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LOW-DENSITY PRIVATE RESIDENTIAL DEVELOPMENT ON CEDAR TREE POINT

Environmental Impact Assessment

Submitted to the Development Control Authority
Antigua and Barbuda

November 4, 2020

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Submitted to

Development Control Authority, Antigua and Barbuda

By

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LOW-DENSITY PRIVATE RESIDENTIAL DEVELOPMENT ON CEDAR TREE POINT

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EXECUTIVE SUMMARY

On February 27, 2020, Abercorn Trust, Inc submitted a G-Application (#G04-2020) to the Development Control Authority (DCA) for a low-density residential construction project on Cedar Tree Point, a low-lying peninsula located in the northwest of the island of Barbuda (Figure 1 and 2). The proposed development consists of two residences (the Abercorn Residence and the DeJoria Residence), an associated back of house area, as well as driveways and outbuildings.

In June 2020, the DCA and Department of Environment (DoE) conducted a site visit to the property along with Deborah Brosnan & Associates. Following the site visit, the agencies conducted due diligence to confirm that the lease was in order and good standing before issuing a Terms of Reference (ToR). In October 2020, the DCA provided Deborah Brosnan and Associates the final Terms of Reference (ToR) for an EIA based on the report from DoE.

This EIA is conducted to professional standards and follows the EIA outline and contents requested by DoE in its ToR. Several assessment methodologies were used including site surveys, published literature, results from previous studies conducted by the science and engineering team, mathematical and simulation models and professional expertise. The ToR specifically requested that Rapid Coastal Erosion; Hydrology and Drainage; Alteration to Wetland and Ecosystems Impacts; Water Resources; Energy-Solar PV; and Climate Change Impacts-Storm Surge be addressed. Each of these topics was assessed and findings are reported in the relevant sections in the EIA.

Project Details and Location

The project is proposed for Cedar Tree Point in the NW area of Barbuda. The site comprises approximately 113.9 acres (16.17 acres plus c.97.7 acres “security buffer”). The residences will be built on the western side in an area characterized by coastal upland vegetation. The project will consist of two residences, a shared back-of-house area, and associated driveways and outbuildings. The Abercorn Residence (15,000sq ft) will be the first residence constructed and will consist of several small structures of wood-frame construction. The DeJoria residence (16,000sq ft) is planned to be built in 3-4 years. A back of house and 2.75 acres solar array has been identified on the plan (Figure 3). The property extends from the ocean to the lagoon, but there are no plans to develop or alter the coastal lagoon.

Cedar Tree Point is a low-lying, relatively flat coastal area with sandy beaches rising from sea level to a dune crest at an elevation of approximately +6ft (+2m) MSL. The dune system consists of a low ridge and valley system that extends from the sandspit north to the Cedar Tree Point, and also runs along the north shore. The proposed project site is currently undeveloped and unoccupied and is not known to have been substantially developed at any point.

Cedar Tree Point is part of the Codrington Lagoon National Park and a RAMSAR site. Development is not encouraged in the area, although two hotels were previously built in this area of the Park and RAMSAR site. The Barbuda Belle Luxury Hotel is 0.95 km from the site and currently operational, and the Lighthouse Resort 5km to the south on the sand spit that was destroyed by Hurricane Irma in 2017 and has not been restored.

Figure 1. Barbuda, with Project Location and Other Sites of Interest.

Figure 2. The western shore Beach at Cedar Tree Point.

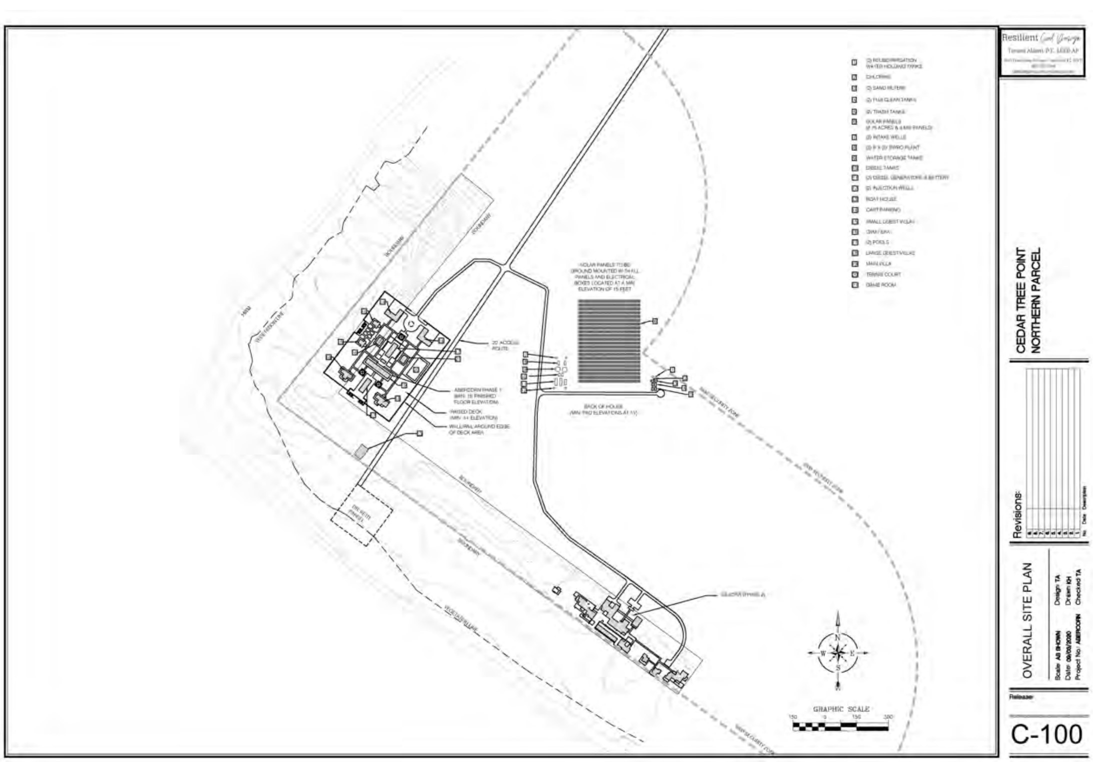

Figure 3. Conceptual Site Plan.

Baseline Studies

Several assessments and methodologies were completed by the project team for this EIA. They included biological surveys of vegetation, seagrass (in the lagoon), birds, sea turtle nesting (Figure 4), a coastal vulnerability study including Wavewatch and SBeach simulations, an evaluation of climate change and sea level rise impacts, in addition to a review of existing and published studies. An evaluation of options and alternatives was conducted for energy, wastewater, potable water and stormwater management, and that provided specific recommendations for each. All these studies were used to determine baseline conditions, risks, potential impacts and mitigation options.

In June 2020, and during a site visit with DCA and DoE, the team noted that the beach at the Point at Cedar Tree Point had eroded and there was a small area of mangrove behind the due at the NW corner. While this area was dry and mangroves in poor condition, it nevertheless indicated a risk of overwash during storms especially during times of beach loss. As a result, the Abercorn Trust relocated its property further back from the beach, to 300ft back from the LPV. A revised plan showing the residence in a new location was submitted to DCA.

Baseline Evaluation

Barbuda is a tropical Island and temperatures average 26.8°C, annual average rainfall is 1165mm/yr but ranges from 45mm (March) to 188mm (October). In essence, rainfall is highly variable, and droughts are not uncommon.

Cedar Tree Point is a low-lying, sandy coastal area that is part of the Palmetto Point geological formation. The dunes have been established primarily by oceanic deposition and wind transportation. Since 2017, when Hurricane Irma created a breach in the sandspit, the area has been separated by inlets from the remainder of Barbuda. It is in effect now an island and can only be accessed by boat. Except for guests staying at the Barbuda Belle Hotel, the development site is infrequently visited by local Barbudans and tourists alike.

The site is within the boundaries of the Codrington Lagoon National Park and is part of the RAMSAR site. The Park was created in 2005 by ministerial declaration under the authority granted by National Parks Act of 1984. In 2006, Codrington Lagoon National Park was identified as a wetland of international importance at the RAMSAR convention (CLNP Management Plan). The lagoon is an important nursery site especially for juvenile lobsters (*Panulirus argus*). Nearby seagrass beds (especially in the more coastal and oceanic areas) are home to conch (*Stombus gigas*). Both species are important fisheries on Barbuda.

The Barbuda frigate bird reserve is located in the lagoon to the southwest of the proposed development (see Section 4.5, Biological Environment). Approximately 5,000 pairs nest in the mangroves, and juveniles spend the early part of their lives in this habitat. This is a major tourist attraction on Barbuda and local tour guides rely on the income from this natural amenity.

The beach is dynamic and based on aerial imagery analysis, there have been periods of significant beach erosion at the Point, particularly following hurricanes. Beach monitoring at Palm Beach (approximately 5km south of the property) conducted by the Antigua and Barbuda Fisheries Division between 1995-2015 indicate that Palm Beach is eroding over the long-term, with a change in mean beach area of -21.09 m^2/yr and mean beach width of -0.56 m/yr. recorded during this period. However, the changes are not linear, as there have been periods of accretion interspersed with beach loss, with periods of beach build up occurring most notably during the years 2000-2003 and 2009-2011. James (2017) concluded that overall trend is one of erosion.

Surveys and Assessments

The property area extends from the marine and coastal dune area on the west and north to the shores of Codrington Lagoon on the east. Field surveys of Cedar Tree Point were conducted by the project team between April and July 2019 and re-confirmed during the June 2020 site visit (Figure 4). In addition, aerial and remote sensing surveys were conducted. Forty-three plant species were recorded of which seven are identified as protected under EPMA (2019). Four distinct vegetation assemblages were identified. Sand Strand Beach Dune, Coastal Shrubland, Coastal Shrubland with Herbaceous Vegetation, and Mangrove and Buttonwood. Vegetation communities were healthy reflecting low human activity and no feral animal impact in the area.

Figure 4. Coastal habitat at Cedar Tree being assessed by the science team.

Seagrass surveys were conducted on the lagoon side using three 30m transects and a total of 90 quadrat surveys. Studies showed patchy distribution of seagrass. The community is dominated by *Halodule wrightii* (shoal grass) with some interspersed *Thalassia testudinum* (turtle grass), in contrast to other areas in the marine and lagoon environment where *T. testudinum* is typically the dominant species.

Six bird species were documented during on-site surveys (birds flying over the site or perched on vegetation were recorded as present). These were: the magnificent frigate bird (*Fregata magnificens)*, Antillean flycatcher (*Myiarchus oberi*), lesser Antillean bullfinch (*Loxigilla noctis*), bananaquit (*Coereba flaveola*), and West Indian whistling duck (*Dendrocygna arborea*) and one warbler (species could not be confirmed, but the yellow warbler is known to be present on the site, while the Barbuda warbler has not been documented there). Of these, frigate birds flying directly over the site were the most commonly observed species (total of 174 birds observed over a two-hour period).

The beaches along the west and north coast of Barbuda are well-known nesting habitat for endangered and threatened sea turtles. The sea turtle team monitored the site for nesting activity in 2019 and 2020. Seven confirmed nests, one unconfirmed nest, and three false crawls were identified along the Cedar Tree Point shoreline, with most nests being observed on the northern shoreline of Cedar Tree Point. All observed sea turtle nesting activity on Cedar Tree Point was by hawksbill sea turtles (*Eretmochelys imbricata*). Green sea turtles (*Chelonia mydas*) have been observed directly offshore in the ocean. Leatherback sea turtles (*Dermochelys coriacea*) have been recorded nesting up to 5km to the south on the sandspit, but no nests were observed on the property. Published research was used to identify other known terrestrial and coastal species likely to occur on the habitats.

Figure 5. Hawksbill sea turtles (*Eretmochelys imbricata*) nest on Cedar Tree Point beaches.

Impacts and Mitigation

Ecological/Biological Impacts and Mitigation

Based on current plans, approximately 10.39 acres of land will be directly and permanently impacted by the proposed residences and associated infrastructure development, amounting to 9.1% of the total project area (parcel and security buffer). The use of any temporary staging areas will increase the area affected, although the staging areas can be replanted and mitigated post-construction. Based on construction of similar sized homes on Barbuda, we estimate about a 100,000sq ft staging area will be needed for the development. The upland vegetation will be most impacted by the development and the beach vegetation (where most sea turtles nest) the least impacted on the ocean side of the property. No impacts on the lagoon side are anticipated as there is no development planned for that location. We do not expect the development to have significant biological impacts and particularly if the residences retain the native vegetation assemblages outside of the main property areas as is intended. Impacted plant species can be replaced with native or commercial stock.

Impacts to upland vegetation can be minimized and mitigated. Several measures are recommended including a detailed mapping of sensitive plants for protection or mitigation, the use of defined transit corridors for equipment, and limits of development. The construction crew must implement proper management practices to ensure minimal habitat impacts. Special attention will need to be given to sea turtle nesting areas (see below). At the time of writing, no decision has been made for a landing site necessary to transport equipment or materials. We anticipate and recommend a RORO type of vessel or barge -- as has been used previously for construction at nearby hotels. It will be critical to identify a landing area of minimal impact and use the recommended mitigation measures identified here to maintain low impact to the site. It may be possible to coordinate efforts with the neighboring property, and we recommend that the owners explore this option. The final location determination will need to be coordinated with the DCA and DoE during the construction phase.

Best management practices (BMP’s) (previously designed) must be used to minimize impacts to sea turtles. These include protecting the dunes, maintaining native vegetation that supports sea turtle nests, and using turtle-friendly lighting during nesting season. We do not anticipate any major impacts on the frigatebird colony, because of its distance from the site, the fact that no activity is proposed in the lagoon, and the apparently lack of impact to the colony by the adjacent hotel. However, colony monitoring is recommended as a prudent step.

Water Environment

There is no significant aquifer or water courses on site. Development is not expected to shift current surface or sub-surface water flow patterns. The plan does not include any alteration to the mangrove wetlands of the lagoon. A 2013 water quality study in Codrington Lagoon and oceanic sites found conditions to be relatively good - it must be noted that this was Pre-Hurricane Irma.

However, stormwater runoff, sewage, and brine from the planned reverse osmosis plant must be properly engineered and managed during construction and operations. This is particularly important because of the location of the development adjacent to Codrington Lagoon and within park boundaries, and because of the importance of the waters to local fisheries. Impacts to seagrass or intertidal vegetation are anticipated to be minor and limited to the area where equipment and supplies are offloaded during the construction phase. Sediment and erosion control measures will be used during the construction phase to limit sedimentation that can negatively affect offshore seagrass beds. During the operational phase, runoff will be controlled via BMPs for stormwater management, such as rain catchment.

The project proposes several low-impact development (LID) methods to manage and conserve water. For instance, cisterns will be used, and treated effluent from the wastewater plant will be utilized for non-potable water uses (e.g. landscaping irrigation) to reduce demand on the desalination plant. In addition, alternatives analyses were conducted to determine best options for stormwater, wastewater, and water supply. The full analysis and recommendations are presented in Section 5.

Site Infrastructure

No public utilities currently exist on site. The proposed development therefore will provide for its own needs with regard to electricity, water, and wastewater. One of the goals of the project is to maximize the use of renewable energy sources.

Energy: Solar can provide sufficient power to meet the development's electricity, and it is estimated that 2.75 acres of solar panels could meet peak power demand during the day. Energy storage (e.g. batteries) and a backup generator would be required when sunlight is not available. Solar could be supplemented with power generation via vertical wind turbines, which carry minimal potential for bird strikes. Diesel generators will be needed for electricity during construction.

Stormwater: Several features of the Abercorn Residence will be designed to minimize stormwater runoff from impervious surfaces and to incorporate LID techniques. These are fully discussed in Section 5.10, Hydrology and Stormwater Management.

Wastewater: The project proposes to treat wastewater on site using a small sewage treatment plant located in the back-of-house area. The plant will be built concurrently with the Abercorn Residence and will be sized appropriately to that residence with expansion capacity for the DeJoria villa which will be built subsequently. A full analysis of wastewater options and recommendations was conducted for the EIA and is presented in Section 5.9.

Water Supply- Reverse Osmosis (RO) Plant: The project will require about 7,000 gallons of potable water per day. A desalination plant (RO plant) will be needed to meet this requirement. Brine (the waste product of RO plants) can have deleterious impacts on seagrass and marine life. If brine is discharged into the sea, the outfall pipe must be located where there is good dilution (good current flow) to ensure that there is no buildup of hyper-saline conditions.

The above systems will be sized to meet the needs of the Abercorn Residence, allowing for later expansion to serve the DeJoria Residence, once built. These systems will be located in a back-of-house area on site, which is proposed to be raised via grading and fill to minimize both the risk of damage to the site infrastructure during a storm event and the risk of impacts to the local ecosystem resulting from this damage.

Air and Noise Environment

In general, air quality is high on Barbuda. Beyond localized dust created by construction (which can be minimized by using BMPs) the project will not impact island air quality. There will be construction noise during the building phase of the project. We conducted a noise analysis using determined formula based on standard construction equipment and estimated ambient noise for the location. Results indicated that construction noise will at times be audible in the adjacent development and frigate bird colony but at levels that are well within general ambient ones. We do not anticipate any significant and long-term impacts. Mitigation including operating during standard weekday working hours and coordinating with the neighboring property are recommended. A review of existing literature does not suggest that there will be long-term harm to the frigate bird colony, but we recommend monitoring in order to ensure any behavioral or other changes are not occurring.

Socio-Economic Assessment and Potential Impacts

The nation of Antigua and Barbuda relies on tourism as its economic mainstay. Tourism services generate 75% of GDP, employing 22.6% of all workers directly and 84.5% when indirect employment is included. However, these figures are for both nations and not for Barbuda alone, and Barbuda has not experienced the increase in tourism similar to its sister isle. With an estimated 1,200 current residents, most are employed in only a few industries. The Barbuda Council has traditionally been the main employer. Fisheries, sand-mining, and small-scale tourism have contributed revenue to the Island. Barbuda Ocean Club reports that it now employs 60 Barbudans.

A development of this small scale fits with the Barbuda vision as outlined by the Barbuda Council Chair (Observer Media 2020) and will have a small impact on the socio-cultural life of Barbuda. Impacts on tourism during the construction phase are likely to be small, though there will be activity in the area of the Barbuda Belle easement. There will be no change in access to beaches which are public throughout Antigua and Barbuda. At least fourteen local jobs will be created during the construction phase of the Abercorn Residence. During the operational phase, the Abercorn Residence will employ at least four individuals and more when guests are present. In addition, several part-time positions and use-of-service providers are anticipated when the owners and guests are present. Additional revenues through tourism, use of tour guides, boat captains etc., are anticipated.

Natural Hazards, Climate Change, Risks and Mitigation

Barbuda is in an active hurricane and seismic zone. A total of 62 hurricanes, including 22 major hurricanes (Category 3 and above) have passed within 200km of the project site since 1851. Hurricane Irma (Category 5) exceeded all forecasts and did major damage to the island, especially to the town of Codrington. Wind and storm surge damage occurred throughout the island. Irma has since become the storm of record for the region.

Strong earthquakes are relatively infrequent but do occur. In 2016, a 6.0 magnitude earthquake was recorded centered about 122km (76 miles) northeast of Barbuda. No significant damage was reported. The return period for a Magnitude 7 is 27 years, and for a Magnitude 8, it is 75 years.

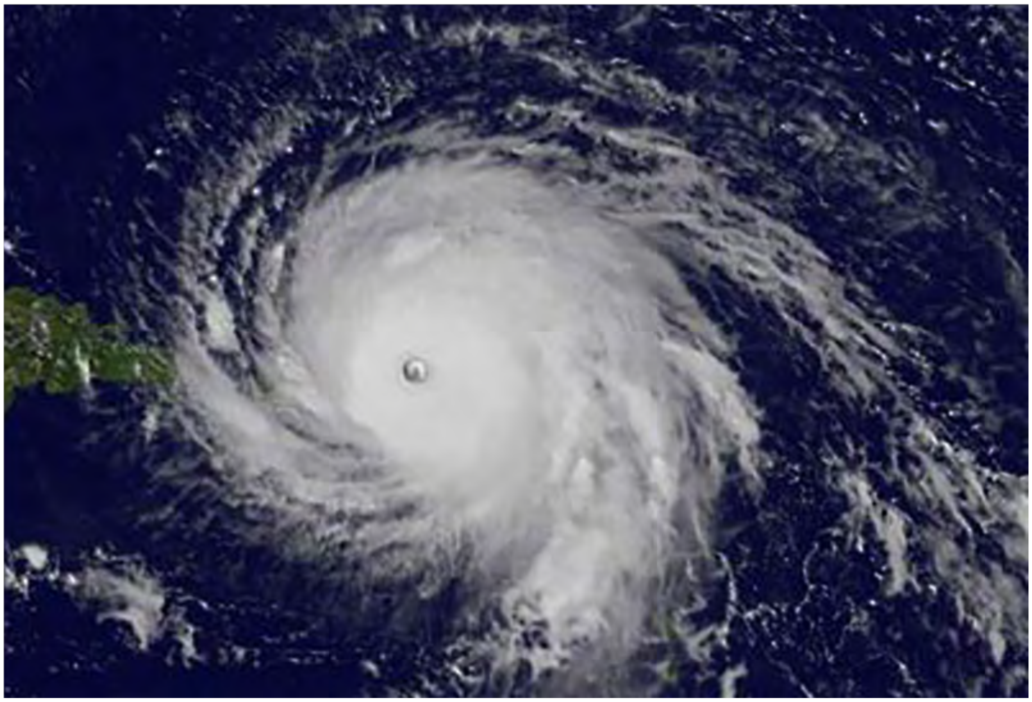

Figure 6. Hurricane Irma (Category 5) made landfall on Barbuda at 0545 UTC 6 Sept. 2017.

Climate Change

Several climate change projections and analyses have been conducted for the Caribbean. While many of these are at a regional level, Caribsave (Simpson et al., 2012) carried out a country assessment for Antigua and Barbuda under low, medium and high emissions scenarios. The main findings suggest the following:

Tropical Storms and Hurricanes**:** North Atlantic hurricanes and tropical storms appear to have increased in intensity over the last 30 years. Observed and projected increases in SSTs indicate potential for continuing increases in hurricane activity, and model projections indicate that this may occur through increases in intensity of events but not necessarily through increases in frequency of storms.

Temperature: Regional Climate Models predict 2.4˚C increase under low emissions scenario and 3.2˚C in higher emissions scenario* by the 2080s.

Rainfall: Downscaled rainfall models are not uniform in their predictions, but most indicate lower rainfall under climate change scenarios.

Sea Surface Temperature (SST): SST is projected to increases by between +0.7˚C and +2.8˚C and by the 2080s across all three emissions scenarios.

The impacts of climate change will affect storm surge and sea level rise with consequences for the development. Appropriate, risk-management based setback and elevations can mitigate these impacts

Coastal Vulnerability Analysis

A coastal vulnerability analysis was carried out to determine risks and propose mitigation. Offshore wave data were extracted from the NOAA WaveWatchIII model at three locations. The STWAVE model was then used to transform these offshore data to wave dynamics specific to Cedar Tree shorelines. In other words, we modelled the height, direction, and periodicity of waves likely to come ashore on the coast. Waves were propagated with site-specific data from the recently collected bathymetry surveys of the nearshore environment. Based on these models, the peak offshore wave height (Point 3 off the NW coast) for a 100-year (Irma-level) hurricane is approximately 5.6 meters or 18.3 ft with a peak wave period of 17 seconds. One-hundred-year surge forecasts developed by the Global Risk Assessment (GAR, 2015) were used in the assessment. SBeach, a numerical simulation model to predict erosion during storms and surge events and developed for nearby areas was incorporated into the assessment

Risk Management

For hurricanes at the intensity of Hurricane Irma – Category 5, the minimum recommended design floor elevation (DFE) for lowest horizontal structural members at Cedar Tree Point is +12.6 ft MSL. Based on the simulation studies and site analysis a minimum nominal setback distance of 200 feet from the mean high-water line is recommended on the ocean side. On the lagoon side, a minimum setback of 100 feet to major structures is recommended. These setbacks are based on the appropriate DFE being applied.

The Abercorn and DeJoria residences are being planned to be built at a finished floor elevation of 14 or 15 ft+MSL. In addition, the Abercorn residence is now 300ft from the LPV and the DeJoria residence is well within the 200ft setback setting. In addition, all homes will be built to seismic code standards.

Conclusions

The Abercorn Trust proposes two residences with shared infrastructure on the Cedar Tree Point area in NW Barbuda. The two residences will be located in a National Park and RAMSAR site. While development in these areas is discouraged, two hotels have been permitted and have operated in this area -- one of them (0.95km away) is still operational. The development fits with the low-density development vision identified by the Barbuda Council.

The development poses low-moderate risk to the overall biology/ecology of the area and these risks can be mitigated by BMPs. These practices include construction planning, transport of equipment on to the island etc. to minimize loss of vegetation and to avoid any harm to nesting sea turtles. However, it is critical that these environmental mitigation protocols proposed here be implemented.

Water is not available and there is no infrastructure on site. These amenities must be constructed, and the owners have conducted analysis to determine the best options including for renewable energy and other LID systems can be used.

A coastal vulnerability analysis identified minimum setback and elevation levels for resilient development and these recommendations are incorporated into the design of both properties.

The project sponsors have stated their intent in the G-application to ensure that the development has the lowest practicable impact on the surrounding environment, and that the development will be built to the highest standards including using renewable energy and BMPs.

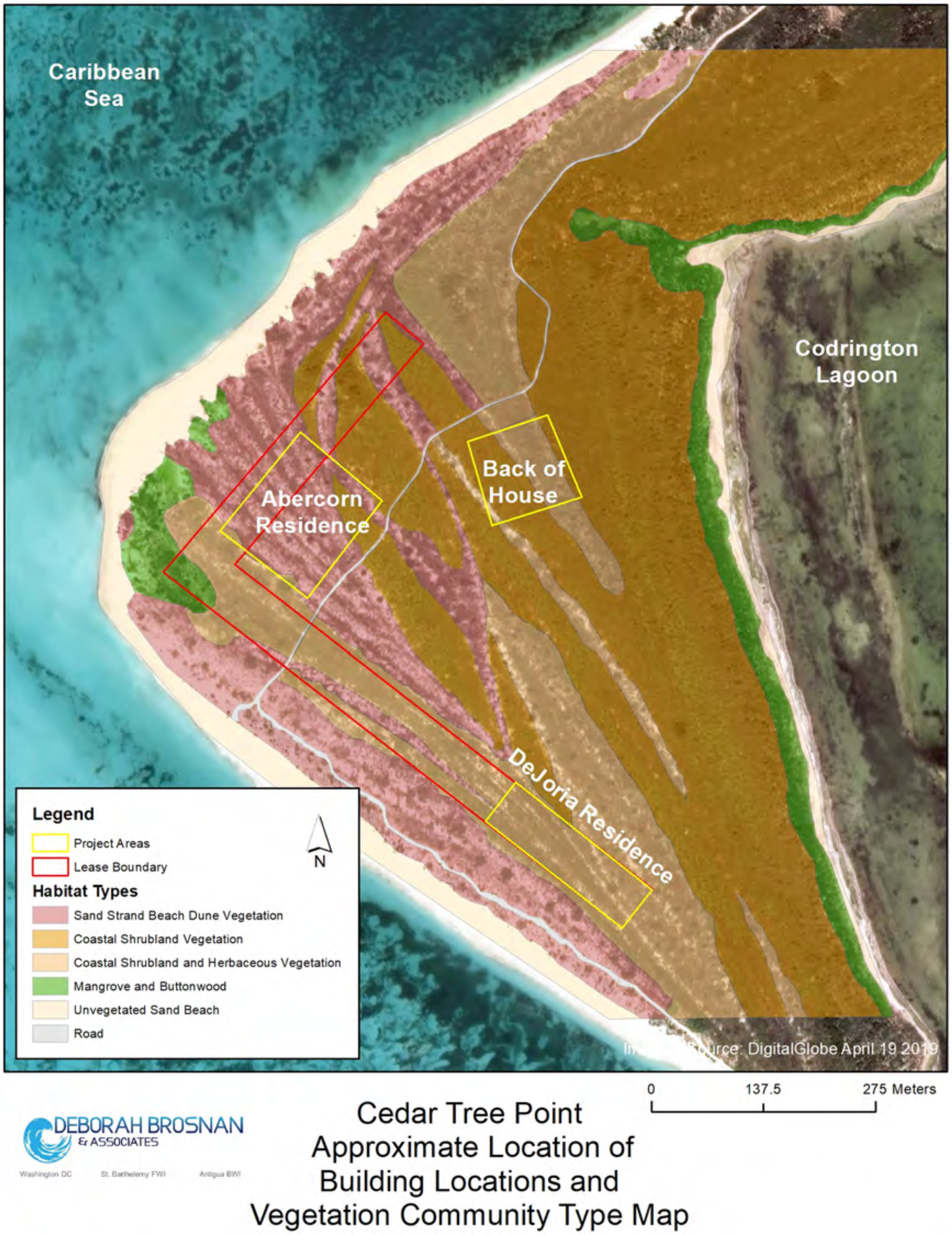

Figure 7. Map showing approximate building locations in relation to vegetation assemblage type mapping.

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SECTION 1.0 INTRODUCTION

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This document is the Environmental Impact Assessment (EIA) for a residential development at Cedar Tree Point, Barbuda. On February 27, 2020, Abercorn Trust Inc. submitted a G-Application (#G4-2020) to the Development Control Authority (DCA) in accordance with Part 4, Sections 17-19 of the Physical Planning Act of 2003. The project proposed a low-density residential project on Cedar Tree Point, a low-lying peninsula located in the northwest of the island of Barbuda. The development consists of two residences (the Abercorn Residence and the DeJoria Residence), an associated back of house area, as well as driveways and outbuildings. In June 2020, the DCA and Department of Environment (DoE) conducted a site visit to the proposed project location. The agencies then conducted due diligence to confirm that the lease was in good standing prior to issuing Terms of Reference (ToR) In October 2020, the DoE provided Deborah Brosnan and Associates the final ToR for an EIA. The EIA completed here follows the structure requested in the ToR provided (see appendix).

The EIA was conducted to professional scientific standards following the Terms of Reference issued by the DCA and as prepared by the Department of Environment in their letter dated September 29, 2020. The ToR specifically requested that Rapid Coastal Erosion; Hydrology and Drainage; Alteration to Wetland and Ecosystems Impacts; Water Resources; Energy-Solar PV; and Climate Change Impacts-Storm Surge be addressed. Each of these topics was assessed and findings are reported in the relevant sections in the EIA.

Project Sponsors

The Abercorn Trust, Inc. is the leaseholder of 16.17 acres plus a security buffer making a total of c. 113.9 acres on Cedar Point Barbuda (see Figure 2.1.6). Mr. Anderson, a British businessman, is the Director of the Abercorn Trust and the lead developer. He has partnered with Mr. John Paul DeJoria for this project.

Abercorn Trust Inc. Contact:
The Law Offices of Damien and Benjamin Steadroy
c/o Benjamin & Co., Attorneys-At-Law,
Nevis St., St. John's,
Antigua.

Mr. John Paul DeJoria is an American entrepreneur, businessman, and philanthropist known for co-founding John Paul Mitchell Systems, and the Patrón Spirits Company. His philanthropic efforts focus on environment and sustainability. He is a major supporter of Sea Shepherd Conservation Society and supports Food4Africa and Grow Appalachia among many other efforts. Mr. DeJoria is also a partner in Peace, Love, and Happiness, Ltd.

The project proposes to build the Abercorn Residence, the DeJoria Residence, and all associated infrastructure (mostly combined for both residences). The Abercorn Residence is planned as a 15,000 square feet villa. The residence will use a traditional style, built with wood-frame construction. The DeJoria Residence is planned as a 16,000 square feet villa and is currently envisioned in a modern style and using modern materials (concrete, steel, glass, etc.). The DeJoria Residence is not expected to commence for 3-4 years following approval in principle. The construction will use green building materials and techniques where possible to minimize the impact of construction. The Abercorn Residence will be for the use of members of the Abercorn Trust and their guests. The DeJoria Residence when built will be for private use by Mr. DeJoria his family and guests.

The lease covers 16.17 acres on Cedar Tree Point and consists of a roughly 200ft wide parcel of land running linearly behind the coastline of Cedar Tree Point plus a security buffer running inland from the edge of the property boundary and for an approximate total area of 113.9 acres (Figure 2.1.5).

The follow legislation and policies have been considered and incorporated into this EIA:

- Physical Planning Act, 2003
- Environmental Protection and Management Act, 2019
- National Sustainable Island Resource Management Zoning Plan (SIRMZP), 2012
- The Barbuda (Coastal Zoning and Management) Regulations, 2014
- Antigua and Barbuda Beach Control Act, 1959
- Codrington Lagoon National Park
- RAMSAR Convention
- Cartagena Convention
- Convention on International Trade in Endangered Species

SECTION 2.0 PROJECT DESCRIPTION

SECTION 2.0 PROJECT DESCRIPTION

Abercorn Trust, Inc., in partnership with Mr. John Paul DeJoria, propose to build two residential properties and associated infrastructure on a parcel at Cedar Tree Point, located on the northwest coast of Barbuda.

The Abercorn Residence is envisioned as a 15,000 square feet villa on the northern and western section of the property leased by Abercorn Trust, Inc. The Abercorn Residence is planned as a traditional style residence, utilizing wood-frame construction. The second residence, the DeJoria Residence, is envisioned as a 16,000 square feet villa at the south end of the property leased to Abercorn Trust, Inc. The DeJoria Residence is envisioned as a more contemporary home, using modern materials (concrete, steel, glass, etc.). Construction is not expected to commence for 3-4 years after Approval in Principle is secured.

Each residence is designed to consist of several smaller buildings connected by terraces and pathways into a single unit. When completed, the Abercorn Residence will consist of nine smaller units arranged in a formal, rectilinear style on a raised, boardwalk-like platform, in addition to a small storage shed at the ground level. The DeJoria Residence will comprise eight smaller buildings laid out in a linear, naturalistic style. The residence will include living space, several small guest houses, gym, pools, gardens and terraces, as well as space for staff, security, and other support services. Both residences are planned to be one-story residences, with the exception of a second-story security watch structure planned as part of the Abercorn Residence.

The Cedar Tree Point site currently lacks any infrastructure for public utilities (water, sewer, electricity). To accommodate these needs, a back-of-house area is planned east of the residences, within the 1000' security buffer surrounding the Abercorn Trust, Inc. property.

Water will be provided by a sea water reverse-osmosis (SWRO) water treatment plant. To increase water use efficiency, rainwater capture systems (cisterns, etc.) will be incorporated into the site design. Wastewater from the site will be processed at a small treatment plant at the back-of-house area. Electricity will be provided via diesel generators and a solar field, also located in the back-of-house area. The intent is to ultimately shift completely to renewable energy and use generators as a back-up.

As the area is now effectively an island, access to the site will be via boat. During the construction phase, equipment is anticipated to be brought to site via a shallow-draft roll on/roll off craft. During the operational phase, access will be via shallow-draft boat. One unpaved road currently exists on site. The development will improve a portion of this roadway and add driveways to access the residences and back-of-house area. The improved road and driveways are planned to use permeable pavers. During the operations phase, traffic on site is expected to largely consist of small electric vehicles, although light trucks may be used by maintenance or landscaping staff.

Project Approach

The project developers are committed to a sustainable and resilient development. For instance, the properties will use solar cells for power generation, and transition towards a zero-carbon electricity source for the property. Other green building techniques being considered for this project include permeable pavements, drought-tolerant landscaping, sustainably sourced materials, including renewable timber and low-carbon concrete, and energy-efficient design. The owners seek to complete and operate the project with the minimum possible carbon footprint.

The project will be designed to respect and protect natural landscape and wildlife. Native vegetation will be the primary landscape. The current sea turtle monitoring program (supported by Mr. DeJoria) will be enhanced to include surveying in the area and sea turtle friendly lights used during nesting season.

Barbuda is exposed to hurricanes and sea level rise impacts. To promote resilience, the project has conducted hydrodynamic analysis and will use setback and elevation methods to minimize these hazard risks. In addition, nature-based solutions will be incorporated to provide additional resilience to the site and project.

Project Location: Cedar Tree Point

Cedar Tree Point is located at the northwest corner of Barbuda. The land consists of a sand dune and beach system. It is part of a geologic formation known as the Palmetto Point formation, formed during the Holocene era c.11,700 year ago.

In 2017, Hurricane Irma breached a series of inlets from the ocean into Codrington Lagoon. Two of these new inlets remain open, one through the sand spit south of the property (which is now a main boat access route into Codrington), and a second in the northern shore east of the Barbuda Belle resort adjacent to a previous inlet. As a result, the property no longer has a permanent land-connection to the main island of Barbuda.

The leased land is currently undeveloped and unoccupied. The nearest structures are the active Barbuda Belle hotel, located 0.95km northeast of the site along the northern shore and adjacent to an inlet. The former Lighthouse Hotel (destroyed during Hurricane Irma), is 5km south of the site on the sand spit, near the breach. Unlike many other parts of Barbuda, the site does not have free-roaming livestock. The project site is not heavily visited, with the exception of guests staying at the nearby Barbuda Belle hotel, and occasional visitors to the Island. Small, shallow-draft tour boats bring visitors to the frigate bird colony located inside the lagoon and to the south of the site. Fishing boats occasionally operate offshore of the project site.

The site is located within the Codrington Lagoon National Park, established in 2005 to conserve the lagoon and associated wetland areas. The Codrington Lagoon National Park was further designated a wetland of international importance in 2006 as part of the RAMSAR convention. Development has already taken place in this area of the Park, notably the Barbuda Belle Hotel and the Lighthouse Resort. The owners have stated their commitment to minimizing any impact on the National Park and RAMSAR site and to actively take steps to enhance the natural resource.

Project Schedule for Implementation

Following receipt of Approval in Principle for the project, construction for the Abercorn Residence and associated infrastructure is expected to begin within 3 months pending approval of any subsequent A-Applications. Construction of the Abercorn Residence and associated infrastructure is anticipated to take 18 months. The DeJoria Residence is expected to commence no earlier than 24 months (more likely between 3-4 years) following of Approval in Principle and pending approval of the associated A-Application. Construction of the DeJoria Residence is anticipated to take 12-18 months. Utilities for the Abercorn Residence will be designed to be expandable. New trains for water desalination, wastewater treatment, electricity, etc. can be seamlessly integrated to serve the DeJoria Residence once constructed.

