under existing conditions wave heights were an average of 0.4m on land with a maximum of 1m at the southeastern boundary. Under proposed conditions, small wave heights were simulated on the ponds of around 0.1m. In the simulation, the rest of the property did not show any inundation and thus no wave heights. Outside of the property the wave heights were like those in the existing scenario.

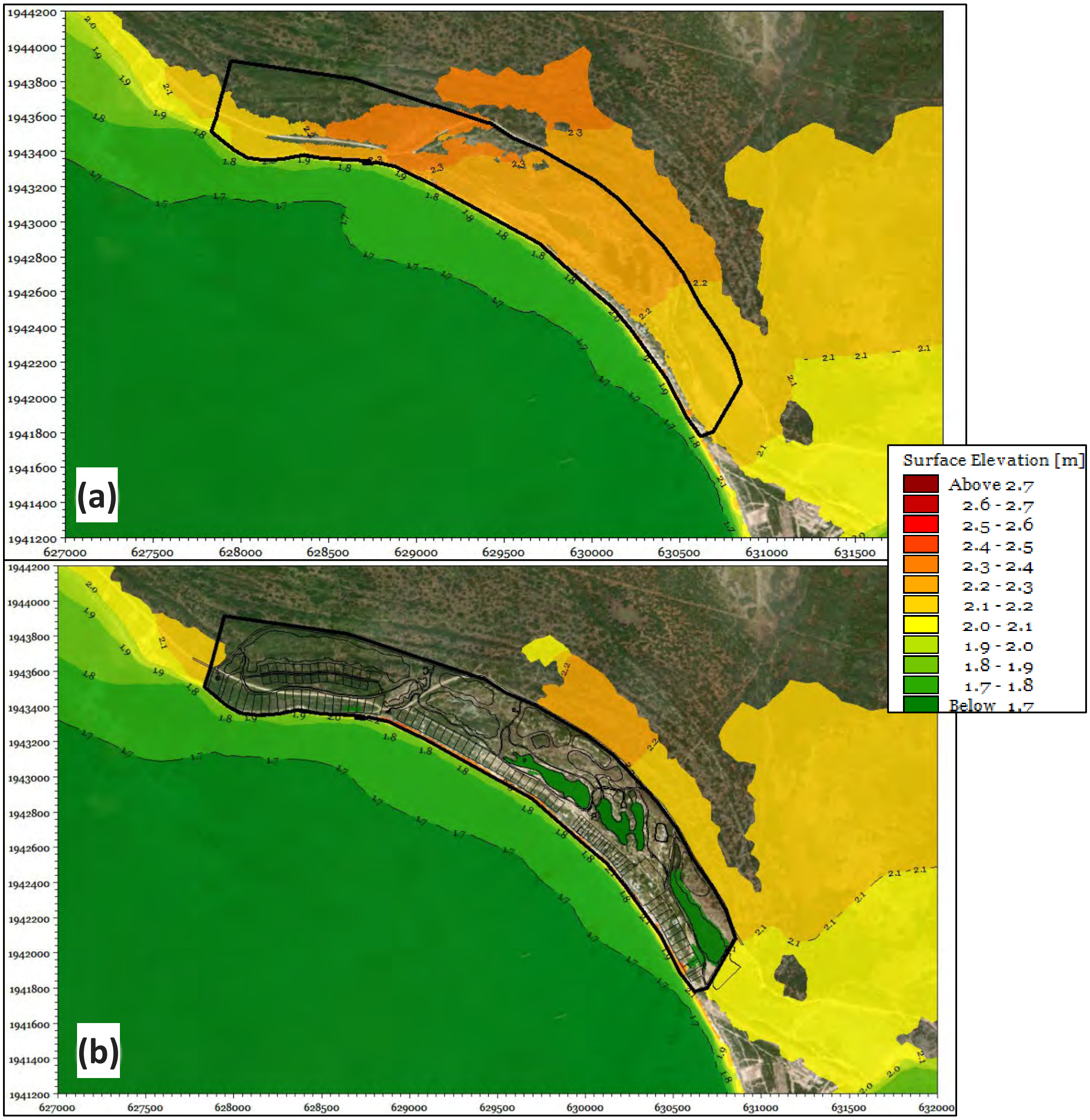

Figure 6.9 Comparison of 50-year storm simulation results for water elevations (a) under existing conditions and (b) with the plan in place

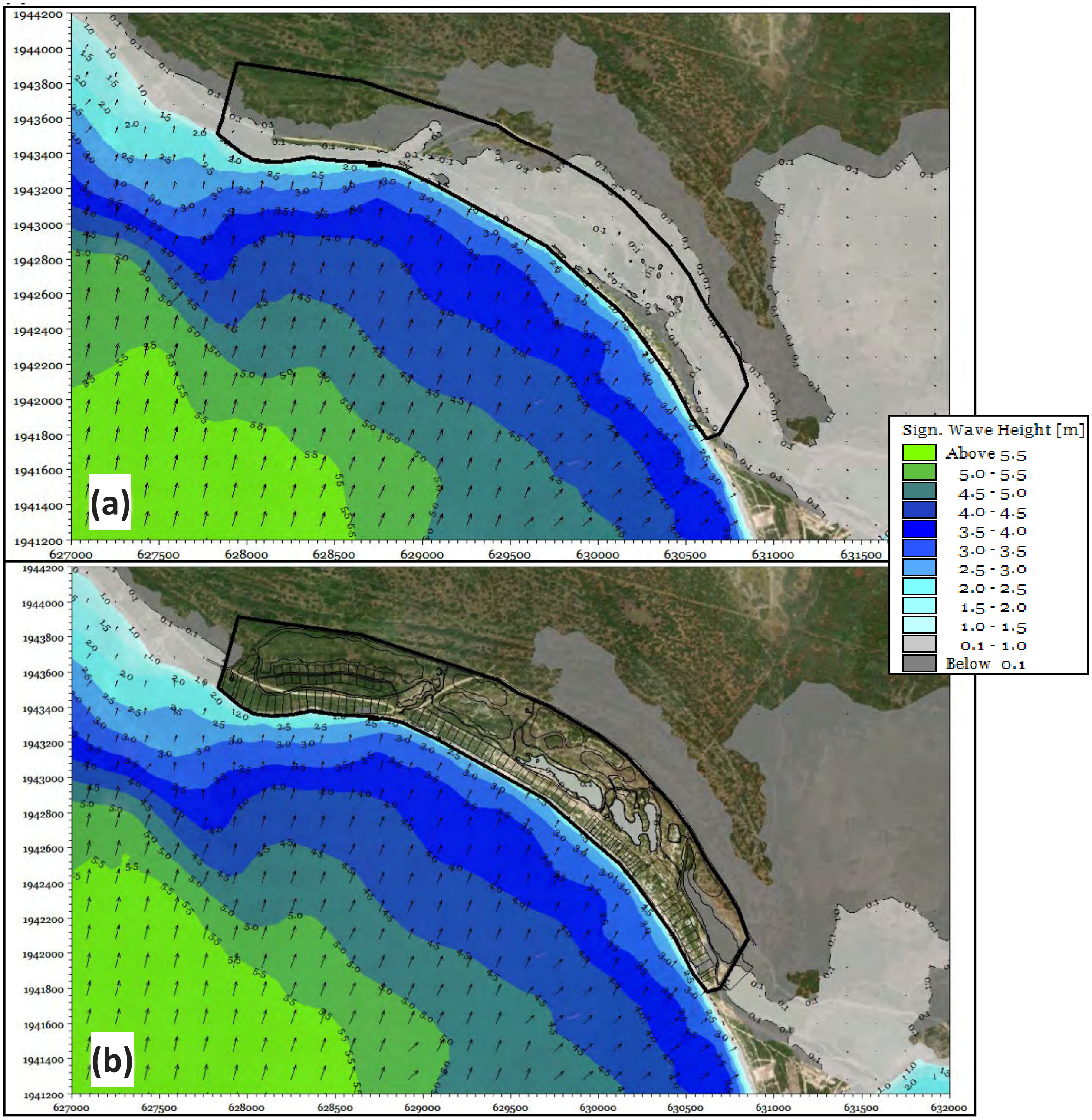

Figure 6.10 Comparison of 50-year storm simulation results for storm waves (a) under existing conditions and (b) with the plan in place

6.3 Hydrologic Analysis and Drainage Master Plan

This section of the report describes the existing drainage features and provides a master drainage plan that channels stormwater runoff from the upper catchment through the site that would tie-in to the beach design.

6.3.1 Methodology for Hydrologic Analysis

The methodology adopted was as follows:

1. Data collection to include:
    - Rainfall information
    - Soils information
    - Land use mapping
    - Topography of the catchment
    - Anecdotal data collection
2. Delineation of the catchments
3. Calculation of runoff for pre- and post-development
4. Proposed grading of site and driveways to ensure all runoff is captured.
5. Hydraulic analysis of the existing river, proposed drains, and drainage features.
6. Assess the impact of the development on the receiving drainage features.

Several International Guideline for preparing Hydrological and Hydraulic Design Reports for Drainage Systems was consulted to guide the designs. The following sizing criteria were used:

- The site drainage shall be sized to handle at minimum the 10-year return period flow.
- The main drains (U Drains and HDPE Pipes) will be sized to accommodate at minimum the 25-year return period flow.
- The major drainage features (trapezoidal earth drain and river) will be sized to accommodate at minimum the 50-year return period flow.

The design strategy is to follow the existing slope of the land and channel surface runoff into the existing drainage features and to the eastern section of the property towards the existing river.

6.3.2 Hydrology

Precipitation Flooding versus Riverine Flooding

A distinction must be made between riverine flooding and what is called precipitation flooding. The major difference is that riverine floodplains have readily identifiable drainage paths, whether they are rivers, streams, ghauts, roadways or constructed channels. Riverine flooding is said to occur when the volume of stormwater runoff exceeds the volume provided by these drainage paths. Precipitation flooding on the other hand is the result of abnormalities in the topography of the land that are not easily identifiable, the overflow of which will cause flooding. A common form of precipitation flooding occurs when natural drainage paths are blocked, routing the runoff elsewhere and causing flooding; another example is in the case of sinkholes, which will pond an area during heavy precipitation.

The project site drainage catchment is particularly flat, which leads to significant ponding on the property after rainfall events. The island of Barbuda does not have any rivers, thus the identification of ponding areas and precipitation flooding will be important.

Catchment Delineation

Existing features of the property were detailed in the *Baseline Conditions Report* (SWI, October 2022). A field investigation and interviews were also carried out to collect additional information on low points and floodplains on the site. Additionally, the road alignment was noted as it would form a significant portion of the filling works on the property.

Detailed topography was provided by the client for the property. Contour lines for the whole island were extracted from the Post-Georges Disaster Mitigation database. These contours were very sparse and focused to the east where the highest point on the island is located. All the topography data was merged and used to delineate the catchment areas that interacted with the property.

The data for the island catchment area had several gaps and was not at a fine enough resolution to allow for processing in the model or further division into sub-catchments (Figure 6.11). This is a significant limitation in the hydraulic analysis, as flows can be dramatically altered based on the slope over which they move. Not having a detailed DEM creates gaps and inaccuracies over the catchment area and means the resulting flows can be taken as an estimate only.

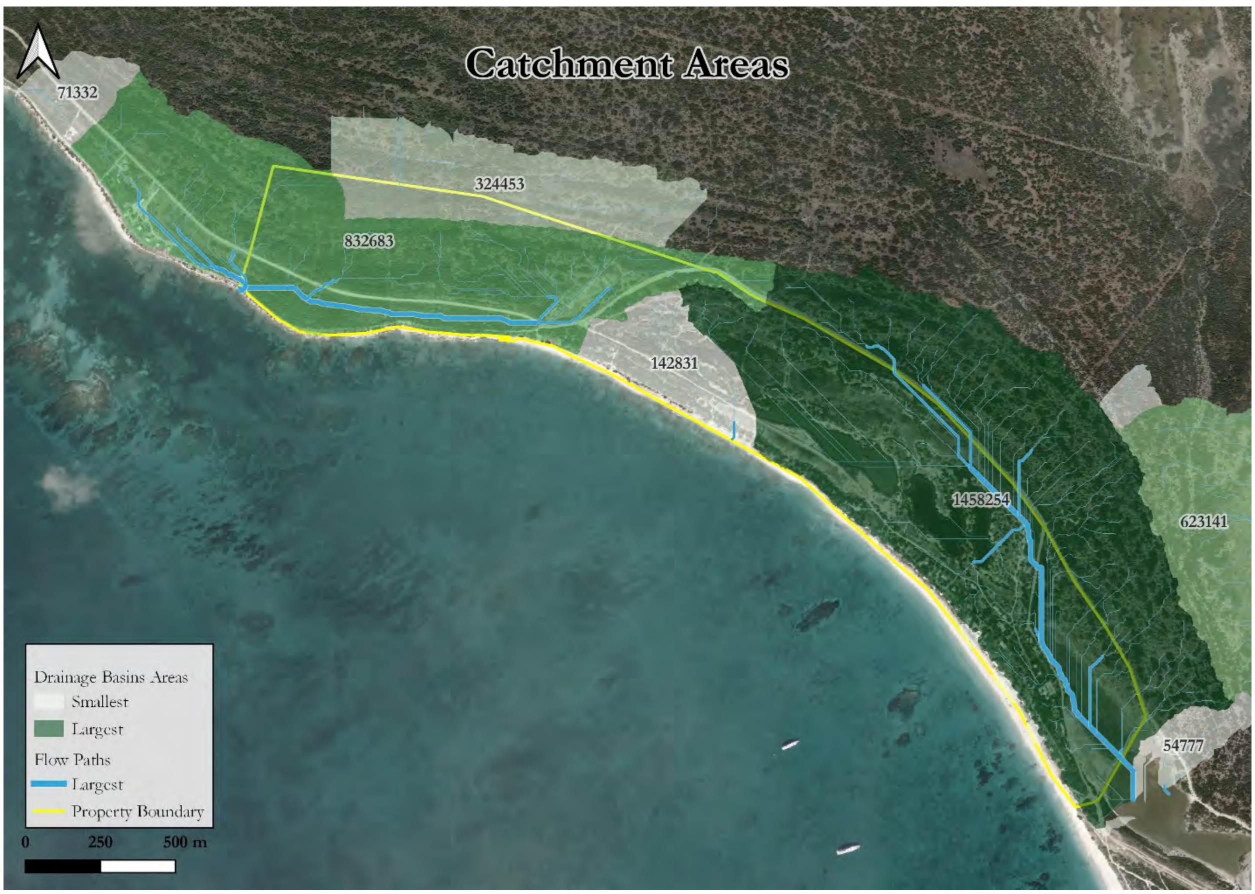

Figure 6.11 Catchment areas for the project site overlain on satellite imagery [© ESRI]

Based on the results of the catchment analysis, there are four catchment areas and drainage paths on the property. The largest catchment is Catchment A, which covers ponds 1, 2 and 3 and has an area of 1.4km^2. Pond 1 is the collection point for Catchment A and acts as the final point for discharge in this area. The northern half of the property drains to a low point near to the property boundary in Catchment B. This catchment has an area of 0.83km^2. Catchment C is located along the centre of the property's beach front. The catchment is smaller than the others with an area of $0.14km^2$. This area drains towards the sea. The fourth catchment (D) has an area of $0.32km^2$ which flows from the 6m ridge.

Soils

The soil types in the catchment are important determinants for how much water is retained in the soil and the resulting peak runoff possible. Significant borehole testing was done across the property to determine the soil and sub-soil layers in the area. This was presented in a lab report by CMT Technologies. It was determined that the land was mainly brown sand and sandy loam with pond areas having clayey sandy loam. The soil type has favourable internal drainage and infiltration properties.

Analysis of Extreme Rainfall

Extreme rainfall data was presented in the Baseline Conditions Report. The return periods used in the design were the 10-year rainfall (223mm/day) and the 50-year rainfall (330mm/day)

Runoff Estimation Using the Rational Method

The rational model is suitable for small urban catchments (less than $1.5km^2$), which means that it is not applicable for the wider watershed, but is ideal for calculating flow for the smaller catchments associated with the site. This method was developed primarily for estimating peak runoff according to the formula:

$Q = CIA$, where

C = runoff coefficient

I = rainfall intensity and

A = area of the catchment

Runoff coefficients were chosen based on the Urban Water Resources council 1992 recommended values.

Study Limitations

As previously discussed, there was a lack of accurate data for this analysis. Most notably the all-island contours were not available at a sufficiently detailed resolution, leading to major gaps and possible inaccuracies in the catchment delineation. Additionally, the soils and land-use data (which are used to determine the Curve Number) had to be averaged across the main catchment, which could in turn lead to over-estimating or under-estimating the flows.

6.3.3 Runoff Results

The calculation of surface runoff, based on a statistical depth of rainfall for a particular return period estimate and selected temporal distribution, was carried out for this project. The resulting peak discharges were calculated using the rational method for all catchments shown (Table 6-3). The generated flows ranged from a catchment minimum of $0.29m^3/s$, to a catchment maximum of $4.27m^3/s$ for the 2 to 100-year event.

Table 6-3 Discharge volumes for catchments delineated

Catchment	Discharges (m^3/s)					
	2	*5*	*10*	*25*	*50*	*100*
A	1.09	1.46	1.72	1.85	2.54	4.10
B	1.14	1.52	1.79	1.92	2.65	4.27
C	0.29	0.39	0.46	0.49	0.68	1.10
D	1.12	1.50	1.76	1.90	2.61	4.21

As shown, the return periods considered vary from 2 years to 100 years, which is typical for a hydrological analysis. The choice of the actual drainage design return period to be used however depends on various factors, including the size of the drainage area, the risk of failure, the importance of the structure, and the desired degree of conservatism.

For the drainage area related to catchment zones A, B and D, a minimum of the 1 in 25-year design rainfall event was used for drainage sizing. This is in line with recommendations for flood protection works for minor drainage systems. This includes inlets, street and roadway gutters, roadside ditches, small channels and swales, and small underground pipe systems. These all collect storm water runoff and transport it to control facilities, previous areas and/or the major drainage system (i.e., natural waterways, large impoundments, gullies, rivers, etc.,).

6.3.4 Proposed Drainage Solutions

Design Criteria

The general site drainage for the project was designed according to specific guidelines set out in international drainage manuals and handbooks.

The following guidelines were adopted:

- On site drainage will be designed to accommodate the 25-year return period event;
- Flood protection from rainfall will be designed against the 25-year return period event;
- Lot and building drainage will discharge surface flows to the existing ponds as best as is practical;
- Minimum and maximum velocities in storm drains shall be 1.0m/s and 3.5m/s, respectively;
- Tail water in receiving water bodies will be as follows:
    - Drains and culvert: normal depth for design flow;
    - Ponds, lakes, and rivers: Normal high-water depth; and
    - Sea and shoreline discharge: Mean High Water.

Drainage Design - Onsite Drainage

It is proposed that the natural slopes on the property be maintained to reduce the amount of cut and fill required. In housing/hotel lot groups (such as those in Phase B), the stormwater runoff will sheet flow across the property into the proposed drainage system. The low areas should be filled, and the site properly graded to improve the efficiency and effectiveness to facilitate proper drainage. It is recommended that suitable measures such as landscaped areas, grasscrete pavers and green spaces be maximized to reduce runoff.

Proposed Drainage Features

The objective of the drainage design is to successfully manage the surface flow and ponding on the site by reducing the potential for flooding, scour and poor water quality discharge along the shoreline or into the sea. The drainage master plan includes a combination of open "U" channels along the proposed roadways inside the development, HDPE pipes and grading of the existing land to direct flows to the ponds. A berm with a finished elevation of +2.5m above mean sea level is being proposed along the perimeter of the ponds. This combination of elements is being proposed to handle the flows generated from the catchment associated with the proposed development. The proposed drainage master plan (shown in Figure 6.12) is as follows:

1. Grading of property towards proposed roadways where practical. For lots that have a natural drainage path away from the road, drains to exit points will be implemented.
2. Flows will be mainly handled by drains to the existing ponds, with areas slated for pond creation being allowed to pond naturally.
3. Existing ponds will have a berm of up to 2.5m above MSL crest elevation to allow for increased storage and to reduce breaching during rainfall events.
4. All drains and drainage features will require regular maintenance and clearing to work best.

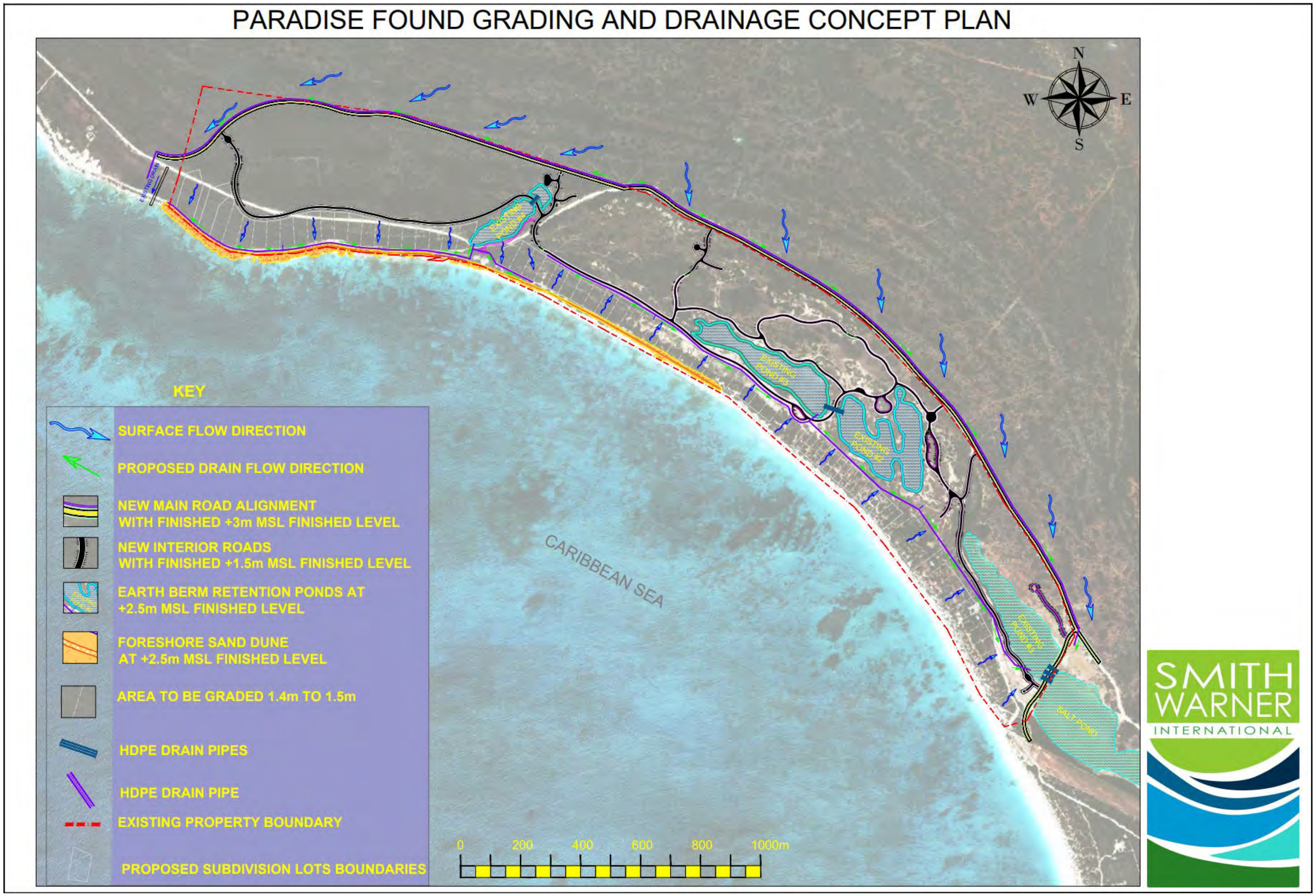

Figure 6.12 Proposed drainage plan

6.3.5 Hydraulics

Road Slopes

It is recommended that the internal roads do not have a gradient in excess of 15%. This will aid in reducing flow velocities off the roadways and reduce the erosion potential.

Drainage Design

The design of the drainage infrastructure was programmed using the Manning's Equation for the design for channels. The Manning's equation is one of the most used equations governing channel flows. It is an empirical equation that applies to uniform flow in channels and is a function of the channel velocity, flow area and channel slope. The drains were designed taking into the consideration recommended values of 1 to 3.5 m/s for velocities.

$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [US]$ $Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [SI]$	Where: Q = Flow Rate, m^3/s (ft^3/s) v = Velocity, m/s (ft/s) A = Flow Area, m^2 (ft^2) n = Manning's Roughness Coefficient R = Hydraulic Radius, m (ft) S = Channel Slope, m/m (ft/ft)

U Channels and HDPE Pipes

Open "U" channels are being proposed along the sides of roadways within the development. The perimeter road drains were designed to accommodate a minimum of $4.3m^3/s$ generated from the 1/25-year event. The north-western lots will have a covered U-drain behind the dune section and along the interior roads. These drains have a design flow of a minimum of $0.51m^3/s$ generated from the 1/25-year event. The central lots have a drain running along the internal road that was designed for a $3.0m^3/s$ flow. Finally, the southern drain behind the phase A lots would have a flow capacity of $1.4m^3/s$.

All drainpipes were designed to accommodate the 1 in 25-year flow ranging from $0.5m^3/s$ to $4.3m^3/s$ to facilitate discharge into existing ponds and drainage features. All HDPE pipes are to be 900mm in diameter.

6.3.6 Drainage Maintenance

The entire drainage network consisting of "U" channels and HDPE pipe culverts, will require regular maintenance and clearing to function properly. It is therefore essential that a maintenance program be developed and maintained to ensure regular cleaning of the drainage systems. The drainage infrastructure should be checked a minimum of once a week for regular maintenance (during the dry season) and after every rainfall event. Additionally, if advisories are issued for storms or heavy rainfall, the drains should be cleaned pre-emptively.

6.3.7 Hydrodynamic Modelling of the Proposed Drainage Solution

The purpose of this exercise was to evaluate the effectiveness of the proposed protective drainage solution in handling the design flood (50-year return period rainfall), as well as to examine the levels of inundation (if any) experienced during the 50-year return period floods, and to propose minimum floor levels for the area surrounding the drainage pathway. Impacts resulting from the discharge hydrodynamics associated with the flood events were evaluated using the two-dimensional MIKE 21 numerical model for both the existing conditions ("do nothing" scenario) and the proposed drainage solution described above. The modelling results were used to predict what would happen during the 24-hour flood event once the proposed solution is implemented.

Figure 6.13 shows the simulation results for a 50-year return period rainfall under existing and proposed conditions. The flow through the site is reduced with the proposed grading in place. The focus of grading effort was along the housing/hotel lots. The areas that have ponding on the site will have a covered concrete drain or HDPE pipe that will carry storm water away from the ponding areas to the existing ponds. In this solution, the existing ponds will have a berm up to 2.5m above MSL. In the simulation, this berm stopped the ponds from breaching under a 50-year rainfall thus providing additional water storage during heavy rainfall events. Overall, the proposed drainage plan can be deemed satisfactory as it performs well under its design 50-year return period flood event.

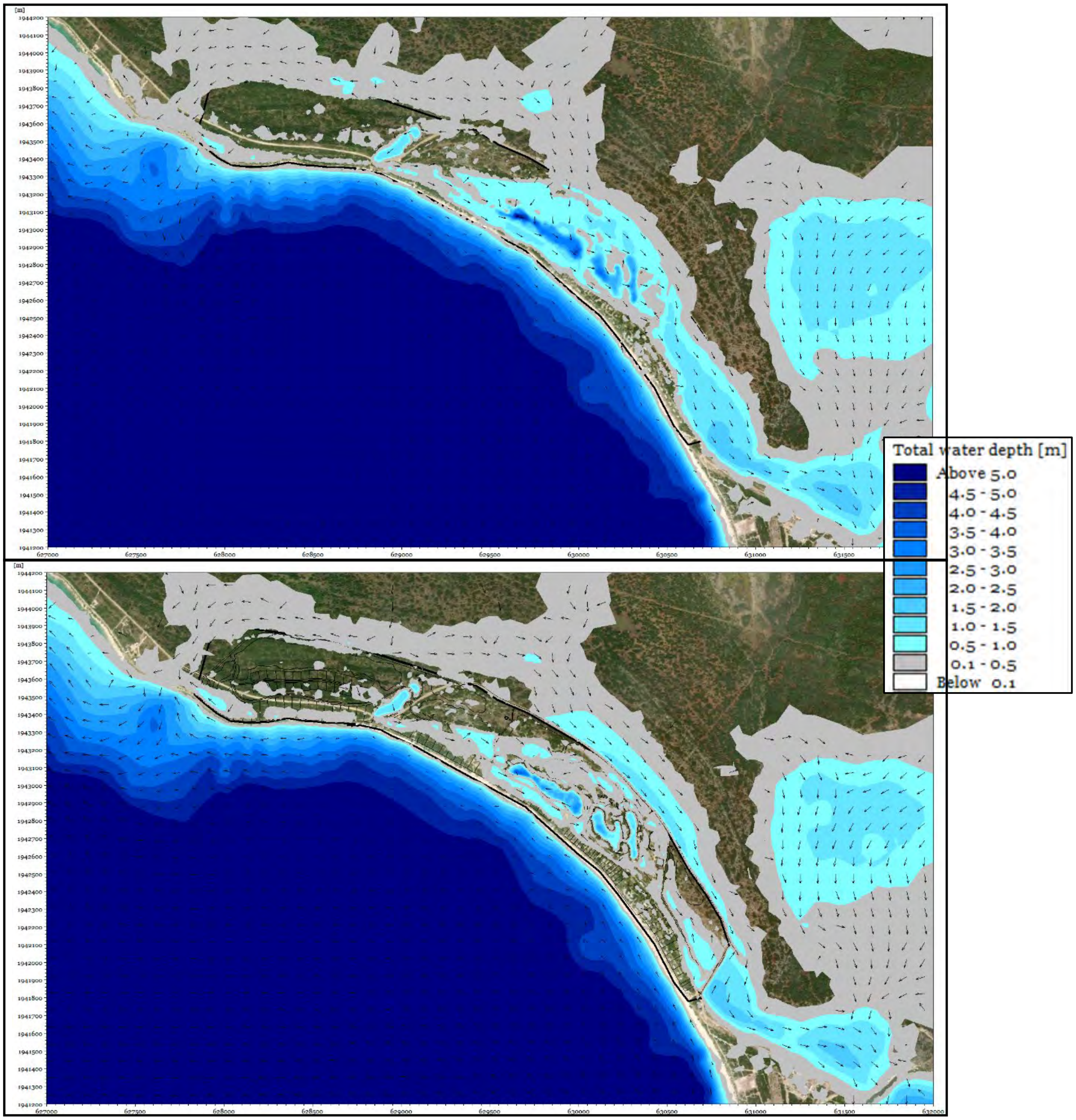

Figure 6.13 Comparison of existing and proposed drainage solutions subjected to a 50-year rainfall event

7 Disaster Management Plan

A Disaster Management Plan (DMP) is attached as Appendix A. It was prepared by Ecoengineering Consultants Limited as, Health, Safety and Environment (HSE) Subconsultant to Smith Warner

International on this assignment. The DMP identifies credible risk scenarios associated with the construction and operation of the development, and sets out procedures for responding to those risks.