2.1 Essential Maps

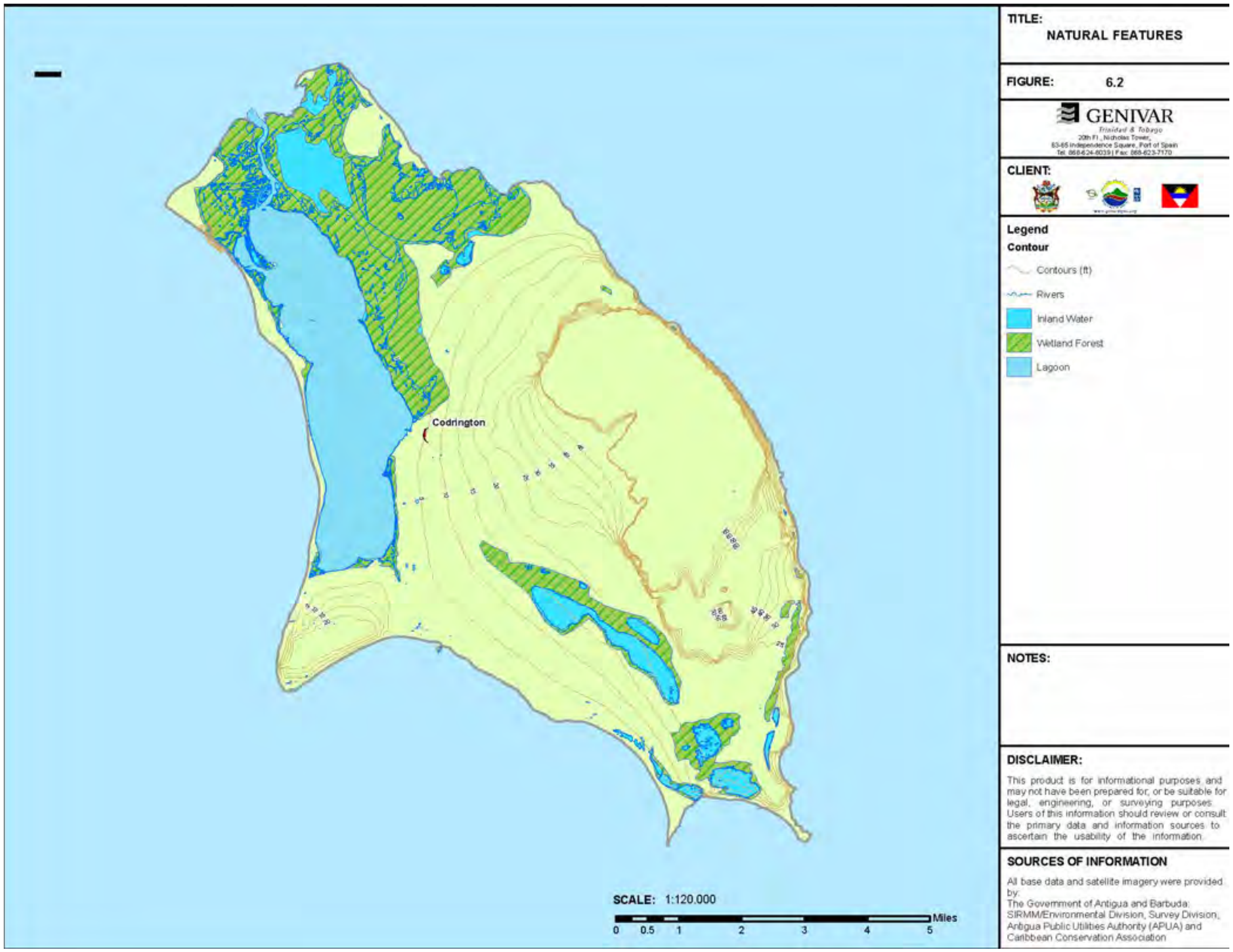


Figure 2.1.1. Barbuda natural features map (source: Genivar, 2011).

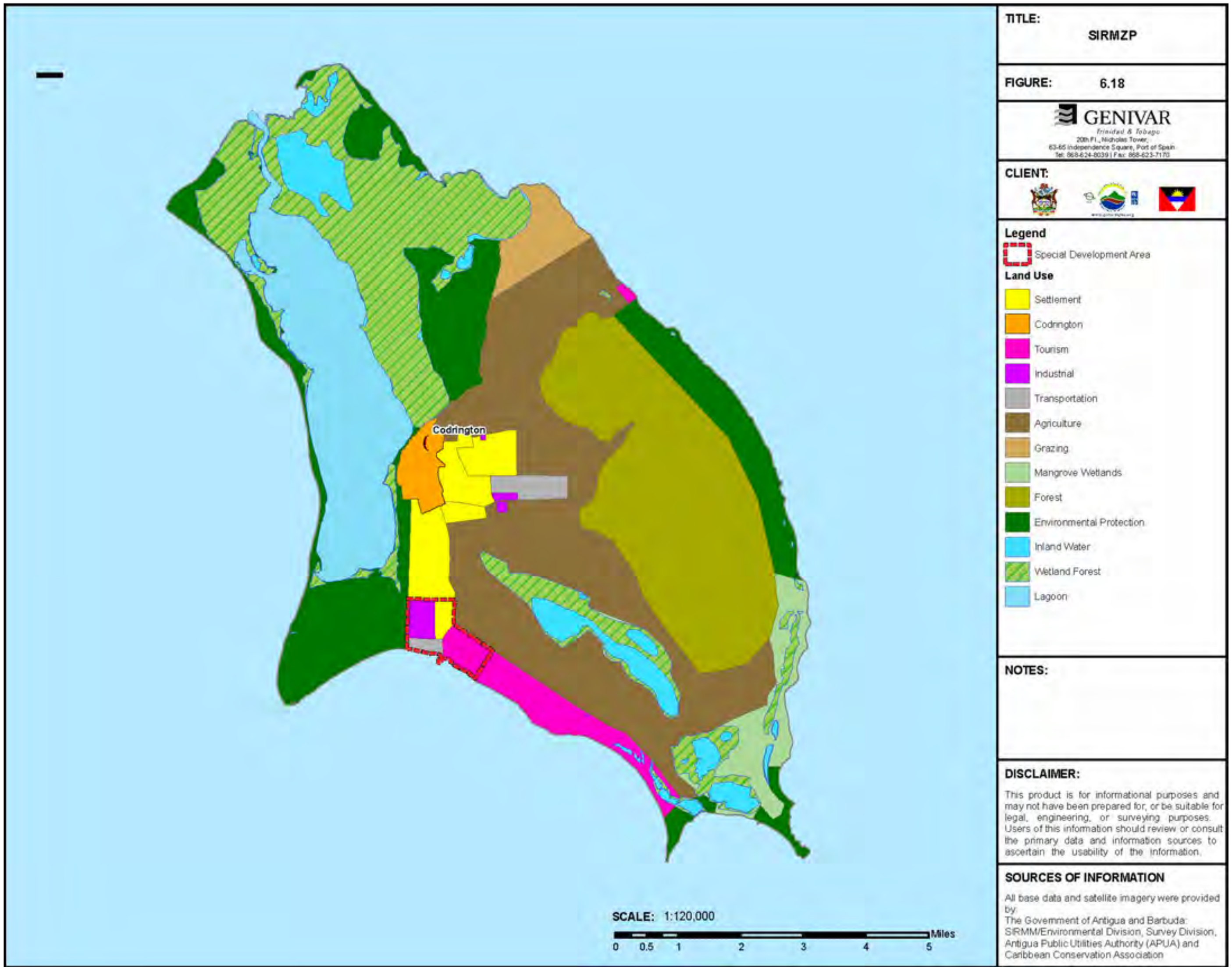


Figure 2.1.2. Sustainable Island Resource Management Zoning Plan (source: Genivar, 2011)

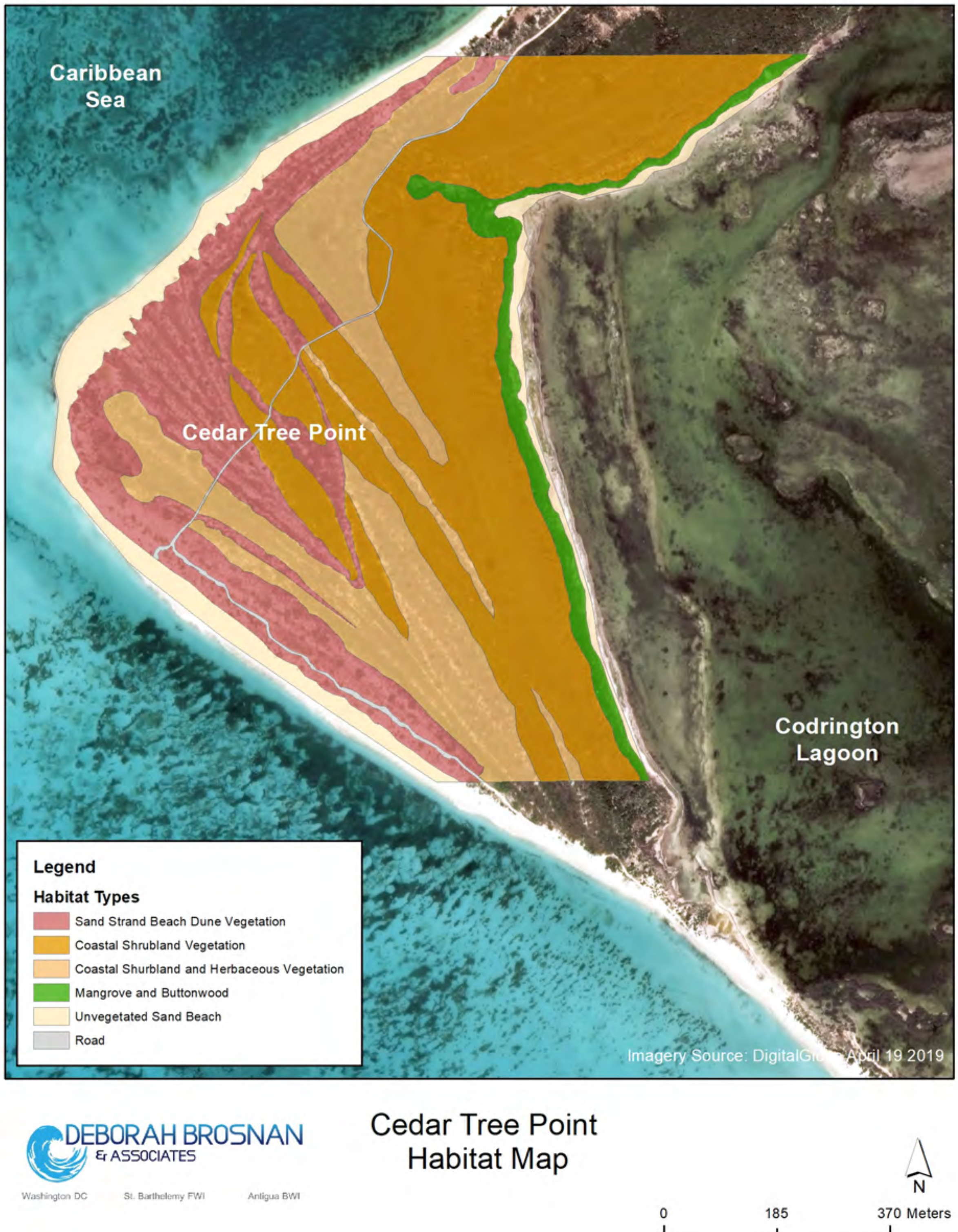


Figure 2.1.3. Site vegetation assemblage map.

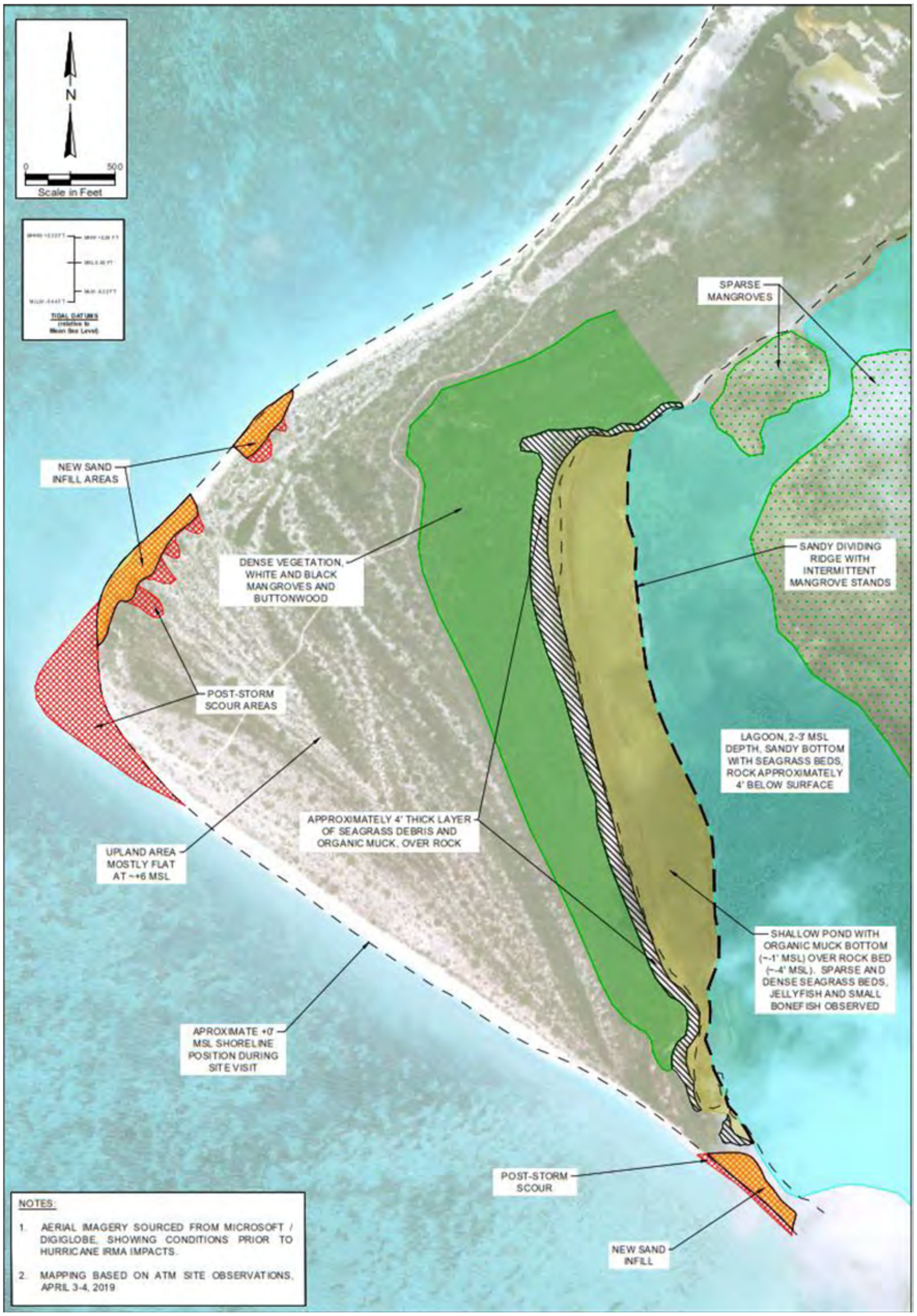


Figure 2.1.4. Project site characterization (based on 04/2019 site visit).

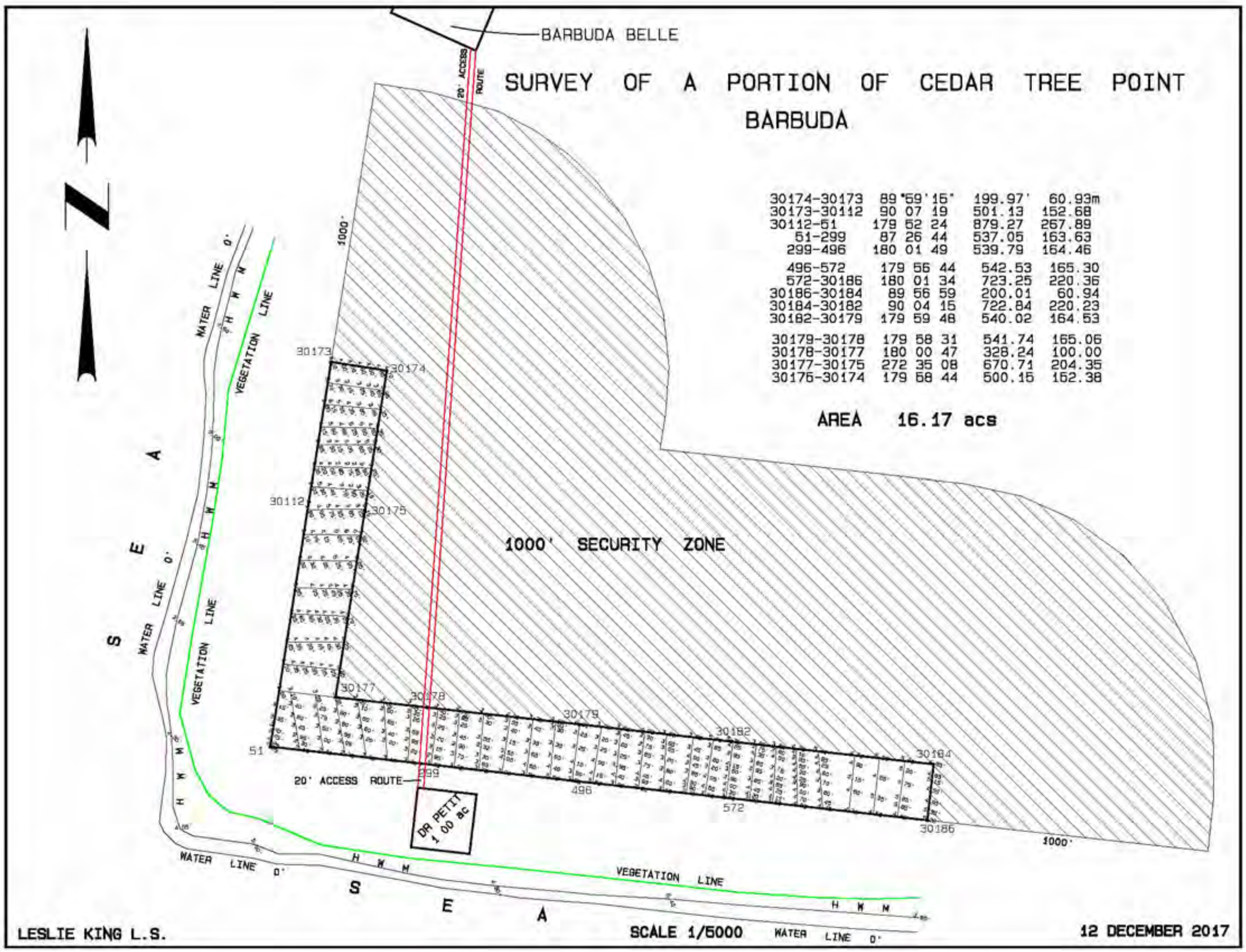


Figure 2.1.5. Topographic survey of Cedar Tree Point parcel.

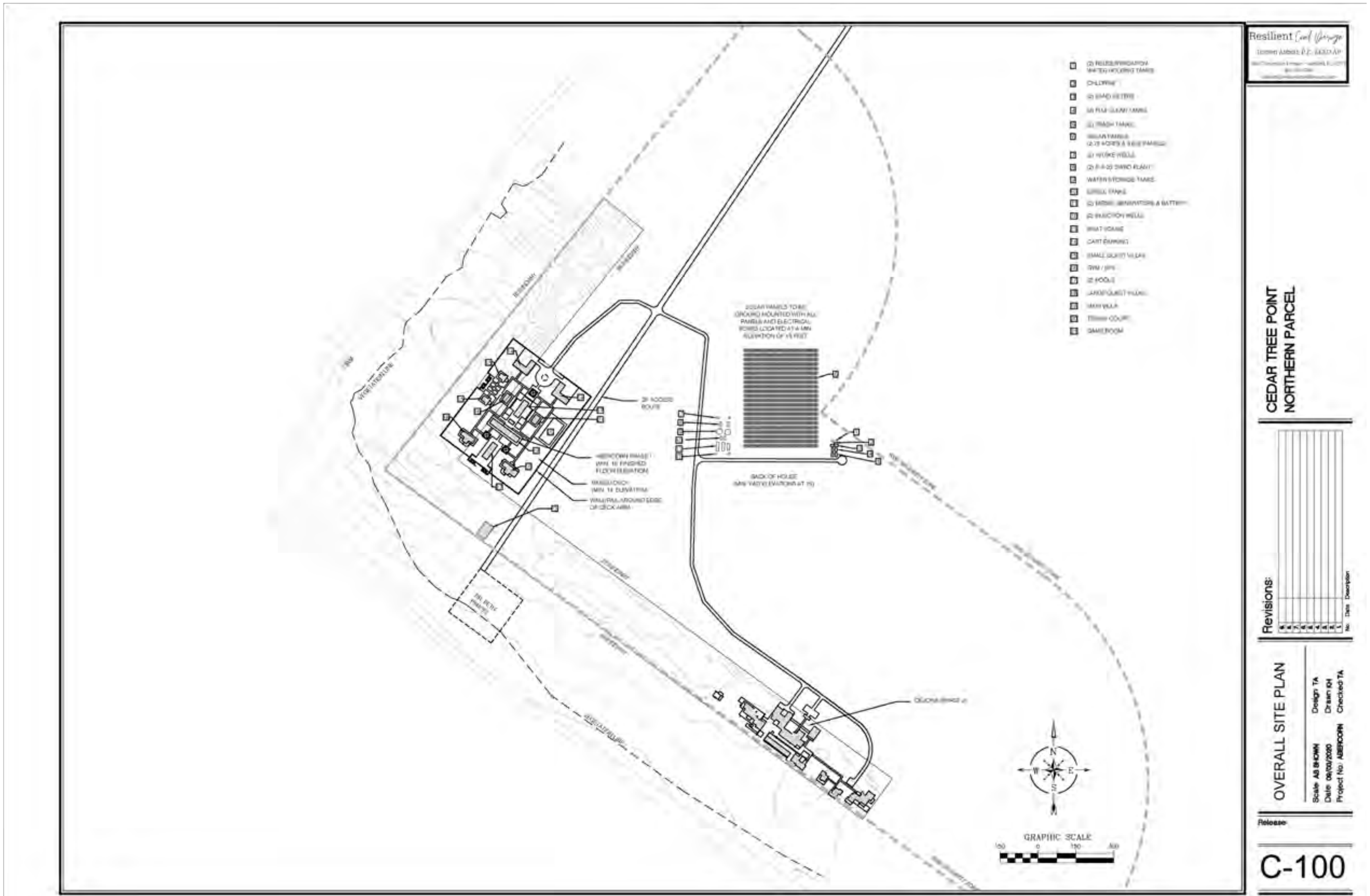


Figure 2.1.6. Conceptual site plan.

2.2 Project Benefits

Direct benefits from the project include employment of local individuals and construction companies during the construction phase of the project. During the operational phase of the project, management, landscaping, security, housekeeping, and kitchen staff as well as tour guides will be employed by the owners.

More specifically, at least fourteen local jobs will be created during the construction phase of the Abercorn Residence. These jobs will be temporary positions during the construction phase. During the operational phase, the Abercorn Residence will employ at least two full-time landscapers and one full-time housekeeper and will provide part-time work for pool maintenance and an engineer. These will be year-round positions, continuing even during periods when Abercorn Residence is unoccupied. In addition, several part-time positions and use-of-service providers (e.g. local tour guides, boat and water sports personnel) are anticipated when the owners and guests are present. Employment data for the second villa is not yet available and will be assessed as the project moves closer to the construction. However, at the time of writing, the project anticipates similar construction and operations employment numbers.

Environmental Support

One of the project sponsors Mr. DeJoria supports the Barbuda Sea Turtle Program. That program has been designed to be locally run and includes training and employment for several Barbudans. This first-of-its-kind GIS-based monitoring program has secured sea turtle tagging for two of the Barbudan sea turtle team. Now entering its third year, the program is linked with the international WIDECAST sea turtle monitoring program, managed by the University of the West Indies.

2.3 Analysis of Alternatives

In the original submission, the Abercorn residence was sited closer to Cedar Tree Point. However, during the site studies, it was clear that Cedar Tree Point has eroded since the original concept was proposed (we cannot say whether this is a temporary or permanent erosion given the highly dynamic nature of the beach). At the same time, a small outcrop of buttonwood and mangrove was documented just behind the dune at the point. The soil was dry and the plants in poor condition. However, their presence indicated to the team present that there is some risk from overwash during storms and/or from the combination of erosion plus storm conditions. As a direct result of these observations and input from DoE, the developer re-sited the property further back from the beach to 300ft from LPV. A revised plan was submitted to DCA showing the new siting.

Alternative energy sources, as well as various stormwater and wastewater management options have been explored during the EIA process and are presented in the relevant sections.

SECTION 3.0 METHODOLOGY

SECTION 3.0 METHODOLOGY

The methodologies used in this EIA are consistent with industry standards. They are similar to other EIAs submitted for coastal developments including Barbuda Preserve (2018) and Coco Point EIAs (2019). Biological studies were carried out using a combination of on-site observations and surveys supplemented with remote sensing and existing literature review. Risk analysis focused on the potential for storm surge during hurricanes and a future Hurricane Irma-level storm event and used standard modelling techniques (e.g. SBeach) and professional expertise. Details on several methodologies are provided below:

3.1 Environmental Baseline

Vegetation**:** Vegetation was directly assessed during site visits between April and July 2019. Species present were recorded and mapped to biological assemblage type. See Section 4.5, Environmental Baseline (See Table 4.5.1 for the full list of plant species).

Seagrass: On April 5, 2019, conducted three 30-meter seagrass transects in the lagoon recording percent coverage of each seagrass species present in 0.25 m^2 quadrats at 1-meter intervals. Additional seagrass assessments were made by the engineering and science teams during April 2019 and from aerial imagery. Description of the seagrass community can be found in Section 4.5, Environmental Baseline – Biological Environment, and Appendix 1 A4- Survey data.

Coral Reefs: No nearshore reefs have been found near the project area either on the ocean or lagoon side. Reefs offshore to the northwest of Cedar Tree Point have been previously surveyed. But there are too distant offshore to be impacted by the project.

Sea Turtles: Members of the Barbuda sea turtle team monitored the site during nesting season in 2019 using standard methods currently being used in the program. Data on sea turtle nesting collected at Cedar Tree Point can be found in Section 4.5, Environmental Baseline – Biological Environment.

Wildlife: A total of four-hours of bird surveys was conducted on Cedar Tree Point. See Section 4.5 and Appendix 1-A4.

3.2 Risk Analysis

Natural Hazards: Climate change and sea level rise (SLR) risks were analyzed as part of this EIA. A 50-year projection of regional SLR using the latest IPCC SLR prediction curves (from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 2014) for a low-end and a high-end scenario were used in this analysis, in addition to data from previous studies and reports conducted by our science and engineering teams. Details can be found in Section 6.1, Natural Hazards and Climate Change.

Storm Surge: Storm surge analysis were conducted using offshore wave data, XBeach and other models. Special consideration was given to values and analysis related to recent Hurricane Irma's impacts on Barbuda as it is now the extreme storm of record. Details on storm surge analysis completed for this project, can be found in Section 6.2, Coastal Vulnerability Assessment.

3.3 Mitigation Measures

Mitigation measures to address specific impacts were developed and proposed. See Section 5.5. for full details.

SECTION 4.0 ENVIRONMENTAL BASELINE

4.0 ENVIRONMENTAL BASELINE

4.1 Land Environment

4.1.1 Soils and Geology

Barbuda is a flat limestone island emerging from the eastern edge of the shallow Barbuda Bank. Covering some 62 square miles (160km^2), it consists of a tilted Oligocene succession of volcanic rocks overlain by fossil rich tuffs and capped by marine limestone. Barbuda first emerged between 15-20 million years ago. There are three main geologic regions: the Highlands formation, located on the elevated eastern portion of the island; the Codrington Formation, found in the lower elevations; and the Palmetto Point formation, a lowland area to the west and north (where the project is located). Formed during the Holocene era (11,700 years ago to present), the Palmetto Point formation is a sand substrate derived from calcareous algae, shells and corals and organized into extensive dune systems (Brasier and Mather, 1975). Much of the land at Cedar Tree Point is thought to have accreted in the area in the last few centuries (Russell and McIntire, 1967).

Soils

Comprehensive studies were carried out by Martin-Kaye (1956), Hill (1966) and Ahmad (1984). The studies show that Barbuda's soils are mostly homogeneous with limestone-derived soils covering 78% of the island. Much of the limestone soil consists of fine-grain particles of biogenic origin e.g. derived from corals, coralline algae and shells (Brasier & Mather, 1975).

Beach sand formations are the predominant soil types, covering most of the property. Mangrove swamp formations can be found on the east side of Cedar Tree Point along the shore of Codrington Lagoon. These soils are porous and drain quickly (Mather, 1971), and watersheds on site are poorly defined.

Soils Suitable for Agricultural Lands

The natural resources assessment for the agricultural sector was carried out in 1992, and classified lands ranging from Class I, the most suitable for agriculture (where only one limiting factor such as salinity, shallow depth, etc. existed) to Class VII, highly unsuitable. In practice, lands assessed as Class VI lands can only be cultivated using intensive conservation and management practices.

On Barbuda, most of the lands are not well suited to agriculture. 18% (6,640 acres (2,687 ha) are assessed as Class III and 33% (12,048 acres (4,486ha)) are assessed at Class IV. The remaining 49% of lands are in categories V or VI. The sand dunes and beach are in these higher classes and unsuitable for agriculture. No lands on the project site have been recommended for agricultural use (GENIVAR, 2011).

4.1.2 Topography

Cedar Tree Point is a low-lying, relatively flat coastal area with sandy beaches rising sharply from the sea level to a dune crest at an elevation of approximately +6ft (c. 2m) MSL. The dune system consists of a well-defined low ridge and valley system that extends from the sandspit north to the

Cedar Tree Point, and also runs along the north shore. The dunes have been established primarily by oceanic deposition and wind transportation. Russell and McIntire (1967) suggest the ridge system running along the north shore may have the result of sands accreting following a break in the fringing reef north of Barbuda caused by a storm event within the last few centuries, accounting for the change in direction of the dune system on site. The ridge and valley systems evident on the southern end of the island on Palmetto Peninsula are generally not as well defined on Cedar Tree Point. On the eastern side of the property, the land slopes gently down to the mangrove-fringed shoreline of Codrington Lagoon.

Current Land Use

The proposed project site is currently undeveloped and unoccupied. The Barbuda Belle Hotel maintains a one-acre easement which extends through the property to the western shore (Figure 2.1.5). The Hotel is located 0.95 km from the property and on the northern shore. The land was zoned for Environmental Preservation in the 2011 Sustainable Island Resource Management Zoning Plan (see Figure 2.1.2) although development has been allowed there.

Since 2017 when Hurricane Irma created a breach in the sandspit, the area has been separated by inlets from the remainder of Barbuda. The area is in effect an island which can only be accessed by boat. Except for guests staying at the Barbuda Belle Hotel, the development site is infrequently visited by local Barbudans and tourists alike.

The site is within the boundaries of the Codrington Lagoon National Park and is part of the RAMSAR site. The Park was created in 2005 by ministerial declaration under the authority granted by National Parks Act of 1984. In 2006, Codrington Lagoon National Park was identified as a wetland of international importance at the RAMSAR convention (CLNP Management Plan).

The Barbuda frigatebird reserve is located in the lagoon to the south of the proposed development (see Section 4.5, Biological Environment). Approximately 5,000 pairs nest in the mangroves, and juveniles spend the early part of their lives in this habitat. This is a major tourist attraction on Barbuda and local tour guides rely on the income from this natural amenity.

4.1.3 Beach Dynamics

Beaches and other uncemented sand-based habitats are by nature dynamic, although patterns over time can be revealed by regular monitoring. We found no long-term beach monitoring studies for the actual site at Cedar Tree Point, although the beach has been described as “seasonally unstable” (CLNP Management Plan, 2009).

We conducted an analysis based on publicly available aerial imagery of the site that revealed significant changes in beach size and shape along Cedar Tree Point between September 2009 and March 2020 (Figure 4.1.2), especially near the Point. Hurricane Irma eroded the beach at the point itself – as can be seen in the September 2017 image below. The sand has mostly recovered but the beach remains dynamic as can be seen for instance in a comparison between July 2019 and March 2020 (Figure 4.1.2).

For additional data, we investigated the results of beach monitoring at Palm Beach (approximately 5km south of the property) conducted by the Antigua and Barbuda Fisheries Division between 1995-2015. These data suggest that Palm Beach is eroding over the long-term, with a change in mean beach area of -21.09 m^2/yr and mean beach width of -0.56 m/yr. recorded during this period. However, the changes are not linear, as there have been periods of accretion interspersed with beach loss, with periods of beach build up occurring most notably during the years 2000-2003 and 2009-2011 (Figure 4.1.1). However, analysis by James (2017) concluded that overall trend is one of erosion.

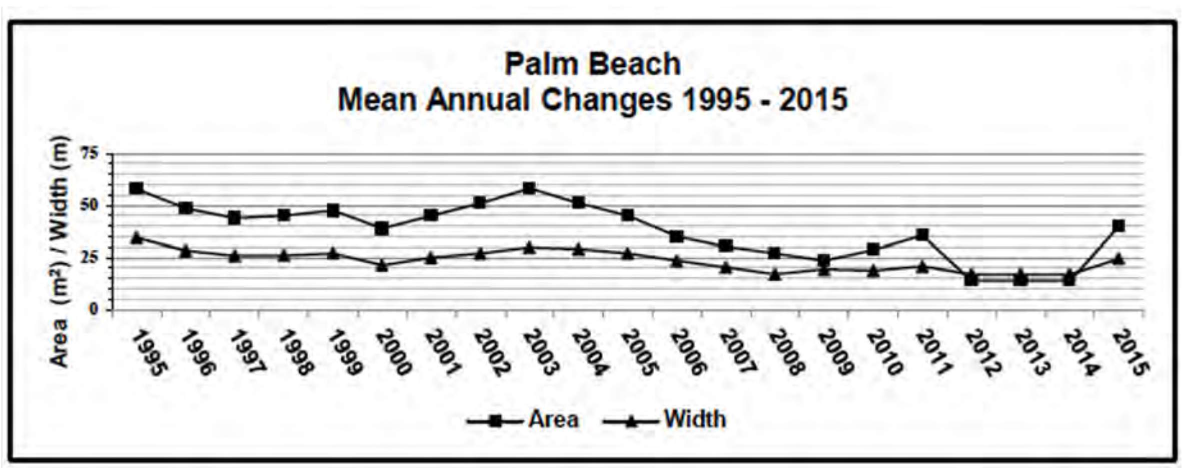


Figure 4.1.1. Changes in beach area and width at Low Bay, Barbuda (just south of Cedar Tree Point) 1995-2015. Source: James, 2017.

Figure 4.1.2. Comparison of Cedar Tree Point beach accretion/depletion, September 2009 – March 2020. The fourth image in the sequence shows conditions one day after Hurricane Irma made landfall on Barbuda. Imagery via Google Earth Analysis, Chapman 2020.

4.2 Air Environment

4.2.1 Climate Data

Barbuda is located within the Tropic of Cancer belt and experiences an island tropical climate. Its geology, location and rainfall classify it as semi-arid island according to UN hydrology and water resources standards (Barragne-Bigot and Yearwood, 1991).

Climate data are frequently reported for Antigua and Barbuda. Data for Barbuda alone are scarce, and most reports combine findings for both islands. However, we conducted a comprehensive search and were able source recent as well as some historic data for Barbuda.

<u>Temperature</u>

According to data compiled by the Antigua and Barbuda Meteorological Service for years 1971-2020 (Figure 4.2.1), the coldest month is February with an average mean daily temperature of 25.1ºC, and the warmest month is August with an average mean daily temperature of 28.2ºC, as measured at Antigua's V.C. Bird Airport (ABMS, 2020). Extreme temperatures have been observed in the summer and winter months, 34ºC recorded in August and 15ºC in January (*Drought Hazard Assessment and Mapping for Antigua and Barbuda*, 2001). Average annual temperature for the years 1973-2018 is shown in Figure 4.2.2. The trendline indicates a steady increase in average annual temperatures in the area during the time period.

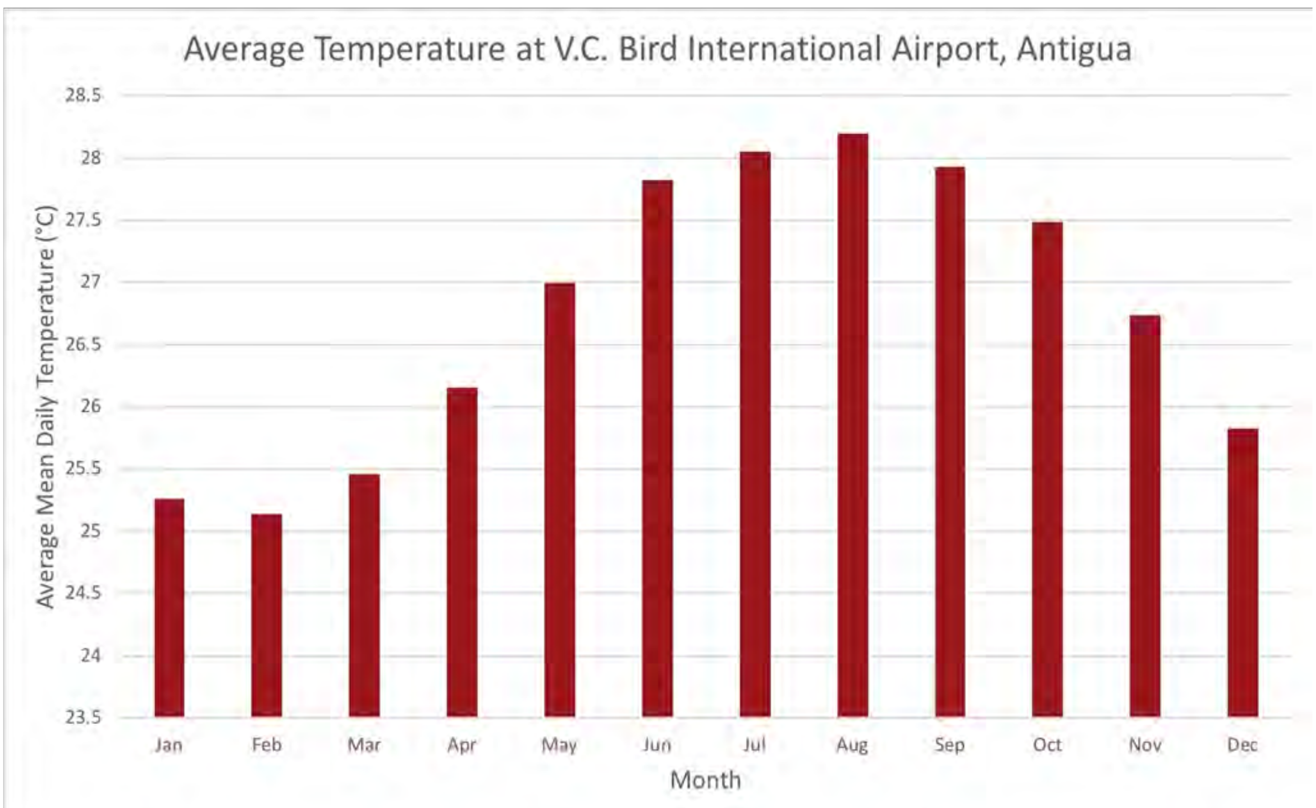


Figure 4.2.1. Average monthly mean daily temperature at V.C. Bird Airport, Antigua for the years 1973-2020. Data from ABMS.