The Plan consists of five chapters and an appendix. The document defines an emergency and indicates levels of emergency, describes the proposed Paradise Found Development, addresses emergency preparedness, sets out steps to be taken when managing a risk incident, and presents emergency response procedures for each of the credible risk incidents.

Appendix A DISASTER MANAGEMENT PLAN

PARADISE FOUND DEVELOPMENT, BARBUDA

December 20, 2022

SUBMITTED BY

PRIME CONSULTANT

SMITH WARNER INTERNATIONAL

UNIT 13, SEYMOUR PARK,
2 SEYMOUR AVENUE,
KINGSTON 10, JAMAICA

TELEPHONE: (876) 978 8950

E-mail: info@smithwarner.com

HEALTH, SAFETY AND ENVIRONMENT SUBCONSULTANT

ECOENGINEERING CONSULTANTS LIMITED

62 EASTERN MAIN ROAD
ST. AUGUSTINE
TRINIDAD, WEST INDIES

TELEPHONE: (868) 645 4420
FAX: (868) 662 7292
E-mail: ecoeng@ecoenggroup.com

TABLE OF CONTENTS

Ecoengineering Consultants Limited
62 Eastern Main Road
St. Augustine, Trinidad, West Indies

Phone: (868) 645 4420 Fax: (868) 662 7292 e-mail: ecoeng@ecoenggroup.com

PARADISE FOUND DEVELOPMENT, BARBUDA

DISASTER MANAGEMENT PLAN

December 20, 2022

1 INTRODUCTION

1.1 Authorization and Layout of Plan

This Disaster Management Plan (DMP) is submitted in response to a stipulation in the Terms of Reference (TOR) for an ESIA for this proposed development. It was prepared by Ecoengineering Consultants Limited as, Health, Safety and Environment (HSE) Subconsultant to Smith Warner International on this assignment. This DMP identifies credible risk scenarios associated with the construction and operation of the development, and sets out procedures for responding to those risks.

This Plan consists of five chapters and an appendix. The remainder of Chapter 1 defines an emergency and indicates levels of emergency, describes the background to this assignment, indicates the scope of the DMP and stipulates the distribution of this Plan and when it must be revised. Chapter 2 is a description of the proposed Paradise Found Development in Barbuda, and Chapter 3 pertains to emergency preparedness, providing administrative information and describing steps which must be taken in advance to ensure that emergencies can be addressed in an efficient and effective manner. Chapter 4 sets out steps to be taken when managing a risk incident, and finally Chapter 5 presents emergency response procedures for each of the credible risk incidents.

1.2 Definition and Levels of Emergency

1.2.1 Definition of an Emergency

NOTE: THROUGHOUT THIS DMP, THE TERMS "CREDIBLE RISK", "RISK INCIDENT" AND "EMERGENCY" ARE USED INTERCHANGEABLY.

During the construction and operation of the Paradise Found development, incidents may occur that put at risk the safety and welfare of employees, clients, visitors and the general public due to injuries, illness, negative environmental impacts and property damage/loss. These incidents are defined as emergencies when they cannot be controlled as part of normal construction or operation procedures. Instead, they must be addressed using structured procedures implemented by specially-designated and trained personnel and with designated emergency response equipment and material.

1.2.2 Levels of Emergency

Three levels of emergency are defined in this DMP, based on the personnel and levels of resources required for response:

- A **Level 1 Emergency** is one which can be brought under control by Paradise Found and contractor personnel, using on-site resources. For example, injuries can be treated by site personnel who have been trained in first aid and fires can be put out by on-site personnel using on-site fire extinguishers

- A **Level 2 Emergency** is one where some assistance from on-island personnel and resources are required to bring the situation under control. In this case, for example, injured persons would require treatment at the Hannah Thomas Hospital for and clean up after a storm surge will require assistance from the Barbuda Fire Department or a local cleaning company.

- A **Level 3 Emergency** is one where off-island personnel and resources are required to bring the situation under control. In this case, for example, injuries are serious enough for the victims to be taken to Antigua or beyond for treatment and rebuilding after a hurricane or earthquake will require more skilled artisans, construction equipment and construction material than is available on Barbuda.

1.3 Background

Paradise Found LLC proposes to construct and operate a resort development on approximately 391 acres (158 ha) of land along the south coast of Barbuda, in the vicinity of Gravenor's Bay, Coco Point and Princess Diana Beach (see Figure 1-1). In a letter dated March 5, 2015, the Barbuda Council indicated that this proposal had received the consent of the People of Barbuda; and a Crown Lease was issued for the land on March 9, 2016. Antigua and Barbuda Act No. 21 of 2015, the Paradise Found (Project) Act, 2015, also pertains to this development.

FIGURE 1-1: LOCATION MAP

Development Application #G10-2021 was submitted on April 14, 2021. This was reviewed by the Department of Environment, who recommended that an Environmental Impact Assessment (EIA) be prepared for this development. This recommendation highlighted environmental concerns pertaining to Hydrology and Drainage, Pollution of Wetlands, Desalination and Reverse Osmosis and Climate Change Impacts. Terms of Reference (TOR) were issued to guide the preparation of the EIA, and these stipulated that a Disaster Management Plan be prepared for the development. This document responds to that stipulation.

1.4 Scope of DMP

The scope of this DMP is defined by a Qualitative Risk Assessment which is provided in the Appendix to this Plan. This Risk Assessment identified credible risk incidents associated with this development, and rated them on the basis of consequences and likelihood using a Risk Rating Matrix. The Credible Risks and their ratings are summarized in Table 1-1. Specific response procedures are provided for each credible risk incident in Chapter 5.

TABLE 1-1 CREDIBLE RISKS AND RATINGS

Credible Risk	Rating
Hurricane Winds	Medium
Storm Surges	Medium
Excessive Rainfall	Medium
Drought	Low
Earthquake	Low
Vehicular Accident	Low
Fire in a Building	Medium
Damaged Piping from an LPG Cylinder, leading to a Fire	Low
Spillage from a Diesel Tank, leading to a Fire	Low
Untreated Sewage Discharge Risk	Medium

1.5 Distribution

This Plan will be distributed to the following Organizations and Agencies:

- Paradise Found, Inc (Developer);
- the Contractor(s) on the Project;
- the Barbuda Council;
- the Barbuda Police Service;
- the Barbuda Fire Service,
- Hanna Thomas Hospital, and
- Neighbours who may be affected by a Risk Incident at Paradise Found.

Each revision to the Plan will be distributed to these agencies as soon as they become available (see Section 1.5, below).

DRAFT FOR CLIENT REVIEW

1.6 Revising the Plan

This Disaster Management Plan will be routinely reviewed at least once a year during the construction phase and once every two years during the operation phase of the development. In addition, it will be reviewed after every emergency and after every drill (see Section 3.6). The purpose of these reviews will be to ensure that the plan remains suitable, relevant and adequate to the construction and operations of Paradise Found Development.

If it is deemed necessary to alter any element of the plan in order to improve its overall effectiveness, then these changes will be made by the Contractor's Health and Safety Officer and approved by the Construction Manager during the construction phase, and by Paradise Found's Health and Safety Officer and approved by Paradise Found's Manager during the operation phase. In either case, the plan will be considered to be revised only when it is signed by the persons who made the changes (Issued by) and who approved the changes (Approved by). Each signed revised plan will be circulated to the various agencies listed in Section 1.4, above. Plans that are no longer current will be taken out of circulation.

2 PROJECT DESCRIPTION

This project description is intended to provide information on the proposed Paradise Found Development, so as to facilitate a proper understanding of this Disaster Management Plan. As shown in Figure 1-1, this Development will be situated in the vicinity of Gravenor's Bay, Coco Point and Princess Diana Beach in Barbuda.

Due to the remote location of the project and the current lack of infrastructure on the island of Barbuda, the project must develop much of its own infrastructure and support facilities. The ambition of the project is that it should ultimately be as independent as possible in food, water, and energy. This is reflected in the Updated Masterplan (November 2022) which is shown in Figure 2-1.

2.1 Overview

This development will include the following facilities:

1) Nobu Beach Inn Clubhouse,
2) Guest Villas,
3) Arrival Area,
4) Beach Bar,
5) Nobu Restaurant / Satellite Restaurant,
6) Sales Village,
7) Spa,
8) Tennis and Kids Club,
9) Farm and Nursery,
10) Logistics and Staff Center, and
11) Home Sites.

The development will also include a road network, a drainage system, water supply, electricity supply and a wastewater treatment plant.

The following sections provide information on development under the following headings:

- Built Facilities,
- Farm and Nursery,
- Road Network,
- Drainage System,
- Water Supply,
- Electricity Supply,
- Wastewater Treatment Plant, and
- Road Traffic.

FIGURE 2-1: DEVELOPMENT PLAN

2.2 Built Facilities

The term “built facilities” is used here to include all of the facilities listed above except the farm and nursery. The proposed numbers of accommodation units within the development are shown in Table 2-1:

TABLE 2-1: NUMBERS OF ACCOMMODATION UNITS

FACILITY TYPE	NUMBER OF UNITS
Hotel	17
Hotel Villas	10
Hotel Estates	53
Inland Lots	27

Designs have not yet been completed for these buildings, but one important feature vis-à-vis project risk is that LPG Cylinders (see Photographs 1 and 2) will be installed both at the new restaurant and at individual homes. Based on present practice, the cylinders at the new restaurant are expected to be 100 lb cylinder, while those at the individual homes are expected to be 20 pound cylinders.

100 lb Cylinder

20 lb Cylinder

PHOTOGRAPHS 2-1 AND 2-2: LPG CYLINDERS

2.3 Farm and Nursery

A farm / nursery will be established to grow plants for use in landscaping the development. A small nursery already exists on site.

2.4 Road Network

Roads will be constructed within the site to service the various elements of the development, of which approximately 80% will be unpaved and 20% will be paved. Two main access roads to the project site will be realigned (see Figure 2-2).

Phase 1 of the road realignment will involve re-routing the road towards the perimeter of the property at the north end of the property boundary (adjacent to Barbuda Cottages), while Phase 2 will involve improving and rehabilitating the old existing road that crosses the salt pond at the south end of the property. Currently neglected and dilapidated, this road previously provided access to Coco Point and Princess Diana Beach, and the new road realignment will maintain access to Gravenor's Bay, Coco Point and Princess Diana Beach. Paradise Found intends to restore this road while prioritizing the drainage and flow to the mangrove, thereby improving the ecological health and stability of the mangrove area.

2.5 Drainage System

As the Development is constructed, consideration will be given to catchment zones in each phase, collection of water, transportation or delivery of water, and disposal of water. The collected water will be conveyed in a closed pipe or open channel system to a point of disposal such as a bio-swale, soakaways, detention ponds, or well. Other areas of the development site will be addressed in a more holistic and non-disruptive way. Rainfall will be handled more naturally, incorporating surface runoff and subsurface runoff, understanding that the existing natural ground is one of good percolation and subsurface runoff that conveys the water to the existing ponds and low-lying areas, filtering water as it travels. Rainwater harvesting systems can also be employed in this development, which will also assist in the management of stormwater runoff. The Development intends to use structural, vegetative, and managerial solutions to treat, prevent, and reduce water pollution caused by stormwater runoff.

Paradise Found intends to bolster the strength and health of the mangroves surrounding the salt pond area to protect the pond and the adjacent regions from future storms of all sizes. This will involve transplanting of mangrove plants where possible and restore the mangrove's health by ensuring that its tidal and freshwater hydrology is functioning normally so that the mangrove may repair itself over time.

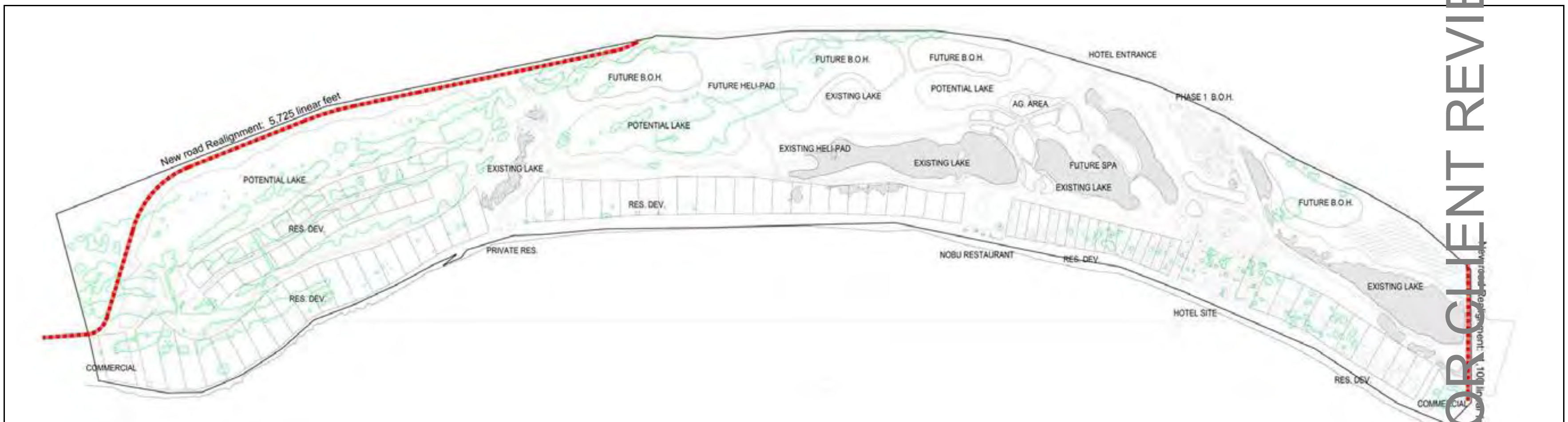

FIGURE 2-2: ROAD REALIGNMENTS 1 AND 2

2.6 Water Supply

Potable water for the hotel and private residences will predominantly be supplied by Flowtronex on-site seawater reverse osmosis desalination plants (SWRO) (there is currently a small SWRO unit and a well on the development site). Additional wells will be required for the new SWRO units. Brine water from the current SWRO unit is discharged into the hypersaline salt pond on site, and the additional SWRO units will either discharge into the same salt pond or into an injection well on the property.

Conscious of the scarcity of fresh water, this demand will be managed by employing water conservation techniques such as rainwater harvesting, installing water-efficient appliances and utilizing drought-tolerant landscape plants and turf grass. The Development plans to incorporate rainwater harvesting into as many community buildings and residential homes.

A minimum of ten days storage supply is planned for the Development. Water from these storage tanks will be piped to individual facilities through a system of buried distribution pipelines, fitted with valves as required. It is envisaged that this flow will be largely by gravity, but pumps will be installed where gravity flow will not be effective.

2.7 Electricity Supply

When fully built out, the projected electrical load demand for the Development will be 1.5MVA. Due to a lack of existing infrastructure on the island, the electrical power demand will initially be met through the use of diesel generators. To fuel these generators, diesel fuel will be stored on site in 9.1 m^3 volume (2.000 imperial gallons / 2,400 US gallons) tanks (see Photograph 2-3). Over time, the reliance on generators will be phased out in favor of more sustainable options, including photovoltaic systems and battery storage. The Development will eventually seek to be energy self-sufficient from these sustainable energy sources, with generators for redundancy.

2.8 Wastewater Treatment Plant

As no municipal wastewater treatment option is available on Barbuda, the Paradise Found development will construct a private facility to treat wastewater produced from the resort, while individual Beachfront Villas will be connected onto their own WWTPs. These will be aerobic treatment units which will produce effluent with a quality as summarized in Table 2-2. Treated effluent will be further disinfected with UV or chlorine and pumped out for landscape irrigation.

PHOTOGRAPH 2-3: EXISTING DIESEL FUEL TANK ON SITE

TABLE 2-2: BIONEST DESIGN EFFLUENT QUALITY

PARAMETER	EFFLUENT CONCENTRATION
pH	6.6 to 7.8
Total Suspended Solids	<2 mg/L
BOD_5	<2 mg/L
COD	<25 mg/L
Total Nitrogen	<12.5 mg/L
Faecal Coliform (after Chlorine Disinfection)	0 CFU/100 mL
Dissolved Oxygen	>3.2 mg/L
Chlorine Residual (after 30 min Contact Time)	>0.5 mg/L

Given the arrangement of wastewater treatment at individual buildings, there will be no need to provide central sewerage throughout the development. Instead, toilet water and gray water will be routed to the wastewater treatment plants through relatively short lengths of buried sewers. Manholes will also be provided where required to facilitate flow or to permit inspection and clearing of chokes.

2.9 Road Traffic

There will be an increase in road traffic during both the construction and operation phases of this Development. During construction, equipment and material must be transported to the site by road. The contractor is likely to bring some construction equipment to the island for use on this project. This will arrive on Barbuda on ships, and will be transported to the site on lowboy trucks. Some construction material will be sourced locally (gravel and sand, premixed cement and asphalt), which will be transported to the site in dump trucks. Other construction material (cement, precast concrete culvert pipes, PVC pipes, roofing sheets, doors and windows, plumbing material and electrical items) will be imported to the island by ship either in shipping containers or as bulk cargo. From the port, these materials will be transported to the site by road.

During the operation of the Development, supplies will be transported to the site in vans and trucks, and waste material will be hauled to the landfill in trucks. Visitors to the Hotel, Villas and Homes will access the site in cars, either owned, taxis or rentals.

3 EMERGENCY PREPAREDNESS

This chapter presents information and describes tasks which must be undertaken before an emergency occurs, to ensure that Paradise Found is prepared to address emergencies in an efficient and effect manner.

3.1 Organization Charts and Responsibilities

This section presents organization charts and describes responsibilities for the construction and operation phases of this project. Responsibilities will be described in significantly more detail in Chapter 5, Emergency Response Procedures.

3.1.1 Construction Phase

Figure 3-1 shows the organization chart for the construction phase of this project. For a disaster which occurs during the construction phase, responsibilities will be as described generally below.

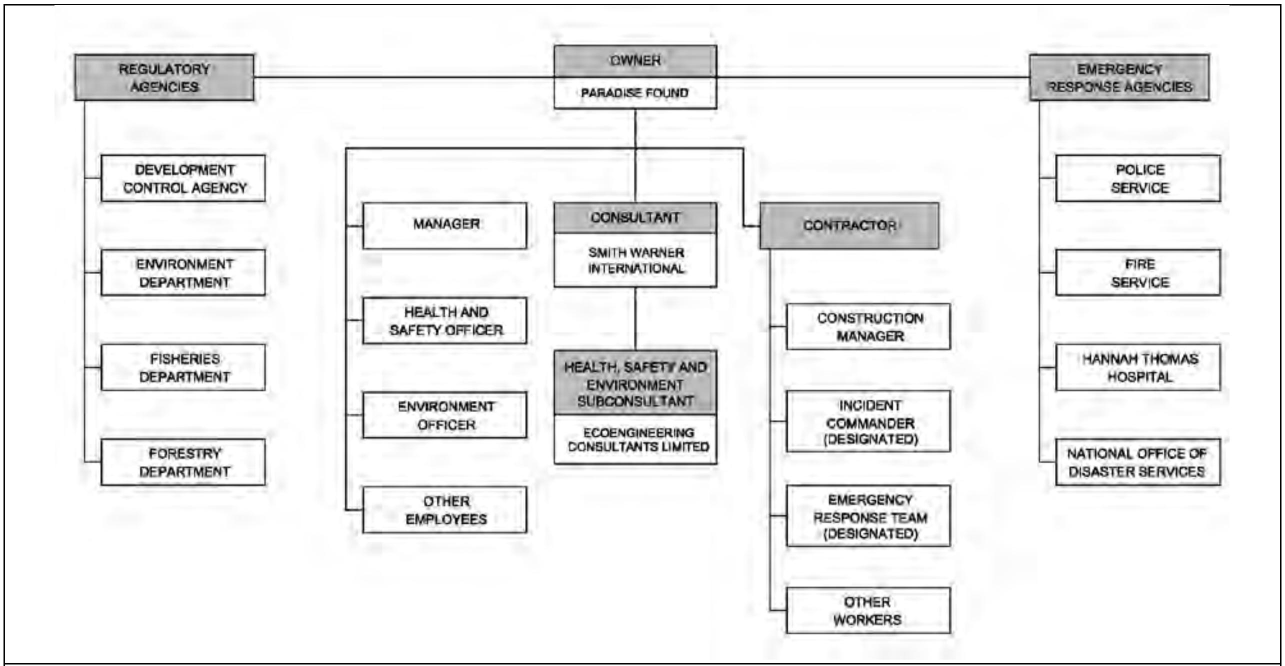

FIGURE 3-1: CONSTRUCTION PHASE ORGANIZATION CHART

a) Paradise Found

During the construction phase, Paradise Found should be staffed with a Manager, a Health and Safety Officer, an Environmental Officer and other staff. As owner of the project, Paradise Found, the Owner, will have the following responsibilities:

- Authorize the spending of funds for implementing the emergency response plan.
- Liaise with and request any additional resources or equipment needed from external agencies.
- Declare and conclude emergencies in consultation with the Contractor and the Consultant. Decision-making will rely on information provided by the National Office of Disaster Services (NODS)., especially in the case of natural disasters.

The Paradise Found Manager will represent Paradise Found in the day-to-day oversight of the construction works and the implementation of the emergency effort. He will supervise the Health and Safety Officer, the Environmental Officer and other employees such as technicians. The Health and Safety and Environmental Officers will assist in assessing the safety and environmental condition of the site following a disaster. They will also verify that the response effort and recovery works are effectively implemented and that the site is suitable for resumption of construction.

The Consultant will liaise with the Owner, the Contractor and the Project Manager in the aftermath of a natural disaster or a fire to advise on:

- The safety of buildings and infrastructure following disasters such as fires, earthquakes and hurricanes which can potentially affect integrity.
- Recovery efforts required for construction to resume.

b) The Contractor(s)

The Contractor will be responsible for constructing the facility and associated works in accordance with the design drawings and specifications. The Contractor's team will be headed by a Construction Manager, who will manage the work of his own staff and subcontractors. His team will also include a designated Incident Commander who will be responsible for the overall management of the response; and an Emergency Response Team which will be made up of firefighters, first aiders, wardens, communications personnel, etc.

The Construction Manager and her/his team will be responsible for:

- Ensuring all information is communicated clearly and calmly to the public and staff.
- Roll call and accountability of all persons at the muster points.

- Ensuring all injured persons are removed from the affected area and are seeking medical care as necessary.

- Reporting to the Paradise Found Manager.

c) Emergency Response Agencies

The Emergency Response Agencies will discharge the following responsibilities:

- The Police Service's responsibilities include:
- ▸ Maintenance of Law and Order,
- ▸ Search and Rescue,
- ▸ Traffic and Crowd Control,
- ▸ Identification of deceased individuals,
- ▸ Establishment of incident command and control.

- The Fire Service's responsibilities include:
- ▸ Assist in detecting, controlling, and suppressing fires.
- ▸ Coordinate national resources for search and rescue operations during an emergency or disaster that is beyond the capabilities of Paradise Found.
- ▸ Search and rescue (land and water).

- Hannah Thomas Hospital will provide ambulance transport and medical attention.

- The National Office of Disaster Services, who will:
- ▸ Inform citizens of an impending or ongoing disaster.
- ▸ Work alongside other first responders, emergency personnel, and private enterprises to reduce the impacts of hazards on the affected site personnel.
- ▸ Verify that adequate evacuation / egress plans exist for Paradise Found.
- ▸ Verify that emergency response plans for Paradise Found are prepared, updated, and implemented as necessary.

d) Regulatory Agencies

Among the Regulatory Agencies:

- The Development Control Authority will advise Paradise Found on rebuilding standards which must be adhered to if buildings and infrastructure which have been damaged or destroyed.

- The Environment, Fisheries and Forestry Departments will be responsible for overseeing the environmental performance of the project. They will also assess damage to environmental components of the site following a hurricane or storm surge and advise on appropriate options which may be adopted during the recovery phase.

3.1.2 Operation Phase

Figure 3-2 shows the organization chart for the operation phase of this project. Responsibilities of the Owner, the Emergency Response Agencies and the Regulatory Agencies are described generally in this section.

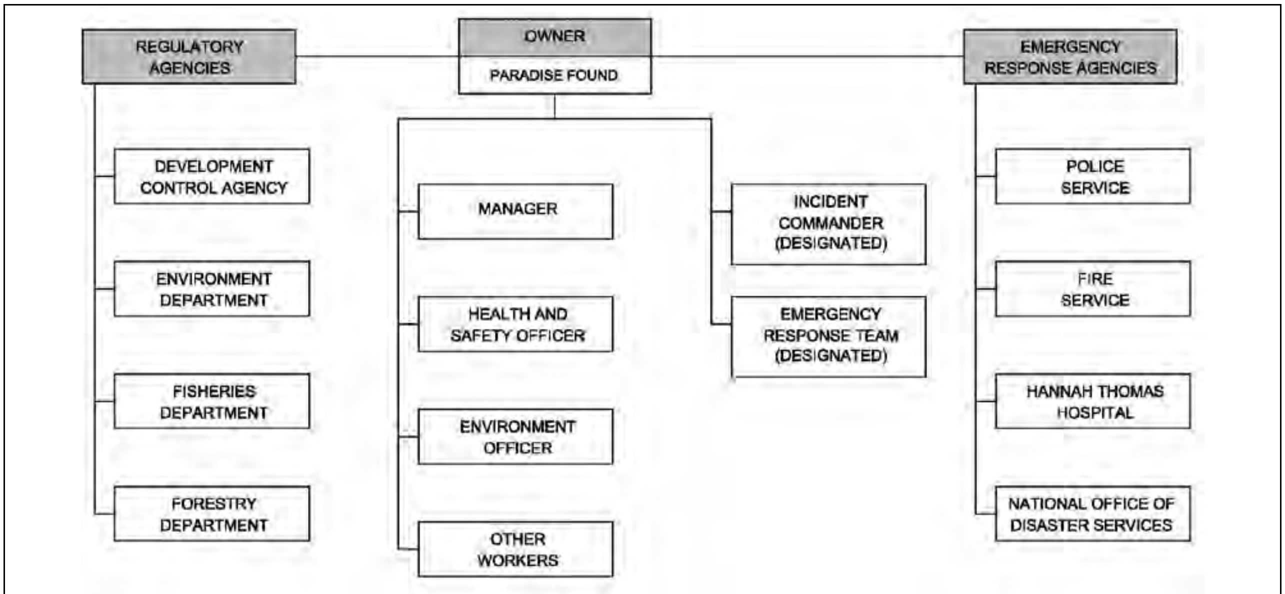

FIGURE 3-2: OPERATION PHASE ORGANIZATION CHART

a) Paradise Found

Staff of Paradise Found during the operation phase should be the same as described in Section 3.1.1 for the construction phase. Paradise Found as Owner will have the following responsibilities:

- o Authorize the spending of funds for implementing the emergency response plan.
- o Liaise with and request any additional resources or equipment needed from external agencies.
- o Designate and train an Incident Commander and an Emergency Response Team.
- o Declare and conclude emergencies.

The Paradise Found Facility Manager will represent the Owner in the day-to-day operation of the resort. oversight of the construction works and the implementation of the emergency effort. He will supervise the Health and Safety Officer, the Environmental Officer and other employees. The Health and Safety Officer will be responsible for accounting for all visitors and staff at the muster points; ensuring all injured persons are removed from the affected area and are seeking medical care as necessary; and assessing the safety of the site for re-entry. Environmental

Officers will assess the environmental condition of the site following a disaster, particularly as it relates to the presence of pollutants. These officers will also verify that the response effort and recovery works are effectively implemented and that the site is suitable for continuation of operations.

In the aftermath of a natural disaster or a fire, Paradise Gardens may need to hire a Consultant to advise on the safety of buildings and infrastructure following disasters such as fires, earthquakes and hurricanes which can potentially affect integrity.

The designated Incident Commander will be responsible for the overall management of the response and overseeing the Emergency Response Team made up of firefighters, first aiders, wardens, communications personnel, etc. He will also liaise with the other members of the response team; obtain up-to-date information and ensure all information is communicated clearly and calmly to the public and staff.

b) Emergency Response Agencies

The responsibilities of specific Emergency Response Agencies comprise:

- The Police Service, whose responsibilities include:
  - Maintenance of Law and Order,
  - Search and Rescue,
  - Traffic and Crowd Control,
  - Identification of deceased individuals,
  - Establishment of incident command and control.

- The Fire Service will:
  - Assist in detecting, controlling, and suppressing fires.
  - Coordinate national resources for search and rescue operations during an emergency or disaster that is beyond the capabilities of Paradise Found.
  - Search and rescue (land and water).

- The Hannah Thomas Hospital will provide ambulance transport and advance emergency medical attention.