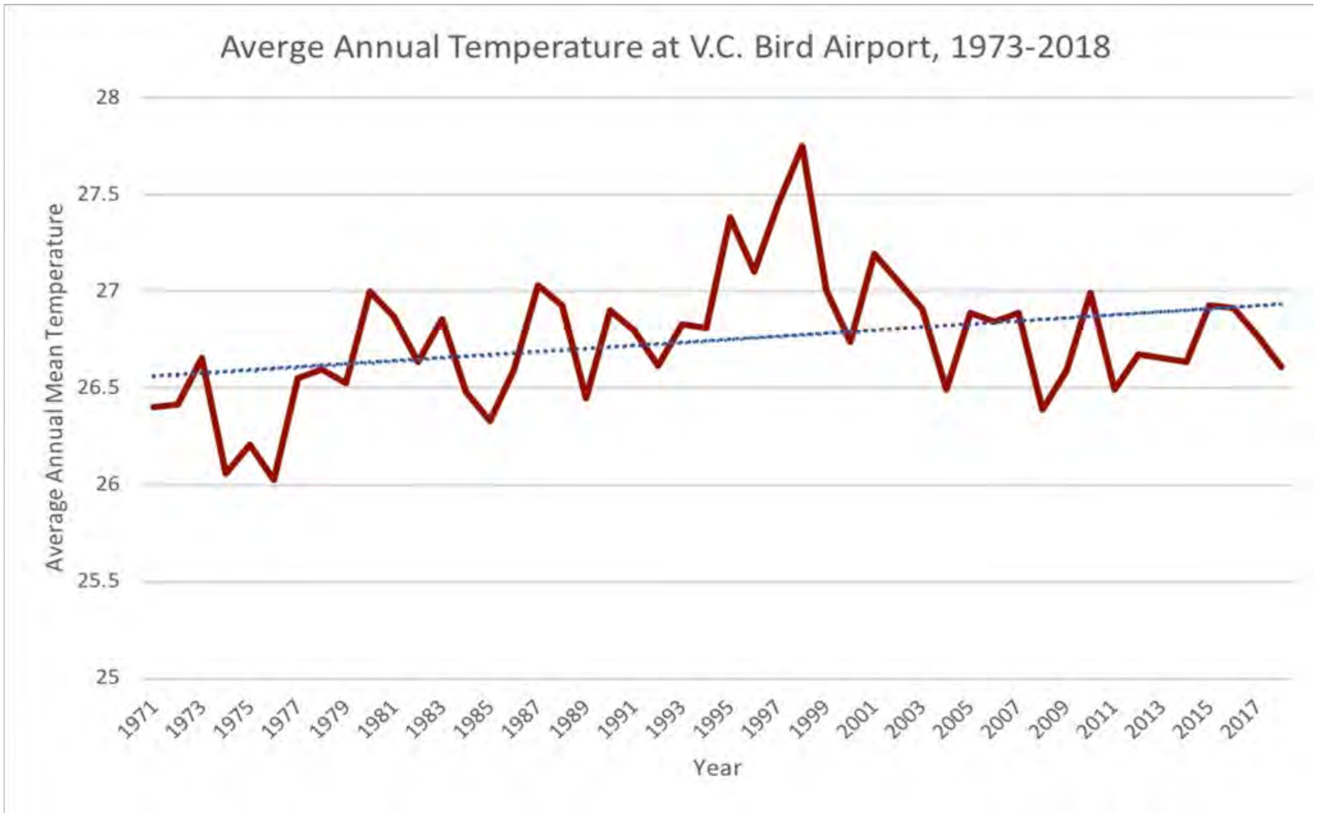


Figure 4.2.2. Average Annual Temperature 1973-2018 at V.C. Bird Airport with trendline. Data from ABMS.

Rainfall

According to data compiled by ABMS for the years 1993-2016 at Codrington, Barbuda, the driest month is March with average monthly rainfall of 45mm, and the wettest month is October with average monthly rainfall of 188mm (Figure 4.2.3). Average annual rainfall was 1165mm, however, rainfall is highly variable year-to-year (Figure 4.2.4), with the rainiest year during this time period (1999) receiving 2101mm of rainfall (180% of the average rainfall level), and the driest year (2000) receiving 622mm (53% of the average rainfall level) (ABMS, 2020).

Raw meteorological data are provided in Appendix 1, Tables A1 and A2.

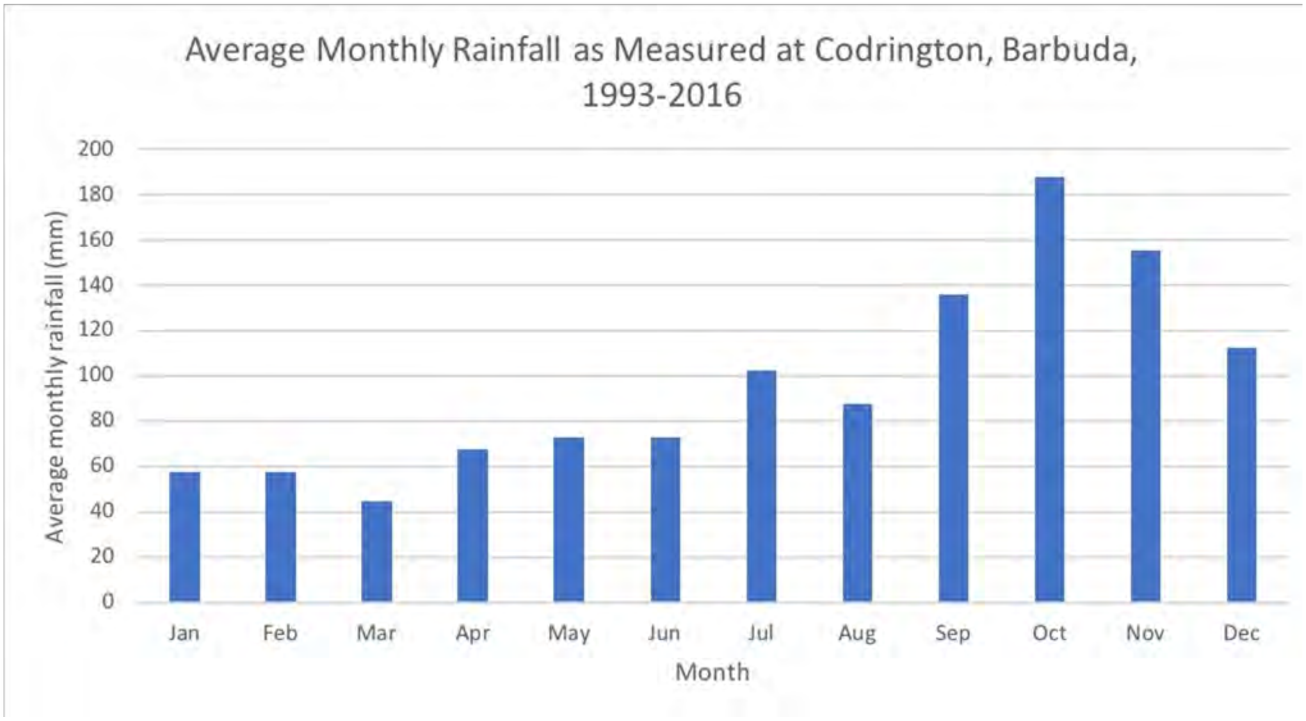


Figure 4.2.3. Average monthly rainfall at Codrington, Barbuda over the years 1993-2016. Data from ABMS.

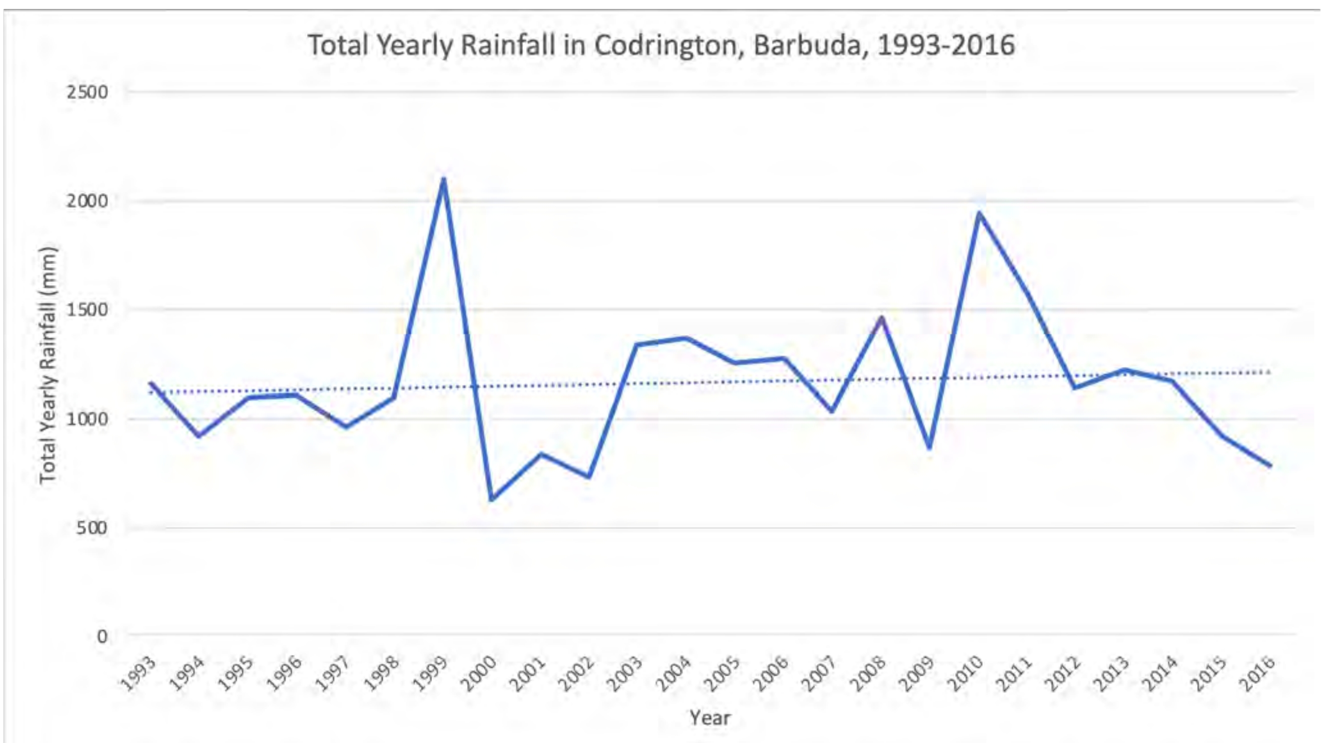


Figure 4.2.4. Total yearly rainfall at Codrington, Barbuda over the years 1993-2016 with trendline. Data from ABMS.

Drought is a recurrent feature of Antigua and Barbuda's climate and has large repercussions for the islands, especially given their relatively small size. The Island Resources Foundation (IRF) identified two periods, between 1964-1968 and 1983-1984, as times of prolonged drought. As illustrated in Figure 4.2.5, drought conditions were experienced throughout the 1960s and 1970s, specifically in the years 1966, 1967, 1968, 1971, 1977, 1983, 1990, and 1991 (*Drought Hazard Assessment and Mapping for Antigua and Barbuda*, 2001).

In 2016, Dale Destin (Antigua Met. Office) reported that Antigua and Barbuda was witnessing the worst drought in recent history and based on records dating back to 1871. Drought conditions can be attributed to a variety of climate-related issues, including an abundance of a dry Saharan air layer (SAL), positive North American Oscillation (NAO), negative Tropical North Atlantic Index (TNA), and El Nino conditions. These climate phenomena can lead to decreased precipitation in the Leeward Island area (Destin, 2016).

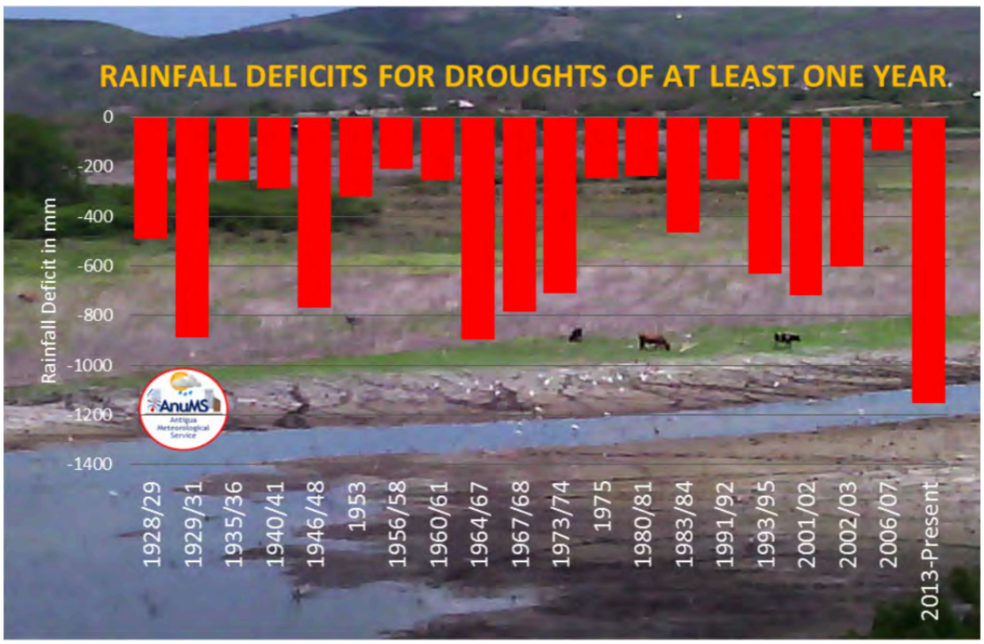


Figure 4.2.5. Rainfall deficit in mm for 1928-2016 (Destin, 2016)

Humidity

The annual average relative humidity as observed at V.C. Bird International Airport, Antigua over the time period 1992-2018 was 75.7%. During this time period, the least humid month was March (72.5%) and the most humid month was October (78.0%) (ABMS, 2020). Humidity data from Barbuda was not available but it is generally consistent with that of Antigua.

Cloud Cover

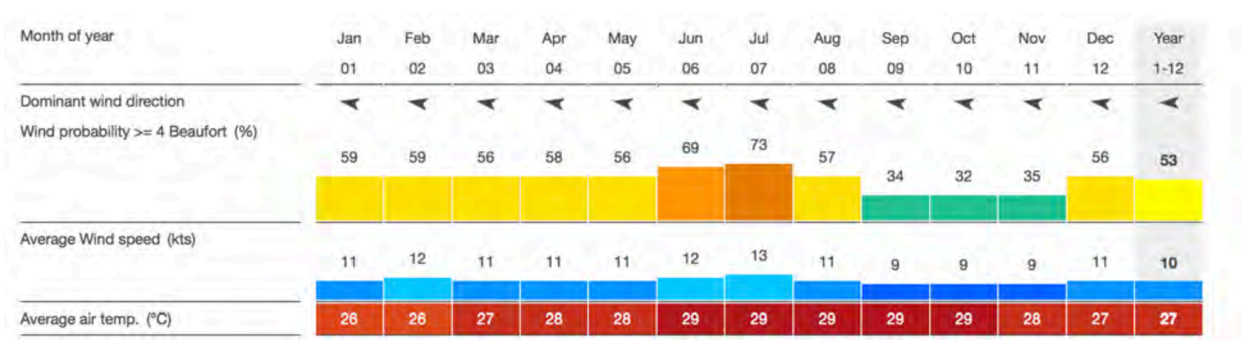
Antigua and Barbuda receive ample amounts of sunlight during the year, including during the wet season, averaging 200-250 hours of sun per month. The islands infrequently experience dense cloud cover, not including scattered cloud conditions, (Dense cloud occurs <6 months/yr.) (*Drought Hazard Assessment and Mapping for Antigua and Barbuda*, 2001).

Wind Speed and Direction

Barbuda is affected by the tradewinds that blow consistently E-W during the year, with slight variations from ENE to ESE especially during summer. Originating in Africa, these trade winds have a major effect on the Islands influencing hurricanes and Sahara dust.

The most comprehensive summary wind statistics are available from VC Bird Airport in Saint George, Antigua. We retrieved available data that ranged from December 2002 to November 2017 (recorded hourly from 7am to 7pm), and these are summarized in the graph below.

Figure 4.2.6 illustrates the average prevailing wind direction is 090 degrees for most of the year, shifting slightly higher to 100-130 degrees for the months of June and July. The average wind speed is 10 knots, and less than 4 on the Beaufort scale. The wind rose patterns, illustrated in Figure 4.2.7, indicate 38.4% of winds come in from the eastern direction, 20.2% come in from the east-southeast direction, 18.6% come in from east northeast direction, and the remaining 20% come in from the northeast and southeast directions.



WIND STATISTICS

Statistics based on observations taken between 12/2002 - 11/2017 daily from 7am to 7pm local time. You can order the raw wind and weather data in Excel format from our historical weather data request page.

Figure 4.2.6. Wind statistics for Antigua/VC Bird Airport, from ("Wind & weather statistics Antigua/VC Bird Airport," 2017).

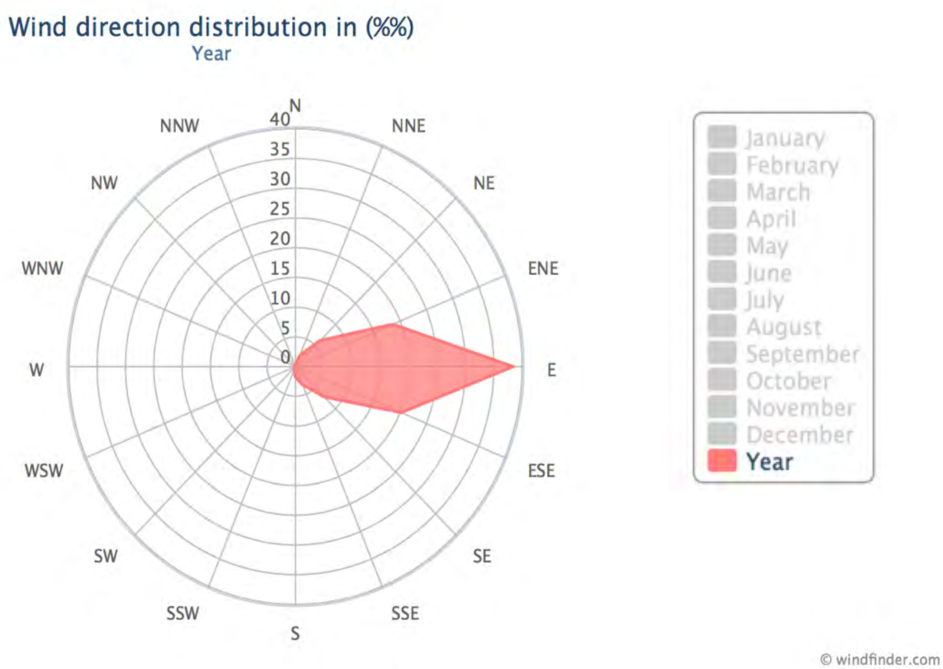


Figure 4.2.7. Wind direction distribution for Antigua/VC Bird Airport, from ("Wind & weather statistics Antigua/VC Bird Airport," 2017).

Air Quality

The UNEP 2015 Air Policy Report for Antigua and Barbuda indicates that the Island has low overall air pollution (UNEP, 2015). The World Health Organization 2014 Ambient Air Pollution Index indicates that Antigua and Barbuda have an annual mean concentration of particulate matter, fine suspended particles of less than 2.5 microns in diameter, of 13 μg/m^3. This is within the US EPA's National Ambient Air Quality Standard range of 12.0 μg/m^3 to 15.0 μg/m^3, ranking Antigua and Barbuda in one of the lowest categories for mean particulate matter concentration across the globe (World Health Organization, 2016). In short, air quality on Barbuda is considered good.

4.3 Noise Environment

Sources of noise will come primarily from construction (site preparation, infrastructure building etc.) during the early phases. Operational noise is expected to be minimal.

The project will follow the World Bank recommendations, ("Environmental, Health, and Safety (EHS) Guidelines: Noise Management," 2007) and conform to noise standards of U.S. Occupational Safety and Health Act of 1970 (OSHA).

Sources of noise associated with construction are generated by equipment utilized at sites for fabrication, modification, removal of structures or facility and that includes related activities such as site clearing, excavation, clean up etc. Construction equipment (like industrial equipment) tends to produce more noise in the lower end of the spectrum.

Bugliarello et al., 1976 measured average noise levels for construction equipment within 50 feet, (Figure 4.3.1) which indicate that noise pollution is manageable and should not be a significant impact.

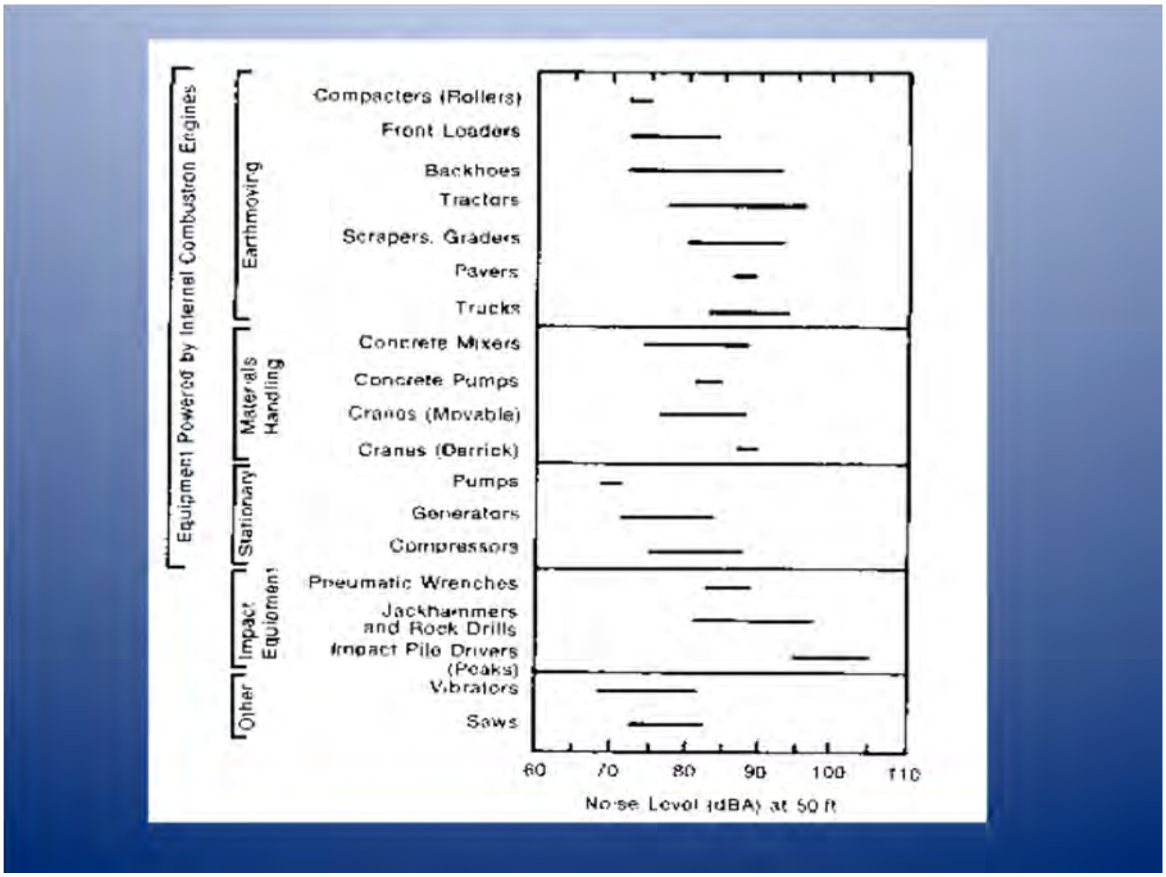


Figure 4.3.1. Noise dBA ranges for common construction equipment at 50 ft (15m) (Bugliarello et al., 1976, adapted from Wiertelak, 2017).

4.4 Water Environment

Barbuda is on the edge of the semi-arid climate spectrum. Rainfall patterns in Barbuda are relatively consistent on a yearly basis, and periods of drought can be seen in historic records, but there is high variability on shorter time frames. It is not uncommon for the island to receive a month's rainfall over the period of a few days or during a single storm. For instance, during Hurricane Lenny (1999), up to 645 mm (25in) fell on Barbuda during the storm, three times the annual average for the island, 205mm (8in). Climate models suggest even higher variability in rainfall may be seen in the future. For additional information on rainfall patterns in Barbuda, please see Section 4.2, Environmental Baseline, Air Environment.

4.4.1 Surface and Groundwater

There are no surface streams on Barbuda, only overflow channels created by flood events and a few seasonal inland lakes. Groundwater can be found in three geological formation on Barbuda (Figure 4.4.1): the Highland Limestone on the east side of the island, the Codrington Limestone, running just west of Codrington to the Highland Limestone formation, and the Palmetto Point Series, on the eponymous point (Barragne-Bigot and Yearwood, 1991). No surface water features exist on the project site, and the project site is outside each all known groundwater formations on Barbuda. No groundwater wells are currently in place on the development site at Cedar Tree Point. Mather, 1971 has noted that there is little potential for worthwhile groundwater development in the area. On Barbuda, potable water systems are generally provided by the Antigua Public Utilities Authority (APUA). There is a water plant supplying the town of Codrington, other places on Barbuda source their own water by wells or RO plant. Water conservation will be an important consideration for any development of the proposed site.

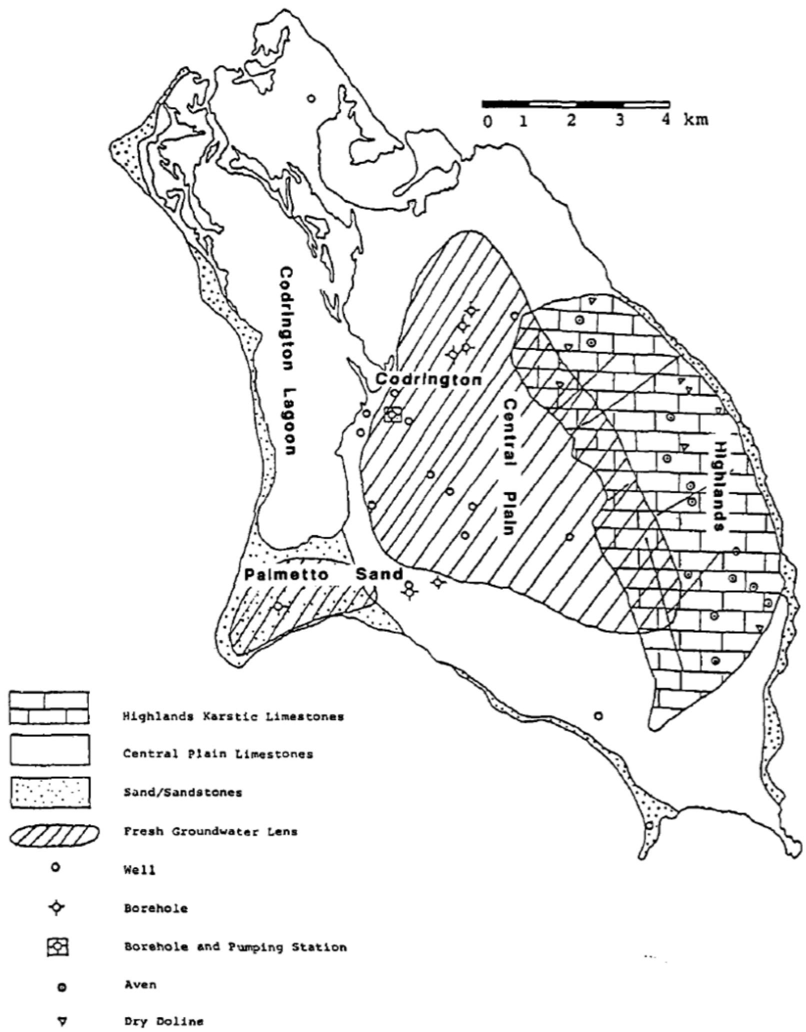


Figure 4.4.1. Hydrogeologic map of Barbuda, adapted from Barragne-Bigot and Yearwood, 1991.

4.4.2 Water Quality

No recent water quality data are available for the oceanic waters off Cedar Tree Point. The most recent data available for water quality assessment in Codrington Lagoon and two sites offshore of Cedar Tree Point comes from a Waitt Institute survey in 2013. The 2013 study included water sampled in the channel, fore and mid-reef, lagoon and Codrington dock. Figure 4.4.2 shows sites surveyed by Waitt Institute scientists for biological features and water quality.

The Waitt Institute study reported that the five water quality nutrient parameters were generally within acceptable levels and "offshore ammonia was within normal levels compared to other marine systems," although within the lagoon ammonia and nitrate levels showed a trend of being higher at sites closer to town. Results of the water quality assessment can be found in Figure 4.4.4 below.

The 2013 Waitt Institute report additionally assessed bacterial abundance in Codrington Lagoon. Their assessment found the number of culturable Vibrionacae bacteria in Barbuda's waters was overall low, even in lagoon waters and near-shore sites. Figure 4.4.3 shows zero culturable Vibrionacae detected, which indicates that the input of sewage and agricultural runoff into Barbuda's waters was low at the time, compared to other sites in the Caribbean (Ruttenberg et al., 2013). Values in Figure 4.4.3 are presented as colony forming units (CFUs) per ml of seawater.

The Waitt Institute report was produced prior to Hurricane Irma. Since then, water movement in Codrington Lagoon has changed considerably with the opening of two breaches. As a result, flushing rates will be higher. Observed water movement suggest that nutrients and other outflow will occur from the lagoon marshes through the northern breaches to the ocean.

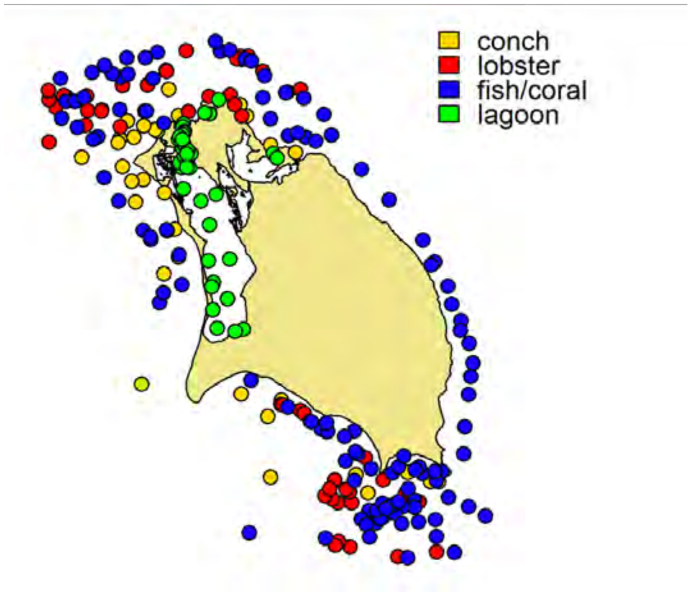


Figure 4.4.2. Sites surveyed by Ruttenberg et al., 2013.

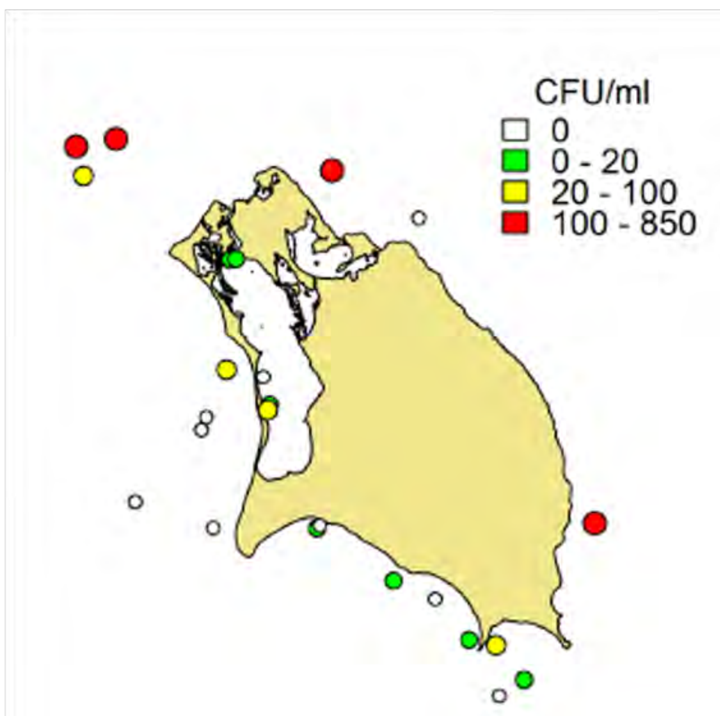


Figure 4.4.3. Abundance of culturable Vibrionaceae at sites around Barbuda, adapted from Ruttenberg et al., 2013.

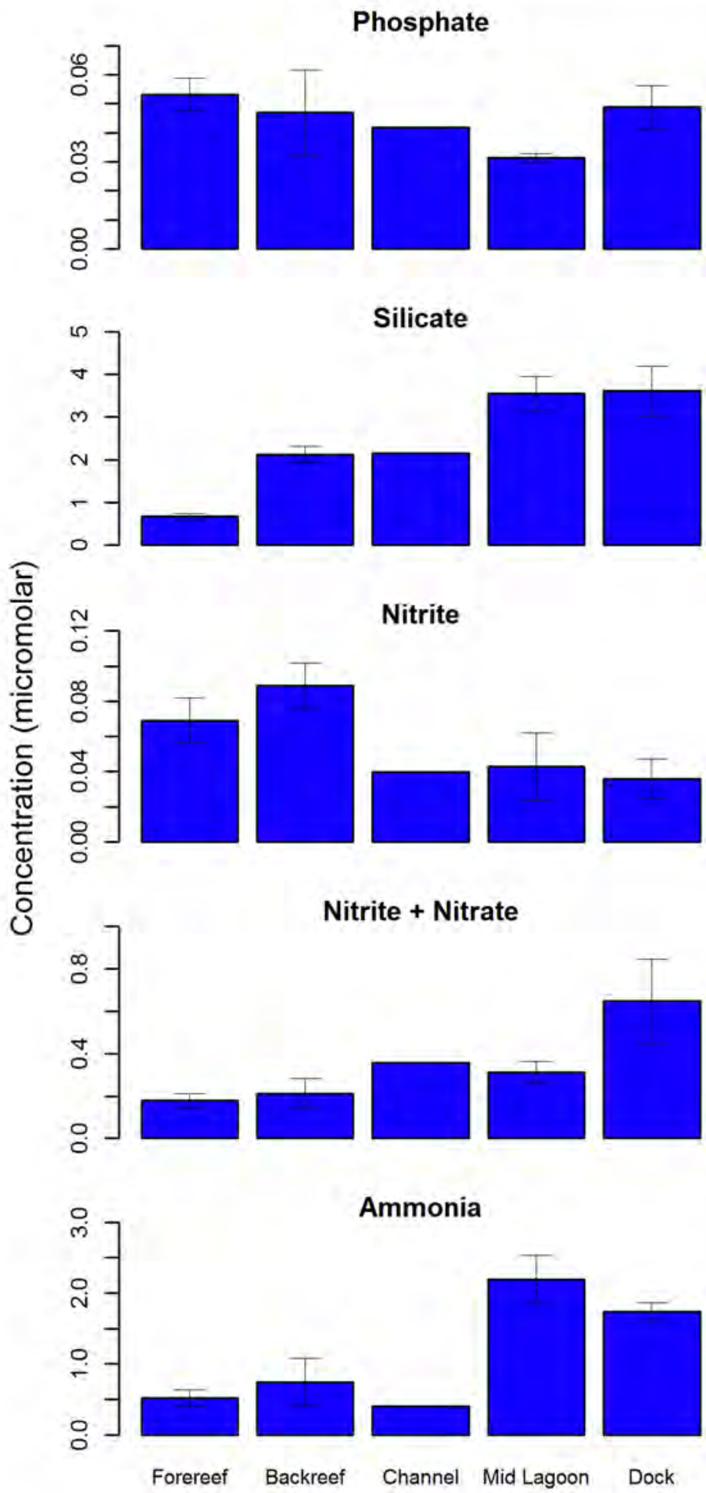


Figure 4.4.4. Water quality parameters grouped by habitat. All values are in micromolar (micromoles per liter). Adapted from Ruttenberg et al., 2013.

4.5 Biological Environment

4.5.1 Upland Habitat and Vegetation

Cedar Tree Point consists of tropical sand dune habitat on the west and north shores that transitions to a lagoon shoreline on the east. The dune habitat has moderate vegetation coverage that extends at least halfway across the sandspit. On the east (lagoon side), the vegetation changes to a dense buttonwood-mangrove dominated system typical of tropical lagoons. The oceanic beaches are dynamic, but the area has been largely resilient against storms and hurricanes. For instance, in 2017 Hurricane Irma eroded large areas of sand from the Point, but the beach quickly recovered.

Ecosystem resilience derives from the interplay between sand dynamics and stabilizing vegetation. Sand provides a habitat for plants that in turn trap more sand to build up the dunes. The plants also provide critical habitat for species, including birds and sea turtles.

Dune ecology is based on a successional pattern of vegetation. Early stage plants (generally fast-growing vines, grasses, and low-lying shrubs) must first be able to root themselves in an environment where the soil (sand) is constantly moving, and at the same time withstand drying winds and salt spray. Once established, these plants anchor the sand, stabilizing the habitat and facilitating the establishment of new plants that tend to be slower growing and woody e.g. Coccoloba (sea grape).

Vegetation Surveys

Vegetation surveys of Cedar Tree Point were conducted between April and July 2019 and consisted of field surveys and remote sensing. The surveys were conducted to record plant species present, identify sensitive species that may require protection, and to aid in the understanding of the overall ecological system of Cedar Tree Point. Sensitive species are those species that are listed as threatened or endangered (as defined by the International Union for Conservation of Nature [IUCN] Red List), regionally endemic (as determined by Pratt et al., 1997), and or have site specific or cultural value to Barbuda. These include for instance the mangroves that provide important fisheries nursery habitat and are used as nesting habitat by the magnificent frigatebird (*Fregata magnificens*). In addition to identifying species present the study classified distinct biological assemblages present on the site.

Results

Forty-three plant species (Table 4.5.1) and four vegetation assemblage types (Figure 2.1.3) were identified during the field survey.

The four vegetation assemblage types were:

- **Sand Strand Beach Dune**
- **Coastal Shrubland**
- **Coastal Shrubland with Herbaceous Vegetation**
- **Mangrove and Buttonwood**

Figure 4.5.1. Sand Strand Beach Due vegetation assemblage.

The **Sand Strand Beach Dune** assemblage (Figure 4.5.1) is found closest to the shoreline and is a salt-tolerant, shrub-dominated community that includes several species of grasses and herbs. These species are highly adapted to dynamic sand environments where sand migrates extensively. Typical species for this community recorded during the surveys are *Coccoloba uvifera* (sea grape), *Conocarpus erectus* (buttonwood), *Scaevola sp., Suriana maritima* (bay cedar), *Ipomea pescarape* (railroad vine) and several species of salt-tolerant grasses. These species are important for sea turtle nesting habitat. For instance, sea grape, buttonwood, and bay cedar are typically reported at sea turtle nesting sites on Barbuda (Barbuda Sea Turtle Program, Annual Report 2019).

Figure 4.5.2. Coastal Shrubland vegetation assemblage.

The **Coastal Shrubland** assemblage (Figure 4.5.2) comprises shrub plants that are taller and denser that those in the beach assemblage. This assemblage is typically landward of the sand strand community and represents a later successional stage. Typical species in the Coastal Shrubland community include *Tabebuia heterophylla* (white cedar) and *Sideroxylon obovatum* (boxwood). Some of the larger species found in the Sand Strand Beach Dune assemblage, notably sea grape, are also found in the Coastal Shrubland community.

Figure 4.5.3. Coastal Shrubland and Herbaceous Vegetation assemblage.

The **Coastal Shrubland with Herbaceous Vegetation** assemblage (Figure 4.5.3) consists of predominantly of herbaceous vegetation, such as *Pluchea carolinensis* (cattle tongue) and *Cordia curassavica* (sage). This is typically a more open assemblage when compared to Coastal Shrubland. Individual sea grape and buttonwood plants are scattered throughout the assemblage. This assemblage is a transitional zone between the Sand Strand Dune assemblage, which is largely located along the western, ocean-side shoreline of Cedar Tree Point, and the Coastal Shrubland assemblage, which is largely found on the eastern, lagoon-side of the site, inland of the Mangrove and Buttonwood assemblage.

Figure 4.5.4. Mangrove and Buttonwood vegetation assemblage.

The **Mangrove and Buttonwood** assemblage (Figure 4.5.4) is found along the eastern portion of the site bordering Codrington Lagoon. Two mangrove tree species, *Laguncularia racemosa* (white mangrove) and *Rhizophora mangle* (red mangrove) dominate the wetland zone in this area. Buttonwood is located landward of the intertidal zone. Mangroves are sensitive species and protected under EPMA 2019. They are environmentally valuable as nursery grounds for juvenile fish, nesting habitat for birds, and also provide coastal protection from storm surge, and biofiltration.

<u>Conclusion</u>

The vegetation community on Cedar Tree Point is generally in healthy condition. Unlike Palmetto Peninsula and other areas on Barbuda, grazers have not trampled or destroyed the habitat. The vegetation on Cedar Tree Point itself is relatively sparse and the typical dune zonation pattern is less pronounced. Instead, beach front (sand strand) species are interspersed with more inland species. This pattern is likely due to the dynamic nature of the sand movement, along with the harshness of physical conditions.

Table 4.5.1. Plant species identified on Cedar Tree Point observed during April 2019 vegetation survey. Plants in **bold** protected per EPMA 2019.

Botanical Name	Common Name	Family	Life Form	Native and/or Endemic (RE) Endangered (E)
Agave karatto	**Century Plant**	**Agavaceae**	**Herb**	**Yes**
Argusia gnaphalodes	Sea Lavender	Boranginaceae	Shrub	Yes/RE
Borrichia arborescens	Seaside Tansy, Bay Wiss	Asteraceae	Shrub	Yes
Bromelia sp	**Air plant**	**Bromeliaceae**	**Herb**	**Yes**
Canavalia rosea	Bay bean	Leguminosae	Vine	Yes
Cassytha filiformis	Love vine	Lauraceae	Vine	No
Castella erecta	Goat bush	Simaroubiaceae	Shrub	Yes
Cenchrus sp.	Burr-grass	Poaceae (Grammineae)	Herb	Yes
Chamaecrista glandulosa	Broom	Euphorbiaceae	Shrub	Yes/RE
Chamaesyce mesembrianthemifoila	Beach Spurge	Euphorbiaceae	Groundcover	Yes
Cladium jamaicense	Sawgrass	Cyperaceae	Herb	Yes
Coccoloba uvifera	Grape, Sea Grape	Polygonaceae	Tree	Yes
Cocos nucifera	Coconut, jelly tree	Arecaceae (Palmae)	Tree	No
Conocarpus erectus	**Buttonwood**	**Chrysobalanaceae**	**Shrub/Tree**	**Yes**
Cordia curassavica	Wild sage	Boraginaceae	Shrub	Yes
Cordia globosa	Black sage	Boraginaceae	Shrub	Yes
Crossopetalum rhacoma	Maidenberry	Celastraceae	Shrub	Yes
Croton flavens	Nail Polish Bush, Balsam	Euphorbiaceae	Shrub	Yes
Cyperus. sp	Cyperus	Cyperaceae	Herb	Yes
Dactyloctenium aegyptium	Crowfoot Grass	Poaceae (Grammineae)	Herb	No
Dodonaea sp.	Hop Bush	Sapindaceae	Shrub	Yes
Erithalis fruticosa	Candlewood, Black Torch	Rubiaceae	Shrub	Yes
Ernodea littoralis	Wild pomegramma, cough bush	Rubiaceae	Shrub	Yes
Fimbristylis sp.	Fimbry	Cyperaceae	Herb	Yes
Gundlachia corymbosa	Yam Bush, Horsebush	Asteraceae	Shrub	Yes/RE
Ipomoea pes-caprae	Beach morning glory	Convolvulaceae	vine	Yes
Jaquinia arborea	Torchwood	Theophrastaceae	Shrub	Yes
Laguncularia racemosa	**White Mangrove**	**Chrysobalanaceae**	**Tree**	**Yes**
Lantana involucrata	Button Sage , mamizou, sage	Verbenaceae	Shrub	Yes
Mosiera (Psidium) longipes	**Mango berry, mangrove berry**	**Malvaceae**	**Shrub**	**Yes/RE**
Paspalum notatum	Saltgrass	Poaceae	Herb	Yes
Phyllanthus epiphyllanthus	Billbush	Euphorbiaceae	Shrub	Yes
Pluchea carolinensis	Cattle Tongue	Asteraceae	Herb	Yes
Rhizophroa mangle	**Red Mangrove**	**Rhizophoraceae**	**Tree**	**Yes**
Scaevola plumier	Scaevola, Gullfeed	Goodeniaceae	Shrub	Yes
Sesuvium portulacastrum	Pondweed, Sea purslane	Aizoaceae	Groundcover	Yes
Sideroxylon obovatum	Boxwood	Sapotaceae	Shrub	Yes/RE
Solanum bahamense	Dolly tomato	Solanaceae	Shrub	Yes
Spartina patens	Spartina	Poaceae	Herb	Yes
Sporobolus sp	Seashore rush grass	Poaceae	Herb	Yes
Suriana maritima	Bay Cedar	Surianaceae	Shrub	Yes
Tabebuia heterophylla	White Cedar	Boranginaceae	Tree	Yes
Tillandsia utriculata	**Air plant**	**Bromeliaceae**	**Epiphyte**	**Yes**

4.5.2 Marine Vegetation

Seagrass beds are present in the marine and lagoon environments adjacent to the site, Seagrass beds provide important habitat for fish and benthic organisms, and food for herbivorous marine life, such as sea turtles. Seagrass communities are critical nursery grounds for lobster, and many fishery species that are part of Barbuda's fishing industry. Previous studies reported the following list of marine subtidal plants from Codrington Lagoon mid-south locations (Deborah Brosnan & Associates, 2018).

Gymnosperms:

- *Thalassia testudinum* (turtle grass)
- *Syringodium filiforme* (manatee grass)
- *Halodule wrightii* (shoal grass)

Algae:

- *Halimeda sp* (calcareous green algae)
- *Penicillus sp* (green brush algae)
- *Neomeris annulata* (fuzzy tip algae)
- *Udotea sp.* (green plate algae)
- *Acetabularia calyculus* (mermaid's glass algae)

In April 2019, biologists conducted three seagrass transect surveys in Codrington Lagoon offshore from the project area (Figure 4.5.7., Appendix 1 Table A.3). At 1 m intervals along each transect, the biologist recorded percent cover and identified species of seagrass present within a 0.25m^2 quadrat. A total of 90 quadrats surveys were completed.

Seagrass covered almost half of the seabed surveyed (48.2% mean coverage, N=90, ST Dev=38.1). Distribution was patchy i.e. areas of bare substrate (mud-sand) were interspersed with dense coverage. A single species, *Halodule wrightii,* dominated the seagrass community, accounting for 46.5% total coverage and amounting to over 90% of the vegetation present. (46.5% mean coverage N=90, ST Dev=38.3). The only other species recorded in the transects was *Thalassia testudinum* (turtle grass) that accounted for 1.6% of total coverage (1.6% mean coverage over 90 0.25m^2 transects, ST Dev=5.6).

The dominance of *H* wrightii contrasts with relative species abundance in the lower part of the lagoon where *T. testudinum* is typically more dominant over *H. wrightii* (Deborah Brosnan & Associates, 2018). A summary of the results of the survey can be found in Table 4.5.2. Full results of the seagrass survey can be found in Appendix 1.-A3.

Table 4.5.2. Summary results of April 2019 seagrass survey in Codrington Lagoon adjacent to project site.

Species	Mean % Cover	Standard Deviation
Halodule wrightii	46.5%	38.13
Thalassia testudinum	1.6%	5.65
	Total % Cover	
Total Species Cover	48.2%	38.13

Figure 4.5.5. Seagrass transect line being laid out during April 2019 survey.

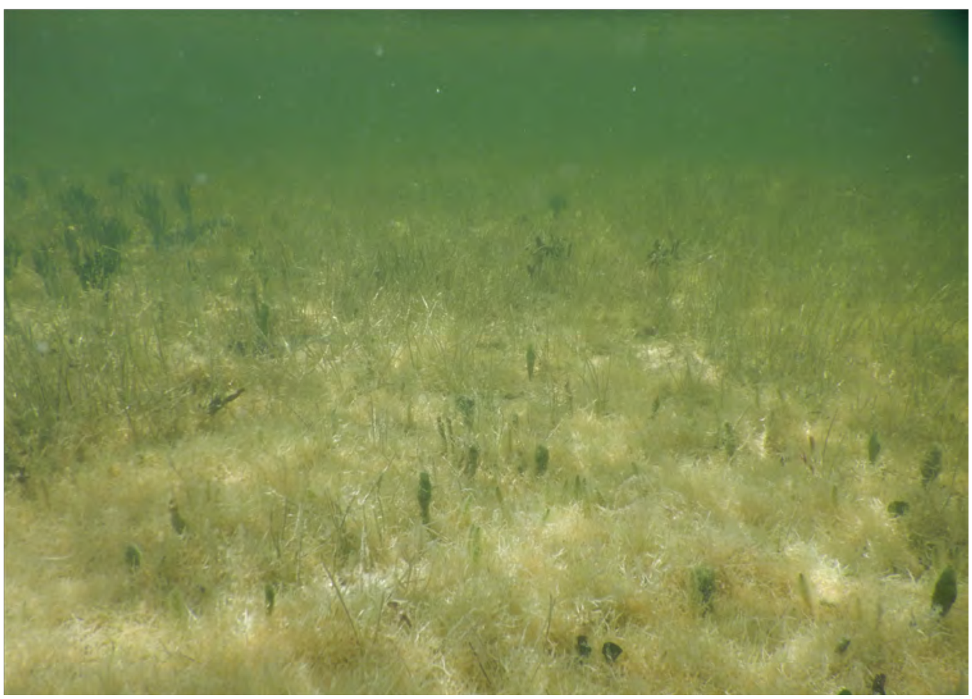


Figure 4.5.6. Seagrass bed in Codrington Lagoon offshore of the project site.

Figure 4.5.7. Location of seagrass surveys conducted April 2019 by Deborah Brosnan and Associates.

4.5.3 Fauna

Eighteen indigenous terrestrial reptiles have been recorded on Antigua, Barbuda and Redonda, together with at least four species that were probably introduced by humans. Four sea turtle species have been documented. Of this list, fourteen terrestrial and marine reptiles have been reported from the Codrington National Park.

Sea Turtles

The three species most commonly found nesting on Barbuda are the green (Figure 4.5.8), hawksbill (Figure 4.5.9), and leatherback (Figure 4.5.10) turtles. However, loggerheads (Figure 4.5.11) have been observed traveling and feeding in the waters of Antigua and Barbuda. According to the International Union for the Conservation of Nature (IUCN), hawksbill sea turtles are listed as Critically Endangered at a global scale, a crisis category, based on an “observed, estimated, inferred, or suspected” population reduction of at least 80% over the previous 10 years or three generations, whichever is longer (Mortimer and Donnelly, 2008). Green sea turtles are classified by the IUCN as Endangered, defined as a reduction in population of at least 50% over the previous 10 years or three generations (Seminoff, 2004). Loggerhead and leatherback sea turtles are classified as by the IUCN as Vulnerable, defined as a reduction in population of at least 30% over the past 10 years or three generations (Casale and Tucker, 2017; Wallace et al., 2013).

Figure 4.5.8. Green sea turtle (*Chelonia mydas*)

Figure 4.5.9. Hawksbill sea turtle (*Eretmochelys imbricata*)

Figure 4.5.10. Leatherback sea turtle (Dermochelys coriacea)

Figure 4.5.11. Loggerhead sea turtle (*Caretta caretta*)

Threats to Sea Turtles

Until 1990, exploitation of marine turtles in Antigua and Barbuda was governed by the Turtle Ordinance of 1927. This law established a four-month closed season from 1 June to 30 September for all marine turtles except the Loggerhead and set a minimum size limit of 20 lb (9 kg). The law was widely ignored. Recognition that these requirements were inadequate to prevent declines in marine turtle numbers led to the adoption of the Fisheries Regulations of 1990 (Section 21 of The Fisheries Act, 1983), which provided for a six-month closed season, larger legal size criteria, and a complete prohibition of disturbance, take, sale, purchase or possession of eggs and undersize turtles, in addition to banning spearfishing. However, illegal turtle harvesting continued. Hoyle (1994) estimated that that approximately 30 turtles and several thousand eggs were taken every year through the 1990s in Antigua and Barbuda. In 1992 CITES assessed Antigua and Barbuda as not meeting the requirements for implementation of CITES, subsequently imposing a 2005 compliance deadline (Fuller et al., 1992). With the help of the FAO, new legislation was developed prohibiting the capture/taking of all marine turtles, turtle eggs and the disturbance of turtles found onshore. The result is a moratorium on the capture of marine turtles. Nevertheless, reports of illegal turtle harvesting are not uncommon (Slater, 2016). In 2013, The Antigua Observer reported on the rapid decline in sea turtles as well as efforts to reverse it (“Saving the Sea Turtles: How Did It All Start?,” 2013). Today, the greatest threats to the remaining sea turtle populations in the Caribbean include coastal development, beach erosion, introduction of exotic species and animals, boating (commercial and recreational), incidental take of fisheries, illegal harvest of adults and eggs, marine debris, and inadequate local protection and enforcement (Buck Island Sea Turtle Research and Monitoring Program, n.d.).

Sea Turtle Monitoring

On August 3, 2018, Deborah Brosnan & Associates established the Barbuda Sea Turtle Monitoring Program, the first comprehensive sea turtle monitoring program of its kind on the island of Barbuda. The GIS/GPS based program consists of routine surveys to locate, record data, monitor the success of hatchings, and tag turtles along select shorelines on Barbuda. This program has been a comprehensive and collaborative effort to implement protocols and methods that are approved by academic scientists, the Government of Antigua and Barbuda, as well the University of the West Indies and Wider Caribbean Sea Turtle Conservation Network. At the beginning of the 2019 nesting season, the Barbuda Sea Turtle Monitoring Program focused its efforts on the shorelines of Coco Point and Palmetto Peninsula. The team then added routine weekly monitoring at Cedar Tree Point. The Cedar Tree Point survey area extends from Barbuda Belle along the Northshore and all along the western shore to just above the Light House Resort. Access to the site which is limited to boat access prevented more frequent monitoring.

Sea turtle activity is recorded as “false crawl” when a female comes ashore but does not nest, “confirmed nest” where the female successfully nested, and “unconfirmed nest” where it appears the female nested, but an egg chamber could not be confirmed. Successful nests are identified with a simple probing-rod tool used to gently probe the sand to find the egg chamber, which typically extend down to 2 feet in the sand (see Figure 4.5.12). Unconfirmed nests are usually older nest sites where a probing-rod cannot identify an egg chamber. The team records comprehensive data on the sea turtle and once a new nest has been recorded the “due-date” for hatching is estimated so that the team can be present to record nesting success and hatchling survival.

Between July 26th and September 5th, 2019, seven confirmed nests, one unconfirmed nest, and three false crawls were identified along the Cedar Tree Point shoreline (Figure 4.5.13). All observed sea turtle nesting activity on Cedar Tree Point was by hawksbill sea turtles. This is consistent with results from other sites surveyed in 2019. Apart from 2 leatherback nests on Palmetto Peninsula, only hawksbill turtles nested or attempted to nest on other sites surveyed. One unconfirmed nest was recorded by our biologist during a site visit with DoE and DCA on June 29th, 2020. During that visit several crawls and possible nests were observed along the west coast beach from the boat during the transit from the breach at Codrington (Lighthouse Resort) to Cedar Tree Point.

Figure 4.5.12. Sea turtle specialist Jepson Prince demonstrating how to confirm a sea turtle nest using a self-made probe.

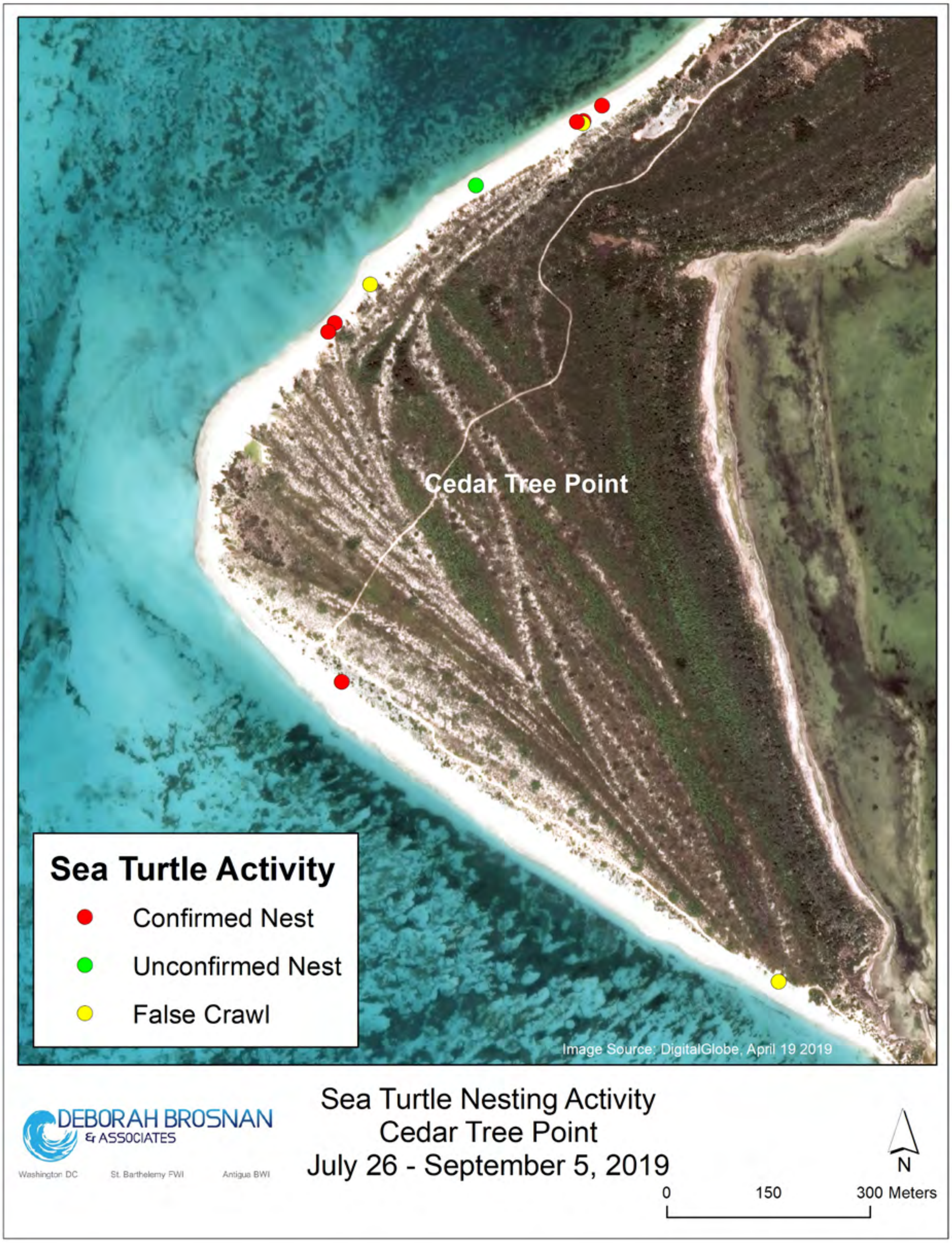


Figure 4.5.13. Sea turtle nesting activity recorded on Cedar Tree Point, Summer 2019.

Figure 4.5.14. Sea Turtle Survey Team Recording Data.

Table 4.5.3. Sea turtle observations at Cedar Tree Point, July-September 2019. Activity type key: CN = Confirmed Nest, UCN = Unconfirmed Nest, FC = False Crawl. Other abbreviations: DNR=Did not record.

Sea Turtle Monitoring Data for Cedar Tree Point 2019								
Date	Time	Lat (dd)	Long (dd)	Species	Activity Type	Distance to High Water Line (cm or m)	Distance to Vegetation (cm or m)	Track Width (cm)
7/26/2019	1041	17.68999	-61.87811	Hawksbill	FC	16.26m	30.48cm	83.82cm
8/1/2019	1120	17.69881	-61.88423	Hawksbill	CN	5.28m	2.29cm	76.20cm
8/9/2019	1058	17.69403	-61.88416	Hawksbill	CN	DNR	0cm	71.12cm
8/15/2019	1127	17.70063	-61.88225	Hawksbill	UCN	10.67m	5.92m	71.12cm
9/5/2019	1056	17.70169	-61.88049	Hawksbill	CN	DNR	DNR	DNR
9/5/2019	1100	17.70148	-61.88074	Hawksbill	CN	DNR	DNR	DNR
9/5/2019	1101	17.70145	-61.88076	Hawksbill	FC	DNR	DNR	DNR
9/5/2019	1102	17.70147	-61.88084	Hawksbill	CN	DNR	DNR	DNR
9/5/2019	1110	17.69932	-61.88372	Hawksbill	FC	DNR	DNR	DNR
9/5/2019	1111	17.69923	-61.88388	Hawksbill	CN	DNR	DNR	DNR
9/5/2019	1114	17.69869	-61.88432	Hawksbill	CN	DNR	DNR	DNR

Other Marine Fauna

The marine environment offshore of Cedar Tree Point consists of a mix of sand and patchy seagrass beds. (Figure 4.5.15). The seagrass beds are typical turtle feeding and conch habitats (Ruttenburg et al. 2013 and personal communications Fisheries Officer, Barbuda 2019). Sea turtles have been observed in the water in the seagrass areas. Patch reefs are located offshore and largely outside of the zone of impact for the two villas. The western near shore waters are designated as an anchoring and mooring zone (The Barbuda [Coastal Zoning and Management] Regulations, 2014).

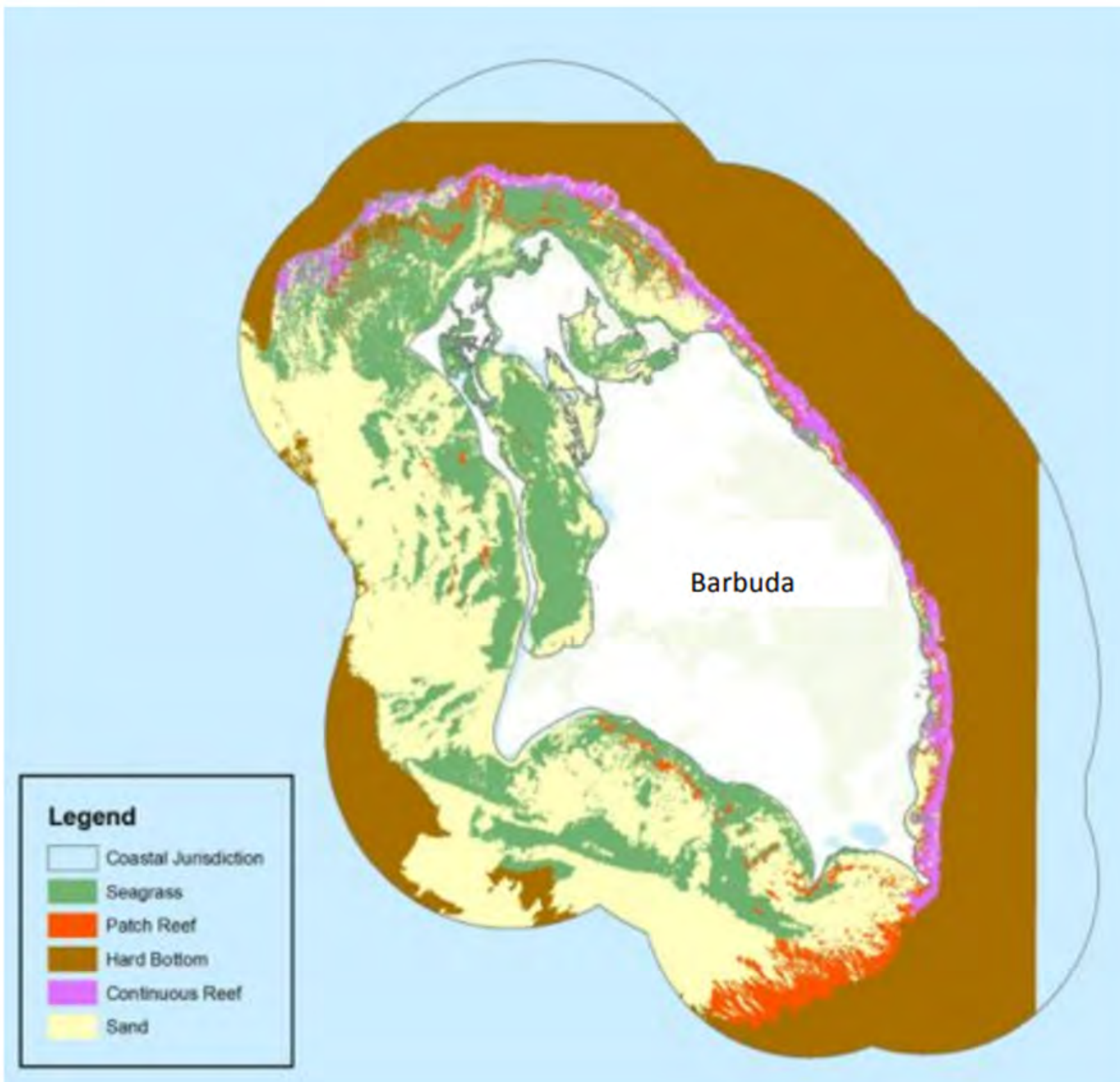


Figure 4.5.15. The marine ecosystems of Barbuda developed via high-resolution satellite imagery (Ruttenberg et al. 2013)

A biological survey of the Codrington Lagoon and offshore waters was completed by the Waitt Institute in 2013. (Note: The report was completed prior to Hurricane Irma, which created a permanent inlet into Codrington Lagoon, an event which has likely influenced the marine community.) For this survey, thirty-seven sites (chosen haphazardly) were surveyed. The Waitt study used a photographic survey of $1m^2$ sections on either side of a 15m transect at each site (a total of $30m^2$ surveyed for each transect).

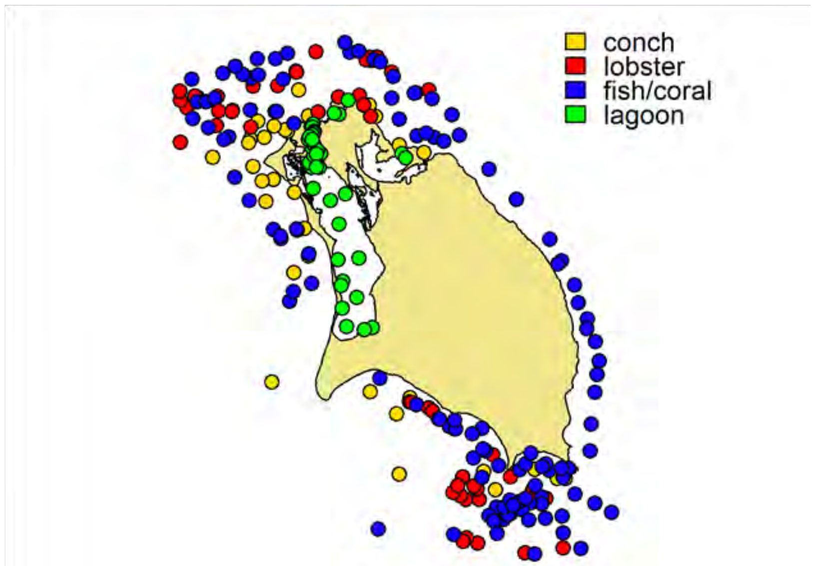


Figure 4.5.16. Biological survey locations in Ruttenberg et al., 2013.

Lobster

Barbuda's spiny lobster (*Panilirus argus)* fishery is the principal source of income for Barbudan fishers (The Caribbean Regional Fisheries Mechanism, 2011). Ruttenberg et al. report that the population distribution in Barbuda is patchy, which may be due to habitat availability and distribution, as well as fishing pressure.

Following a pelagic larval phase, spiny lobsters settle in nursery habitats such as lagoon, mangrove, and seagrass ecosystems (Briones-Fourzán et al., 2003). Surveys conducted by Ruttenberg et al. indicate that legal sized populations (>95mm carapace length) are largely distributed on offshore reefs north and south of Barbuda. Sub-legal sized (<95mm carapace length) lobster prefer habitats near the northern entrance to the lagoon and in small patch reefs. South of Cedar Tree Point on the western coast, a small patch reef provides a near -shore habitat for juvenile lobster as noted in Figure 4.5.17. Lobster were also found in the northern reaches of the lagoon by Ruttenberg et al. (Figure 4.5.18). All lobsters observed in the lagoon were of sublegal size, consistent with Peacock, 1974, which concluded that Codrington Lagoon is primarily a nursery habitat for lobster. Our biologists observed a juvenile lobster in lagoon seagrass habitat during the biological surveys.

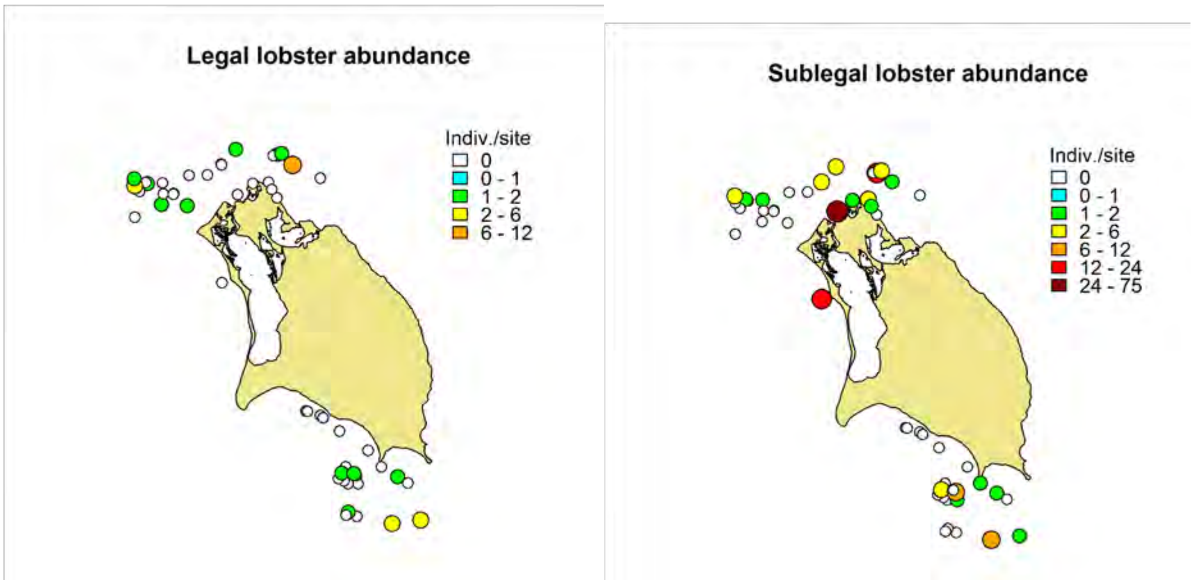


Figure 4.5.17. Abundance of legal-sized (>95mm carapace length) and sublegal-sized lobster around Barbuda. Values represent the number of lobsters at each site. Source: Ruttenberg et al, 2013.

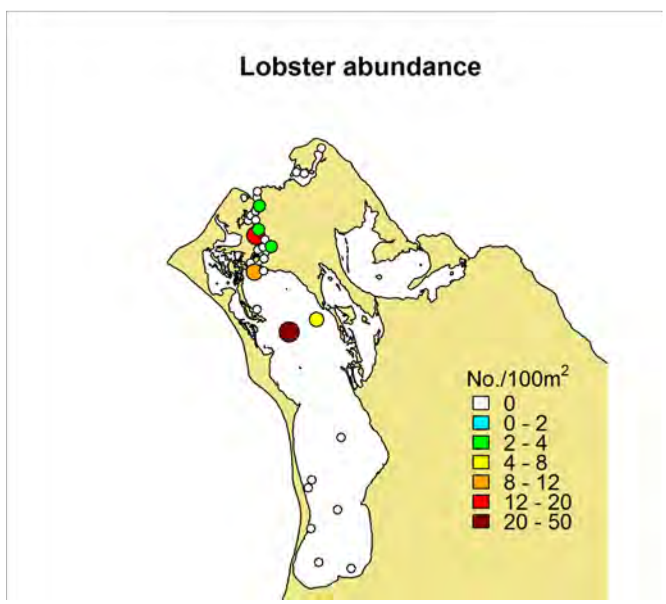


Figure 4.5.18. Abundance of lobster in Codrington Lagoon. All lobsters recorded were of sub-legal size.

Conch

Conch (*Strombus gigas*) is an important fishery on Barbuda. Out of the 35 seagrass beds surveyed by Ruttenberg et al., conch occurred in 86% of sites. Juvenile conch abundance surpasses the abundance of adult conch throughout sites around Barbuda, likely due to intensive fishing pressure. The seagrass beds on the northern and western coasts adjacent to the Cedar Tree Point property are habitat for juvenile conch (Figure 4.5.19).

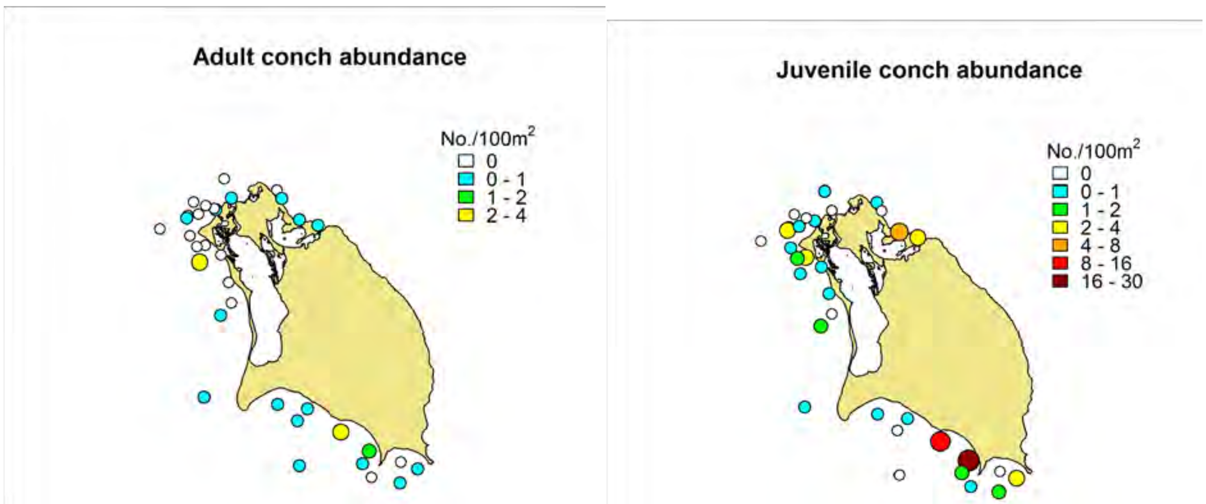


Figure 4.5.19. Abundance of conch at sites surveyed around Barbuda. Values are in numbers per 100 m^2.

Marine Fish

Fourty-four different fish species most were found in the northern/channel section by Ruttenberg et al. None except between 0-2 graysnapper (*Lutjanus griseus*) per 100m^2 in the lower part of the lagoon. This pattern is not surprising given the distance to the end of the lagoon, the low-flow shallower water and lower habitat diversity in the lower lagoon (Figure 4.5.20).

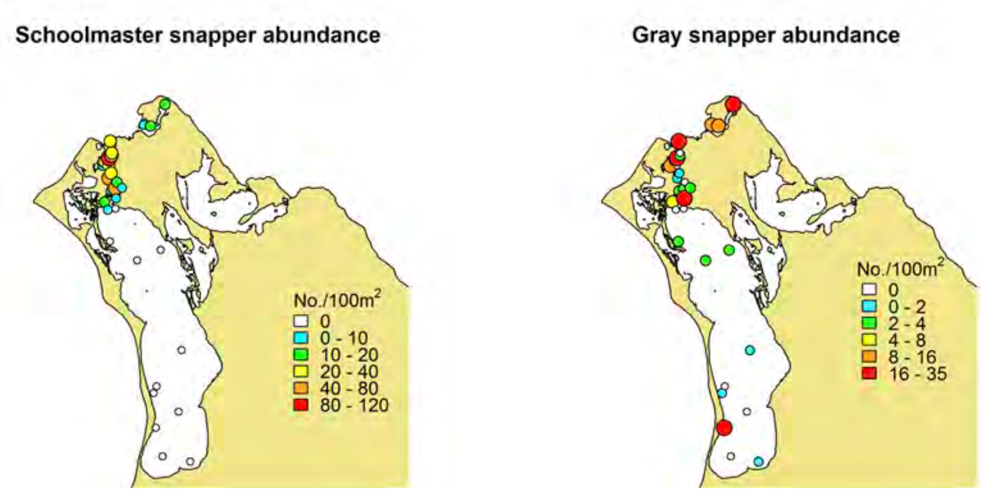


Figure 4.5.20. Abundance of schoolmaster snapper and gray snapper in Codrington Lagoon. Values are in numbers per 100 m^2.

Brackish-Freshwater Fish

Only one brackish/freshwater water fish has been recorded, the mangrove rivulid (*Kryptolebias marmoratus*) which was first recorded by Hoedeman, 1958 and found in Bull Hole and Low Pond. *K. marmoratus* was also the only brackish/freshwater fish reported in Codrington Lagoon by Deborah Brosnan and Associates, 2018. The Codrington National Park Management Plan lists the species as being widespread. Up to 7.5cm (3 inches) long, it occurs in brackish water environments, moist substrates, and mangrove roots during drought periods. Rivulids are capable of withstanding hypersaline and high temperature conditions and can survive for 2 months on land. It is often found associated with red mangroves and living in the burrows of land crabs Cardisoma. Overall the mangrove rivululid is widespread and not threatened (NatureServe and Lyons, 2019). None were recorded during the site surveys.

Terrestrial Reptiles

The Giant or Forest woodslave (*Thecadactylus rapicauda*), common throughout the Lesser Antilles, and the Dwarf woodslave (*Sphaerodactylus elegantulus*) are found in Antigua and Barbuda. Three species of anole lizard can be found on Antigua and Barbuda: *Anolis leachi,* endemic to Antigua and Barbuda, *A. wattsi* (Figure 4.5.21), likely endemic as well, and *Anolis nubilus*, which is endemic to Redonda. *Anolis leachi* and *Anolis wattsi* have been introduced in other island nations (Bermuda in the case of the former, St. Lucia and Trinidad in the case of the latter). Some (e.g. Malhotra and Thorpe, 1999) consider the *Anolis wattsi* community on Barbuda to be a separate species, *Anolis forresti* (Daltry, 2007).

Ground lizards of the Teiidae family are represented by the omnivorous Antiguan ground lizard (*Ameiva griswoldi*) (Figure 4.5.22) endemic to Antigua and Barbuda, and locally abundant on Barbuda (Daltry, 2007). *Anolis* and *Amaeiva* are common and have high biomass especially in some of the more forested areas (e.g. *Anolis wattsi* up to 7,143/ha on forested parts of Great Bird Island; *Amaeiva griswoldi* up to densities of 483/ha on Red Head Island). The parthenogenic microteliid *Gymnophthalamus underwoodi* is a relatively new introduction and has become established across Antigua and Barbuda. Additionally, two reliably identified species of snake are found on Antigua and Barbuda. The blind snake (*Typhlops monastus geotomus*) is common on both Antigua and Barbuda (Daltry 2007). The critically endangered Antiguan racer (*Alsophis antiguae*) became extirpated and was reintroduced to two offshore islands but is not present on Barbuda (Daltry and Mayer, 2016, Daltry, 2007). In addition, Codrington National Park Management Plan identified the Green Iguana (*Iguana iguana*) as occurring within the Park although it is not recorded in Lindsay or in Caribbean Herpetology records (http://www.caribherp.org/, accessed October 2020) and little information is available on its potential introduction or spread. (*I. iguana* has been noted as replacing the native species *I. delicatissima* on Antigua which has been prey for mongoose and other predators).

Figure 4.5.21. Watt's anole *(Anolis wattsi)*

Figure 4.5.22. Antiguan ground lizard (*Amaeiva griswoldi).*

The red-footed tortoise (*Geochelone carbonaria*) is present on Barbuda but is not native or endemic to the island; it was almost certainly introduced to Antigua and Barbuda from South America by early Amerindian visitors (Censky, 1988; Daltry, 2007). These tortoises are not uncommon and are often kept as pets and even relocated. (22 captive-bred tortoises were released on Antigua's Green Island between 1997-2007). The national reptile list also contains four geckos, three of which appear to occur on Barbuda but only two of which have been recorded in Codrington National Park.