- The National Office of Disaster Services who will:
  - inform citizens of an impending or ongoing disaster.
  - Work alongside other first responders, emergency personnel, and private enterprises to reduce the impacts of hazards on the affected site personnel.
  - Verify that adequate evacuation / egress plans exist for Paradise Found.
  - Verify that emergency response plans for Paradise Found are prepared, updated, and implemented as necessary.

c) Regulatory Agencies

The responsibilities of specific Regulatory Agencies comprise:

- The Development Control Authority will advise Paradise Found on rebuilding standards which must be adhered to if buildings and infrastructure which have been damaged or destroyed are to be reconstructed.

- The Environment, Fisheries and Forestry Departments will be responsible for overseeing the environmental performance of the project. They will also assess damage to environmental components of the site following a hurricane or storm surge and advise on appropriate options which may be adopted during the recovery phase.

3.2 Muster Points and Evacuation Routes

Muster points and evacuation routes must be chosen relatively early in the construction and operation phases. Muster points are relatively safe locations where persons can gather when an emergency occurs, to verify that everyone is accounted for and available to receive instructions. On this project, multiple muster points will be required. Evacuation routes will be used to move from the hotel, the villas and houses to the appropriate muster point in each case. Muster points and evacuation routes must be clearly marked and maintained unobstructed throughout the construction and operation phases.

3.3 On-Site Resources

Equipment and materials must be provided on site to respond to emergencies. This will include:

- Buildings designed and designated as Emergency Shelters,
- A Siren System at the Hotel to warn Guests and Staff when an Emergency arises,
- Oversized Water Tanks to provide Fire Fighting Water in storage,
- Fire Extinguishers in the Hotel and in individual Houses,
- Adequately stocked First Aid Kits in the Hotel and in individual Houses,
- Supplies of Non-Perishable Food in the Hotel and in individual Houses,
- Generators at the Hotel for use in case of Loss of Electricity Supply, and
- Walkie-Talkie Radio Sets for use by Incident Commanders and Emergency Response Teams.

3.4 Training

All personnel who will be called upon to respond to an emergency must be trained in advance to carry out their functions. The training will include the following:

- **Construction Manager** and **Paradise Lost Project Manager** must receive project-specific training on what constitutes a risk incident, to whom this information is to be communicated and by what method communication is to be done.
- Designated **Incident Commanders** must be trained in Incident Command and Incident Analysis. Standard courses on these topics are available in the West Indies (for example, in Barbados, Jamaica and Trinidad and Tobago).
- **Other Members of the Incident Response Team** must be trained in First Aid, including CPR. Again, standard First Aid Courses are available in the West Indies (for example, in Barbados, Jamaica and Trinidad and Tobago).

Each training course listed above will have a period of validity (for example, three years in the case of First Aid Training), and training must be repeated before the end of that period of validity in each case.

3.5 Drills

Drills may take the form of desk-top exercises or full-scale exercises. The first two sub-sections below describe these two types of drills, and the third summarizes the frequencies of drills.

3.5.1 Desk-Top Drills

A Desk-Top Drill consists of group discussions where participants talk through the steps which will have to be taken in the event of the type of emergency under consideration, guided by a Moderator. An Auditor will also be present to listen to the discussion and take notes, but the Auditor will not take part in the discussions.

At the end of the Desk-Top Drill, the Auditor will report to the group on:

- What went Right - instances where the group demonstrated a proper understanding of the necessary steps;
- Problems Encountered – instances where particular steps were misunderstood or were forgotten altogether;
- Recommendations for Additional Training - based on the results above; and
- Recommendations of Changes – ways in which specific steps may be altered to improve their effectiveness.

The purpose of the Audit is NOT to assign blame, but rather to continually improve emergency response capabilities.

3.5.2 Full-Scale Drills

During a full-scale drill, personnel are expected to perform the necessary steps under the supervision of the Incident Commander and assisted by the Emergency Response Team. Such drills are vital to ensure that personnel understand and are competent in responding to different types of emergencies. Because they are more disruptive to normal operations, Full-Scale Drills are undertaken less frequently than Desk-Top Drills. Full-Scale Drills are also audited as described for Desk-Top Drills in Section 3.5.1.

3.5.3 Frequency of Drills

Table 3-1 summarizes the topics, types and frequencies of drills on this project.

TABLE 3-1: TOPICS, TYPES AND FREQUENCIES OF DRILLS

TOPIC	TYPE	FREQUENCY	PARTICIPANTS
Tropical Storm and Hurricane Preparedness Drill (including High Winds, Storm Surges and Intensive Rainfall)	Desk-Top	Twice per year, once before the start of the Rainy Season and once during the Rainy Season	- Construction Phase: Building Contractor(s) and Paradise Found Personnel. - Operation Phase: Paradise Found Personnel and available house owners.
Drought Preparedness Drill	Desk-Top	Once per year	Paradise Found Personnel and Landscaping Service Providers.
Earthquake Preparedness Drill	Desk-Top	Twice per year	- Construction Phase: Building Contractor(s) and Paradise Found Personnel. - Operation Phase: Paradise Found Personnel and available House Owners.
Vehicular Accident Drill	Desk-Top	Twice per year	- Construction Phase: Building Contractor(s) and Paradise Found Personnel.

TOPIC	TYPE	FREQUENCY	PARTICIPANTS
			- Operation Phase: Paradise Found Personnel and Available House Owners.
	Full-Scale	Every 18 months	Paradise Found Personnel
Fire Drill	Desk-Top	Twice per year	- Construction Phase: Building Contractor(s) and Paradise Found Personnel.
			- Operation Phase: Paradise Found Personnel and available House Owners.
	Full-Scale	Every 18 months	Paradise Found Personnel and Available House Owners.

3.6 Communication Systems

Several types of communication systems will be used on this project during emergencies, as shown in Table 3-2.

TABLE 3-2: COMMUNICATION SYSTEMS

PARTY 1	PARTY 2	COMMUNICATION SYSTEMS
Paradise Found Manager	Designated Incident Commander	i. Word-of-Mouth, ii. Mobile Phones
Paradise Found Manager or Incident Commander	Police Service, Fire Service, Ambulance or Hannah Thomas Hospital	Telephone (see Contact Numbers in Table 3-3)
Incident Commander	Emergency Response Team Members	i. Mobile Phones, ii. Walkie-Talkie Radios
Paradise Found Manager or Incident Commander	Owners Occupiers of Villas and Houses	Telephone (contact list to be developed and updated continuously by the Paradise Found Manager's Secretary as villas and houses are occupied.
Paradise Found Manager or Incident Commander	Neighbours who may be affected by a Risk Incident at Paradise Found Development	Telephone (contact list to be developed and updated fortnightly by the Paradise Found Manager's Secretary.

TABLE 3-3: PHONE NUMBERS OF KEY RESPONSE AGENCIES

RESPONSE AGENCY	PHONE NUMBER
Hannah Thomas Hospital	+1 (268) 460 0076
Ambulance Service	+1 (268) 736 5100
Fire Service Emergency Numbers	911 or 999
Police Service Emergency Numbers	911 or 999
National Office of Disaster Services	+1 (268) 462 4206

4 MANAGING AN EMERGENCY

This chapter describes the steps in managing an Emergency, as defined in Section 1.2.

4.1 Declaring an Emergency

Identifying an Emergency is the responsibility of the Construction Manager during the construction phase, and the Paradise Found Manager during the operation phase. As soon as an Emergency is identified, the Construction Manager or the Paradise Found Manager will declare the Emergency and notify the designated Incident Commander.

4.2 Activating the System

Immediately upon being notified that an Emergency has been declared, the Incident Commander will assume responsibility for activating and implementing the Emergency Response System. Activating the system will consist of the following actions:

- Assemble the Emergency Response Team.
- Rapidly analyse the incident and identify at-risk parties.
- Notify at-risk parties of the emergency.
- Determine the level of emergency (see Section 1.2.2).
- Notify the Hospital, Ambulance Service, Fire Service and Police Service of the emergency. This notification will be <u>for immediate action</u> in the case of Level 2 or Level 3 emergencies, but <u>for information only</u> in the case of a Level 1 Emergency.

Communication systems in each case are listed in Section 3.6.

4.3 Release of Equipment and Material

Once an Emergency has been declared, the Construction Manager and the Paradise Found Manager must instruct their subordinates that equipment and material on the site are to be released to the Incident Commander upon request for use in emergency response. The person releasing equipment and material must keep lists of what has been handed over, including the date and time of handing over.

4.4 Risk Reduction Measures

The heart of this Disaster Management Plan, as with any Emergency Response Plan, is the implementation of risk reduction measures. This task may be required in the design phase, the construction phase or the operation phase of the project, depending on the nature of the measures to be implemented. Table 4-1 summarises risk reduction measures to be implemented on the Paradise Found Development.

TABLE 4-1: SUMMARY OF RISKS AND RISK REDUCTION MEASURES

RISK	BRIEF DESCRIPTION	RISK REDUCTION MEASURES	RISK SIGNIFI-CANCE
Hurricane Winds	Wind associated with a major hurricane (Category 3 or higher)	o Design buildings to resist wind loads as prescribed in the Caribbean Unified Building Code (CUBiC). o Inform arriving visitors about evacuation procedures. o Arrange for evacuation when a hurricane watch or warning is issued. o Provide specially-reinforced buildings within the development to serve as hurricane shelters for staff and any visitors who cannot (or decide not to be) evacuated ahead of the arrival of a hurricane.	**MEDIUM**
Storm Surges	Surges resulting from a tropical cyclone passing through the Region.	o Observe the 100 foot (30 m) setback which has been established for Barbuda. o Design shoreline buildings on 8 to 10 foot (2.4 to 3 m) stilts to cater for storm surges.	**MEDIUM**
Excessive Rainfall	Intensive rainfall resulting from a tropical cyclone crossing or close to Antigua and Barbuda, or due to other weather phenomena.	Design the on-site drainage system to efficiently remove storm water from the vicinity of buildings and landscaped areas (this will reduce but not entirely eliminate consequences of an excessive rainfall event).	**MEDIUM**
Drought	Mechanical failure of a desalination plant during a	o Stand-by arrangements for the purchase of potable water	**LOW**

RISK	BRIEF DESCRIPTION	RISK REDUCTION MEASURES	RISK SIGNIFI-CANCE
	period of drought.	until the desalination plant is repaired. o Arrange for the timely repair of the desalination plant, including the availability of skilled technicians and the purchase of parts.	
Earthquake	Antigua and Barbuda are situated in a seismically-active zone and have experienced tremors and aftershocks.	Design earthquake-resistant structures as specified in the Caribbean Unified Building Code (CUBiC).	**LOW**
Vehicular Accident	Accident involving a truck during the construction phase, or cars, vans and trucks during the operation phase.	o Provided Defensive Driving training for employees of the development, especially those who drive trucks. o Car rental companies must ensure that the guest who will be driving have valid drivers licenses, and are aware that driving in Barbuda is on the left hand side of the road.	**LOW**
Fire in a Building	Fire in any building at the hotel, the villas or the individual houses.	o Provide Fire Hydrants every 100 feet (30 m) along the roads within the Development. o Store of Water for Fire Fighting within the Development. o Provide Fire Alarms and Sprinkler Systems in each building. o Inform visitors about fire alarm and evacuation procedures.	**MEDIUM**
Risk at an LPG Cylinder	Damaged piping from a 100 lb or 20 lb LPG cylinder, leading to a fire	o Shut off the Cylinders when they are not in use, and o Routinely inspect the LPG piping for signs of damage or rusting, and replace if these are found.	**LOW**

RISK	BRIEF DESCRIPTION	RISK REDUCTION MEASURES	RISK SIGNIFI-CANCE
Risk at a Diesel Tank	Spillage from a diesel tank, leading to a fire	o Adhere to the standard practice of providing Secondary Containment around the Diesel Tank, o Remove spilled Diesel from the Secondary Containment as soon as practicable, and o Provide a foam-type Fire Extinguisher within the Development.	**LOW**
Untreated Sewage Discharge Risk	Arises out of the failure of one or several of the 91 sewage treatment systems which will be constructed at the hotel, the villas and the houses; leading to eutrophication in the receiving pond and/or human health concerns.	o Select wastewater treatment systems that are adequately sized to receive the combination of toilet waste and grey water from the hotel, villas and houses; o Carefully choose the types of chemicals which are used in toilets, sinks and bathrooms and for laundering at the hotel, villas and houses; so that they are not incompatible with the aeration of aerobic wastewater treatment systems. o Maintain and repair all of the wastewater treatment systems in strict accordance with the manufacturer's recommendations. To facilitate this, have a standing arrangement with a suitably competent firm to undertake this work on a regular schedule.	**MEDIUM**

4.5 Evacuation (When Necessary)

All Emergencies do not require evacuation, but arrangements must be made in advance to effect rapid evacuation if this becomes necessary. Such arrangements would include:

- o Designate members of the Emergency Response Team to check buildings to ensure that no one is left behind.
- o Provide wheel chairs and stretchers, with attendants, to remove persons who require assistance (elderly persons, the infirm and those who may be affected by smoke inhalation).
- o Arrange for vehicles to transport persons off-site, as required.
- o Activate emergency shelters, as required.

4.6 Ending an Emergency

When an Emergency has been brought fully under control and risks have been eliminated, the Incident Commander will declare that it is ended. Buildings and areas must be assessed by competent persons for safe re-entry and safe resumption of construction or operation work. The members of the Emergency Response Team will return to their normal duties, and other persons can return to the locations from which they were evacuated. Equipment which was released for use in emergency response will be returned to the persons from whom it was obtained, along with any unused materials.

4.7 Post-Emergency Review

As soon as convenient after the Emergency has ended, a Post-Emergency Review should be conducted. Participants should include the Paradise Found Manager, the Construction Manager (if the emergency was during the construction phase), the Incident Commander, the Emergency Response Team and representatives of Government Response Agencies (if available). As with drills (see Section 3.5), the review should focus on:

- o What went Right - instances where the steps taken were effective in addressing the emergency and reducing risk;
- o Problems Encountered – instances where particular steps were not effective or could not be undertaken for practical reasons;
- o Recommendations of Changes – ways in which specific steps may be altered to improve their effectiveness, and
- o Recommendations for Additional Training - based on the results above.

Again, the purpose of the Review is **NOT** to assign blame, but rather to continually improve emergency response practices. Information from this post-emergency review is to be used to revise and update the Disaster Management Plan, as appropriate.

5 EMERGENCY RESPONSE PROCEDURES

This chapter outlines general procedures for a number of critical incidents, including natural disasters that may occur during the construction and operation of the development. These include:

- o Hurricane Winds,
- o Storm Surges or Excessive Rainfall,
- o Drought,
- o Earthquake,
- o Vehicular Accident,
- o Fire, and
- o Untreated Sewage Disposal Risk.

5.1 Hurricane Winds

Antigua and Barbuda have experienced a total of 21 tropical cyclones (tropical storms and hurricanes) since 1950, of which 6 were major hurricanes. Given the type of damage which can result from hurricane winds, Paradise Found must ensure that there are specially-reinforced buildings within the development to serve as hurricane shelters for staff and any visitors who cannot (or decide not to) be evacuated ahead of the arrival of a hurricane, and ensure access to such buildings as needed.