The following reptile species were reported from Codrington Lagoon National Park and compiled from several publications by Deborah Brosnan & Associates, 2018:

- *Thecadactylus rapicauda* (forest gecko)
- *Sphaerodactylus elegantulus* (dwarf gecko)
- *Anolis leachi* (green lizard)
- *Anolis wattsi* (Watts or brown lizard)
- *Ameiva griswoldi* (ground lizard)
- *Typhlops monastus* (blind snake)
- *Iguana Iguana* (green iguana)
- *Geochelone carbonaria* (red-footed tortoise)
- *Caretta caretta* (green turtle) **Endangered**
- *Chelonia mydas* (hawksbill turtle) **Critically Endangered**
- *Eretmochelys imbricata* (loggerhead turtle) **Vulnerable**
- *Dermochelys coriacea* (leatherback turtle) **Vulnerable**

Amphibians

The only amphibian recorded from the area is the tree frog *Eleutherodactylus johnstonei* (CLNP Management Plan) and which has been widely introduced in the Antilles and parts of S. America (Horwith & Lindsay, 1997, p. 45).

Threats to Turtles, other Reptiles and Amphibians: Habitat Loss

Lizards depend on a diversity of dune vegetation for habitat, perch sites, refuges from predators, and food. The loss of sand dunes and dune communities threatens the abundance of lizard populations. Dune vegetation loss also puts turtles at risk.

Mammals

The only native mammals reported on Barbuda are seven species of bats. Bat species known to exist on Barbuda generally roost in the cave systems on the east side of the island, although some individuals have been seen occupying structures in Codrington (Pedersen et al., 2007). No known records of bats roosting in the vicinity of Cedar Tree Point exist, and it is unknown if bats visit Cedar Tree Point.Feral livestock roam widely on Barbuda; however, during our surveys none were present on Cedar Tree Point, probably because there is no land connection to mainland Barbuda.

The black rat (*Rattus rattus*) and the larger brown rat (*R. norvegicus*) were probably introduced during early European settlement and have spread throughout Antigua and Barbuda and are likely present at the project site. Specific problems attributed to rats include predation on eggs and juvenile lizards, turtles and other reptiles, and habitat modification by selectively feeding on seeds and seedlings.

Birds

Some 99 species of terrestrial, shore and sea birds have been identified in Codrington Lagoon National Park. Over half (57%) of these are migrants passing through the island in spring and/or fall. The arrival of fall migrants is timed to coincide with rains and storms. Storms bring seaweed onto the beach which is laden with small invertebrates on which the birds feed. The most significant and iconic avifauna on Barbuda is the magnificent frigate bird (*Fregata magnificens*) (Figure 4.5.23). A colony of about 10,000 frigate birds nest in the northwestern corner of the lagoon – the frigate bird sanctuary. This site is recognized as one of the more important nesting sites for the species in the Caribbean. It is a major tourist attraction on Barbuda. The frigate bird sanctuary lies to the south of the proposed development and the birds fly over Cedar Tree Point and fish in the offshore waters. None are known to nest on the mangroves on the lagoon side of the property.

Two species of warblers are found on Barbuda. The Barbuda warbler (*Setophaga subita*) (Figure 4.5.24) is endemic to Barbuda with a population estimated at between 1,000-2,500. It is found in a variety of habitats on Barbuda particularly highlands. Mahabir (2010) found that the Barbuda warbler appears to avoid habitat occupied by the resident yellow warbler *Dendroica petechia* (Figure 4.5.24). Yellow warblers were found closely associated with mangrove habitat, and high-canopied trees more closely associated with the Barbuda warbler. Mahabir identified a yellow warbler on Cedar Tree Point. A post Hurricane Irma warbler survey did not include any sampling points on Cedar Tree Point (Rivera-Milán et al., 2017).

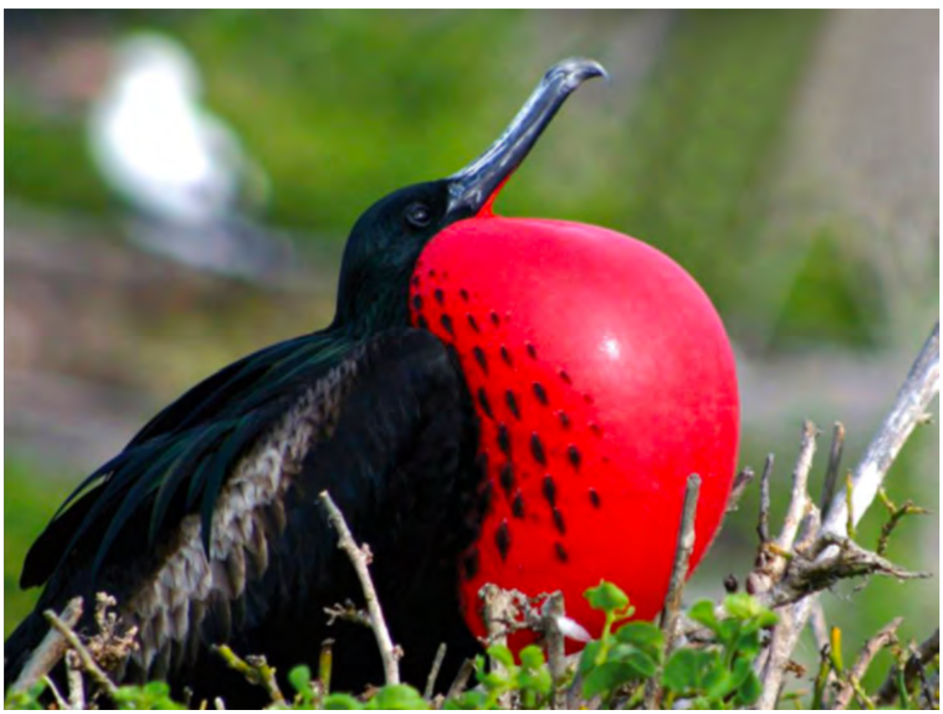


Figure 4.5.23. Magnificent frigate bird (*Fregata magnificens*).

Figure 4.5.24. Barbuda warbler (left) and yellow warbler (right)

In the vicinity of Codrington Lagoon several bird species are visible especially at dusk when they are flying to their roosting sites in the interior of the island (none nesting in the Park or proposed development site). These include pigeons, doves and duck species. Traditionally, these species were widely hunted for food. Regional endemics have been observed from the Park including White-tailed tropic birds, Red-billed tropic bird and West Indian Whistling duck, but these are quite rare (Codrington Lagoon National Park Barbuda Management Plan). Tropic birds have been observed flying and feeding offshore of Cedar Tree Point by the science team.

The following bird species of birds have been recorded Codrington Lagoon National Park by as compiled by Deborah Brosnan & Associates from several studies:

- *Fregata magnificens* (frigatebird)
- *Setophaga subita* (Barbuda warbler)
- *Phaethon aethereus* (red-billed tropic bird)
- *Phaethon lepturus* (white-tailed tropic bird)
- *Myiarchus oberi* (lesser Antillean flycatcher)
- *Zenaida aurita* (Zenaida dove)
- *Columba squamosal* (red-necked pigeon) **Regionally Endemic**
- *Columba leucocephaia* (white-crowned pigeon)
- *Dendrocygna arboreal* (whistling duck) **Regionally Endemic**
- *Calidris sp.* (sandpiper)
- *Ardea alba* (great egret)
- *Pelecanus occidentalis* (brown pelican)

Cedar Tree Point Bird Monitoring

A survey of bird species at Cedar Tree Point was completed in April 2019 for this report. For the study, all bird species and numbers of individuals observed were recorded over a 30-minute interval at each of 8 locations on Cedar Tree Point (i.e. 8x30min counts at eight separate locations for total sampling time of 4 hours) (Figure 4.5.25). Birds flying and perched on vegetation were recorded. The magnificent frigatebird was the most common species observed flying over the

site. Other species observed on the site included the lesser Antillean flycatcher (*Myiarchus oberi*), lesser Antillean bullfinch (*Loxigilla noctis*), bananaquit (*Coereba flaveola*), and West Indian whistling duck (*Dendrocygna arborea*). One warbler was observed on site, but the species could not be confirmed. A summary of the results can be found in Table 4.5.4. Full data are provided in Appendix 1, Table A.4.

Table 4.5.4. Total number of birds recorded over a 4-hour period (8x30 min counts) at eight separate locations on Cedar Tree Point, April 2019.

SPECIES TOTALS	
Magnificent Frigatebird	174
Lesser Antillean Flycatcher	5
Bananaquit	11
Lesser Antillean Bullfinch	3
West Indian Whistling Duck	2
Warbler (Species Unknown)	1

Figure 4.5.25. Observation points for April 2019 bird survey.

4.6 Socioeconomic Environment

4.6.1 Overall Summary

The nation of Antigua and Barbuda relies on tourism as its economic mainstay. Tourism services generate 75% of GDP employing 22.6% of all workers directly and 84.5% when indirect employment is included. Periods of economic growth have been driven by increased investment in the tourism industry and related activities (Antigua and Barbuda Country Profile 2010, 2010, GENIVAR, 2011). However, these figures represent the Islands of Antigua and Barbuda combined; it is widely recognized that Barbuda has failed to experience the same level of growth and expansion and applying these figures to Barbuda could be misleading.

Barbuda has relied primarily on light tourism and fishing with other sectors making up a small part of the local economy. The closest settlement to the proposed project is the town of Codrington, the only town on the island. The population was estimated at 1,600 according to the 2011 Census, although estimates put the population at 1,800 when Hurricane Irma struck in 2017. Today it is estimated at between 1,000-1,200.

Most jobs are provided by the Barbuda Council. However, the PLH, Barbuda Ocean Club now employs about 60 Barbudans. There are few opportunities for professional training or high-skilled employment.

4.6.2 Human Development

The UN Human Development Report analyses socio-economic data to generate human development indices (HDI) for countries around the globe. Data are reported for Antigua and Barbuda as a single nation and are not available for Barbuda separately. The most recent report was published in 2019. Antigua and Barbuda's HDI index for 2018 is 0.776 — which put the country in the high human development category — positioning it at 74 out of 189 countries and territories. Between 1990 and 2018, Antigua and Barbuda's life expectancy at birth increased by 5.4 years, mean years of schooling increased by 2.2 years and expected years of schooling decreased by 0.8 years. Antigua and Barbuda's GNI per capita increased by about 41.0 percent between 1990 and 2018 (UNDP, 2019).

Table 4.6.1. Human development indices for Antigua and Barbuda in 2018 (UNDP, 2019)

Year	Life Expectancy (Years)	Expected Years of Schooling	Mean Years of Schooling	GNI Per Capita (2011 PPS$)	HDI Value
2018	76.9	12.5	9.3	$22,201	.776

4.6.3 Sustainable Development

The UN sustainable development dashboard contains a selection of 11 key indicators. Environmental sustainability indicators represent a mix of level and change indicators related to energy consumption, carbon dioxide emissions, change in forest area and freshwater withdrawals, and natural resource depletion.

Environmental threat indicators are based on mortality rates attributed to environmental factors including household and ambient air pollution and unsafe water, sanitation and hygiene services, as well as percentage of degraded land and IUCN Red List index value (a measurement of aggregate extinction risk across species groups)

Table 4.6.2 below provides the number of indicators in which Antigua and Barbuda performs: better than at least two thirds of countries (i.e., it is among the top third performers), better than at least one third but worse than at least one third (i.e., it is among the medium third performers), and worse than at least two thirds of countries (i.e., it is among the bottom third performers) (UNDP, 2019).

Table 4.6.2. Sustainable development indices for Antigua and Barbuda in 2018 (UNDP, 2019)

	Environmental sustainability (7 indicators)			Environmental threats (4 indicators)			Overall (11 indicators)			Missing indicators
	Top third	Middle third	Bottom third	Top third	Middle third	Bottom third	Top third	Middle third	Bottom third	
	Number of indicators									
Antigua and Barbuda	0	1	2	2	1	0	2	2	2	5

4.6.4 Settlement Profile

The settlement pattern in Barbuda is driven largely by the fact that land is considered communally owned with control over land distribution resting with the Barbuda Council. Virtually all of the residents on the island live in a single settlement, Codrington, which was established next to the large Codrington Lagoon. This settlement is relatively compact with lots ranging between and 400m^2 (4,306ft^2) and 600m^2 (6,548ft^2) in size. Residential, commercial and institutional functions were interspersed throughout the town. Development outside of Codrington consisted mainly of isolated high-end tourist resorts, until more recently when the PLH Barbuda Ocean Club began construction on Palmetto Peninsula (including on the former Beach Club hotel site on Palmetto Point) and on the site of the former Coco Point resort on Coco Point. Some Barbudans have acquired leases to large, semi-rural lots in the interior (GENIVAR, 2011). There are no permanent residents or residential structures on Cedar Tree Point.

Construction has begun on a new airfield east of Codrington, intended to replace the small airstrip at the south end of Codrington, which is currently the main point of entry for aircraft. The new airport location and project was identified in the SIRMZP 2011. Barbuda's seaport lies on the south shore of the island and serves as a passenger and commercial port. The port is widely recognized to be in poor condition and in need of upgrading.

4.6.5 Current and Historic Site Usage

Compared to other parts of Barbuda, little is known about the historic site usage of Cedar Tree Point. Archaeological interest in Barbuda has mostly focused on the older, eastern geologic region of the island. No historic structures are known to exist on the project site. In more modern times, the areas adjacent to the site have been developed for tourism, with construction of the Barbuda Belle and Lighthouse Hotels. The Lighthouse Hotel was destroyed during Hurricane Irma and has not been rebuilt, however Barbuda Belle also badly damaged was rebuilt and is operational. The frigatebird colony south of the project site is an important tourist attraction on the island. However, the project site itself contains no documented sites of cultural or economic importance (Figure 4.6.1).

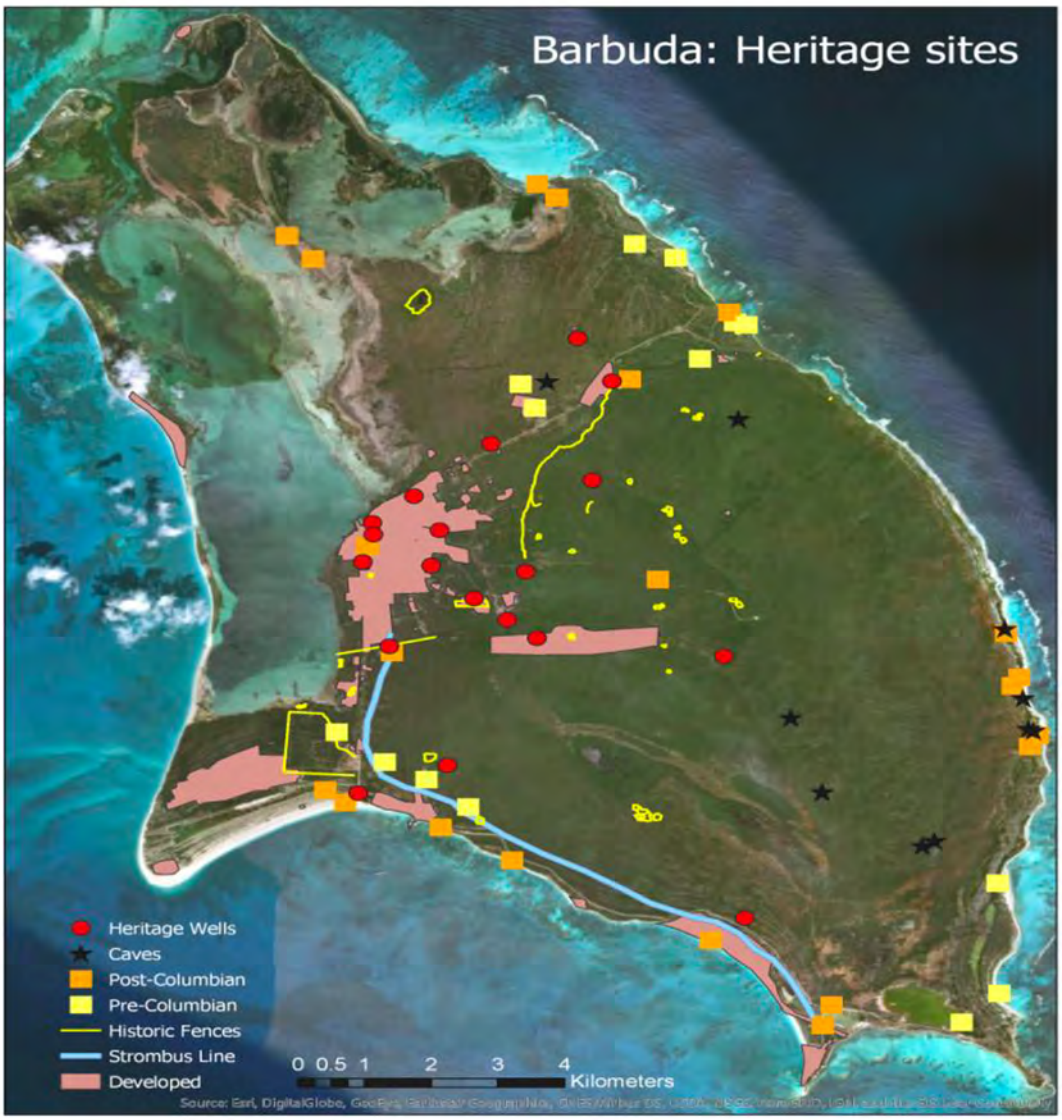


Figure 4.6.1. Location of cultural heritage sites in Barbuda (Source: Boger, Perdikaris, and Rivera-Collazo, 2019)

SECTION 5.0 ANTICIPATED IMPACTS AND MITIGATION MEASURES

SECTION 5.0 ANTICIPATED IMPACTS AND MITIGATION MEASURES

5.1 Prediction of Impacts

This impact assessment was conducted based on several methods as appropriate and available for the parameters. They included: field assessments conducted specifically for this EIA, existing published data (scientific and gray literature), development of mathematical and other simulation models; consideration of biodiversity and any protected status afforded to species and landscapes present. The specific methods are described in the appropriate sections.

The Terms of Reference requests consideration of carrying capacity for each habitat zone. Carrying capacity, is the maximum number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural, social, cultural and economic environment for present and future generations. Carrying capacity is a complicated term and generally applied at larger and more regional scales than at the level of individual residences or habitat zones within a 113.9-acre area. Small sub-habitats of a few acres do not represent a system for which stand-alone carrying capacity can be calculated with any accuracy or reliability.

There are several carrying capacity measures, including environmental, physical, economic, and real carrying capacity. Additionally, the carrying capacity for any given area is not fixed. It can be altered by, for instance, technology and resource management practices. Typically, carrying capacity is determined by four primary limiting variables: food availability, water supply, living space, and environmental conditions. These key factors are used because they have the ability to limit or even reduce a population by lowering birth rates, increasing the death rate, or encouraging migration from unsustainable locations.

We do not have sufficient information to determine the carrying capacity for this residential development and as previously noted the zones are small. If we use, for example, biological productivity per capita as an indication of the potential of a geographic area to support the population of that area, it does not take into account the effects of biomass transfers between different geographic areas or locations, nor effects of varying amounts of time spent in the area. In essence, most of these types of models assume that the individual or population is in a finite space and closed system, and pertinent information necessary for calculating carrying capacity is known. For the proposed two residences, the owners or guests will not be in a closed system. In addition, the number of people present at any one time will vary. For instance, the Abercorn Trust (for the purpose of this EIA) informed us that approximately a maximum of 20 guests may be present but only for a short period of time (e.g. 2 weeks). This is a density 1 person per of 0.8 acres for a limited period. At other times if a couple (owners) and 2 staff are present, this will amount to a density of 1 person per 4 acres. These densities and frequencies are not likely to result in significant depletion of water, food, environment or living space nor have a detrimental effect on the biology of the human population present. Use of technology (e.g. the proposed renewable energy) will also reduce the demand for external energy supplies.

We have addressed this underlying question using environmental footprint (which is sometimes associated with carrying capacity (populationeducation.org, 2014).

Environmental Footprint

The area comprises: 113.9 acres in total: 16.17 acres plus 97.73 acres identified as "security buffer". Of this, the footprint of the Abercorn residence is 0.33 acres and that of the DeJoria residence is 0.36 acres. The Abercorn "compound" identified in the plan and including the residence covers 4.2 acres in total, and we expect some of this area will be landscaped. For the DeJoria residence, we estimate a 1.5 acre "sphere of influence" including the residence and potential areas of landscaping. An area of 2.75 acres in the security zone was set aside for a solar array. In addition, 1.94 acres comprise the remainder of back of house, roads, outbuildings and other infrastructure. The remainder of the habitat is left untouched based on the current plans. In total, based on the estimates above, this amounts to approximately 10.39 acres out of 113.9 acres or 9.1% of the total leased land that will have a permanent environmental footprint. The use of any temporary staging areas will increase the area affected, although the staging areas can be replanted and mitigated post-construction. Based on construction of similar sized homes on Barbuda (e.g., The DeJoria residence Coco Point), we estimate that an approximately 100,000sqft staging area will be needed for the development.

5.2 Land Environment

5.2.1 Impacts

The project proposes a low-density residential development consisting of 2 villas on a 16-acre plot on Cedar Tree Point, (G-Application 4-2020). The development is within the boundaries of the Codrington Lagoon National Park and a RAMSAR site. Development in the park is not encouraged - the Sustainable Island Resource Management Zoning Plan (GENIVAR, 2011) has not recommended development in the Park, consistent with the Codrington Lagoon National Park Management Plan (2009). However, two developments have previously been permitted and constructed in this area of the park: The Barbuda Belle Luxury Beach Hotel, which opened in 2007 along the north shore approximately 0.95 km from the proposed Abercorn Villa, and The Lighthouse Bay Resort on the sand spit about 5km to the south and which opened in 2014. Barbuda Belle was damaged during Hurricane Irma (September 2017) but rebuilt quickly and continues to operate. Lighthouse Bay Resort, built on the sandspit and with little setback, was destroyed during Hurricane Irma and now lies partly collapsed in the ocean. It has not been repaired.

The developer's overall approach is to reduce the carbon footprint as much as is practicable and adopt low impact development strategies and including rainwater collection to reduce the operational water demand, and solar panels to eliminate the need for reliance on non-renewable energy sources (discussed below).

The land impacts will include short-term construction impacts as well as the permanent presence of two villas and associated support systems (e.g., RO plant and energy production). Short term impacts will include clearing for construction, the need to use a shallow draft (probably RORO vessel) to bring equipment onshore, and the management of a construction effort and waste. For a qualitative comparison of land impacts, we note that the adjacent Barbuda Belle has apparently had light impact on the environment (although it required reconstruction post Hurricane Irma, and when significant construction equipment has been needed on site). In this development, careful management of the landscape and equipment can reduce any long-term impacts on the proposed site. At the time of writing, there has been no RORO landing site proposed. From an environmental perspective, landing along the sandy shore is a better option, provided sea turtle nesting sites are not harmed. But this option will need to be more carefully evaluated when the construction plans are finalized, and vessel identified. At that stage, we believe a more accurate assessment and environmental guidance can be provided to minimize any potential impacts. As the landing and management of equipment and construction materials has taken place on adjacent properties, we recommend that the owners explore coordinating with the neighboring hotel.

The development will not significantly impact erosion. However, the Cedar Tree Point and associated beaches are dynamic, and the beaches naturally erode and accrete. During one of the site visits, there was significant beach erosion observed at the Point (of Cedar Tree Point) and evidence of occasional overwash on the NW corner behind a low dune (evidenced by a small outcrop of mangroves -- although the habitat itself was dry). Based on these observations, the siting of the Abercorn Residence was set back further from the beach for a final setback of 300ft from LPV to minimize risks to the property and to allow for natural beach processes.

Long term impacts such as vegetation clearing, the need for energy, stormwater and wastewater treatment as well as hurricane and storm risks have been assessed and, where significant, they can be mitigated. These are discussed below.

5.2.2 Mitigation

As described above (and see Section 2.3), based on erosion and storm risks, the siting of the Abercorn Residence was set back further from the beach for a final set back of 300ft from LPV. At the time of writing, no development or disturbance has been identified as likely to impact the lagoon or coastal mangrove fringe. For all other identified potential impacts including biology, ecology, wastewater, infrastructure, solid waste etc., each topic is presented as a separate impact and mitigation in the following sections. Below, we present an overview of measures to mitigate natural hazards and natural and construction-based erosion. However, a full natural hazard (climate change/storm surge) evaluation is presented in Section 6.0.

<u>Natural Hazards</u>

<u>Hurricanes including Storm Surge and Sea Level Rise</u>

The villas will be designed and built to standards that minimize risks from natural hazards and climate change. Based on the hydrodynamic models conducted and outlined in Section 6.0, for a worst-case scenario storm (Category 5), a Design Flood Elevation (DFE) +12.6ft MSL was recommended along with a setback of 200ft from the High Water Mark (HWM) on the seaward side, and a 100ft setback from the HWM on the mangrove side. The Abercorn Residence is now proposed to be built 300ft from LPV. The DeJoria Residence is well within the setback. Finished Floor Elevations of between 14 and 15 feet +MSL are proposed in the current design.

To meet these standards for resilience, the preliminary design proposes to use fill material to elevate the footprint of the DeJoria Residence, the back-of-house area, and driveways (Figures 5.2.1 – 5.2.3). (The Abercorn Residence is proposed to be built on a raised platform, rather than fill material, to meet or exceed the DFEs identified for risk reduction on site.) Fill material for the site will be sourced responsibly, be free of contaminants, and will meet all standards outlined in the building code of Antigua and Barbuda. Buildings will be designed and constructed to Miami-Dade County, Florida standards for hurricane protection.

The site also has natural dunes that act as natural storm surge barriers and these will be conserved and protected. (See also Section 6.0, Risk Analysis for details of setback/elevation calculations)

Seismic Risk Management

Barbuda is a seismically active island due to the presence of a subduction zone east of Barbuda at the meeting of the North American and Caribbean Plates. The Caribbean Uniform Building Code (CUBiC) codes for building in seismic zones has been incorporated into the building code of Antigua and Barbuda (Gibbs, 1998). This code will be the minimum standard used by the development.

Natural and Construction-based Erosion Risks

The development is expected to have minimum impacts on coastal erosion. Measures have been taken to ensure that the siting of the properties reduces risks to properties and to beach dynamics.

The construction will take place on sandy soil. To minimize land-based erosion and its effects on the coastal environment, several erosion control methods are recommended to be implemented during construction. These include standard measures such as silt fences, earthen dikes used as appropriate to stop or slow the movement of runoff. Strategies to minimize the area of disturbance should be adopted during the construction phase, including establishment defined transit corridors for equipment and vehicles, limiting access to the construction site, protecting stockpiles from wind and rain action, and re-seeding areas cleared of vegetation as early as practicable. In addition, stormwater management measures are proposed to further limit any land-based erosion and runoff into the marine environment.

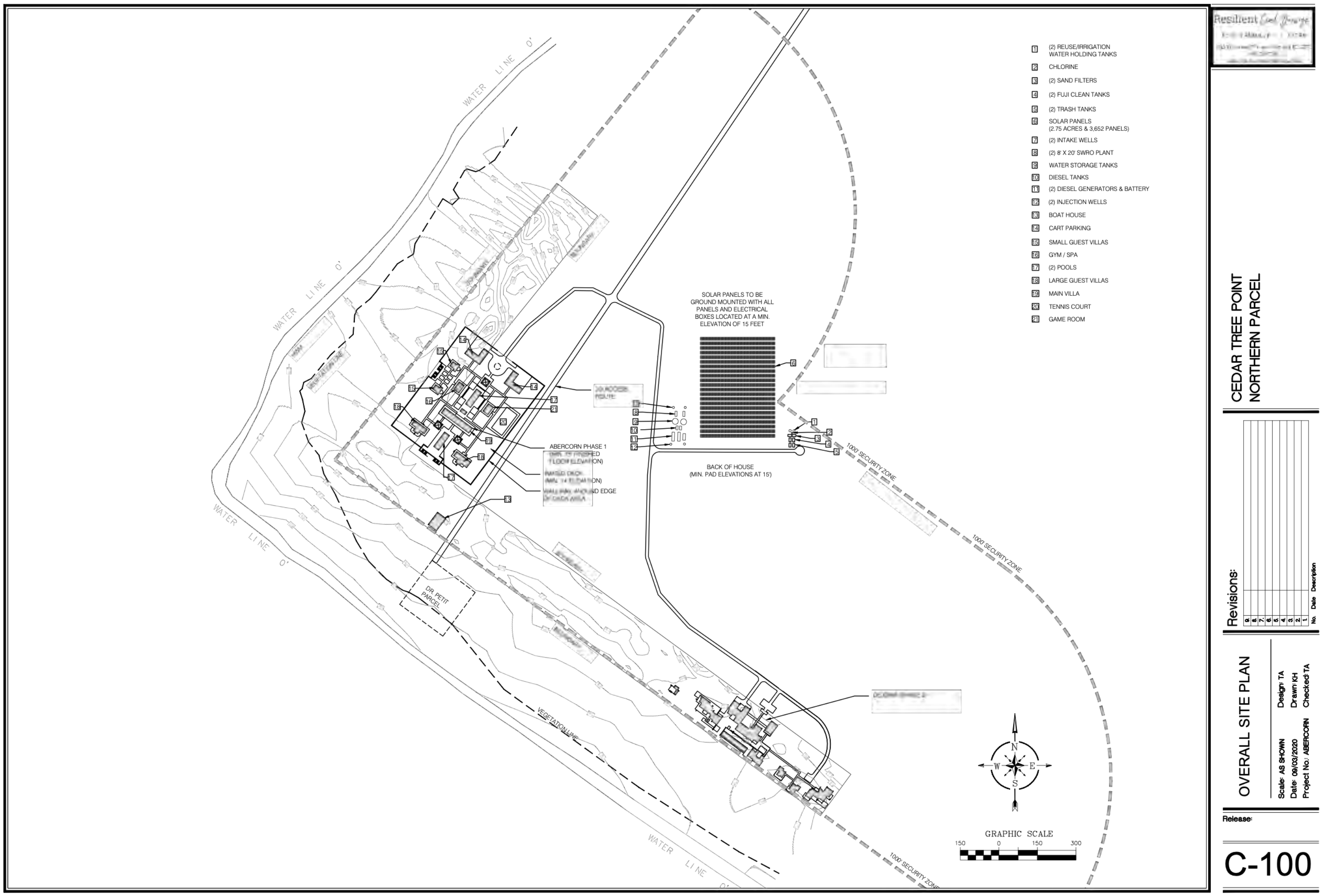


Figure 5.2.1. Preliminary site plan for the construction proposed on Cedar Tree Point, Barbuda.

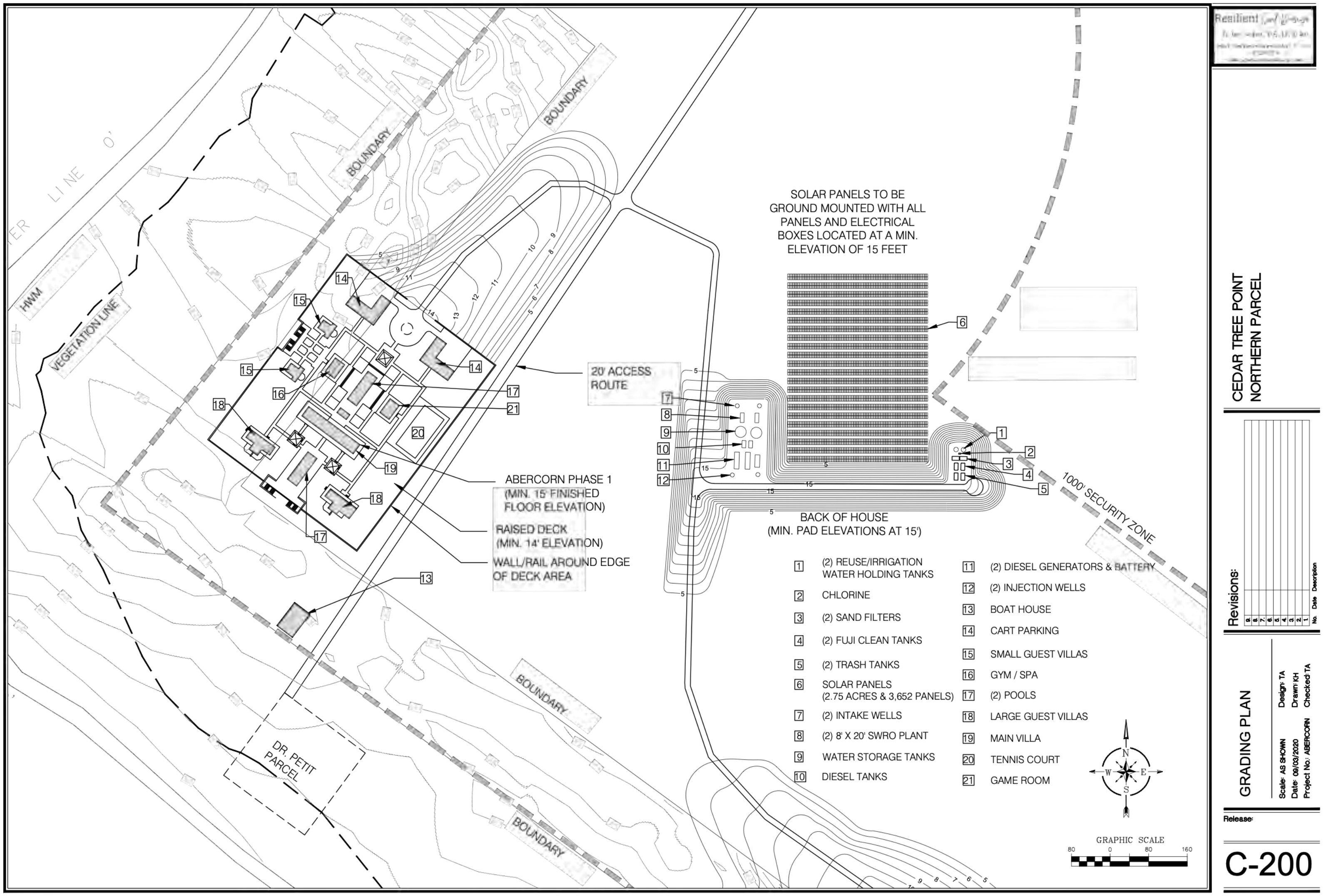


Figure 5.2.2. Preliminary grading plan for proposed Abercorn Residence and back-of-house area.

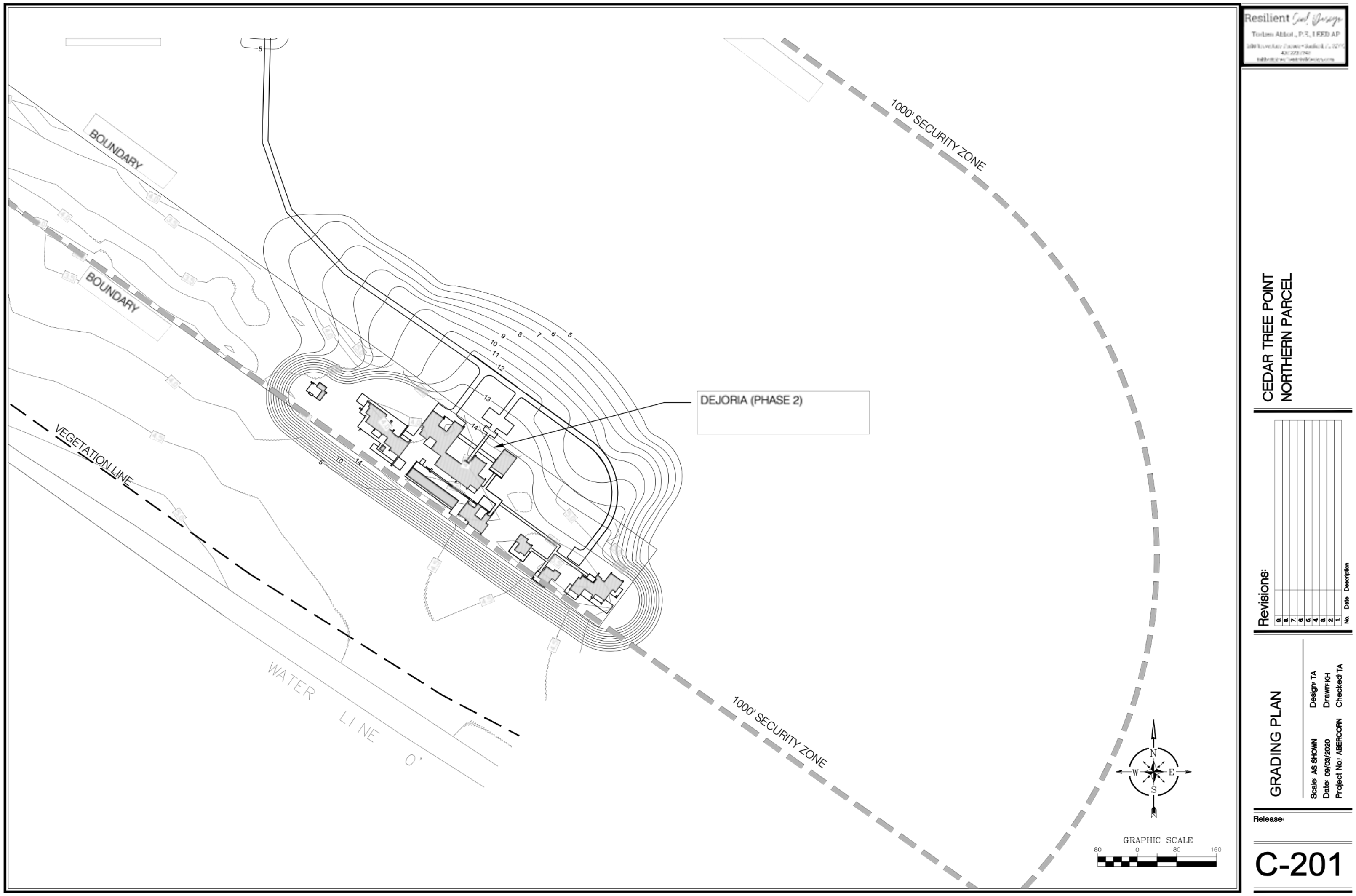


Figure 5.2.3. Preliminary grading plan for proposed DeJoria Residence.

5.3 Air Environment

5.3.1 Anticipated Impacts

Air quality on Barbuda is good. Any potential impacts on air quality from this project will be associated with the construction phase. The construction phase for the Abercorn Residence will last approximately 18 months, and the construction phase for the DeJoria Residence will last 12-18 months, with the former starting within a few months of approval and the latter, a few years after approval.

Dust is typically a concern during the construction phase of development projects especially as a result of the dry, drought-prone, and windy Barbudan climate. Potential sources of dust on site include loose soils and fill stockpiles. Construction is also anticipated to utilize gas or diesel-powered construction equipment, trucks, and generators, although exhaust from these sources is not anticipated to result in significant deleterious effects to the local air quality given the small size of the structures to be built, the phased schedule for construction, and the steady prevailing winds at the project site. Because the prevailing winds (tradewinds) blow consistently from east to west, no impact to adjacent properties (e.g. Barbuda Belle) are anticipated. Overall, we anticipate that any impacts on air quality will be local and limited.

No significant impact is anticipated to air quality during the operational phase of the project. Sources of dust present during the construction phase will not persist into the operational phase – remaining fill material will be spread or disposed of and disturbed soils will be stabilized and revegetated. Ultimately little to no fossil fuel combustion is planned to occur on the site as the villas are planned to utilize solar power. A generator will be present on site as a backup for emergencies but will not be employed full-time.

5.3.2 Mitigation Measures

Measures to minimize dust movement during windy conditions and to maintain air pollutant threshold criteria, including U.S. EPA and World Health emissions standards for vehicles and generator equipment, should be implemented during the construction phase of the project.

Strategies to minimize dust movement include:

- Using water trucks to spray down exposed areas or surfaces.
- Sealing and/or re-vegetating disturbed areas as soon as possible after completion of each stage of construction works.
- Using wind breaks.
- Minimizing double-handling of materials.
- Seeding, stabilizing, covering or containing stockpiles where necessary.

Modern equipment that is industry compliant and in good working which operate at emission levels keeping with EPA National Ambient Air Quality Standards for particulate matter (PM), carbon monoxide, lead, nitrogen dioxide, ozone, and sulfur dioxide are recommended for use on this project (“NAAQS Table,” n.d.).

5.4 Noise Environment

5.4.1 Anticipated Impacts

Noise impacts will be limited primarily to the construction phase of the project. They will be temporary and localized. In order to assess any significant noise impacts on the frigate bird colony and neighboring properties, we conducted a general noise assessment. We used the standard methods applied in EIA studies (Construction Noise Impact Assessment Manual (CNSAM), Biological Assessment Preparation V02-2012).

Noise impact decreases with distance from the project site. The following formula is used to determine the distance construction noise must travel to drop to ambient noise levels (in other words how far away an individual must be before construction noise blends-in with background noise)

$$D=D_o*10^{((\text{Const. noise} - \text{ambient sound level})/\alpha)}$$

Where D = distance from the noise source in feet, D_o is the reference noise distance in feet, and α = 25 where soft ground exists and 20 where hard ground is more common (e.g. WSDOT, 2019).

Several pieces of equipment can combine to create a higher noise level. Table 5.4.1 gives the rules for combining decibel (dBA) values. When multiple pieces of equipment operate on site, the three loudest pieces of equipment should be considered together.

Table 5.4.1. Rules for combining noise levels (adapted from WSDOT, 2019 after USDOT, 1995)

When two decibel values differ by:	*Add the following to the higher decibel value:*
0 or 1 dBA	3 dBA
2 or 3 dBA	2 dBA
4 to 9 dBA	1 dBA
10 dBA or more	0 dBA

Typically, many different pieces of equipment are operating at once on a construction site. Although noise from multiple sources at the same location results in louder levels than a single source alone, the decibel is measured on a logarithmic scale, so noise levels cannot be added by standard addition. Therefore, the above equation is used. As part of the assessment the scientists would identify (if known) the three loudest pieces of equipment, to be used add the two lowest levels together using Table 5.4.1 and add the result of the loudest piece of equipment using the same formula.

For this exercise at Cedar Tree Point, we assumed an excavator, operating generator, and pneumatic drill would be operating simultaneously. At a distance of 50 feet, the noise level of an operating excavator is estimated at 81 dBA, that of an operating generator at 81 dBA, and that of an operating pneumatic tool 85 dBA. If these three pieces of equipment are operating simultaneously, using the formula above, the total noise level will be 88dbA. (The combined noise of the excavator and generator is 84 dBA (81 + 3 dBA = 84 dBA, and adding in the pneumatic tool at 85 + 3 dBA = 88 dBA.)

We then selected an average ambient noise level of 40 dBA for Cedar Tree Point. This was based on analyses from several studies (e.g., CNSAM 2012, WDOT 1994 and later). Ambient noise in rural locations are typically 35-40 dBA (EPA, 1978). However, background and ambient sound levels vary by location even for undisturbed wooded areas. In addition, wind and wave noise can significantly raise ambient noise levels in the coastal zone. A noise analyses on the San Juan Islands (USA) identified an ambient level of about 35 dBA, with regular noise intrusions from local traffic and aircraft overflights ranging from 45 to 72 dBA respectively (WSDOT 1994). A study on the Mt. Baker-Snoqualmie National Forest listed forested ambient levels between 52 and 60 dBA (USDA Forest Service 1996). However, the Olympic National Forest programmatic biological assessment uses an estimated ambient level of 40 dBA for undisturbed wooded areas (USDI 2003). As part of the analysis, we also incorporated features including hard (e.g. open water) and soft ground (vegetation or soil) into the analysis.

Analysis

Based on an ambient noise level of 40 dBA for Cedar Point, a construction noise of 88dBA will decrease to ambient noise level at a distance of 4,159 ft (1.25 km(over soft ground and 12,559ft (3.82km) over hard ground (open water) In other words, an individual 1.25 km away from the site (when the three machines are operational) will effectively not distinguish the construction noise from ambient noise.

The closest part of the construction site to the neighboring property (Barbuda Belle Luxury Hotel) is 0.95km (3,117ft) and noise will travel almost entirely soft ground (α = 25). The closest part of the site to the frigatebird colony is 1.25km (4,101ft) over a mix of hard and soft ground (α = 20). This indicates that that some degree of noise from construction will be heard at these locations. However, it will not be significantly above ambient levels.

Specifically, using 88 dBA construction noise level, noise heard at Barbuda Belle would be 43.1 dBA – only slightly elevated from typical rural ambient noise:

$$D=D_o*10^{((\text{Const. noise} - \text{ambient sound level})/\alpha)}$$
$$3117=50*10^{((88-x)/25)}$$
$$x = 43.1 \text{ dBA}$$

Under the same criteria construction noise at the frigate bird colony would reach 49.7 dBA (slightly louder as the open water does not dampen the sound as much as vegetation and sand)

$$D=D_o*10^{((\text{Const. noise} - \text{ambient sound level})/\alpha)}$$
$$4101=50*10^{((88-x)/20)}$$
$$x = 49.7 \text{ dBA}$$

As a standard of comparison, this is less than that noise levels recorded at a remote forest site (see above). Additionally, WSDOT, 2019 identifies 50 dBA as “quiet” and the equivalent to ambient noise in a suburban residential area or a lightly trafficked road heard from a distance of 100ft. WSDOT and characterizes this level of noise as “quiet”.

Finally, sound can reach 70dBA in urban zones or when more industrial equipment is being used. For Barbuda Belle and the frigate bird colony to “experience” this level of sound construction noise on site would need to be 114.9dBA and108dBA respectively.

In conclusion, it is likely that some construction noise will be audible at certain times at neighboring properties and the frigate bird colony. But the noise level is not anticipated to be extreme based on the assumed calculations.

5.4.2 Mitigation Measures

We recommend that the developers and construction team alert the Barbuda Belle during anticipated times of high-noise activity or construction traffic. This will minimize disturbance to the Hotel and promote good neighborly interactions.

On a more general level, it is recommended that the project adopt the necessary precautions accordance with the World Bank and Occupational Safety and Health Act standards for construction and operations, ("Environmental, Health, and Safety (EHS) Guidelines: Noise Management," 2007) and conform to noise standards of U.S. Occupational Safety and Health Act of 1970 (OSHA). Construction should follow standard operations guidelines, including confining construction to normal working hours during periods of increased tourist traffic.

Table 5.4.2. Permissible Noise Exposure Limits for Employees per 29 CFR § 1910.95(b)(2).

Duration per day (hours)	Sound Level (dBA) Slow Response
8	90
6	92
4	95
3	97
2	102
1.5	105
1	110
<0.25	115

Construction noise is not anticipated to cause significant disturbance to frigatebirds in the area due to the sporadic nature of construction noise, the distance of the site from the colony, and the temporary nature of construction. Regular monitoring of the frigatebird colony during the construction period is recommended to ensure no unintended effects on the community.

5.5 Water Environment

5.5.1 Anticipated Impacts

Overall, impacts to water resources from the project are anticipated to be small. There is no significant aquifer or water courses on site, and development is not expected to shift current surface or sub-surface water flow patterns. The plan does not include any alteration to the mangrove wetlands of the lagoon. The construction will be on inland sandy soils and no wetlands are included in the proposed built areas.

However, stormwater runoff, sewage, and brine from the planned reverse osmosis plant must be properly engineered and managed during construction and operations. This is particularly important because of the location of the development adjacent to Codrington Lagoon and within park boundaries and because of the importance of the waters to local fisheries.

The project proposes several low-impact development (LID) methods to manage and conserve water. For instance, cisterns and treated effluent from the wastewater plant will be utilized for non-potable water uses (e.g. landscaping irrigation) to reduce demand on the desalination plant.

Specific concerns and any impacts for stormwater, wastewater, and a reverse osmosis plant are addressed below under Impacts. A short mitigation section for each element follows. However, a full evaluation and recommendations for options that provide a more integrated management and mitigation approach are discussed in Sections 5.9, 5.10, and 5.11.

Stormwater

During construction and operations, managing stormwater will be critical for the health of the adjacent ecosystems, especially marine and coastal habitats, as well as to land stability. On construction sites, stormwater runoff can lead to localized erosion and loss of construction materials such as gravel and stored items. During storm events, fertilizers, pollutants (e.g. oil) and other chemicals can be transported to marine waters. Stormwater runoff on tropical islands can be particularly damaging to coastal ocean resources. Sediments hinder photosynthesis by blocking sunlight and reducing marine productivity, and smother marine life leading to biological degradation. Runoff from rainfall can carry harmful pesticides into the coastal zone. Sediments create murky waters, hindering marine recreation and negatively affecting the ocean aesthetic for visitors and residents. Nitrogen and phosphorous from fertilizers used on gardens and landscapes encourages algal blooms and which play a significant role in ecosystem degradation (Venu, Moore, & Crile, 2014) particularly of coral reefs and tropical marine habitats. Coastal mangrove lagoons are less susceptible to the issues above because they are typically shallow muddy habitats and can play an important role infiltering sediments and runoff.

Due to the small scale of these projects, and if proposed management options are followed, we do not anticipate stormwater problems to the coastal ocean environment. However, we note a stormwater management plan is critical to support the environment and minimize risks and options are provided here in Section 5.10, Hydrology and Stormwater Management.

Wastewater

Sewage and wastewater discharge are known to cause long-term changes in tropical marine environments. Human activities on land have increased nutrient inputs to coastal waters from deforestation, wastewater, fertilizer, and other sources. Additionally, sewer overflow resulting from storm surge or extreme rain events can negatively affect local habitats and human health. The small scale of the development (2 residences) and the LID approach indicates that impacts will be low.

Reverse Osmosis Plant

The proposed development will use a reverse osmosis desalination and treatment process to provide potable water for the villas. Either ocean or deep well injection disposal will be considered but further work is needed to identify the best brine disposal option.

5.5.2. Mitigation Measures

Stormwater

Several features of the Abercorn Residence have been designed to minimize stormwater runoff from impervious surfaces and to incorporate LID techniques. These are fully discussed in Section 5.10, Hydrology and Stormwater Management.

Wastewater

The project proposes to treat wastewater on site using a small sewage treatment plant located in the back-of-house area. The plant will be built concurrently with the Abercorn Residence and will be sized appropriately to that residence with expansion capacity for the DeJoria villa which will be built subsequently. A full analysis of wastewater options and recommendations was conducted for the EIA and is presented in Section 5.9.

Water Supply: Reverse Osmosis Plant

The project will require about 7,000 gallons of potable water per day. A desalination plant (RO plant) will be needed to meet this requirement. Brine (the waste product of RO plants) can have deleterious impacts on seagrass and marine life. If brine is discharged into the sea, the outfall pipe must be located where there is good dilution (good current flow) and to ensure that there is no buildup of hyper-saline conditions.

5.6 Biological Environment

5.6.1. Upland Vegetation Impacts.

Cedar Tree Point is lightly developed - Barbuda Belle Luxury Hotel is the only other nearby development. The area's relative isolation from large scale development and free-roaming livestock is reflected in the health of the vegetation and biological community types.

The proposed development of two villas is a low-density project, but like all developments, it will have some impact on the landscape. In Section 4.5, we provided a biological baseline survey. In this section, we discuss the nature and extent of impacts on the biological environment and propose mitigation measures.

In general, the project design has taken into consideration the vegetation landscape and has minimized the impacts to vegetation to the best possible degree. Two areas are planned for residential housing: Abercorn Residence and DeJoria Residence. A third area will be developed for back of house facilities (Figure 5.6.1). In total, 9.1% of the landscape will be impacted. Based on the current design three of the five species assemblages will be impacted.

- Sand Strand Beach Dune: Approximately 11% of this assemblage type will be impacted.
- Coastal Shrubland Vegetation: Approximately 6% of this assemblage type will be impacted.
- Coastal Shrubland with Herbaceous Vegetation: Approximately 9% of this assemblage type will be impacted.

Sand Strand Beach Dune*:* The Sand Strand Beach Dune community type is the sparsest of the community types and is generally found on the western side of Cedar Tree Point. It will be impacted by the construction of the Abercorn Residence. Sensitive species found in this community type are; *Chamaecrista glandulosa* (Jamaican Broom)*, Mosiera longipes* (mangrove berry), and *Argusia gnaphalodes* (sea lavender) (Table 5.6.1). All three species are listed as Regionally Endemic according to Pratt et al., 1997. Mangrove berry and sea lavender are also described as vulnerable in Antigua and Barbuda due to development and overgrazing. Mangrove berry is designated as a protected species in EPMA 2019 (Table 5.6.1).

Coastal Shrubland Vegetation: Coastal Shrubland Vegetation community type will be impacted by the back of house area (Figure 5.6.1). Coastal Shrubland Vegetation is the most common community type found at Cedar Tree Point. This community type is generally found inland and supports large shrubs and trees such as clusters of *Coccoloba uvifera* (sea grape) and buttonwood. Sensitive species found in this community type are: buttonwood*, Gundlachia corymbosa* (Yam Bush), *Sideroxylon obovatum* (boxwood), *Jaquinia arborea* (Torchwood), and *Tabebuia heterophylla* (white cedar), (Table 5.6.1).

Coastal Shrubland with Herbaceous Vegetation: The Coastal Shrubland and Herbaceous Vegetation community type is found in all three proposed building locations. Many of the same species found in the Coastal Shrubland Vegetation community type are also found here. The difference between the community types is that shrubs and trees are less dense. Typically found are scattered sea grape and buttonwood amongst dense herbaceous species such as *Pluchea carolinensis* (cattle tongue), *Croton flavens* (nail polish bush), and dense patches of *Lantana involucrata* (button sage).

Table 5.6.1. provides a list of sensitive species recorded and that are in the development impact. Five of them are listed as protected under Section VIII of the 2019 Antigua and Barbuda Environmental Protection and Management Act (EPMA). Section VIII of 2019 EPMA provides for sustainable environmental protection and management of natural resources. Other sensitive species present but occurring outside the development footprint include red mangroves and white mangroves along the lagoon shore, and sea lavender in the coastal shrubland. Coconut palms were observed around the cabana near the point; however, the area is not within the property boundary.

Table 5.6.1. List of sensitive plant species recorded at Cedar Tree Point that are likely to be impacted by the development footprint. (No IUCN Endangered or Threatened plant species were identified at Cedar Tree Point)

Species	Common Name	Regional Endemic (Pratt et. al., 2009)	Listed Species under Section VIII 2019 EPMA
Agave karatto	Century plant	X	X
Bromelia sp.	Air Plant		X
Chamaecrista glandulosa	Jamaican broom	X	
Conocarpus erectus	Buttonwood	X	X
Gundlachia corymbose	Yam bush	X	
Jaquinia arborea	Torchwood	X	
Mosiera longipes	Mangrove berry	X	X
Sideroxylon obovatum	Boxwood	X	
Tabebuia heterophylla	White cedar	X	
Tillandsia utriculata	Air Plant		X

The development will permanently impact about 9.1% of the leased area and in the coastal upland habitats. Because the species are abundant through the project site, we do not anticipate significant impacts to the species or habitat. In addition, plants can be replaced either by planting from local stock or commercially. Buttonwood is present in the upland area and will be impacted. This species (often considered a mangrove) is an opportunistic species occurring in upland habitats as well as among mangrove forests. It is fast growing and it is typically not salvaged because of the ability to replace it with commercially or locally grown plants.

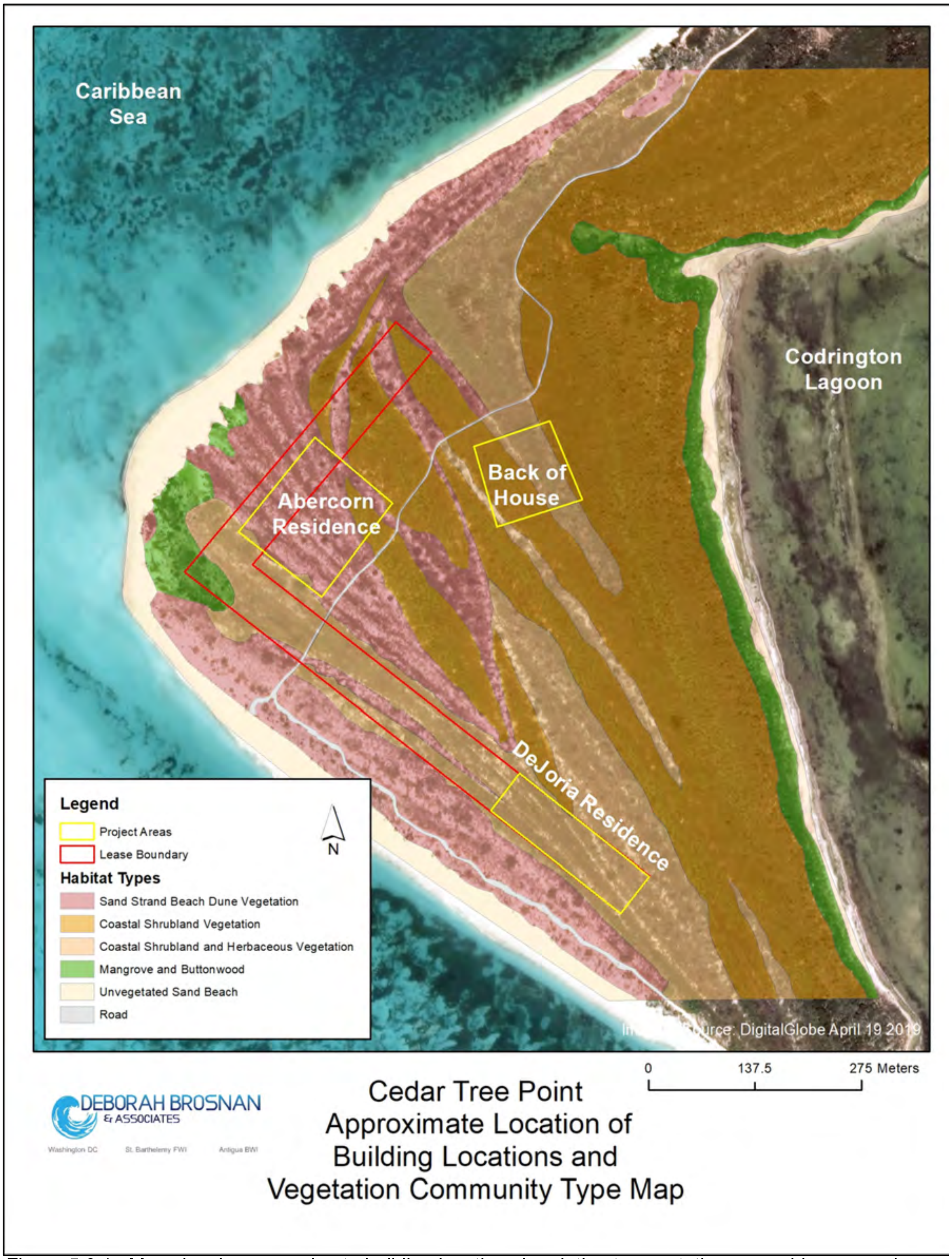


Figure 5.6.1. Map showing approximate building locations in relation to vegetation assemblage mapping.

5.6.2 Intertidal and Marine Vegetation Impacts

Codrington Lagoon forms the eastern boundary of the leased land, including the security zone. The Lagoon is a diverse ecosystem comprised of mangroves, seagrass beds, algal mats, tidal and mud flats. These habitats support a diversity of marine species such as juvenile lobster, reef fish among others. The current plans show no construction or development activity in this area and any impacts to marine and intertidal vegetation are anticipated to be minimal.

5.6.3 Upland Terrestrial Fauna Impacts

Minimal impacts to reptile and amphibian habitat will occur with the displacement of coastal shrubland communities with low density villas. Since Cedar Tree Point will remain largely undeveloped, these species may migrate to surrounding areas of coastal shrubland. No impacts to mammals are expected. We are not recommending mitigation for terrestrial reptile, amphibian, or mammal species.

Birds

Magnificent frigate bird (Fregata magnificens)

The Barbuda frigate bird colony is located SE of the proposed development in Codrington Lagoon. As the largest regional nesting colony (c 5,000 pairs) it is biologically important. It is also an important source of tourism revenue to Barbuda. Tour guides offer a unique experience to visitors who can get within a couple of feet of these large seabirds.

The IUCN lists the species as of "Least Concern" due to its abundance. Early studies on the colony were started by Diamond in 1972. A literature search did not find studies showing negative impacts on the colonies from light development within several miles of nesting sites, and the adjacent Barbuda Belle would not appear to impact the species. There is evidence of some colonies in the wider Caribbean being extirpated primarily due to introduction of feral animals. Anecdotal reports of development leading to habitat and bird declines are reported in Diamond and Schreiber (2002). However, the birds on the Barbuda colony do not appear to be harmed by eco-tourism.

We do not anticipate any impacts from the operation of the residences on the frigate bird colony, except that it may increase tourism revenue to Barbuda. Construction noise is unlikely to cause harm to the colony (see Section 5.4). No activity is planned in the lagoon to disturb the habitat.

Barbuda Warbler

The distribution of the yellow and Barbuda warblers appears to be negatively correlated. Mahabir did not record the Barbuda warbler in the Cedar Tree Point area but he did record a yellow warbler there. During our surveys, we observed a single warbler, but the species could not be definitively identified.

Because the Barbuda warbler is distributed on the island primarily in highlands and plains areas (habitats not found at Cedar Tree Point) and because this species has not been confirmed to be present at the project site, we do not anticipate impacts and are not recommending mitigation measures for this species.

5.6.4 Marine and Freshwater Fauna Impacts

Sea Turtles

The sea turtle monitoring program recorded hawksbill (*Eretmochelys imbricata*) turtle nests along the northern and western shoreline of the site during 2019 and 2020 seasons. Green sea turtles (*Eretmochelys imbricata*) have been observed in the marine waters offshore (personal communication, Fisheries Officer, Barbuda). No leatherback turtle (*Chelonia mydas)* nests have been recorded on the site but they have been recorded south of the property line on the sandspit (WIDECAST Antigua and Barbuda, personal observation, science team 2018). The construction and operations of the proposed development have the potential to affect all three species.

Impacts are possible during construction and operations. Given the property's lack of road access to Barbudan ports of entry, RORO barges and/or other marine transportation means will be necessary to transport vehicles, equipment, and materials needed for construction will have to be brought to the beach. Moving equipment and driving on the beach near the vegetation line during nesting season as well as disturbing vegetation can damage or disrupt nesting.

Lighting along the beachfront properties at night during the construction and operational phases of the project can affect sea turtle nesting behavior and hatchling success. During a hatching event, hatchlings immediately orient themselves toward the brightest horizon, which in unlit natural conditions is the open horizon of the sea (Choi & Eckert, 2009). Light from a variety of sources, directly on the beach or indirectly emanating from lights in inland areas, can misdirect hatchlings, leading them away from the sea. (See Annex 3 for protocols on sea turtle monitoring during construction and lighting etc.)

Lobster and Conch

Codrington Lagoon is recognized as a nursery site and habitat for Caribbean Spiny Lobster (*Panulirus argus*) and queen conch (*Strombus gigas*). Juvenile lobsters are known to use Codrington Lagoon as a nursery and early life stage habitat. During the April 2018 seagrass survey, one juvenile lobster was observed in the lagoon. Juvenile and adult conch are associated primarily with seagrasses (especially *Thalassia testudinum*) (Stoner, 2003).

The project is unlikely to directly impact lobster or conch populations or the overall biodiversity of the local marine ecosystems. However, care must be taken to manage offshore seagrass beds in the marine habitat during construction.

5.6.5 Upland Vegetation Mitigation

The entirety of Cedar Tree Point lies within the Codrington Lagoon National Park and RAMSAR site, an area internationally recognized as ecologically important. Mitigation measures to offset impacts are critical to preserving the integrity of this important resource.

The project design has taken into consideration minimizing impacts by limiting the area of construction to three defined areas. The preserved remaining areas will continue to support local wildlife and provide adequate seed production to sustain these habitat types. In addition, impacts to the Sand Strand Beach Dune, a critical habitat along the west shoreline for sea turtle nesting, is mostly avoided. Other best practices and mitigation measures to reduce impacts to sensitive vegetation and to enhance the existing ecology of the area include the following:

1. Minimize work zones and establish defined corridors for equipment to minimize the area impacted, as previously recommended in Section 5.2. Areas that allow equipment access and staging may be clearly marked. Any work outside of these areas may be prohibited to avoid impacts to the surrounding vegetation.
2. Prior to construction, additional surveys to ground truth plant species and densities is recommended. This will provide an accurate record of impacts within the construction footprint and provide the information needed for a robust management plan.
3. Based on further assessment, a management plan to replace impacted sensitive plant species can be developed. This will ensure that any impacts to sensitive vegetation are off set to preserve the ecological function of the site.
4. Maintain and enhance the Sand Strand Beach Dune habitat. This community type is vital to sea turtles nesting on the beach. Enhancing this community with additional planting of sea lavender, bay cedar, and sea grape will aid in stabilizing areas that were damaged by Hurricane Irma and provide improved resilience for future storms.

5.6.6 Marine/Intertidal Vegetation Mitigation

Impacts are expected to be minimal. BMPs to minimize erosion and runoff during construction should be implemented to protect marine habitats from runoff and sedimentation, and LID strategies should be incorporated into the design of the development to minimize alterations to the natural hydrology of the site.

5.6.7 Upland Terrestrial Fauna Mitigation

<u>Birds</u>

Potential impacts to the magnificent frigatebird can be minimized and avoided using best practices for construction and operations. Noise impacts are expected to be temporary and limited to the construction phase of this project. Regular frigatebird monitoring should be completed to ensure that construction activities are not disrupting the colony or nesting activities. Construction transport and staging areas to bring equipment to the site will need to be carefully planned and should not be located near the frigatebird nesting colony.

5.6.8 Marine Fauna Mitigation

<u>Sea Turtles</u>

Many sea turtles prefer to select wide, obstacle-free beaches for nesting. Coastal beachfront development can reduce the quality of this type of habitat. Setbacks from the shoreline should be implemented as recommended in Section 6.0 (Risk Analysis) and should minimize the need vehicle traffic in sea turtle nesting habitat, in addition to adding a level of resilience to the proposed development. Impacts to sea turtle nesting habitat can also be managed by minimizing the footprint of the landing area for equipment, avoiding vehicle traffic on the beach, using defined transit corridors, revegetating cleared areas as early as practicable, and limiting access to the site during construction (as recommended in Section 5.2).

Before construction begins, the area should be surveyed for sea turtle nesting activity. All nests identified should be clearly marked as to avoid any direct impact during construction activities. It is recommended that comprehensive sea turtle monitoring take place throughout the duration of construction. The Barbuda Sea Turtle Monitoring Program has previously visited the site for data collection, however due to the remote location of the area and necessary marine transportation, the team has not been able to visit the site on a regular basis. Improving access to transportation for the team is recommended to allow for a weekly assessment of turtle nesting activity on site. Furthermore, it is recommended that the sea turtle team be supported in long-term.

Proper light management can drastically reduce the disorienting effect on sea turtle hatchlings. Alternative types and colors of lights, including low-pressure sodium vapor lights or red colored lights, can illuminate the beach without impacting sea turtle behavior. Other strategies to minimize the effect of lighting on sea turtles include low light placement, directional focus, shielding, and covering windows. Detailed protocols for sea turtle friendly lighting, as well as construction protocols to minimize impacts to turtles are recommended for use on this project.

5.7 Socioeconomic Environment

5.7.1 Anticipated Impacts

The proposed project is low density. A development of this small scale fits with the Barbuda vision as outlined by Barbuda Council Chair (e.g. Council Chair Ms. Beazer Observer Media Radio May 2020). Beach access will be fully maintained in accordance with Antigua and Barbuda regulations.

At least fourteen local jobs will be created during the construction phase of the Abercorn Residence. These jobs will be temporary positions during the construction phase. During the operational phase, the Abercorn Residence will employ at least two full-time landscapers and one full-time housekeeper and will provide part-time work for pool maintenance and an engineer. These will be year-round positions, continuing even during periods when Abercorn Residence is unoccupied. In addition, several part-time position and use-of-service providers (e.g. local tour guides, boat and water sports personnel) are anticipated when the owners and guests are present. Employment data for the second villa is not yet available and will be assessed as the project moves closer to the construction. However, at the time of writing, the project anticipates similar construction and operations employment numbers.

The project is expected to have positive impacts on island revenue including from tourism (e.g., increasing the need for tour guides to the frigate bird colony and other natural locations). We do not anticipate significant impacts to the local fisheries, except that owners and guests are likely to buy fish and lobster directly from local fishermen, increasing their revenues.

There will be construction activity within 0.95km of Barbuda Belle for the building of the Abercorn residence which will be visible to the guests. A one-acre easement (path leading to a beach facility) runs just south of the proposed Abercorn Residence. The DeJoria Residence is located further south and is less visible.

5.7.2. Mitigation Measures

The owners must ensure that construction is carried out with consideration for adjacent property owners, and with all necessary coordination with government oversight bodies and regulators. Regulators and stakeholders will be notified in advance of the start of construction and of any major efforts that may be occurring. Coordination with the regulatory agencies on environmental issues will be completed by a qualified representative. DCA, DoE, and the Fisheries Department will be notified of all on-site incidents within 24 hours and will be notified of any major changes to the construction schedule, as needed. All work on site should proceed per United States Occupational Safety and Health Administration (OSHA) guidelines for worker protection.

5.8 Solid Waste

Solid waste is a recognized challenge for small islands across the world. It has been an ongoing challenge for Barbuda and Hurricane Irma exacerbated the issue. Solid waste will be generated during the construction and operational phases of the project. Construction waste may include lumber, concrete, brick, stone, wire, and other building materials, and packing. It is also likely to include hazardous items, such as paints and oils. Operational waste is anticipated to consist of typical household waste (food containers and scraps, lawn and garden cuttings). Minimal solid waste from sewage is anticipated during the operational phase. See Section 5.9 (Sewage Treatment) for additional details about wastewater processing.

Given the challenge posed by solid waste disposal on a small, sparsely populated island like Barbuda, the volume of waste produced should be minimized as much as possible. Reuse and composting strategies will be used as appropriate, with other materials compacted and exported from the island for disposal in accordance with Antigua and Barbuda Law and with applicable international laws and treaties. There is currently no recycling program on Barbuda.

5.9 Wastewater/Sewage Treatment

The project proposes to treat wastewater on site using a small sewage treatment plant located in the back-of-house area. The plant will be built concurrently with the Abercorn Residence and will be sized appropriately to that residence with expansion capacity for the second villa which will be built later.

Based on the development program, approximately up to 5,600 gallons per day of wastewater treatment will be needed ultimately for the Abercorn Residence and the DeJoria Residence combined. The treatment system should be constructed in phases as the development proceeds. If the demand is heavy (e.g. on holiday weekends or extended family holiday times), we recommend some storage such that the plants don't get overloaded and the plants are fed continuously through the week.

5.9.1 Overview and Analysis of Alternatives

Wastewater (sewerage) systems in Barbuda have largely consisted of septic tanks, cesspits and soak-aways, all of which can result in nutrient discharge harmful to the marine environment. There are many alternative wastewater treatment systems available that could be utilized at the project site. Below we analyze several potential options for the proposed development.

One potential method is a package plant. A package plant would provide primary and secondary treatment, and the effluent would be available for irrigation use. Some treatment of the effluent would be needed to minimize odors. Package plants come in many styles and sizes and are typically metal-based and self-contained. The plant would be shipped to the site preassembled and would only need to be connected to the wastewater collection system. However, the volume of wastewater requiring treatment for this project is small and too variable for a package plant. At peak loads, the plant could operate well, but when only a few people are onsite the biology may not survive and the plant would need to be restarted. This would make the plant significantly more difficult to operate.

A forced air plant is another type of wastewater treatment system that could be used on site. These plants are easier to operate than package plants, can take overloading without upsetting, and can run at low volumes more easily than a package plant. They are similar to septic tanks with bubblers in the bottom that maintain aerobic conditions in the wastewater, significantly speeding up the biology. Figure 5.9.1 shows a fully installed Fujiclean forced air system (four brown tanks). The concrete block walls contain sand filters, which provide additional treatment before chlorination and storage in the tanks along the left side (to be used later for irrigation). The pictured unit is twice the size needed for this project. A forced-air system such as the one pictured in Figure 5.9.1 would produce very little solid waste so long as grease traps are used to keep grease from being introduced into the system and quat-based cleaning products (quaternary ammonium compounds) are not introduced into the system.

Figure 5.9.1. A Fujiclean forced-air wastewater treatment system with sand filter

Additional options are to use membrane plants. A membrane plant is the most expensive option presented here and consumes more electricity, produces a higher quality of effluent, and takes more skill to operate relative to the other options. The plant works by forcing wastewater through membranes at high pressure. This is the only option that does not require biology to treat the wastewater and therefore can handle the greatest variations in loading.

Lastly, are septic tanks and drain fields. These systems are limited to treatment of 5,000 gallons per day and do not allow effluent to be used for irrigation. Septic tanks and fields are more likely to introduce contaminants to the local ecosystem than the other options presented. They are a poor choice, and they are not being considered for this project

5.9.2 Recommendation

Based on the analysis of acceptable alternatives discussed above, a forced air plant sized to the Abercorn Residence and designed for expansion to accommodate the DeJoria Residence is recommended. One train can be installed initially with the construction of the Abercorn Residence and the second one added later as the DeJoria Residence is constructed. Combined with sand filter secondary treatment and chlorination, the effluent can be used for landscape irrigation. Based on the topography of the site, small grinder pump lift stations and pressure pipes to the wastewater treatment plant are anticipated to be needed.

If the demand is anticipated to be heavy during holidays, or other occasions, storage such that the plants don't get overloaded and the plants are fed continuously through the week is recommended.

5.10 Hydrology and Stormwater Management

The fundamental concepts of stormwater management on tropical islands are not entirely different from other regions, insofar as the mechanics of stormwater flow are concerned: water flows downhill, flood control remains an engineering priority, impervious cover and compacted soils generate surface runoff, and the first flush carries the greatest level of contaminants. However, tropical island habitats feature environmental conditions different from continental and/or temperate habitats which must be designed for. For example, variance in the frequency and intensity of precipitation is higher in the tropics than in temperate regions. Geological regimes common in the tropics, such as Barbuda's limestone geology, must be considered in BMP design, as well. The ability to source construction and engineering materials in remote island locations must be considered as well (NOAA Coral Reef Conservation Program, 2014). However, recent development on Barbuda has increased the opportunities to source appropriate materials.

The development is unlikely to have significant impacts on the hydrology of the area. Mather, (1971) noted that there is little potential for worthwhile groundwater development in the Cedar Tree area. As stated in the G-Application for this project, the stormwater system will be designed to protect the surrounding environment and conserve water.

An integrated water management approach will be used to manage storm water and to conserve water for non-potable uses. In essence, Low-impact development (LID) techniques will be incorporated into the project design to minimize stormwater and runoff impacts during the operational phase of the project. LID is an approach to development that efficiently manages stormwater to protect natural resources by attempting to mimic natural processes. It is also an efficient way to conserve water and use the resource wisely. LID techniques slow the flow of water before it reaches the ocean, allowing for stormwater to become a resource rather than a liability. LID also seeks to avoid disturbance of existing vegetation, soils, and wetlands to the maximum extent possible (e.g., minimizing site disturbance, maintain vegetated buffers along waterways) and reduce the amount of impervious cover (and thus stormwater runoff) generated on a site. Runoff that is generated through structural and nonstructural practices is filtered, recharged, reused or otherwise to reduce runoff from the site.

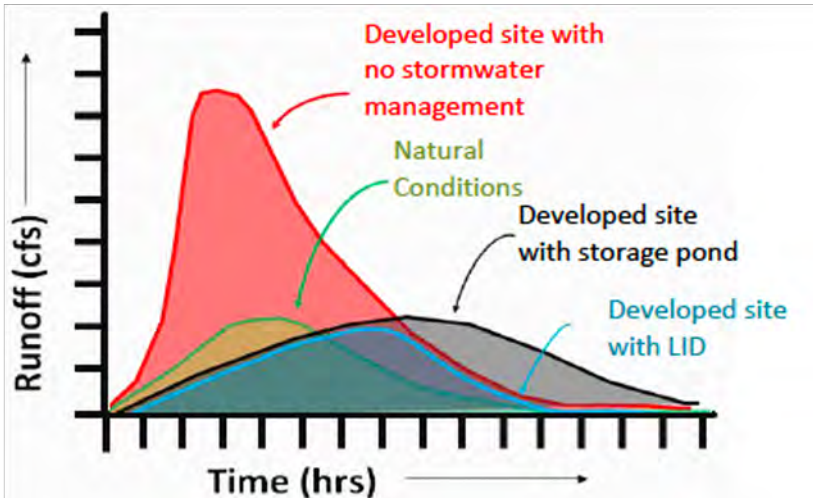


Figure 5.10.1. Hydrograph comparison of development regimes.
Adapted from NOAA Coral Reef Conservation Program, 2014.

Figure 5.10.1 is a representative hydrograph that illustrates changing stormwater management objectives over time. The hydrograph illustrates a significant increase in the amount of runoff (area under the curve) when a natural, undeveloped site (represented by the green curve) is developed without attention to LID strategies (as shown on the red curve). Notably, the developed condition also exhibits a higher, earlier peak flow. Use of detention basins (black curve) help reduce peak flow but extend the length of time that large volumes of stormwater runoff are seen, exacerbating downstream erosion. A LID approach (blue) that reduces total runoff volume and peak flow better mimics the natural condition. Several LID techniques exist that are widely used, and they include:

- *Pervious Pavement:* Installing surfaces that allow stormwater to infiltrate into the ground or a BMP structure, reducing the amount and velocity of stormwater runoff.
- *Rain Gardens:* Engineered garden areas that capture large volumes of water in order to allow it to infiltrate gradually rather than run off.
- *Retaining Ponds/Constructed Wetlands:* Water features that incorporate aerobic and anaerobic water treatment into their construction. Wetlands can be designed to retain water, creating extra storage during rain events. Wetland vegetation can also be strategically placed around ponds and other waterways to treat stormwater runoff before it enters the waterway.
- *Rain Catchment:* Capturing stormwater and storing it for non-potable use in tanks (above or below ground), open ponds, or other water features.

Specific LID strategies to be used on Cedar Tree Point will be identified as the project moves out of the conceptual phase. However, a number of the strategies outlined above have already been identified for use, notably pervious pavements and rain catchment.

The development plans to use pervious pavement, minimizing impervious surfaces mostly to areas around the buildings. The Abercorn Residence is planned to be constructed on a boardwalk-like raised deck that connects the buildings (constructed at an elevation of approximately 14 feet with an FFE of 15ft). Rainwater from the roof and deck will be channeled into cisterns located underneath the deck area. Surrounding the deck area will be a combination wall (below deck height) and rail (above deck). The wall will be designed to allow passage of flood water from extreme flood events.

Potable and Non-Potable Water Management

Water management is designed to be integrated into the LID approach as much as possible However, generating potable water will require the use of a reverse osmosis (RO) plant. Based on the development program 7,000 gallons per day of potable water will be needed ultimately (when both residences are completed). We recommend three days of storage or 21,000 gallons.

Potable water in Antigua and Barbuda is provided by APUA. There is a water plant supplying water to the town of Codrington on Barbuda, but most other places on the island source their own water. Most water in Barbuda is sourced from three main methods: desalination (RO plant), rain catchment, or in some select areas, wells into the limited freshwater lens. Mather, 1971, notes that it is extremely unlikely that a freshwater lens exists on the project site and so the third method is not an option here. Catchment for non-potable water has been discussed above and will be used by the development.

A desalination or Reverse Osmosis (RO) plant is recommended for this development. An RO Plant (also referred to as SWRO, Sea Water Reverse Osmosis) sources sea water that is forced through membranes that allow only the passage of fresh water, leaving behind a concentrated brine mix. The brine is either returned to the sea or disposed of in deep injection wells. At the time of writing, there have been no surveys conducted on Barbuda to determine if well or marine disposal is the better option. If brine is to be disposed of at sea, the outfall must be positioned in an area of good flow to quickly dilute the brine and away from sensitive resources. In a previous study, we estimated that when outflow pipes are located in seagrass habitats approximately 2m of seagrass are damaged by the outflow pipes, but the area impacted by brine discharge is limited provided there is adequate water current.