As a hurricane approaches Barbuda, the National Office of Disaster Services (NODS) will issue a Hurricane Watch to indicate a possible threat within 48 hours, followed by a Warning to indicate that a hurricane is expected in 36 hours or less. On being informed of a Hurricane Watch for the island, steps will be taken to protect people and equipment such that construction or operation can resume efficiently afterwards. The following actions will be taken on receipt of official bulletins from NODS.

5.1.1 Construction Phase Emergency Response

For Hurricanes which arise during the Construction Phase:

a) The Incident Commander will:

- o Declare the level of the emergency depending on the severity of the tropical cyclone; and update the level of emergency if the intensity of the hurricane changes.

- o Assemble the Emergency Response Team.

- o Assume control of Emergency Shelters.

- o Arrange for inspecting / “sweeping” areas to ensure all personnel and visitors have been accounted for.

- Coordinate emergency response at Paradise Found with national emergency response efforts.
- Notify external agencies such as Fire Service, Police Service and the Hospital if rescue or medical attention are required.
- Issue evacuation orders (when appropriate).
- Request from the Contractor any additional equipment or materials that are needed for emergency response.
- Advise the Paradise Found Manager of any injuries so that the next of kin may be notified.
- Declare when the emergency has ended, on advice from Government Agencies.

b) The Contractor will:

- Ensure that glass windows are boarded up when a Hurricane Warning is issued.
- Ensure that fuel reserves for generators are filled and units are operational.
- Secure equipment and materials onsite or remove them to a safe storage location.
- Send workers home sufficiently early to ensure that on-site personnel are out of harm.
- Ensure that all workers who remain on site have safe accommodation and arrange for temporary accommodation / shelters for workers.
- Select and notify the employees who are to return to the site after the storm has passed.
- Provide or acquire any additional equipment or material needed from emergency response as requested by the Incident Commander.
- Inform the Incident Commander of any injuries or fatalities.
- Notify workers of the all clear once the Incident Commander has declared that the emergency has ended.

Throughout any incident response period, the Contractor will inform and update the Paradise Found Manager of actions taken.

c) The Paradise Found Manager will notify the next-of-kin of any injured persons.

d) Staff, Visitors and Other Persons who remain on site will:

- Remain in a safe area and not attempt to evacuate or leave the area unless absolutely necessary or when instructed to do so by a member of the Emergency Response Team.
- Check their surroundings for hazards (such as debris, flooding, etc.), and report such to the Emergency Response Team.
- Notify the Emergency Response Team of any injured persons.
- Provide assistance to the Emergency Response Team as and when requested.

5.1.2 Operation Phase Emergency Response

For Hurricanes which arise during the Operation Phase, the basic approach would be to evacuate visitors from Barbuda as long as there is sufficient advance notice and the ferries and planes continue to operate. The Paradise Found Manager and her / his staff will assist visitors in arranging flights and getting them to the airport or sea port. In addition:

a) The Incident Commander will undertake the same tasks as listed in Section 5.1.1(a), except that equipment and material will be requested from the Paradise Found Manager.

b) The Paradise Found Manager will undertake the tasks listed for the Contractor in Section 5.1.1(b), and will notify the next-of-kin of any injured persons (see Section 5.1.1(c).

c) On-site Personnel and Visitors will undertake the same tasks as listed in Section 5.1.1(d).

5.2 Storm Surges or Excessive Rainfall

Tropical Cyclones (tropical storms and hurricanes) may result in storm surges and excessive rainfall which can cause flooding of the site, but storm surges may also result from tropical cyclones passing some distance from Barbuda and excessive rainfall may occur independent of tropical cyclones. Periods of excessive rainfall are normally forecast by the Meteorological Office, but forecasting of storm surges is not available. Following the declaration of an Emergency arising from a storm surge or excessive rainfall by the Construction Manager (construction phase) or the Paradise Found Manager (operation phase), the following actions will be undertaken.

5.2.1 Construction Phase Emergency Response

For Storm Surges or Excessive Rainfall which occur during the Construction Phase:

a) The Incident Commander will:

- o Declare the level of the emergency depending on the level of damage which has been experienced.
- o Assemble the Emergency Response Team.
- o Assume control of on-site Emergency Shelters.
- o Arrange for inspecting / “sweeping” areas to ensure all personnel and visitors have been accounted for.
- o If an island-wide emergency response effort has been mounted, coordinate the Paradise Found emergency response with that effort.
- o Notify external agencies such as Fire Service, Police Service and the Hospital if rescue or medical attention are required.
- o Issue evacuation orders (when appropriate).
- o Request from the Contractor any additional equipment or materials that are needed for emergency response.
- o Advise the Paradise Found Manager of any injuries so that the next of kin may be notified.
- o Declare when the emergency at Paradise Found has ended.

b) The Contractor will:

- o Fuel generators and bring them into use as required. If on-site generators have been damaged by flooding, replacement units must be obtained as soon as practical.
- o Secure equipment and materials onsite or remove them to a safe storage location.
- o Send home workers who are not immediately required for the emergency response, but advise them when they should return to work.
- o Ensure that all workers who remain on site have safe accommodation and arrange for temporary accommodation / shelters for workers.
- o Provide or acquire any additional equipment or material needed from emergency response as requested by the Incident Commander.

- Inform the Incident Commander of any injuries or fatalities.
- Notify workers of the all clear once the Incident Commander has declared that the emergency at Paradise Found has ended.

Throughout any incident response period, the Contractor will inform and update the Paradise Found Manager of actions taken.

c) The Paradise Found Manager will notify the next-of-kin of any injured persons.

d) Staff, Visitors and Other Persons who remain on site will:

- Remain in a safe area and leave the area when instructed to do so by a member of the Emergency Response Team.
- Check their surroundings for hazards (such as debris, flooding, etc.), and report such to the Emergency Response Team.
- Notify the Emergency Response Team of any injured persons.
- Provide assistance to the Emergency Response Team as and when requested.

5.2.2 Operation Phase Emergency Response

For Storm Surges or Excessive Rainfall which occur during the Operation Phase:

a) The Incident Commander will undertake the same tasks as listed in Section 5.2.1(a), except that equipment and material will be requested from the Paradise Found Manager.

b) The Paradise Found Manager will undertake the tasks listed for the Contractor in Section 5.2.1(b) and will notify the next-of-kin of any injured persons (see Section 5.2.1(c)).

c) On-site Personnel and Visitors will undertake the same tasks as listed in Section 5.1.1(d).

5.3 Drought

This emergency relates to a mechanical failure of a desalination plant at the time of a drought. Such an event can affect both construction and operation of Paradise Found Development, but it will be more significant during operation of the resort because of the potentially large number of visitors who will be present on a continuous basis.

This is one type of emergency when the Incident Commander may not assume control of the situation and call up the Emergency Response Team. Instead, desalination plant failure during a drought can be managed by the Construction Manager (construction phase) or the Paradise Found Manager (operation phase).

5.3.1 Construction Phase Emergency Response

In the event of the mechanical failure of an on-site desalination plant during a drought during the construction phase,

a) the Contractor will:

- Liaise with the Paradise Found Manager to request an emergency water supply from off-site sources.
- Temporarily discontinue construction work activities which require a significant water supply.
- Temporarily demobilize construction workers from the site, keeping only Security Personnel, the Incident Commander and Members of the Emergency Response Team in case another type of emergency should arise.

b) the Paradise Found Manager will:

- Assist the Contractor in obtaining an emergency water supply from off-site sources.
- Temporarily discontinue high-water-demand activities such as watering of landscaped areas.
- Temporarily demobilize employees from the site, keeping only Supervisory Staff and Security Personnel who are required to secure and maintain the site.

c) All personnel who remain on site while the desalination plant is non-functional will obey all emergency water conservation measures temporarily instituted by the Construction Manager or the Paradise Found Manager.

5.3.1 Operation Phase Emergency Response

In the event of the mechanical failure of an on-site desalination plant during a drought during the operation phase,

a) the Paradise Found Manager will:

- Request an emergency water supply from off-site sources.

- Respond to the needs of any visitors who encounter a situation where water is critically needed.

- Advise all guests of the situation and the length of time that it is expected to take to repair the desalination plant.

- Assign administrative staff to assist guests who decide to leave in making travel arrangements.

- Temporarily discontinue high-water-demand activities such as circulating water in swimming pools and watering of landscaped areas.

- Temporarily demobilize employees from the site, keeping only Supervisory Staff, Security Personnel and a Skeleton Staff to maintain the reduced operation of the Development.

b) All persons (staff, homeowners and visitors) who remain on site while the desalination plant is non-functional:

- Must obey all emergency water conservation measures temporarily instituted by the Paradise Found Manager.

- Will advise the Paradise Found Manager if any situations arise where water is critically needed.

5.4 Earthquake

In the event of an earthquake, all personnel must take cover to protect themselves until tremors have subsided. Emergency response can then commence. Following the declaration of an Emergency arising from earth tremors and aftershocks by the Construction Manager (construction phase) or the Paradise Found Manager (operation phase), the following actions will be undertaken.

5.4.1 Construction Phase Emergency Response

If an earthquake occurs during the construction phase,

a) The Incident Commander will:

- Declare the level of the emergency depending on the severity of damage caused by the tremors and aftershocks; and update the level of emergency if the intensity of the hurricane changes.

- Assemble the Emergency Response Team.

- Assume control of on-site Emergency Shelters.
- Arrange for inspecting / “sweeping” areas to ensure all personnel and visitors have been accounted for.
- On completion of the structural inspection by the Contractor, declare and cordon off any areas of the site that are unsafe and therefore access by untrained personnel is not permitted.
- Coordinate emergency response at Paradise Found with national emergency response efforts.
- Notify external agencies such as Fire Service, Police Service and the Hospital if rescue or medical attention are required.
- Issue evacuation orders (when appropriate).
- Request from the Contractor any additional equipment or materials that are needed for emergency response.
- Advise the Paradise Found Manager of any injuries so that the next of kin may be notified.
- Declare when the emergency has ended when the site has been rendered safe and all injured persons have been cared for.

b) The Contractor will:

- Conduct a head count of construction workers and advise the Incident Commander of any persons who are not accounted for.
- Verify that emergency access / egress routes are clear and safe.
- Control persons entering the site.
- Conduct an inspection of buildings and structures and inform the Incident Commander of any buildings and structures which are unsafe.
- Ensure that generators are fuelled and operational.
- Secure equipment and materials onsite or remove them to a safe storage location.
- Send non-essential workers home in a timely fashion to ensure that on-site personnel are out of harm.

- Ensure that all workers who remain on site have safe accommodation and arrange for temporary accommodation / shelters for workers.
- Inform workers when they are expected to return to work.
- Provide or acquire any additional equipment or material needed for emergency response as requested by the Incident Commander.
- Inform the Incident Commander of any injuries or fatalities.
- Notify workers of the all clear once the Incident Commander has declared that the emergency has ended.

Throughout any incident response period, the Contractor will inform and update the Paradise Found Manager of actions taken.

c) The Paradise Found Manager will notify the next-of-kin of any injured persons.

d) Staff, Visitors and Other Persons who remain on site will:

- Remain in a safe location until the tremors have abated and departure from the site is approved by the Incident Commander.
- Check their surroundings for hazards (such as fire, spills, hazardous structures etc.), and notify a member of the Emergency Response Team of such hazards.
- Notify a member of the Emergency Response Team of any injured persons.
- Provide assistance to the Emergency Response Team as and when requested.

5.4.2 Operation Phase Emergency Response

For tremors and aftershocks which occur during the operation phase,

a) The Incident Commander will undertake the same tasks as listed in Section 5.4.1(a), except that equipment and material will be requested from the Paradise Found Manager.

b) The Paradise Found Manager will undertake the tasks listed for the Contractor in Section 5.4.1(b) and will notify next of kin of injured persons (see Section 5.4.1(c).

c) On-site Personnel and Visitors will undertake the same tasks as listed in Section 5.4.1(d).

5.5 Vehicular Accident

Vehicular accidents are another instance when deployment of the full Emergency Response Team may not be necessary. Depending on how far the accident occurs from the site, the Police and Ambulance may arrive on the scene before personnel can be mobilized from the site, and they will begin emergency response without awaiting the arrival of Contractor or Paradise Found personnel. Notwithstanding, at least the Incident Commander must visit the scene of the accident as soon as practical after it has occurred. Therefore, the Incident Commander must be dispatched to the scene by the Construction Manager (if the accident has occurred during the construction phase), or by the Paradise Found Manager (if the accident has occurred during the operation phase). In addition, at least two members of the Emergency Response Team should be put on standby until the Incident Manager has evaluated the seriousness of the accident.

Upon arrival at the scene of the accident, the Incident Commander will:

- Initiate first aid to injured parties if she/he arrives before the ambulance, or assist the ambulance personnel if they arrive first.
- Call in other members of the Emergency Response Team if additional help is required.
- Advise the Paradise Found Manager of the names of injured parties so that the next of kin can be notified.
- Establish the Level of Emergency. An accident will always start as a Level 2 Emergency because the Police will be involved, but it may escalate to a Level 3 Emergency if the doctors at Hannah Thomas Hospital determine that injuries are so severe that the patients must be taken off-island for treatment.
- Gather and document information on the nature of the accident and possible causes, as well as the names and contact information of the Police Officers on the scene and any witnesses.

5.6 Fire

A fire can occur in a building or can result from a leak at the diesel tank or from a gas leak from LPG cylinders. Following the declaration of an Emergency related to a fire on site by the Construction Manager (construction phase) or the Paradise Found Manager (operation phase), the following actions will be undertaken.

5.6.1 Construction Phase Emergency Response

a) The Incident Commander will:

- Declare the level of the emergency depending on the size of the fire and the risk of spreading; and update the level of emergency if the fire escalates.

- Assemble the Emergency Response Team.

- Inform the Fire Service of the Fire, and clearly indicate whether they are required on site.

- Assume control of on-site Emergency Shelters.

- Designate a sufficient Exclusion Zone around the Fire where only the Fire Service and the Emergency Response Team may enter.

- Arrange for inspecting / “sweeping” areas to ensure all personnel and visitors have been accounted for.

- Call out the Fire Service if the Fire threatens to escalate beyond the capability of on-site resources to contain it and extinguish it.

- Notify external agencies such as Ambulance Service, Police Service and the Hospital if rescue or medical attention are required.

- Issue evacuation orders (when appropriate).

- Request from the Contractor any additional equipment or materials that are needed for emergency response.

- Advise the Paradise Found Manager of any injuries so that the next of kin may be notified.

- Declare when the emergency has ended, on advice from Government Agencies.

b) The Contractor will:

- Ensure that all valves are open to permit the free flow of water from the Fire Water Tank to the Hydrants closest to the Fire.

- Ensure that generators are fuelled and operational.

- Conduct a head count of all Construction Workers to ensure that they are all accounted for.

- Secure equipment and materials onsite or remove them to a safe storage location.

- Send non-essential workers home in a timely fashion to ensure that on-site personnel are out of harm.

- Ensure that all workers who remain on site have safe accommodation and arrange for temporary accommodation / shelters for workers.

- Select and notify the employees who are to return to the site after the fire has been extinguished.

- Provide or acquire any additional equipment or material needed for emergency response as requested by the Incident Commander.

- Inform the Incident Commander of any injuries or fatalities.

- Notify workers of the all clear once the Incident Commander has declared that the emergency has ended.