The RO plant is anticipated to be the largest single consumer of electricity in the proposed development. It will be worthwhile to structure the plant to run during the daytime so it can be powered by solar energy. The plant should be sized for the Abercorn Residence with room for additional trains to be constructed once the DeJoria Residence is built. If wells are used, the intake and discharge wells should be sized for both residences as most of the cost in drilling wells is getting the well drilling equipment to and from the site. The intake and discharge wells should be sized for the ultimate development since much of the cost associated with drilling wells and other RO construction involves getting equipment to the site. The water plant as well as power plant need to be hardened to withstand a major hurricane.

Landscaping/Irrigation

Irrigation can be accomplished by using potable water, effluent from the wastewater treatment plant or rainwater catchment or a combination of these sources. However, the usage of the latter two sources for this purpose should be maximized to reduce demand on the RO plant, which, as stated above, is the single largest consumer of electricity on the site and produces a brine waste that must be disposed of.

Based on the development program, it is estimated that a total of 12,200 gallons per day will be needed during the operational phase for the Abercorn Residence and the DeJoria Residence combined. These estimates do not account for any water conservation measures such as the use of native and drought tolerant plants that naturally occur in the area.

While less irrigation water is needed during the rainy season, a base level of irrigation is typically required (unlike potable water which is occupancy dependent). These estimates are without the use of water conservation measures such as use of native plants that are adapted to drought conditions. The wastewater treatment plant is anticipated to treat 5,600 gallons per day at maximum capacity (See Section 5.9, Sewage Treatment), leaving a shortfall of some 6,600 gallons per day. This shortage can be made up by the use of cisterns sized to store sufficient rainwater through the dry season. If needed, the cistern water can be augmented with potable water from the desalination plant during periods of low occupancy.

Fire Protection

We recommend that pools and cisterns be used for fire protection. This has been implemented elsewhere in the Caribbean. A backup is required in case there is a fire when a pool is empty. Sufficient volume can also be maintained by setting a minimum cistern volume or a specific cistern dedicated to fire. An apparatus that can draw water from the pools or cisterns will need to be kept available on site.

5.11 Infrastructure

There are no public utilities currently on the proposed development site. The development will provide for its own needs with regard to electricity, water and wastewater. Given the sensitivity of the project site, which falls within a National Park and an internationally recognized RAMSAR site, careful consideration of these issues is necessary to minimize environmental impact.

We evaluated different options to provide energy, water, and sewer services to the site and identify options that will minimize impacts, and these are discussed here. (See Appendix 1, Table A.5)

5.11.1 Electricity

The public electric company is Antigua Public Utilities Authority (APUA). APUA electrical distribution on Barbuda is largely limited to the town of Codrington. There is currently no distribution to Cedar Tree Point and no connection is anticipated in the near future.

Based on information provided from Abercorn Trust Ltd., we estimated that the peak demand for the Abercorn Residence and the DeJoria Residence combined will be 500 kW.

Electricity can be generated and distributed in several ways. Diesel and natural gas are considered reliable sources of electricity but produce greenhouse gases when burned. Alternative energy sources such as solar and wind can be used but would need to be combined with energy storage systems and/or a petroleum-based backup generator.

Diesel fired generators are common throughout the Caribbean. The generators run on varying degrees of diesel fuel. The grade of the fuel depends on its purity and its cost is reflected. Diesel fueled generators are the most common and the fuel is readily available in the area. Natural gas is available in Antigua, and Barbuda Ocean Club just signed an agreement to introduce LNG to its development in Barbuda.

Solar can provide sufficient power to meet the development's electricity although at a higher cost and use of developable land when compared to diesel. It is estimated that 2.75 acres of solar panels could meet peak power demand during the day. The National Renewable Energy Laboratory (NREL) estimates approximately 5.5 acres per MW for fixed panel small (less than 20MW) PV solar fields. Energy storage and/or a backup generator would be required when sunlight is not available.

The near constant wind in Barbuda makes wind power an excellent alternative source of electricity. However standard (horizontal) wind turbines should not be used near the adjacent frigate bird sanctuary because of the risks to the birds. In essence, these risks eliminate this option. Smaller vertical wind turbines are however an option, as they carry minimal potential for bird strikes. The vertical wind turbine shown in Figure 5.11.1 only produces 2-4 kW but can be serviced from a stepladder. Power generation via vertical turbines is technically feasible but would require an energy storage system or a backup generator. Energy storage is most commonly supplied by batteries.

The above methods of electricity generation can be combined in different ways. These include for instance, diesel generators with solar.

Figure 5.11.1. Typical vertical wind turbine.

From a practical perspective, it is recommended that diesel generators be used during the construction of the Abercorn Residence, as diesel will also be needed for the construction equipment. This can be augmented with renewables as solar is already planned (and potentially wind power). Batteries would need to be paired with the renewables to balance the power fluctuations common with these systems. At least two prime generators would be installed for the first phase of construction. Generators are typically installed in an “N+1” arrangement in order to meet electrical demand with one generator not working. Based on the preliminary estimates for the electrical need of the Abercorn Residence, this could be two 250 kW generators or three 125 kW generators for more flexibility (but likely higher cost). Generator sizing should be reviewed and updated as the project is developed, and electrical loads are better known.

One of the goals of the project is to maximize the use of renewable energy sources. This can be achieved with a combination of solar, wind, battery and diesel generators, with energy generated in the same sequence i.e. with solar as the primary source and diesel as the backup. Diesel generators should be sized to handle critical loads. Solar, wind and energy storage can be added toward the end of the first phase of construction or later, as it may be difficult to implement renewables while supporting the initial construction work. Maintaining grid stability becomes more challenging around 50% renewable use, and batteries are needed to smooth out power fluctuations. The additional cost of going beyond 90% is likely to be cost prohibitive given the minor gains. In addition to energy and cost considerations, the likely impact of hurricanes on solar panels and/or wind turbines should be considered. They are likely to be damaged in a strong storm (although maximum efforts to minimize damage should be implemented). In the event of storm damage to these energy sources, the development would need to rely on a functioning diesel generator backup system. As such, the diesel generators and fuel storage should be hardened to survive a hurricane.

5.11.2 Water

Landscaping/Irrigation

Irrigation can be accomplished by using potable water, effluent from the wastewater treatment plant, rainwater catchment, or a combination of these sources. However, the usage of the latter two sources for this purpose should be maximized to reduce demand on the RO plant, which, as stated above, is the single largest consumer of electricity on the site and produces a brine waste that must be disposed of.

Based on the development program, it is estimated that 12,200 gallons per day will be needed during the operational phase for the Abercorn Residence and the DeJoria Residence combined. While less irrigation water is needed during the rainy season, irrigation is needed regardless of occupancy (unlike potable water which is occupancy dependent).

The wastewater treatment plant is anticipated to treat 5,600 gallons per day at maximum capacity (See Section 5.9, Sewage Treatment), leaving a shortfall of at least 6,600 gallons per day to meet water demand for irrigation. Cisterns for rainwater catchment should be sized to store a volume of water sufficient to meet this demand through the dry season to the greatest extent practicable. However, during periods of low occupancy, it is anticipated that the cisterns will need be augmented with potable water from the SWRO plant to meet irrigation water demand. Use of drought tolerant and native landscaping is also recommended to reduce total irrigation water demand.

Fire Protection

It is recommended that pools and cisterns be used for fire protection. This has been done elsewhere in the Caribbean. A backup is required in case there is a fire when a pool is empty. Sufficient volume can also be maintained by setting a minimum cistern volume or a specific cistern dedicated to fire. An apparatus that can draw water from the pools or cisterns will need to be kept available on site.

5.11.3 Wastewater

A forced air plant sized to the Abercorn Residence and designed for expansion to accommodate the DeJoria Residence is recommended. One unit can be installed initially with the construction of the Abercorn Residence and the second one added later as the DeJoria Residence is constructed. Combined with sand filter secondary treatment and chlorination, the effluent can be used for landscape irrigation. Based on the topography of the site, small grinder pump lift stations and pressure pipes to the wastewater treatment plant are anticipated to be needed. For additional information on wastewater systems, please see Section 5.9, Sewage Treatment.

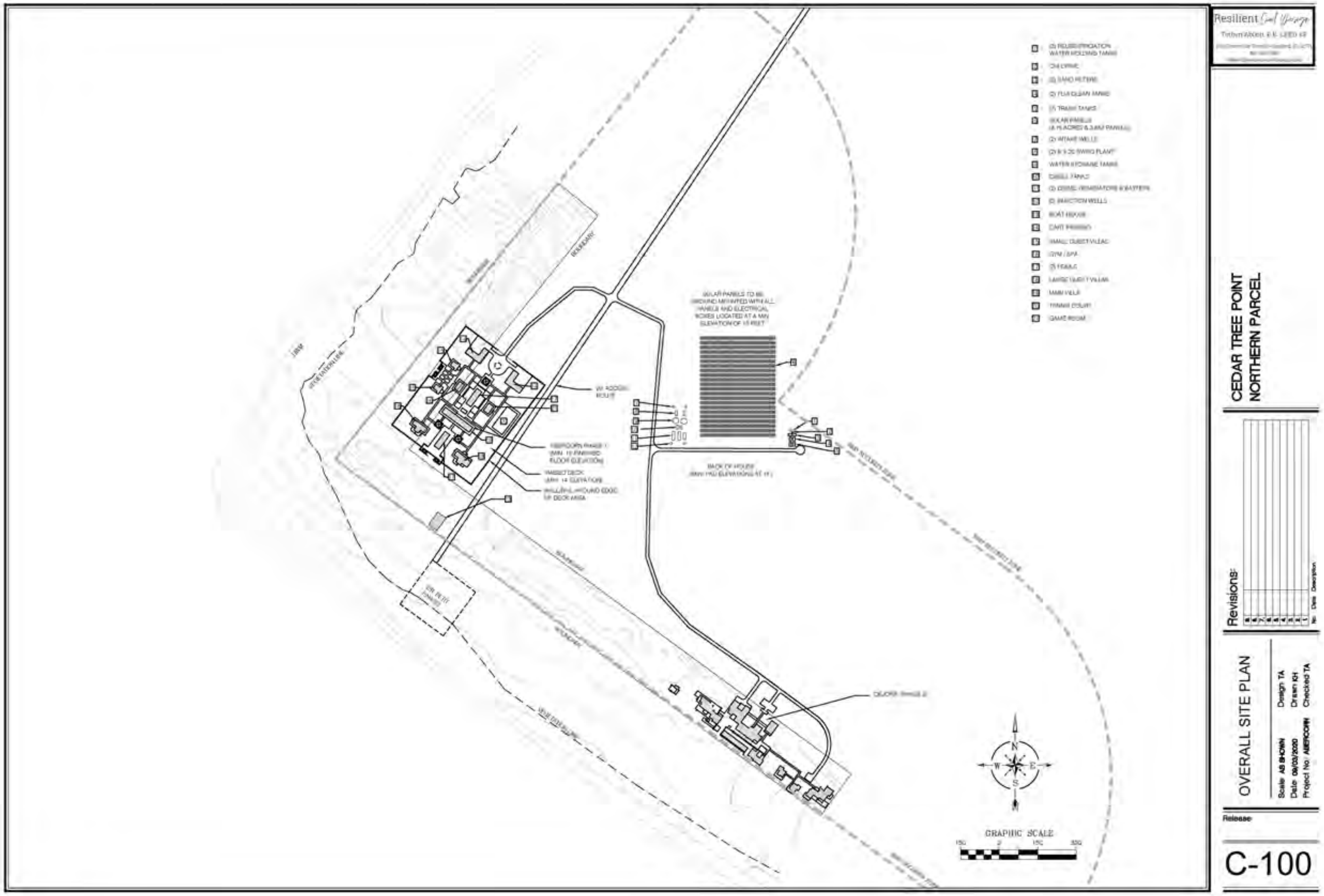


Figure 5.11.2. Proposed layout of site infrastructure.

SECTION 6.0 RISK ANALYSIS

SECTION 6.0 RISK ANALYSIS

This section assesses the risks from natural hazards and climate change and presents the findings from a coastal vulnerability assessment. These data were then used to evaluate setbacks and elevations that minimized current and future (out to c 50 years) risks. Finally, a summary risk matrix table for the major elements of the development is included.

6.1 Natural Hazards and Climate Change

Barbuda is exposed to hurricanes, seismic events and vulnerable to the impacts from climate change and sea level rise.

6.1.1 Hurricanes

Barbuda lies in the Atlantic Hurricane Region and is exposed to tropical storms that are most likely to occur between June 30th and November 1st (Hurricane Season).

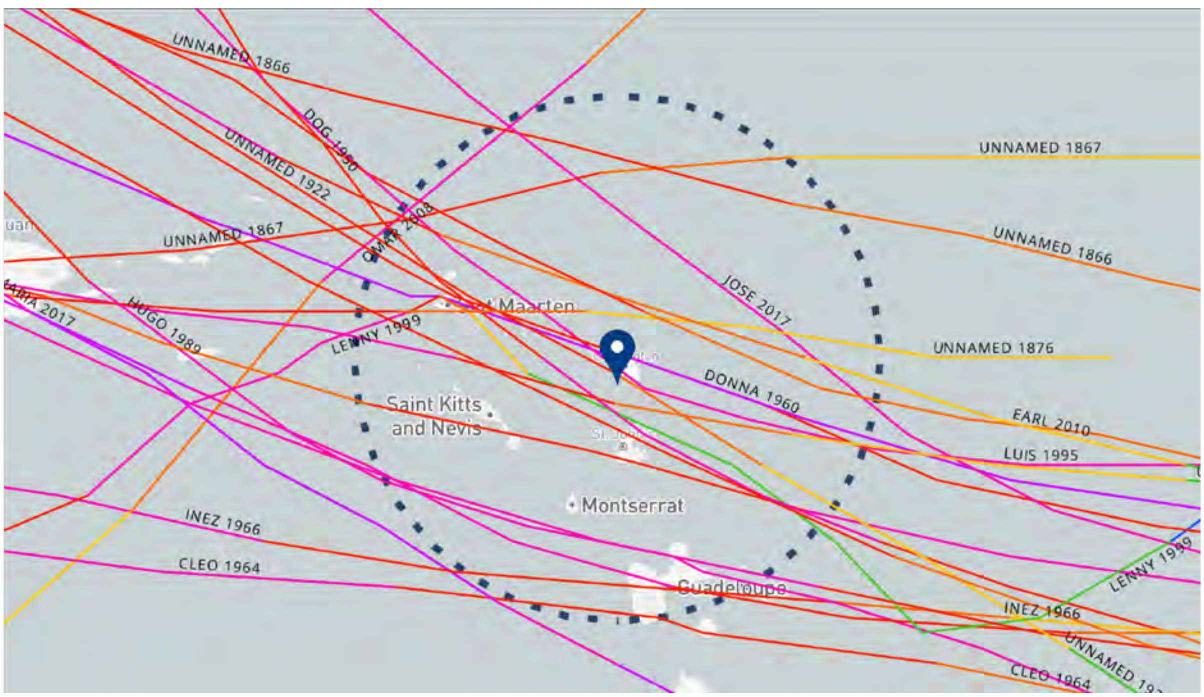


Figure 6.1.1. Tracks of major hurricanes (Cat 3 and above) coming within 200km of Cedar Tree Point, 1851-present (source: NOAA, 2020).

A total of 62 hurricanes including 22 major hurricanes (Category 3 and above) have passed within 200km of the project site since 1851 (NOAA, 2020). Figure 6.1.1. The most damaging hurricanes to affect Antigua and Barbuda occurred in 1928, 1960 and 1995 and 2017. From 1950 to 1988, Barbuda was spared the onslaught of hurricanes with only four major hurricanes approaching within 200km of the project site, and only one making landfall on Antigua or Barbuda (Donna Cat. 3 1960). However, during the period 1989-2020, they were affected by nine major hurricanes, three of which made landfall, (Luis, Cat. 4 1995, Georges Cat 3 1998, Irma Cat 5 2017).

Hurricane Irma made landfall on 6th September 2017 as a Category 5 storm, causing widespread devastation on Barbuda, while damage on Antigua was relatively light. Winds at over 190mph were recorded. One life was lost, and most residents were left homeless. The island has not fully recovered from this event. Hurricane Irma has become the "storm of record" for the region.

Table 6.1.1 summarizes the average return period for each category of hurricane based on the historical record from 1900 -- 2004.

Table 6.1.1. Average return period for each category of hurricane (*Country Risk Profile: Antigua and Barbuda*, 2005)

Hurricane Category	≥1	≥2	≥3	≥4	5
Return Period (yrs)	3	8	12	21	106

6.1.2 Storm Surge

A storm surge is a coastal flood of rising water commonly associated with low pressure weather systems like hurricanes. In essence, it is a measure of the rise in water beyond that expected from the normal tidal range. Two main meteorological factors, the amount of fetch (the area over which the wind acts) and low pressure (which creates a dome of water under and after the storm's center) interact with local factors such as state of the tide, the orientation of the water body relative to storm path, bathymetry, and wind speed to affect storm surge. Sea level rise will increase storm surge. Storm surge is typically calculated for a specific storm, and several models exist to predict the expected surge levels. However, general predictions can be made based on a "typical" storm that is likely to occur. Inundation refers either to the area that is covered or flooded by surge or the process of flooding itself. Storm surge will cause inundation onto coastal landscapes.

Changes to the frequency or magnitude of storm surge experienced at coastal locations in Barbuda are likely to occur as a result of the combined effects of:

- Increased mean sea level (MSL) in the region, which raises the base sea level over which a given storm surge height is superimposed.
- Changes in storm surge height resulting from changes in the severity of storms.
- Physical characteristics of the regional bathymetry and topography which determine the sensitivity of the region to storm surge by influencing the height of the storm surge generated by a given storm. Human activities can change topography and other local features, altering storm surge risks.

<u>Storm Surge: Historic Studies</u>

Storm surge modeling for locations on Barbuda was completed by Organization of American States (OAS) Post-Georges Disaster Mitigation Project (2001). Their modelling identified the majority of the north shore of Barbuda as a high-risk zone for storm surge. To address the serious risks posed by storm surge, an updated model was outlined in the 2015 Global Risk Assessment (GAR 2015). This has been incorporated into the coastal vulnerability analysis and assessment used to estimate risks, setback and elevation levels at Cedar Tree Point for this report. The coastal vulnerability analysis can be found in Section 6.2 of this EIA.

6.1.3 Climate Change

Climate models have demonstrable skill in reproducing the large-scale characteristics of the global climate dynamics. Multiple Global Climate Models (GCM) can be downscaled into Regional Climate Model (RCM) projections to simulate the climate at a finer spatial scale over a small area, e.g. a country. These projections provide a better physical representation of the local climate of that area, and changes in the dynamic climate processes at a national scale can be projected. Downscaling also increases variances and uncertainty. For some factors (e.g. rainfall) downscaled models can result in projections of both increases and decreases in the same factor, and models are highly divergent with changes in storm frequency. Thus, in some cases in the downscaled models, certain changes are obvious and consistently detected (e.g. temperature) but the degree and direction of change is not consistent.

Several projections and analyses have been conducted for the Caribbean. While many of these are at a regional level, Caribsave (Simpson et al., 2012) carried out a country assessment for Antigua and Barbuda. Their general conclusions on changing conditions are shown in Table 6.1.2.

Table 6.1.2. Anticipated impacts of climate change for Antigua and Barbuda, adapted from Caribsave (2012)

Temperature: Regional Climate Model (RCM) projections indicate an increase in mean annual temperatures spanning 2.4˚C and 3.2˚C by the 2080s, in higher emissions scenario*.

Precipitation: General Circulation Model (GCM) projections of rainfall is highly variable. Results show both overall increases and decreases with amounts ranging from -31mm/month to +13 mm/month by 2080 and under the higher emissions scenario. Most projections tend toward decreases. The RCM projections, driven by HadCM3 boundary conditions, indicate large decrease in annual rainfall (-18%) when compared to simulations based on ECHAM4 (-5%).

Sea Surface Temperatures (SST): GCM projections indicate increases in SST throughout the year. Projected increases range from +0.7˚C and +2.8˚C by the 2080s across all three emissions scenarios.

Tropical Storms and Hurricanes: North Atlantic hurricanes and tropical storms appear to have increased in intensity over the last 30 years. Observed and projected increases in SSTs indicate potential for continuing increases in hurricane activity, and model projections indicate that this may occur through increases in intensity of events but not necessarily through increases in frequency of storms.

*(A2: Higher emissions scenario, emissions continue to rise: A1B medium-high, emissions increase rapidly but plateau after 2050: B1 low emissions scenario)

Recent scientific advances are now making it possible to detect a climate-change signal in individual hurricane and extreme rainfall events. This will greatly improve our ability to assess and manage risks. But for now, based on current data, it is fair to say that the major trends in the Caribbean are clear (i.e. sea level is rising), but the variances are large, and the actual scales of change are hard to predict with the precision that we would like for development-scale planning.

6.1.4 Sea Level Rise

The most recent global projections from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2014 project the higher end and worst-case scenario to be just below 1m by 2100 (shown in red line and confidence cone on Figure 6.1.2). In general, based on the assessment the regional SLR for Barbuda is on par with the global rate. However, more recently, Nurse (2017) found Caribbean SLR rates are generally higher than the global average by ~1.8mm per year, (Nurse, 2017).

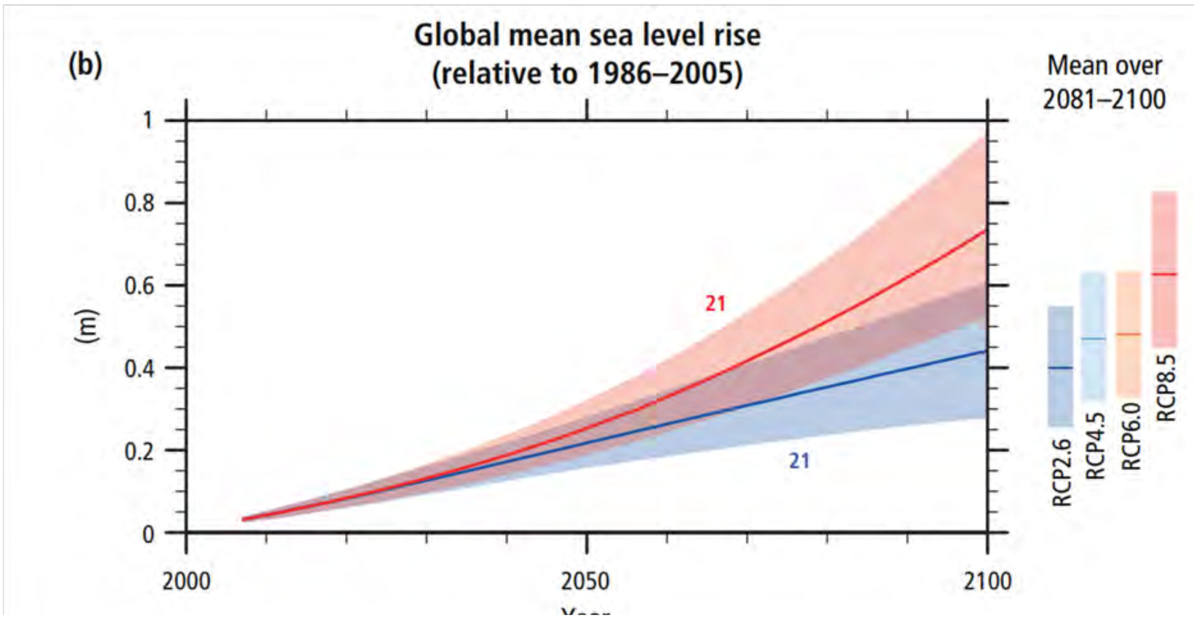


Figure 6.1.2. Global Mean Sea Level Rise Projections from 2006 to 2100 (IPCC, 2014) and Uncertainties (Shaded) Under Various Emission Scenarios (Blue – Low End, Red – Worst Case).

6.1.5 Seismicity: Earthquakes

Antigua and Barbuda are located in active seismic zones. The last major earthquake reported in Barbuda occurred in 1974 (CCRIF, 2013). In 2016, a 6.0 magnitude earthquake was recorded centered about 122km (76 miles) northeast of Barbuda. No significant damage was reported.

Figure 6.1.3 (below) illustrates the pattern of earthquake activity Magnitude > 4 in the region for the past 300 years. The information below in Table 6.1.3 summarizes the average return period for earthquakes of various magnitude ranges occurring within 250km of St Johns, Antigua, based on the historical record of the past 300 years (CCRIF, 2005).

Table 6.1.3. Return periods for Magnitude 6, 7, and 8 earthquakes on Antigua and Barbuda.

Earthquake Magnitude	>6	>7	>8
Return Period (years)	15	27	75

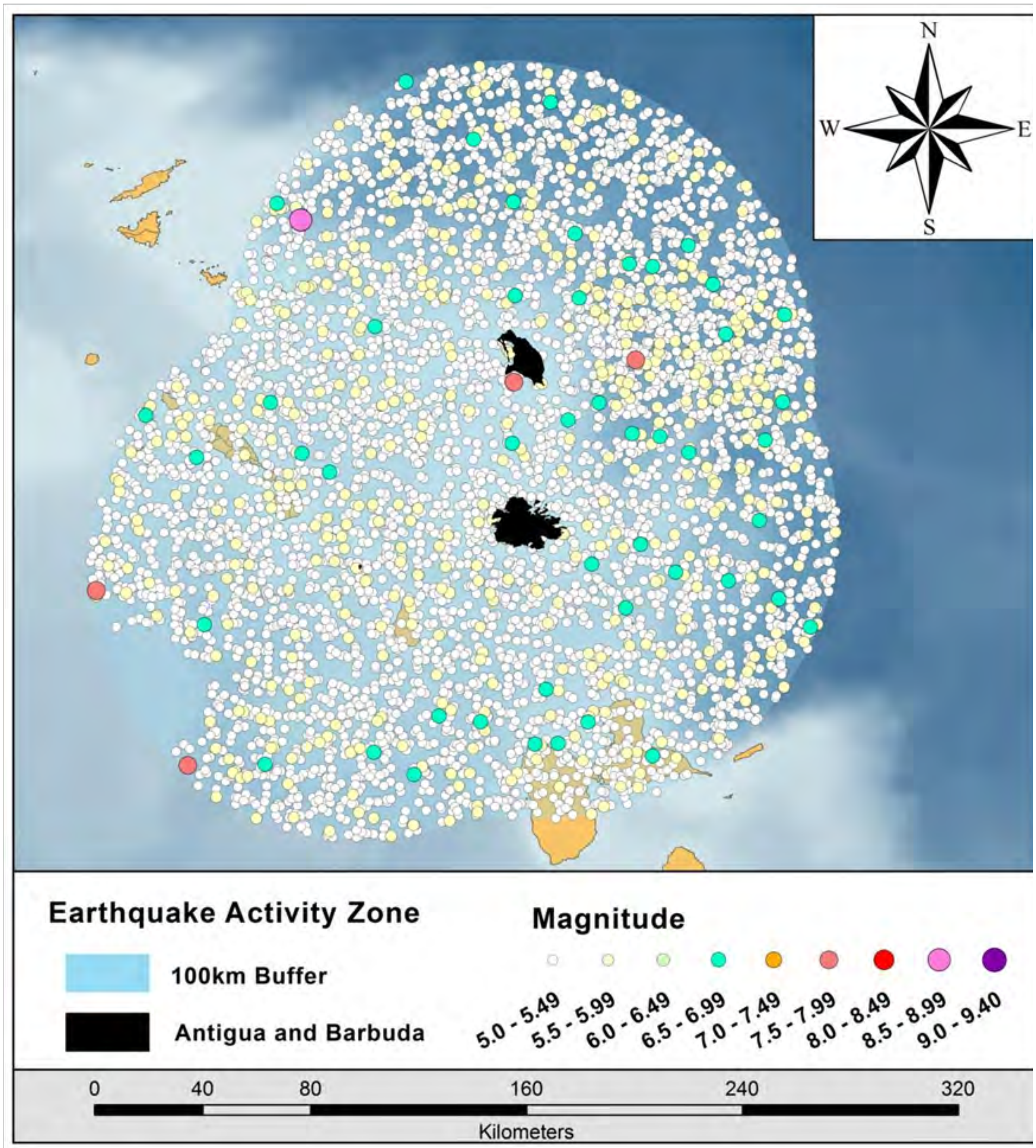


Figure 6.1.3. Earthquake activity with magnitude > 5 in Barbuda region (Source: CCRIF, 2013)

6.2 Coastal Vulnerability Assessment

To determine site-specific vulnerability, we first need to understand regional and island-wide wave and storm patterns. We assessed and quantified regional storm surge and extreme wave conditions. Hydrodynamic analysis using SBeach and WaveWatch models were run to assess vulnerability and in order to evaluate setback and elevation options. In addition to the modeling studies, between March 30-April 4, 2019, the Cedar Tree Point property was assessed for coastal vulnerability risks and opportunities.

Hurricane Irma breached the sandspit just south of the Lighthouse Resort and turned Cedar Point peninsula into an island. Our observations of the breach since Hurricane Irma in 2017, along with our team's prior studies (pre-Irma), indicate that the breach is stabilizing and evolving into an inlet. In addition, the two inlets located near the Barbuda Belle appears to have recovered sufficient tidal prism following Hurricane Irma to remain open and are largely of navigable draft.

Offshore Wave Propagation

Offshore wave data were extracted from the NOAA WaveWatchIII model at three locations (WW1, WW2, WW3 – see Figure 6.2.1). The STWAVE model was then used to transform these offshore data to wave dynamics specific to Cedar Tree Point shorelines. In other words, we modelled the height, direction and periodicity of waves likely to come ashore on the coast. Waves were propagated with site-specific data from the recently collected bathymetry surveys of the nearshore environment. Based on these models, the peak offshore wave height (Point 3 off the NW coast) for a 100-year (Irma-level) hurricane is approximately 5.6 meters or 18.3 ft with a peak wave period of 17 seconds.

Table 6.2.1 (below) shows the resulting offshore significant wave heights (Hs) for extreme return periods based at each of the three WW points. Waves at all three points are predominantly from the east with significant wave heights typically ranging from 1-3m (which is expected given the predominance of the easterly trade winds). At Point 2 and Point 3 (closest to the property), waves are generally smaller and occur less often that at Point 1, however, larger swells from the north and northeast are observed and occur more frequently at Point 3.

Table 6.2.1. Barbuda WaveWatchIII return period extreme value analysis (offshore wave heights propagated to the coastline).

Return Period (Years)	Point 1		Point 2		Point 3	
	Hs (m)	Tp (sec)	Hs (m)	Tp (sec)	Hs (m)	Tp (sec)
1	3.9	8	1.1	5	3.4	10
5	5.5	10	3.2	6	4.2	11
10	7	12	4.4	7	4.5	12
25	9.2	14	5.7	8	4.9	13
50	11.1	16	6.6	9	5.2	15
100	13	16	7.5	11	5.6	17

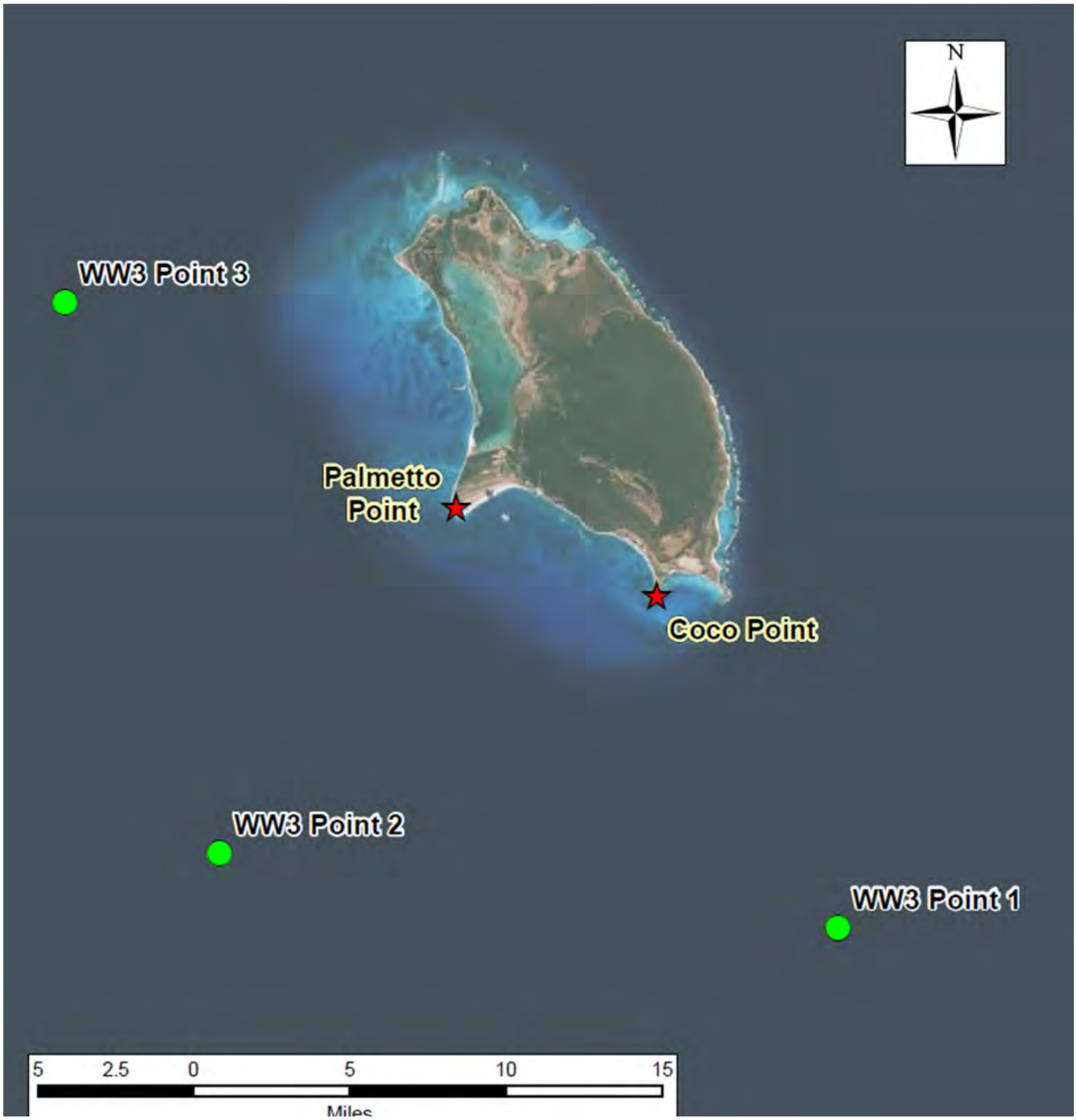


Figure 6.2.1: NOAA WaveWatchIII extraction locations.

Tidal Range

A review of tide range data from NOAA Station 9761115, Barbuda, indicates a normal (predicted) tide range show in in Figure 6.2.2. However, during the site assessment the observed water levels appeared to be approximately 0.5ft or 0.15m higher than predicted tides for these dates. Observed water levels in Barbuda have been consistently 0.3 to 0.6ft (0.09-.18m) higher than predictions since late January of 2019. Similar increases have been observed at other regional stations including 9751401 Lime Tree Bay, and 9751381 Lameshur Bay, St. John. This water level increase appears to be related to large-scale meteorological oscillations which are not accounted for in water level prediction.

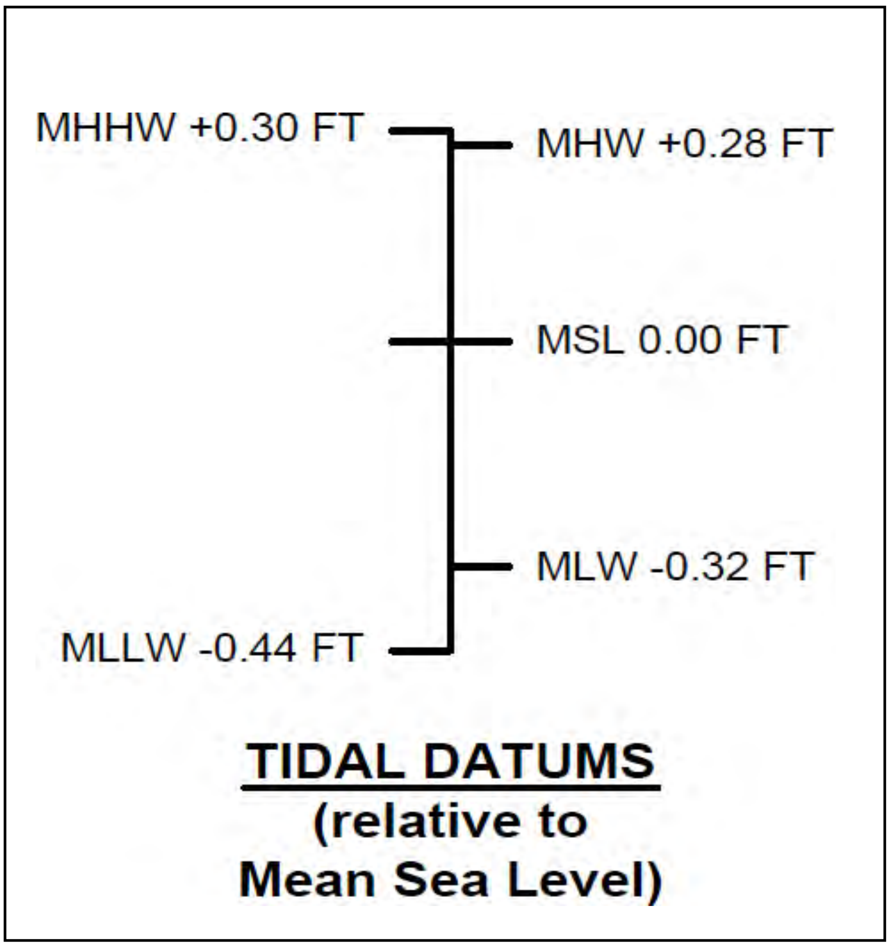


Figure 6.2.2. Tidal Datum Ranges Relative to MSL.

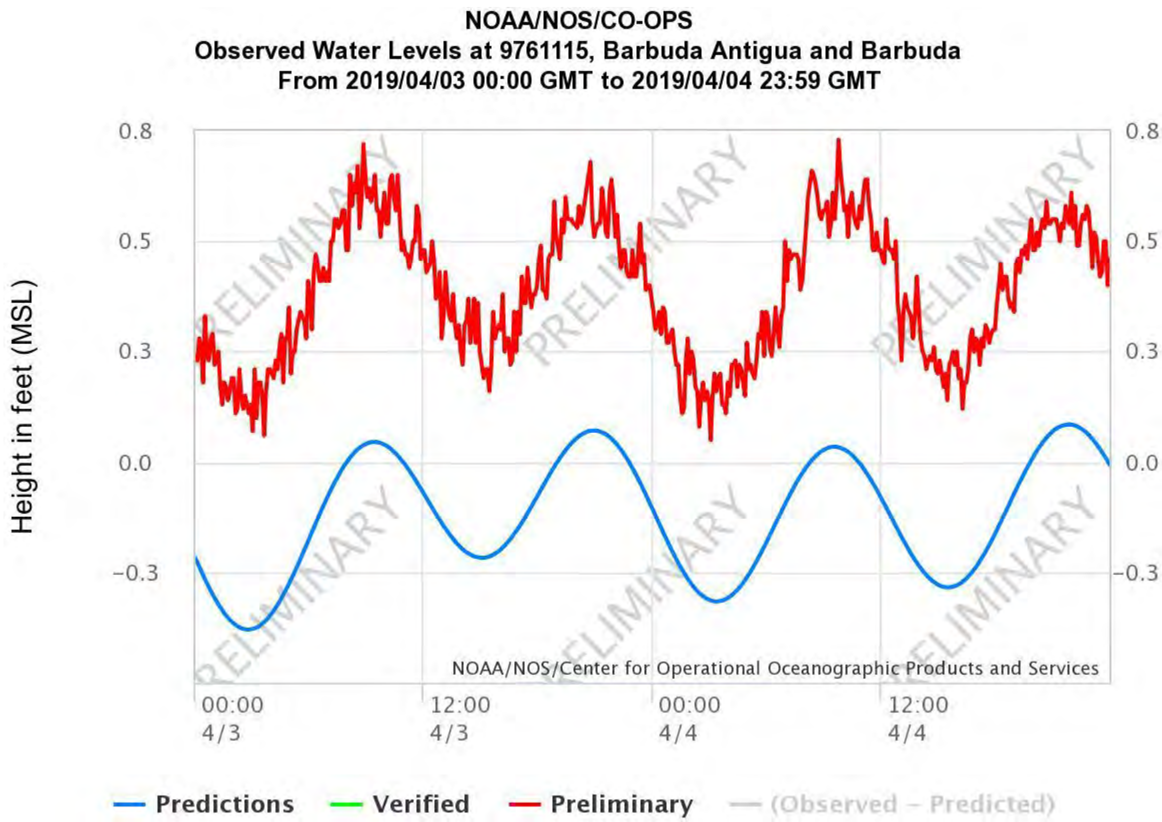


Figure 6.2.3. Predicted and Observed Water Levels NOAA Station 9761115, Barbuda (April 3-4, 2019).