Throughout any incident response period, the Contractor will inform and update the Paradise Found Manager of actions taken.

c) The Paradise Found Manager will notify the next-of-kin of any injured persons.

d) Staff, Visitors and Other Persons who remain on site will:

- Remain in a safe location until the fire has been extinguished and entry into restricted areas has been approved by the Incident Commander.

- Check their surroundings for hazards (such as smoldering material, spills of fuel or lubricants, hazardous structures, etc.), and notify a member of the Emergency Response Team of such hazards.

- Notify a member of the Emergency Response Team of any injured persons.

- Provide assistance to the Emergency Response Team as and when requested.

5.6.2 Operation Phase Emergency Response

For fires which occur during the operation phase,

a) The Incident Commander will undertake the same tasks as listed in Section 5.6.1(a), except that equipment and material will be requested from the Paradise Found Manager.

b) The Paradise Found Manager will undertake the tasks listed for the Contractor in Section 5.6.1(b) as well as notify next-of-kin of injured persons as indicated in Section 5.6.1(c).

c) On-site Personnel will undertake the same tasks as listed in Section 5.6.1(d).

5.7 Untreated Sewage Discharge Risk

This is yet another type of emergency where the Incident Commander and full Emergency Response Team need not be mobilized. Instead, the response can be managed by the Construction Manager (during the construction phase) or the Paradise Found Manager (during the operation phase.

a) When it is discovered that a sewage treatment system has failed, the appropriate manager will:

- Notify all staff, construction workers and visitors of the situation.
- Contact the Supplier of the Sewage Treatment System (construction phase) or the contracted Repair and Maintenance Service Provider and arrange for them to come to the site and attend to the problem in the shortest time practical.
- Arrange to have an Engineer trace the path by which untreated sewage is flowing to one of the ponds.
- In consultation with the appropriate Health, Safety and Environment Officers, establish a Restricted Zone around the receiving salt pond.
- Ensure that any person who begins to show symptoms of a gastro-intestinal illness is taken to see a private doctor or taken to the Hannah Thomas Hospital.

b) All other persons on site must obey the restricted zone to avoid contact with sewage-contaminated water.

APPENDIX:

QUALITATIVE RISK ASSESSMENT

SMITH WARNER INTERNATIONAL

EIA FOR PARADISE FOUND RESORT DEVELOPMENT

DISASTER MANAGEMENT PLAN:
QUALITATIVE RISK ASSESSMENT

This Qualitative Risk Assessment, which forms an appendix to the Disaster Management Plan for Paradise Found Development in Barbuda, begins with an Initial Risk Identification, followed by description of the Risk Rating Method. Each succeeding section pertains to the rating of a specific Credible Scenario.

DRAFT FOR CLIENT REVIEW

A.1 INITIAL RISK IDENTIFICATION

Risks associated with this development include those arising from Natural Hazards as well as those arising from project activities. Led by Ecoengineering Consultants Limited (Ecoeng), the Smith Warner International (SWI) Team identified the following risks for analysis:

- Hurricane Winds,
- Storm Surges,
- Excessive Rainfall,
- Drought,
- Earthquake,
- Vehicular Accident,
- Fire in a Building,
- Risk at an LPG Cylinder (damaged piping from an LPG Cylinder, leading to a Fire),
- Risk at a Diesel Tank (spillage from a Diesel Tank, leading to a Fire), and
- Untreated Sewage Discharge Risks.

Useful information pertaining to each of these risks was obtained during meetings with Government Agencies in July, 2022. Based on that information and Ecoeng's considerable experience in preparing Qualitative Risk Assessments (QualRAs), these risks were developed into Credible Scenarios (see subsections below).

The Terms of Reference for the EIA for Paradise Found Development suggests that climate change risk should also be addressed in this DMP. Projected effects of climate change in the West Indies[1] include:

- More Frequent and More Intense Tropical Storms and Hurricanes,
- Longer Dry Seasons and Shorter Wet Seasons,
- Rise in Sea Levels and Increased Likelihood of Storm Surges,
- More Intense Rains leading to Increased Flash Floods.

All of these effects are included among the risks listed above, so a separate analysis of climate change risk to this Development was not considered necessary.

[1] https://www.caribbeanclimate.bz/blog/2013/06/25/climate-change-and-the-caribbean-what-do-we-need-to-know/

A.1.1 Hurricane Winds

This Credible Scenario relates to wind associated with a major hurricane (Category 3 or higher). Antigua and Barbuda have experienced a total of 21 tropical cyclones[2] (tropical storms and hurricanes) since 1950, of which 6 were major hurricanes:

- Baker[3] in 1950 – Category 3 with sustained winds of 185 km/h in the vicinity of Antigua and Barbuda;
- Dog[4] in 1950 - Category 4 with sustained winds of 130 km/h and gusts of 144 km/h in the vicinity of Antigua and Barbuda;Donna[5] in 1960 – Category 3 in the vicinity of Antigua and Barbuda;
- Luis[6] in 1995 – Category 4 with sustained winds of 217 km/h in the vicinity of Antigua and Barbuda;
- Georges[7] in 1998 – Category 3 with sustained winds of 151 km/h and gusts up to 186 km/h in the vicinity of Antigua and Barbuda; and
- Irma[8] in 2017 – Category 5 with sustained winds of 285 km/h in the vicinity of Antigua and Barbuda.

A.1.2 Storm Surges

Unlike Hurricane Winds, which are worst when hurricanes pass over or close to Barbuda, Storm Surges may also be generated by tropical cyclones that pass some distance from Barbuda. Information provided by the Development Control Authority at a meeting on July 14, 2022, is that storm surges of 8 to 10 feet (2.4 to 3 m) have been experienced in Barbuda.

A.1.3 Excessive Rainfall

Excessive / Intensive Rainfall is frequently associated with hurricanes and other tropical cyclones, of which the following are examples:

- Hugo[9] in 1989 caused extensive flooding in Antigua;
- Jose[10] in 1999 caused flooding in Antigua and Barbuda;
- Lenny[11] in 1999 caused 65% flooding in Barbuda; and
- Omar in 2008 resulted in 230 mm of rainfall in Antigua and Barbuda.

Excessive rainfall may also occur independent of tropical cyclones, and the effects of Climate Change in the West Indies appear to be increasing the frequency of excessive rainfall which is not associated with hurricanes and tropical cyclones. The location of this project closely

[2] https://en.wikipedia.org/wiki/Category:Hurricanes_in_Antigua_and_Barbuda
[3] https://en.wikipedia.org/wiki/Hurricane_Baker_(1950)
[4] https://en.wikipedia.org/wiki/Hurricane_Dog_(1950)
[5] https://en.wikipedia.org/wiki/Hurricane_Donna
[6] https://en.wikipedia.org/wiki/Hurricane_Luis
[7] https://en.wikipedia.org/wiki/Hurricane_Georges
[8] https://en.wikipedia.org/wiki/Hurricane_Irma
[9] https://en.wikipedia.org/wiki/Hurricane_Hugo
[10] https://en.wikipedia.org/wiki/Hurricane_Jose_(1999)
[11] https://en.wikipedia.org/wiki/Hurricane_Lenny

adjacent to salt ponds increases the potential for flooding as water levels in the ponds increase due to excessive rainfall.

A.1.4 Drought

Fresh water is a scarce commodity in Barbuda. The mean annual rainfall on the island[12] is only 939.8mm (37 inches), and ground water sources are generally brackish. As a result, potable water must be produced by desalination. The Drought Risk Map[13] for Barbuda, prepared by the Organization of American States, shows the project area to be in a zone of high drought risk. This scenario envisages mechanical failure of the desalination plant during a drought.

A.1.5 Earthquake

Antigua and Barbuda are situated in the northern Leeward Islands, in a seismically-active zone. Examples of recent earthquakes in the vicinity of Antigua and Barbuda are:

- Magnitude 5 Earthquake[14] on February 16, 2022, 53.6 km ESE of Falmouth, Antigua; and
- Magnitude 5 Earthquake[15] on September 20, 2021, located 71.5 km ESE of Falmouth, Antigua.

At meetings on July 11, 2022, the representatives of the Hannah Thomas Hospital and the Police Service both indicated that earthquake risk should be addressed in this analysis.

A.1.6 Vehicular Accident

The potential for vehicular accidents arises both during the construction phase and the occupancy phase of the Paradise Found Development. During the construction phase, there will be a significant number of vehicles (cars as well as trucks) transporting personnel, equipment, material and waste to and from the project site. During the occupancy phase, the majority of visitors to Paradise Found Development are expected to rent vehicles which they will drive themselves. Visitors from North America and Europe will be unfamiliar with driving on the left side of the road.

A.1.7 Fire in a Building

The potential for fire in a building exists for the Paradise Found Development, as it exists for any built development.

[12] https://www.weather-atlas.com/en/antigua-and-barbuda-climate#climate_text_1
[13] https://www.oas.org/pgdm/hazmap/drought/bar_map.pdf
[14] https://www.ccrif.org/publications/hazard-event-report/preliminary-event-briefing-earthquake-antigua-and-barbuda-february?language_content_entity=en
[15] https://www.ccrif.org/publications/hazard-event-report/final-event-briefing-earthquake-antigua-and-barbuda-september-20?language_content_entity=en

A.1.8 Risk at an LPG Cylinder

LPG Cylinders will be installed both at the new restaurant and at individual homes. Based on present practice, the cylinder at the new restaurant is expected to be 100 lb cylinders, while those at the individual homes are expected to be 20 pound cylinders. Damage to the cylinders themselves is very uncommon, so this Credible Scenario is based on damage to the line connecting the cylinder to the stove, leading to leakage of LPG gas and subsequently a fire.

A.1.9 Risk at a Diesel Storage Tank

Diesel Storage Tanks will be used within the development to provide fuel for generators, desalination plants, etc. Based on the size of the diesel tank presently on site, the tank in the new development is expected to be 9.1 m^3 in volume (2.000 imperial gallons / 2,400 US gallons). Complete failures of such tanks are very uncommon, so this Credible Scenario is based on a spill of diesel during loading the tank or from failure of the piping, followed by ignition.

A.1.10 Untreated Sewage Discharge Risks

When Phases 1 and 2 of this Development come into operation, the estimated potable water demand will be 682,000 L/day (150,000 gallons per day). Applying a conversion factor of 85% potable water to sewage, an estimated 580,000 L/day (128,000 gallons per day) of sewage will be produced on this site. Almost 12% of this amount will come from the Hotel and Back of House Facility, and this will be treated in a 68 L/day (15,000 gallons per day) Bionest aerobic treatment unit. The remaining 88% will be treated in smaller individual treatment units at individual villas and houses. Based on a total of 90 villas and houses, there will be 91 wastewater treatment systems on this property at full build-out. This scenario is based on the mechanical or biological failure of several of these wastewater treatment systems, resulting in the release of poorly treated or untreated sewage into surface drainage, leading to one or several of the salt ponds on site.

A.2 RISK RATING METHOD

Risk is defined as a factor of the consequences of a Credible Scenario and the likelihood of occurrence. In this Qualitative Risk Assessment, the level of risk is determined using a Risk Rating Matrix, as will be described in this section.

A.2.1 Consequences

The risk ranking matrix used on this assignment is based on:

- Consequences to Persons,
- Consequences to the Environment, and
- Financial Consequences.

In each case, the consequences are defined at five levels of severity:

1. Minor,
2. Notable,
3. Significant,
4. Important, and
5. Major.

These levels are defined in the following sub-sections.

A.2.1.1 Consequences to Persons

Consequences to persons relate to injury or fatality, and the levels of consequences are as follows:

LEVEL OF CONSEQUENCE	DEFINITION
Minor	Injury / illness that can be treated with first aid, not requiring the attention of a medical professional.
Notable	Injury / illness requiring trained medical attention without time away from work or a hospital stay.
Significant	Injury / illness requiring a stay at the hospital.
Important	Loss of one life or irreversible health damage or physical injury without loss of life.
Major	Death of more than one person.

A.2.1.2 Consequences to the Environment

Consequences to the environment relate to damage to plants or animals, or discharges/emissions that affect ambient noise, air quality, water quality or soil conditions. The levels of consequences are as follows:

LEVEL OF CONSEQUENCE	DEFINITION
Minor	Impacts which affect a limited area and will naturally remediate over time.
Notable	Impacts which are reversible but require proactive steps in the short term to afford remediation.
Significant	Damage which can only be remediated using sustained measures in the medium to long term.
Important	Permanent, irreversible damage to a common species or an environmental component which is prevalent locally.
Major	Permanent, irreversible damage to a rare or endangered species or locally unique environmental component.

A.2.1.3 Financial Consequences

Financial consequences relate to damage to property or possessions, expressed as replacement cost. The levels of consequences are as follows:

LEVEL OF CONSEQUENCE	DEFINITION
Minor	Less than $US 25,000.
Notable	$US 25,000 to $US 249,999.
Significant	$US 250,000 to $US 499,999.
Important	$US 0.5 million to $US 1.49 million.
Major	More than $US 1.5 million.

A.2.2 Likelihood

The likelihood that a specific Credible Scenario will occur is also expressed at five levels, as follows:

LEVEL OF LIKELIHOOD	DEFINITION
Near-impossible	Has never been reported previously in the West Indies.
Improbable	Reports of previous occurrence in the West Indies are few or not well documented.
Occasional	Not expected to occur more than once in a decade.
Probable	Expected to occur between once per decade and once per year.
Frequently Occurs	Expected to occur more than once per year.

A.2.3 Risk Rating Matrix

This matrix was used to rate each of the Credible Scenarios listed in Section A.1:

CONSEQUENCES				LIKELIHOOD				
SEVERITY	Applicable Type			A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
	To Persons	To the Environ	Financial					
1: Minor				LOW	LOW	LOW	LOW	LOW
2: Notable				LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant				LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

This matrix is formatted as follows:

- The first column lists the five levels of consequences (lowest to highest, top to bottom).
- The next three columns indicate the type of consequence which is applicable to the analysis, the applicable cell being marked with an "X".
- The next five columns each pertain to a different level of likelihood (lowest to highest, left to right).
- Within the last five columns, the risk rating corresponding to each combination of consequence and likelihood are shown as "Low" (coloured in green), "Medium" (coloured in yellow) and "High" (coloured in red).

To apply this matrix, risk reduction measures for a particular Credible Scenario are determined. The applicable levels of consequence and likelihood for that Credible Scenario are evaluated, assuming the effective implementation of the risk reduction measures. The values are then applied to the respective rows and columns, and the risk rating is given by the cell where they intersect. Where a scenario gives rise to consequences of more than one type, the one with the highest level is used.

The interpretation of the risk ratings are as follows:

- Risks rated "Low" are considered to be tolerable.
- Risks rated "Medium" should be reduced As Low as Reasonably Practicable (ALARP). That is, additional risk reduction measures must be sought in an attempt to reduce the rating to "Low". However, "Medium" risks are tolerated if it is not possible to reduce them to "Low" after applying the additional risk reduction measures.
- Risks which are rated "High" are considered to be unacceptable, and must be reduced to "Medium" or "Low" by applying additional risk reduction measures. If it is not possible to reduce the risk of a Credible Scenario below "High", then the activities giving rise to that scenario should not be undertaken.

A.3 SCENARIO 1 - HURRICANE WINDS

This scenario pertains to winds associated with a major hurricane.

A.3.1 Risk Reduction Measures

Three risk reduction measures are available to address this scenario:

- Design buildings to resist wind loads as prescribed in the Caribbean Unified Building Code (CUBiC).
- Inform arriving visitors about evacuation procedures.
- Arrange for evacuation of visitors when a hurricane watch or warning is declared.

- Provide specially reinforced-buildings within the development to serve as hurricane shelters for staff and any visitors who cannot (or decide not to be) evacuated ahead of the arrival of a hurricane.

A.3.2 Consequences

Assuming the effective implementation of the risk reduction measures above, the projected consequences of this Scenario are:

- Notable Injuries to Persons (requiring trained medical attention without time away from work or a hospital stay); and

- Significant Damage to Properties ($US 250,000 to $US 499,999).

A.3.3 Likelihood

The frequency of major hurricanes passing within 120 km of Barbuda is once every 15 years[16]. This is classified as an "Occasional" level of likelihood.

A.3.4 Rating

This scenario is rated as a Medium Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
SEVERITY	Applicable Type			A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
	To Persons	To the Environ	Financial					
1: Minor				LOW	LOW	LOW	LOW	LOW
2: Notable	X			LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant			X	LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

[16] http://www.antiguamet.com/Climate/STATS/AntiguaBarbudaTCClimo.pdf

A.4 SCENARIO 2 - STORM SURGES

This scenario pertains to surges arising from tropical cyclones.

A.4.1 Risk Reduction Measures

During a meeting on July 14, 2022, the Development Control Authority advised on two risk reduction measures:

- Barbuda has a 100 foot (30 m) setback from the shoreline, which is greater than the setback in Antigua.
- Buildings should be designed on 8 to 10 foot (2.4 to 3 m) stilts to cater for storm surges.

A.4.2 Consequences

Assuming the effective implementation of the risk reduction measures above, the projected consequences of this Scenario are:

- Notable Injuries to Persons (requiring trained medical attention without time away from work or a hospital stay); and
- Notable Damage to Properties ($US 25,000 to $US 249,999).

A.4.3 Likelihood

Storm surges may arise from minor as well as major hurricanes, and named storms can pass within 120 km of Barbuda is once every 3 years[17]. This is classified as a "Probable" level of likelihood.

A.4.4 Rating

This scenario is rated as a Medium Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
SEVERITY	Applicable Type			A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
	To Persons	To the Environ	Financial					
1: Minor				LOW	LOW	LOW	LOW	LOW
2: Notable	✖		✖	LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant				LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

[17] http://www.antiguamet.com/Climate/STATS/AntiguaBarbudaTCClimo.pdf

A.5 SCENARIO 3 - EXCESSIVE RAINFALL

This scenario pertains to intensive / excessive rainfall, which may be associated with tropical cyclones or may occur at other times.

A.5.1 Risk Reduction Measures

The only practical measure to reduce this risk is to design the on-site drainage system to efficiently remove storm water from the vicinity of buildings and landscaped areas. This will reduce but not entirely eliminate consequences of an excessive rainfall event.

A.5.2 Consequences

Assuming the effective implementation of the risk reduction measure above, the projected consequences of this Scenario are:

- Notable Water Damage to Properties ($US 25,000 to $US 249,999); and
- Minor Water Damage to Landscaped Areas (affecting a limited area which will naturally remediate over time.).

A.5.3 Likelihood

Rainfall sufficiently intense to cause flood damage is expected to occur up to once per year, but not more than once per year. This is classified as a "Probable" level of likelihood.

A.5.4 Rating

This scenario is rated as a Medium Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
SEVERITY	Applicable Type			A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
	To Persons	To the Environ	Financial					
1: Minor		✖		LOW	LOW	LOW	LOW	LOW
2: Notable			✖	LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant				LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

A.6 SCENARIO 4 - DROUGHT

This scenario pertains to drought conditions, and envisages mechanical failure of the desalination plant during a drought.

A.6.1 Risk Reduction Measures

Two risk reduction measures are available to address this scenario:

- o Have stand-by arrangements for the purchase of potable water until the desalination plant is repaired.
- o Have a standing contract for the timely repair of the desalination plant, including the availability of skilled technicians and the purchase of parts.

A.6.2 Consequences

Even with the risk reduction measures above, temporary loss of water supply will have the following consequences:

- o Notable cost of Repair of the Desalination Plant and Purchasing of Water ($US 25,000 to $US 249,999); and
- o Minor Drought Damage to Landscaped Areas (affecting a limited area which will naturally remediate over time).

A.6.3 Likelihood

The project area is situated in an area of high drought risk (see Section A.1.4), but the likelihood of mechanical failure of the desalination plant during a drought is not expected to occur more frequently than once every 10 years. This is classified as an “Occasional” level of likelihood.

A.6.4 Rating

This scenario is rated as a Low Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
SEVERITY	Applicable Type			A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
	To Persons	To the Environ	Financial					
1: Minor		X		LOW	LOW	LOW	LOW	LOW
2: Notable			X	LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant				LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

A.7 SCENARIO 5 - EARTHQUAKE

This scenario pertains to tremors and aftershocks arising from earthquakes located some distance from Barbuda.

A.7.1 Risk Reduction Measures

The appropriate risk reduction measure is to design earthquake-resistant structures as specified in the Caribbean Unified Building Code (CUBiC).

A.7.2 Consequences

The historical record shows no severe structural damage from earthquakes in the recent past. As such, the credible consequences would be minor damage to structures (less than $US 25,000). Personal injury is not considered a credible consequence.

A.7.3 Likelihood

Based on the historical record, damage to structures from earthquakes is not expected to occur more frequently than once every 10 years. This is classified as an “Occasional” level of likelihood.

A.7.4 Rating

This scenario is rated as a Low Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
	Applicable Type							
SEVERITY	To Persons	To the Environ	Financial	A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
1: Minor			X	LOW	LOW	LOW	LOW	LOW
2: Notable				LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant				LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

A.8 SCENARIO 6 - VEHICULAR ACCIDENT

This scenario involves a vehicular accident involving an employee or guest at the development.

A.8.1 Risk Reduction Measures

To address this scenario, employees of the development should be provided with Defensive Driving training, especially those who drive trucks. Persons responsible for renting cars to guests must ensure that the guest who will be driving has a valid drivers license, and are aware that driving in Barbuda is on the left hand side of the road.

A.8.2 Consequences

At a meeting with the Barbuda Police Service on July 11, 2022, Ecoeng was informed that there are very few traffic accidents on the island, resulting in minor vehicular damage and personal injury. Serious injuries and fatalities are not a problem.

A.8.3 Likelihood

As noted above, there are reported to be very few accidents in Barbuda. Based on this statement from the police, it is anticipated that the likelihood of a traffic accident involving an employee or visitor to Paradise Found development would be Probable (expected to occur between once per decade and once per year).

A.8.4 Rating

This scenario is rated as a Low Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
SEVERITY	Applicable Type			A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
	To Persons	To the Environ	Financial					
1: Minor	X		X	LOW	LOW	LOW	LOW	LOW
2: Notable				LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant				LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

A.9 SCENARIO 7 - FIRE IN A BUILDING

This scenario involves a fire at one of the buildings at the development. At a meeting with the Fire Department on July 11, 2022, Ecoeng were informed that the only fire truck on the island is based at the airport, so it will take approximately 15 minutes for the fire truck to reach a fire in the Paradise Found development. Further, the Fire Service is equipped to fight fires in multi-storey buildings (more than 2 floors) nor at closely-spaced buildings.

A.9.1 Risk Reduction Measures

At the meeting on July 11, 2022 (see above), the Fire Service recommended the following risk reduction measures pertaining to a building fire at Paradise Found:

- Provision of Fire Hydrants every 100 feet (30 m) along the roads within the Development;
- Storage of Water for Fire Fighting within the Development;
- Provision of fire Alarms and Sprinkler Systems in each Building; and
- Inform visitors about fire alarm and evacuation procedures.

A.9.2 Consequences

Even assuming that the risk reduction measures listed above are effectively implemented, a fire can result in significant damage ($US 250,000 to $US 499,999) before it is put out, especially if it spreads to a second building. The presence of fire alarms will alert occupants to evacuate the building when a fire begins, but it is possible that an occupant can suffer notable injury (requiring trained medical attention without time away from work or a hospital stay) from smoke inhalation (for example) before being evacuated.

A.9.3 Likelihood

The Barbuda Fire Department did not provide information on the frequency of building fires on the island, but based on experience elsewhere in the West Indies this is expected to be an Occasional Scenario (not expected to occur more than once in a decade).

A.9.4 Rating

This scenario is rated as a Medium Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
SEVERITY	Applicable Type: To Persons	To the Environ	Financial	A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
1: Minor				LOW	LOW	LOW	LOW	LOW
2: Notable	X			LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant			X	LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

A.10 SCENARIO 8 - RISK AT AN LPG CYLINDER

This scenario pertains to damaged piping from an LPG Cylinder, leading to a Fire.

A.10.1 Risk Reduction Measures

The measures available to reduce the risk of this scenario are:

- Shut off the Cylinders when they are not in use, and
- Routinely inspect the LPG piping for signs of damage or rusting, and replace if these are found.

A.10.2 Consequences

A fire associated with this scenario can result in:

- Significant Injury (requiring a stay at the hospital) to Persons in the Kitchen; and
- Notable Damage ($US 25,000 to $US 249,999) to the building.

A.10.3 Likelihood

Incidents of this type have been reported in the West Indies, but they are very few. This is therefore considered to be an Improbable Scenario.

A.10.4 Rating

This scenario is rated as a Low Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
SEVERITY	Applicable Type			A	B	C	D	E
	To Persons	To the Environ	Financial	Near Impossible	Improbable	Occasional	Probable	Frequently Occurs
1: Minor				LOW	LOW	LOW	LOW	LOW
2: Notable			✖	LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant	✖			LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

A.11 SCENARIO 9 - RISK AT A DIESEL TANK

This Scenario relates to spillage of fuel at a Diesel Tank leading to a Fire.

A.11.1 Risk Reduction Measures

The measures available to reduce the risk of this scenario are:

- Adhere to standard practice of providing Secondary Containment around Diesel Tanks,
- Remove spilled Diesel from the Secondary Containment as soon as practicable, and
- Have a foam-type Fire Extinguisher available within the Development.

A.11.2 Consequences

A fire associated with this scenario can result in:

- Significant Injury (requiring a stay at the hospital) to Persons in the vicinity of the Diesel Tank at the time of the Fire;
- Significant Damage (which can only be remediated using sustained measures in the medium to long term) to Vegetation in the area of the Diesel Tank; and
- Minor Damage (Less than $US 25,000) to the Diesel Tank itself. Damage to Buildings is not anticipated since the Diesel Tank will be situated some distance from buildings.

A.11.3 Likelihood

Incidents of this type have been reported in the West Indies, but they are very few. This is therefore considered to be an Improbable Scenario.

A.11.4 Rating

This scenario is rated as a Low Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
	Applicable Type							
SEVERITY	To Persons	To the Environ	Financial	A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
1: Minor			✖	LOW	LOW	LOW	LOW	LOW
2: Notable				LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant	✖	✖		LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

A.12 SCENARIO 10 – UNTREATED SEWAGE DISCHARGE RISK

This scenario relates to the failure over time of several of the 91 wastewater treatment systems on this site, leading to the release of untreated or poorly treated sewage into surface drains which discharge into the salt ponds on site.

A.12.1 Risk Reduction Measures

In several parts of the West Indies (for example, Trinidad and Tobago) there is a history of failure of small biological sewage treatment systems due to inappropriate selection of units, the introduction of harmful chemicals (such as the use of strong bleaches to clean the toilets) or lack of adequate maintenance. Risk reduction measures are therefore:

- Select wastewater treatment systems that are adequately sized to receive the combination of toilet waste and grey water from the hotel, villas and houses;
- Carefully choose the types of chemicals which are used in toilets, sinks and bathrooms and for laundering at the hotel, villas and houses; so that they are not incompatible with the aeration of aerobic wastewater treatment systems.
- Maintain and repair all of the wastewater treatment systems in strict accordance with the manufacturer's recommendations. To facilitate this, have a standing arrangement with a suitably competent firm to undertake this work on a regular schedule.

A.12.2 Likelihood

The implementation of the risk reduction measures listed above will reduce but not entirely eliminate the possibility of failure of wastewater treatment units at Paradise Found Development. The large number of units (91, total) also increases the likelihood that at least some of them will fail over time. Based on experience elsewhere in the West Indies, it is estimated that failures will occur more frequently than 1 every 10 years, defined as "probable".

A.12.3 Consequences

Two sets of consequences may be anticipated when poorly or untreated sewage is discharged to the salt ponds:

- o Eutrophication, and
- o Human Health Consequences.

Eutrophication[18] describes the process by which excessive plant and algal growth occurs due to the increased availability of one or more limiting growth factors needed for photosynthesis, such as nutrient fertilizers. Untreated sewage is rich in nitrogen and phosphorus, and so it is a contributor to eutrophication. Eutrophication creates dense blooms of noxious, foul-smelling phytoplankton that reduce water clarity, limiting light penetration, reducing growth and causing die-offs of plants. Furthermore, high rates of photosynthesis associated with eutrophication can deplete dissolved oxygen and dissolved inorganic carbon, and raise pH; all of which adversely affect plant and animal life in water bodies. Eutrophication can be reversed, but requires sustained measures in the medium term. The environmental consequence is therefore defined as "significant" (see Section A.2.1.2)

Sewage and wastewater contain bacteria, fungi, parasites, and viruses[19] that can cause intestinal, lung, and other infections such as diarrhea, fever, cramps, and sometimes vomiting, headache, weakness, or loss of appetite. The presence of such contaminants in the salt ponds may lead to potential exposure of persons to sewage by hand-to-mouth contact or by wiping the face with contaminated hands or gloves. Exposure can also occur by skin contact, through cuts, scratches or penetrating wounds. Certain organisms can also enter the body through the surfaces of the eyes, nose and mouth and by breathing them in as dust, aerosol or mist. The illnesses listed above often require a stay at hospital for treatment, so this human health consequence is defined as "significant" (see Section A.2.1.1).

A.12.4 Rating

This scenario is rated as a Medium Risk, as shown below.

CONSEQUENCES				LIKELIHOOD				
SEVERITY	Applicable Type			A Near Impossible	B Improbable	C Occasional	D Probable	E Frequently Occurs
	To Persons	To the Environ	Financial					
1: Minor				LOW	LOW	LOW	LOW	LOW
2: Notable				LOW	LOW	LOW	MEDIUM	MEDIUM
3: Significant	X	X		LOW	LOW	MEDIUM	MEDIUM	HIGH
4: Important				LOW	MEDIUM	MEDIUM	HIGH	HIGH
5: Major				MEDIUM	MEDIUM	HIGH	HIGH	HIGH

18 https://www.nature.com/scitable/knowledge/library/eutrophication-causes-consequences-and-controls-in-aquatic-102364466/

19 https://dhss.delaware.gov/dph/files/sewagefaq.pdf