Storm Surge

Storm surge values were taken from several regional sources, data specific to past projects conducted by our coastal engineering partner (ATM) and made available to us, as well as Barbuda specific studies. Special consideration was given to values and analysis related to recent Hurricane Irma's impacts on Barbuda. SBEACH a numerical simulation model for predicting beach, berm, and dune erosion due to storm waves and water levels, was used in previous Barbuda studies and incorporated here.

Results of the modeling developed by the Global Risk Assessment (GAR, 2015) and extracted from the shoreline project areas are presented in Table 6.2.2. These water level values are referenced to Mean Sea Level and show the surge predictions for various return periods up to a 250-year event. While the surge during Hurricane Irma exceeded all 100-yr surge predictions, the modeling developed by the Global Risk Assessment (GAR, 2015) agrees rather well with data measured during Hurricane Irma. Older studies such as the Organization of American States' Unit for Sustainable Development and Environment (OAS/USDE) Post-Georges Disaster Mitigation (PGDM) Barbuda Hazard Mapping (2001) suggested lower surge values and are not considered here.

Table 6.2.2. Global Assessment Risk (GAR) 2015 surges at Barbuda.

Return Period	Meters, MSL	Feet, MSL
10-yr	1.1	3.61
25-yr	1.65	5.41
50-yr	2.18	7.15
100-yr	2.28	7.48
250-yr	2.45	8.04

Hurricane Irma (2017) surpassed all previous surge predictions for Barbuda. A tide gauge on the island, maintained by the Antigua and Barbuda Meteorological Service, recorded a peak water level of 7.9 ft Mean Higher High Water (MHHW), suggesting that inundation of at least 8 ft above ground level occurred on parts of the island, (NOAA National Hurricane Center-NHC, 2017). Note that MHHW is 0.3 ft above Mean Sea Level (MSL), based on NOAA (National Oceanographic and Atmospheric Administration) and tidal datums for Barbuda (Station 976115), so the measured peak water level from Irma would equate to a surge of 8.2 ft above MSL.

Mitigation of Storm Surge

Building elevations (base flood elevations and finished floor elevations) and setbacks are used to mitigate storm surge. Data from the coastal vulnerability analysis was used to assess base flood elevations and surge risks.

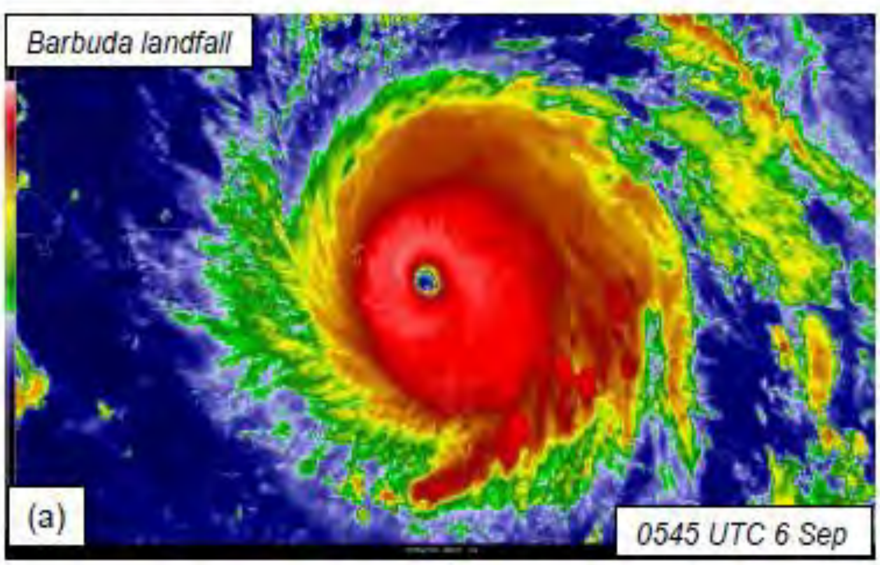


Figure 6.2.4. Hurricane Irma, Barbuda Landfall

Base Flood Elevation

The Base Flood Elevation (BFE) is used in the US to determine flood insurance rates and construction guidelines for coastal and flood prone areas. Numerical modeling of storm surge, wave setup, wave runup and overtopping, and breaking wave heights and overland wave propagation is generally performed to determine the maximum wave crest envelope, which is rounded up to the nearest foot to produce the BFE.

A simplified analysis of total still water elevation (SWEL) and depth-limited breaking wave height can produce a reasonable approximation of the BFE. In this example we have used an approximate worst-case scenario (WCS) based on Hurricane Irma. The upland grade elevation at Cedar Tree Point appears be relatively flat at an elevation of approximately +6 ft MSL. (Because construction is typically calculated in feet and FEMA mapping is developed in feet, all calculations are provided here in feet.) The maximum storm surge during Hurricane Irma reached +8.2 ft MSL, meaning that most of the project area will have experienced some inundation. This corresponds to a Coastal High Hazard Area or VE Zone in FEMA mapping requirements, and specific coastal construction guidelines are applicable.

Simplified BFE Approximation for a Category 5 Storm equivalent of Hurricane Irma

Surge Elevation (Irma): +8.2 ft MSL
Wave Setup: 1.7 ft
Total Still Water Elevation (SWEL): = Surge + Wave Setup = +9.9 ft MSL
Approximate Ground Elevation at Structure: +5 ft MSL
Water Depth at Structure: SWEL – Ground Elevation = 4.3 ft
Depth Limited Wave Height: Water Depth at Structure * Breaking Wave Coefficient (ranges 0.6 – 0.78)
Low = 4.3 ft * 0.6 = 2.6 ft;
High = 4.3 ft *0.78 = 3.4 ft
Base Flood Elevation: SWEL + 70% Depth Limited Wave Height = 8.2 ft + 3.4 ft * 0.7 = 11.6 ft

Design Flood Elevation

The recommended Design Flood Elevation (DFE) includes a freeboard margin of 1 ft above the BFE. The DFE or Finished Floor Elevation (FFE) corresponds with the minimum recommended elevation for the lowest horizontal structural member for buildings located in Coastal High Hazard Areas.

For hurricanes at the intensity of Hurricane Irma – Category 5, the minimum recommended elevation for lowest horizontal structural members at Cedar Tree Point is +12.6 ft MSL. Elevation of structures may be achieved using structural fill material, or by building above grade on piles. This elevation is provided for general guidance and some reduction in this value may be attained through design features including protective dunes. In addition, the developers may opt to use a different or higher risk level. For instance, building to a Category 3 storm level risk would reduce the FFE recommendation.

Recommended Development Setbacks

The property is located on a dynamic headland and relatively stable coastal zone. A construction setback from the shoreline is warranted both to accommodate natural fluctuations in shoreline position and to reduce the potential for storm-related structural impacts. Based on review of the property and similar studies conducted by our team on Barbuda, a minimum nominal setback distance of 200 feet from the mean high-water line is recommended. On the lagoon side, a minimum setback of 100 feet to major structures is recommended. These setbacks are based on the appropriate DFE being applied.

Overall Conclusions

The site is vulnerable to a major storm event. However, the level of risk is similar to other coastal sites on Barbuda and within the region. Further, this level of risk can be appropriately managed through the adoption of appropriate building standards and minimum construction setbacks and Design Flood Elevations (DFE or FFE) for proposed structures (as noted above). Additionally, incorporating sand dunes (existing dune or dune construction), can affect setback and elevation levels (i.e. lowering both). For instance, creating a dune ecological easement for coastal protection as well as sea turtle habitat can also reduce storm surge vulnerability. We recommend that the developer consider incorporating a protected dune plan or easement for these reasons.

Sea level rise due to climate change can be expected to increase the vulnerability of the site to storm surge, although enhancements to natural protective features (e.g. dune creation) or use of more conservative setbacks and FFEs can provide an increased level of protection.

6.3 Emergencies

Potential emergencies on site may result from natural sources identified elsewhere in this EIA, including strong storms/hurricanes and associated flooding and storm surge, seismic risks, and sea level rise, and internal factors such as medical emergencies, accidents, and security breaches. During construction, all work on site will proceed per United States Occupational Safety and Health Administration (OSHA) guidelines for worker protection, and relevant agencies (NODS, DCA, DoE, and/or the Fisheries Department) will be notified of all on-site incidents within 24 hours and will be notified of any major changes to the construction schedule, as needed. Due to the isolated nature of the project site, it is recommended for the operational phase of this project that the project sponsors develop an emergency response protocol for the end users of the residences and their guests as a guide during internal and external emergency situations. As it appears (at the time of writing this EIA) that the construction will be overseen by the PLH/BOC partner construction team (Discovery Land Company), their established procedures and emergency equipment will be applied here.

6.4 Risk/Impact Matrices

Throughout this EIA, we use two types of impact assessment methods. The first is based on data, e.g., field data, models. The second is a qualitative evaluation matrix that is part of the standard for Risk/Impact Assessment Tool for island development. This tool incorporates qualitative assessment in addition to quantitative data. It is designed to identify and prioritize potential hazards and risks generated by the project. Assessment criteria are used to rank a source activity for its environmental impact. Each component is described and evaluated for impact with mitigation options identified.

The Impact Evaluation Matrix is described below in the accompanying table. Results of separate analyses for site preparation, landscaping, and residences/infrastructure construction, are shown on the following pages.

Table 6.4.1. Impact Evaluation Matrix description

Criteria	Type	Description
Nature	Direct Impact Indirect	Refers to whether a source will act directly or indirectly on a target species or habitat etc.
Direction	Positive Negative	Positive implies species, natural communities or processes have a higher likelihood of persistence and viability, Negative means the opposite
Likelihood	Not Likely Potential Certainty	Scale of impact Not likely c 10% chance; likely 10-70% chance; certainty >70% chance of occurring
Scale	Specific habitat Island level National/Regional/ International	Scale of the impact from a specific habitat to larger geographic area
Duration	Temporary Long term	Temporary means either only during construction or the impact lasts for <3 years: Long term > 3years
Reversibility	Reversible Irreversible	Reversible means that the species or habitat will recover naturally; Irreversible means that the species or community is lost to the project and impact should be mitigated
Overall Significance		Describes the significance of impact
Mitigation Options		Identification of mitigation actions (described in more detail in the text)

Climate Change

Table 6.4.2. Climate Change Risk Matrix

Impact	Forecast	Significance/Risk*	Mitigation
Sea Level Rise	An increase of between +0.3m to +0.6m SLR forecast by IPCC models by 2700	High Significance High Risk	Use of appropriate setbacks, design flood elevations and (where possible) natural ecosystems
Air Temperature	Increase of between +2.4°C to +3.2°C forecast	High Significance Medium Risks	Include contingencies for impacts of higher water and electricity use in higher temperatures. Factor in higher evapotranspiration in water budgets.
Precipitation And Drought	Precipitation Diverging results among models -31mm to +13mm per month	Risks range from low (more rain) to high (more drought) depending on climate model used.	Plan for high variability in rainfall and use LID to capture and store rainfall and manage runoff.
Sea Surface Temperatures	Increases of 0.7°C to 2.8°C by 2080	Risks to marine processes and distributions of marine species	This is a regional scale phenomena that cannot be mitigated. Monitor sensitive species and take conservation measures (agreed upon with Environment/Natural Resources agencies in advance) if necessary
Hurricanes and Storms	Models diverge on changes in frequency and intensity	High Significance High Risk	SLR mitigations (above) apply here. Also implement an effective Disaster Risk Reduction (DRR) plan and Eco-DRR process such as Maintaining and protecting the protective natural resources such as dune and lagoonal mangroves

**Risk levels based on IPCC climate change assessment risks.*

Site Preparation and Construction

Table 6.4.3. Site Preparation and Construction Risk Matrix

Criteria	Type	Description
Nature and Direction	Direct, Negative	Direct impacts on native vegetation. Direct impacts on areas to be cleared for construction of residences and associated infrastructure. Localized impacts to seagrass possible at location where equipment is offloaded. Localized impacts to sea turtle nesting habitat along land transit corridors for equipment. Temporary and localized noise impacts at location where equipment is offloaded. Potential for soil/water contamination if chemicals handled improperly (e.g. diesel, oil, paints, etc.)
Likelihood	Certainty	
Scale	Limited	Overall low-density development. Permanent impacts to be footprint of residences and infrastructure. Recovery of upland habitat possible over time in other construction areas and transit pathways.
Duration	Short term	Direct impacts during period of construction only.
Reversibility	Reversible	Area impacted by construction equipment transit pathways may be able to recover with proper management and mitigation.
Overall Significance	Moderate	
Mitigation Options		Minimize work zones and establish defined corridors for equipment to minimize the area impacted. Complete additional surveys to ground truth plant species and densities prior to construction. Develop and execute management and mitigation plans for impacted sensitive plant species Maintain and enhance the Sand Strand Beach Dune habitat. Monitoring of sea turtle nesting on site during nesting season and adhere to BMPs for construction to protect Sea Turtles. Regular monitoring of frigate bird colony and coordination with Barbuda Belle to minimize noise-related impacts. Construction best practices to be followed to avoid spills and accidents.

Vegetation and Landscaping

Table 6.4.4. Vegetation and Landscaping Risk Matrix

Criteria	Type	Description
Nature and Direction	Direct, Negative, and Positive	Positive impacts will be in the use of native species that also enhance resilience and ecosystem services. Potential negative impacts are associated with the use of decorative species that may pose pest risks, require more water and/or fertilizer. At this early stage there is no landscape plan. We note that there are strict rules on the importation of non-native species to the Islands Plant Protection (PP) must be contacted.
Likelihood	Certainty	
Scale	Limited	This is a low-density development and will maintain native vegetation over most of the site. The main impacts anticipated are the use of decorative species surrounding the residences. However, PP must be involved in the importation of any non-natives to keep out pests and diseases.
Duration	Long Term	This is a permanent construction.
Reversibility	Irreversible but some options exist to change landscaping	The residences are intended to be a permanent feature of the site.
Overall Significance	Low- Moderate (assuming PP guidelines on importation followed)	Discussed above
Mitigation Options		Minimize non-native species and use native species for landscaping to the greatest extent practicable. Reuse rainwater catchment and treated wastewater effluent for irrigation of minimize demand on reverse osmosis system. Minimize fertilizer use.

Operation

Table 6.4.5. Operational Risk Matrix

Criteria	Type	Description
Nature and Direction	Direct, Negative	Previously undeveloped site. Direct impacts on habitat within footprint of structures. Impacts to surrounding habitat from human presence on site (e.g., production of solid waste, storage of hazardous household materials, lighting at night, direct interaction with wildlife)
Likelihood	Certainty	
Scale	Limited	Overall low-density development to be visited and used by owners and their guests only.
Duration	Long-term	Structures and associated infrastructure are intended to be a permanent feature of site.
Reversibility	Irreversible	Habitat within footprint of structures to be lost permanently.
Overall Significance	Moderate	
Mitigation Options		Maintain and enhance the Sand Strand Beach Dune habitat. Monitoring of sea turtle nesting on site during nesting season and adhere to BMPs for lighting to protect Sea Turtles. Proper upkeep and maintenance of wastewater, reverse osmosis, and stormwater management systems to avoid impacts to local ecosystem. Use of solar electricity and other zero emission sources (e.g. wind) to the greatest extent practicable to minimize impacts from burning of fossil fuels on site. Follow BMPs for storage and handling of chemicals (cleaning products, diesel, etc.).

SECTION 7.0 ENVIRONMENTAL MONITORING AND MITIGATION PLAN

SECTION 7.0 ENVIRONMENTAL MONITORING AND MITIGATION PLAN

The Cedar Tree Point project recognizes that there is potential for environmental risk during the construction phase of this project. To minimize these risks, a Best Practices and associated Environmental Monitoring and Management Plan (EMMP) will be used to institute the necessary care and oversight as the development moves forward with construction.

Following approval in principle a construction application (A-Application) will be submitted to the DCA that will outline the specific construction plan. The Cedar Tree Point Construction EMMP will ensure that any adverse environmental effects are minimized during construction of the site. We feel that it is important to minimize impacts by instituting a protocol-driven plan based on best practices and that will sustain through the completion of construction. Protocols will adhere to best management practices used in the U.S. and will be appropriate for the work being undertaken. The EMMP effort will be commensurate with the scale of the development which is two villas and associated infrastructure. As required, monthly reports will be submitted to DCA/DoE.

The Cedar Tree Point Construction plan EMMP should be submitted within eight weeks prior to construction to better inform construction activities as they scale-up on the site. Included in the Construction EMMP should be specific protocols to minimize impacts to sensitive vegetation and wildlife and protection of the integrity of the RAMSAR site and National Park. Key species requiring careful management and monitoring are listed below.

- Protected plant species found on site; mangrove species, mangrove berry, bromeliads and agave plants on site.
- Sea turtle - protect and monitor nesting activity during construction.
- Magnificent frigatebird - we do not anticipate any significant impact on the colony but recommend prudent monitoring to ensure no construction disturbance.

Some key species protocols that will be included in the final Construction EMMP are already being implemented at other developments on the island, notably Coco Point and Barbuda Preserve. They include a sea turtle monitoring and protection protocol, a native and plant management protocol and mitigation plans to replace plants after construction is complete. Other elements that will be included are construction debris management, monitoring of water quality, and protocols for industrial construction lighting.

SECTION 8.0 SUMMARY AND CONCLUSIONS

SECTION 8.0 SUMMARY AND CONCLUSIONS

This EIA is prepared for the construction of two private residences and associated outbuildings and infrastructure on Cedar Tree Point, Barbuda. It has been prepared and organized according to the sections outlined in the Terms of References.

A comprehensive summary of the findings and conclusions of this report can be found in the Executive Summary.

8.1 Conclusions

The project is a low-density residential development. The limited scope of development consequently limits the extent of the project's impact on the local environment and the island's milieu. Sustainable development strategies are planned to be used to further limit the impacts associated with the development. The project proponents are known for their philanthropic support for matters related to the environment and sustainability and are committed to the use of sustainable infrastructure for the development.

However, it is recognized that this project falls within a relatively undisturbed portion of the Codrington Lagoon National Park, a RAMSAR-designated wetland of international importance. Although this is not the first development within the Park, and there is an operational luxury boutique hotel built nearby, the critical importance of protecting this unique resource must be recognized. It is therefore critical that the recommendations and BMPs outlined in this EIA be adhered to in order to avoid impacts to wetland and mangrove habitats, incur the lowest practicable impact on the surrounding environment, ensure environmental impacts are mitigated where they cannot be avoided, and to ensure that the residences and infrastructure are resilient to strong storm events that are a regular feature of the local climate.

Additionally, the project will be designed to be resilient. Minimum design flood elevations and setbacks based on a storm event with impacts equivalent to those of Hurricane Irma have been calculated and will be incorporated into project design to reduce the risk to the development posed by strong storms regularly experienced in the area.

The vision for the project is a small private development that exhibits respect for the environmental and sociocultural context in which it exists, and the project sponsors look forward to working with the government of Antigua and Barbuda to ensure the success of this vision.

SECTION 9.0 REFERENCES

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APPENDIX 1 DATA AND ANALYSIS

APPENDIX 1. DATA AND ANALYSIS

Table A.1 Meteorological Data: Mean Daily Temperature Date (°C) for V.C. Bird Int'l Airport, Coolidge Antigua.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
1971	25.4	24.8	25.5	26.2	26.1	27.4	27.5	27.4	27.5	27.2	26.3	25.5	26.4
1972	25.3	24.8	24.9	25.8	26.3	27.5	27.8	27.8	27.8	27.1	27	24.9	26.4
1973	25.5	24.8	25.4	26.2	27.4	27.8	28.2	28	27.4	27.3	26.5	25.4	26.7
1974	24.6	24.6	25	25.3	26.3	27.2	27.8	27.9	26.6	26.4	26.1	24.9	26.1
1975	24.3	24.7	25.1	25.7	26.2	27.5	27.9	27.9	27.4	26.9	25.9	25	26.2
1976	23.8	23.9	24	25.2	26.4	27.1	27.6	27.6	27.8	27.3	26.9	24.7	26
1977	25.1	25.3	25.3	25.8	27	27.8	28.2	27.8	27.5	27.4	26	25.4	26.6
1978	25	25.2	25.5	26.1	26.9	27.8	27.6	27.7	28.1	27.2	26.4	25.7	26.6
1979	24.7	25.2	25.2	26	26.8	27.8	27.7	28.3	27.1	27.1	26.6	25.8	26.5
1980	24.9	25.2	25.5	26.6	28	28.4	28.2	28.4	28.2	27.8	27.1	25.7	27
1981	25.7	25.5	26.1	25.8	27.2	27.9	28	28.3	27.9	27.2	27	25.8	26.9
1982	25.5	25.1	25.2	26.1	27	27.8	27.7	28	27.8	27.3	26.1	26	26.6
1983	25.3	25.1	25.7	26.5	27.2	28.1	28.4	28.2	28.4	27.4	27.2	24.8	26.9
1984	25.1	25.2	25.3	26.1	26.6	27.5	27.7	28.1	27.3	27.3	25.6	26	26.5
1985	24.8	24.9	24.8	25.2	26.6	27.6	28	28.2	27.7	26.9	26.2	25.1	26.3
1986	25.2	24.5	25.4	25.8	26.7	27.7	27.7	28.1	28.2	27.9	26.3	25.7	26.6
1987	25.4	25	25.6	27.3	27.1	27.8	28.4	28.8	28.5	27.9	26.8	25.8	27
1988	25.5	25.3	25.5	26.3	27.4	28.3	28.4	27.7	27.8	27.6	26.8	26.5	26.9
1989	25	24.9	25	25.7	26.6	27.4	28.4	27.9	27.5	27.3	26.2	25.5	26.5
1990	25.8	24.9	25.4	25.8	27.3	27.9	28.3	28.6	28.4	27.2	27.2	26	26.9
1991	25.5	25.1	25.6	26.2	27	27.8	28	28.4	28.3	27.4	26.7	25.6	26.8
1992	25.1	25.4	25.6	26.2	27	27.9	28.2	28.1	27.7	27	26.6	25.7	26.7
1993	25.1	24.8	25.6	26.2	26.6	27.9	27.9	28.3	28.1	28	27.4	26.1	26.8
1994	25.6	25.2	25.5	26.2	27.2	27.8	28	28.3	27.5	27.4	27	26	26.8
1995	25.5	25.6	25.5	26.5	28	28.6	29.1	28.7	28.3	28.7	27.7	26.4	27.4
1996	25.9	25.9	26.2	26.8	27.3	27.7	27.9	28.4	28.2	27.9	27.2	25.8	27.1
1997	25.7	25.6	25.5	26.2	27.7	28.6	28.7	28.9	28.8	28.3	28.1	27.3	27.5
1998	26.1	26	26.7	27.3	28.3	29	29.3	29.2	28.8	28	27.3	27	27.8
1999	25.6	24.9	26.1	26.5	27.5	28.2	28.1	28.6	28.2	27.9	26.7	25.8	27
2000	25.1	25	24.8	25.9	27	27.6	28	28.3	28.1	27.9	27.1	26.1	26.7
2001	25.7	25.4	25.8	26.4	27.5	28.2	28.3	28.5	28.8	28.1	27	26.6	27.2
2002	26.2	25.4	26.1	26.2	27.1	28	28	28.3	28.2	27.7	27.1	26.3	27.1
2003	25.6	25.6	25.8	26.6	27.2	27.5	27.9	28.4	28.4	27.7	26.4	25.8	26.9
2004	25.1	25.1	25.3	26.5	26.6	27.5	27.4	28.4	27.7	27	25.8	25.5	26.5
2005	24.8	24.4	26	27.1	27.9	28	28.1	28.3	28.3	27.3	26.4	26.1	26.9
2006	25.1	25	25.4	26.5	27.5	28.1	28	28.1	28.2	27.4	26.7	26.1	26.8
2007	25.3	25.6	25.8	26.5	27.6	28.1	28.2	28.2	27.8	27	26.7	25.9	26.9
2008	24.9	24.9	24.9	25.6	26.4	27.7	28.2	28.3	27.3	26.9	26.3	25.3	26.4
2009	25.2	24.8	24.6	25.6	26.3	27.2	28.1	28.3	27.9	27.8	27.1	26.2	26.6
2010	25.6	25.7	26.9	26.6	27.6	28.2	28.2	28.3	28	27	26.5	25.3	27
2011	25.4	25	25.1	25.8	26.6	28	27.6	27.6	27.5	27.6	26.4	25.3	26.5
2012	25.1	25.2	25.3	25.9	26.3	27.8	28	28.1	28.2	27.1	27	26.1	26.7
2013	25.3	25.2	25.3	25.8	26.5	27.4	27.7	28.2	28	28	26.6	25.9	26.7
2014	25.4	25.3	25.3	25.9	26.5	27.5	27.9	27.8	27.9	27.7	26.9	25.5	26.6
2015	25.5	25.5	25.5	26.2	27.2	27.7	27.9	28.1	28	28.1	27	26.4	26.9
2016	25.4	25.6	25.7	26.3	27.2	27.8	28.2	28.2	28	27.8	26.6	26.2	26.9
2017	24.8	25.3	25.5	25.9	26.8	27.5	28.2	28.5	27.6	26.9	27.4	26.9	26.8
2018	25.6	25	25.5	26.1	26.4	27.6	27.8	28	27.7	27.3	26.5	25.8	26.6
2019	24.8	25.2	25.5	26	26.5	27.6		28	28.2	28	27.6	26.2	
2020	25.2	25.3	25.2	26.7	27.5	28.2	28.2	28.3	28				
Monthly Mean	25.3	25.1	25.5	26.2	27.0	27.8	28.1	28.2	27.9	27.5	26.7	25.8	

Table A.2. Rainfall totals in millimeters for Park, Codrington (17.63°N, 61.82°W)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1993	79	0	0	213	196	30	175	41	239	86	74	23	1156
1994	76	53	28	89	28	36	25	25	254	122	124	56	917
1995	46	114	38	122	46	43	102	284	25	130	43	104	1097
1996	25	58	84	58	71	66	163	53	71	117	175	160	1102
1997	33	130	25	10	25	38	122	61	99	328	69	20	960
1998	56	15	28	43	74	51	58	137	69	206	175	183	1095
1999	99	48	43	81	112	292	107	56	170	323	671	99	2101
2000	20	51	23	56	36	56	48	25	104	58	145	0	622
2001	58	33	13	43	23	38	89	84	10	97	61	290	838
2002	53	25	117	76	3	33	25	84	23	104	119	66	729
2003	46	38	25	53	46	112	43	64	56	343	318	196	1339
2004	23	84	107	64	155	53	142	18	163	185	262	117	1372
2005	56	74	10	117	51	124	155	132	114	267	119	33	1252
2006	99	61	10	76	76	97	124	64	109	328	168	61	1273
2007	48	53	69	43	10	51	109	36	254	191	61	104	1029
2008	173	86	46	46	25	83	47	145	300	333	118	56	1458
2009	37	95	35	22	100	37	42	73	82	244	44	51	863
2010	37	10	84	150	105	245	267	133	128	148	127	250	1938
2011	31	74	44	26	88	90	186	177	429	19	201	212	1578
2012	84	24	21	80	64	4	221	106	82	312	58	86	1142
2013	69	20	123	21	295	85	66	96	70	98	126	154	1223
2014	47	67	34	38	43	22	43	117	125	229	204	204	1173
2015	50	123	14	34	12	19	9	52	183	206	137	83	920
2016	30	50	53	65	71	38	82	37	107	30	130	85	779
2017	102												
Mean Rainfall	59	58	45	68	73	73	102	87	136	188	155	112	1165

Biological Survey Data

Table A.3 Results of April 2019 seagrass survey in Codrington Lagoon adjacent to project site.

Transect	Quadrat #	% *Halodule wrightii*	% *Thalassia testudinum*	Total % Cover (0.25m)
T1	1	100	0	100
T1	2	30	0	30
T1	3	20	0	20
T1	4	30	0	30
T1	5	90	0	90
T1	6	50	0	50
T1	7	95	0	95
T1	8	100	0	100
T1	9	100	0	100
T1	10	100	0	100
T1	11	100	0	100
T1	12	100	0	100
T1	13	100	0	100
T1	14	95	0	95
T1	15	50	0	50
T1	16	15	0	15
T1	17	20	0	20
T1	18	5	0	5
T1	19	10	0	10
T1	20	0	0	0
T1	21	3	0	3
T1	22	1	0	1
T1	23	5	0	5
T1	24	20	0	20
T1	25	30	0	30
T1	26	90	0	90
T1	27	95	0	95
T1	28	90	0	90
T1	29	100	0	100
T1	30	100	0	100
T2	1	2	0	2
T2	2	25	0	25
T2	3	10	0	10
T2	4	20	0	20
T2	5	100	0	100
T2	6	50	20	70
T2	7	30	30	60
T2	8	70	5	75
T2	9	20	0	20
T2	10	3	20	23
T2	11	5	3	8
T2	12	15	0	15
T2	13	20	30	50
T2	14	50	15	65
T2	15	90	0	90
T2	16	40	5	45
T2	17	20	0	20
T2	18	40	0	40
T2	19	50	0	50
T2	20	95	0	95
T2	21	80	0	80

Table A.3 (cont'd) Results of April 2019 seagrass survey in Codrington Lagoon adjacent to project site.

T2	22	100	0	100
T2	23	100	0	100
T2	24	80	10	90
T2	25	35	0	35
T2	26	25	0	25
T2	27	5	0	5
T2	28	0	0	0
T2	29	5	0	5
T2	30	0	0	0
T3	1	5	0	5
T3	2	90	0	90
T3	3	95	0	95
T3	4	95	0	95
T3	5	90	0	90
T3	6	90	10	100
T3	7	80	0	80
T3	8	100	0	100
T3	9	100	0	100
T3	10	90	0	90
T3	11	70	0	70
T3	12	50	0	50
T3	13	50	0	50
T3	14	40	0	40
T3	15	40	0	40
T3	16	15	0	15
T3	17	20	0	20
T3	18	20	0	20
T3	19	20	0	20
T3	20	20	0	20
T3	21	30	0	30
T3	22	35	0	35
T3	23	10	0	10
T3	24	0	0	0
T3	25	5	0	5
T3	26	0	0	0
T3	27	0	0	0
T3	28	0	0	0
T3	29	0	0	0
T3	30	0	0	0

Table A.4. Bird observations at Cedar Tree Point, April 2019.

Date	Location	Species	Common Name	Observations	Name	Interval Time
4/5/19	A	*Fregata magnificens*	Magnificent Frigatebird	12	Calvin Gore	7:45 - 8:15 am
4/5/19	A	*Myiarchus oberi*	Lesser Antillean Flycatcher	1	Calvin Gore	7:45 - 8:15 am
4/5/19	B	*Fregata magnificens*	Magnificent Frigatebird	60+	Laura Flynn	7:45 - 8:15 am
4/5/19	C	*Coereba flaveola*	Bananaquit	1	Calvin Gore	8:30 - 9:00 am
4/5/19	C	*Loxigilla noctis*	Lesser Antillean Bullfinch	1	Calvin Gore	8:30 - 9:00 am
4/5/19	C	*Fregata magnificens*	Magnificent Frigatebird	24	Calvin Gore	8:30 - 9:00 am
4/5/19	D	*Coereba flaveola*	Bananaquit	3	Laura Flynn	8:30 - 9:00 am
4/5/19	D	*Myiarchus oberi*	Lesser Antillean Flycatcher	3	Laura Flynn	8:30 - 9:00 am
4/5/19	D	*Fregata magnificens*	Magnificent Frigatebird	5	Laura Flynn	8:30 - 9:00 am
4/6/19	E	*Fregata magnificens*	Magnificent Frigatebird	39	Laura Flynn	8:00 - 8:30 am
4/6/19	E	*Loxigilla noctis*	Lesser Antillean Bullfinch	2	Laura Flynn	8:00 - 8:30 am
4/6/19	E	*Unknown species*	Warbler Unk	1	Laura Flynn	8:00 - 8:30 am
4/6/19	F	*Coereba flaveola*	Bananaquit	3	Calvin Gore	8:00 - 8:30 am
4/6/19	F	*Fregata magnificens*	Magnificent Frigatebird	20	Calvin Gore	8:00 - 8:30 am
4/6/19	F	*Myiarchus oberi*	Lesser Antillean Flycatcher	1	Calvin Gore	8:00 - 8:30 am
4/6/19	G	*Fregata magnificens*	Magnificent Frigatebird	10	Laura Flynn	8:45 - 9:15 am
4/6/19	H	*Dendrocygna arborea*	West Indian Whistling Duck	2	Calvin Gore	8:45 - 9:15 am
4/6/19	H	*Coereba flaveola*	Bananaquit	6	Calvin Gore	8:45 - 9:15 am
4/6/19	H	*Fregata magnificens*	Magnificent Frigatebird	4	Calvin Gore	8:45 - 9:15 am

Table A.5. Development Project and Utilities Demand Data and Calculations

Appendix - Programming revised on: 8/21/20

Abercorn - Phase 1

description	basis (units)	quantity	S.F. or seats / unit	Total Potable (gpd)	Total Sanitary (gpd)	indoor(sf) / outdoor (sf)	Electrical Demand (KVA)	
Small Guest Villa	200 gpd/unit	2	735	400	340	735/635	22	
Large Guest Villa	400 gpd/unit	1	1,725	400	340	1,7235/955	15	
Large Guest Family Villa	800 gpd/unit	1	1,895	800	680	1,895/955	17	
Game Villa	0.12 gpd/sf	1	864	104	88	864/992	5	
Gym Villa	0.12 gpd/sf	1	864	104	88	864/950	5	
Main Gathering Villa	40 gpd/seat	1	25	1,000	850	3,785/2410	60	
Laundry/Mechanical				150	128		20	
SWRO & WWTP							40	50 combined
Staff Quarters	100 gpd/person	1	8	800	680		15	
3 Pools							12	
				3,758	3,194		211	

Phase 1 Potable Water and Sanitary Sewer Use	**3,758**	**3,194**	**Electric Load (KVA)**	**211**
Phase 1 Total Irrigation Water Use	**6,959**			

Dejoria - Phase 2

description	basis (units)	quantity	S.F. or seats / unit	Total Potable (gpd)	Total Sanitary (gpd)	indoor(sf) / outdoor (sf)	Electrical Demand (KVA)
Main House	1500 gpd/unit	1	12,000	1,500	1,275		90
Large Guest Home	600 gpd/unit	1	5,000	700	595		35
Guest Homes	300 gpd/unit	2	2,500	600	510		40
SWRO & WWTP							30
Pools							12
				2,800	2,380		207

Phase 2 Potable Water and Sanitary Sewer Use	**2,800**	**2,380**	**Electric Load (KVA)**	**207**
Phase 2 Total Irrigation Water Use	**5,185**			

Total Potable Water and Sanitary Sewer Use	**6,558**	**5,574**	**Electric Load (KVA)**	**418**
Phase 2 Total Irrigation Water Use	**12,144**			

Occupancy

This is a rough estimate.

For 8 weeks per year, occupancy 10-20 people,

For 12 weeks per year occupancy 10-25 people (including children)

The occupancy will not necessarily be continuous but expect it to be higher in the season (i.e. when it's winter in the northern hemisphere).

The individuals occupying the property will change too, so for instance a group of 10 people may be there for a week and the following week it could occupied by a different 10 people.

At all times - 2-3 people will occupy the property. There will be maintenance visiting e.g. landscaping, etc.

Assume Phase 2 up to 20 people

occupancy type	potable	sanitary	notes
caretakers	300	240	(all year)
small groups	1500	1200	(min 8 weeks of year)
large groups	3750	3000	(min 12 weeks of year)
phase 2	3000	2400	
full Ph1 & Ph2	6750	5400	

ANNEX 1 Disclosure of Consultants Engaged

ANNEX 1: DISCLOSURE OF CONSULTANTS ENGAGED

DEBORAH BROSNAN, PH.D.

Dr. Deborah Brosnan has 30 years of experience in crafting science-based solutions to environmental risk and with a specialty in Small Island Developing States. She brings extensive experience in leadership and management combined with scientific knowledge to help resolve a diversity of challenging situations.

PRESIDENT AND FOUNDER, DEBORAH BROSNAN & ASSOCIATES
A company focused on solutions to environmental risks globally, provides expertise in land land/sea planning and decisions, disaster risk reduction and climate change, endangered species. Science based, strategically and solution focused and serving clients in all sectors 2011-present. St Barthelemy FWI, Antigua BWI, and Washington D.C.

FOUNDER AND CEO, SUSTAINABLE ECOSYSTEMS INSTITUTE
A non-profit organization that integrated science and carried out scientific research to address environmental problems throughout the USA 1994-2011. Established and grew organization, focused on endangered species, forestry, oceans, laws and policies & held several multi-million IDIQ government contracts. Built and deployed effective multi-sector and multi-disciplinary outcome orientated teams Recruited 1,000 credentialed scientists to affiliate as on-call experts.

ACADEMIC APPOINTMENTS
Full Adjunct Professor of Biology Virginia Tech. Faculty of the Global Change Institute and Fellow of Global Forum for Urban and Regional Resilience. 2012- Present.
Environment and Policy Faculty. One Health Institute, University of California Davis, 2011- 2015
Senior Visiting Researcher, Smithsonian Institution 2013-2016.
Visiting Scholar, Stanford University, Dept. of Biology 2009-2010 and 2002-2003.
Visiting Professor Northwestern School of Law. Developed and co-taught marine science and law, and curriculum on ecological science and law. 1999- 2002 and on occasional basis.

EXPERIENCE
Science-based Environmental Risk Reduction and Problem-Solving
Dr. Brosnan has led several teams that successfully resolved national environmental challenges involving multiple interests and complex issues where financial and environmental stakes were high and costs escalating (e.g., several high-risk/high-profile situations e.g., Everglades Restoration, endangered species) and for multi-sector clients. The process she developed was independently evaluated as the subject of a Ph.D. dissertation (by M. McEathron) and won praise from all sides in the environmental debate for its effectiveness. Dr. Brosnan hold an MOU with the U.S. Dept. of Interior US Geological Survey to provide scientific advice and resources during hazards and crises and has held IDIQ with US Government. Specific Project Examples: S, Florida Everglades Restoration: Management of the Missouri River; Columbia River Dredging and Endangered Species: Atlantic Salmon (State of Maine); Land Use/Development California, Caribbean, Colorado, High-altitude wetlands, public-private partnership for marsh restoration. Dr. Brosnan has provided expert testimony to US Senate and US House Committees

Sustainable Development
Private land use and development is often fraught with investment and regulatory risks. Private landowners, investors, and resort developers have sought Dr. Brosnan's assistance on investment and development strategies in a diversity of environmental areas. Work has included

sustainable forestry practices under land management and compliance; Resort and private development covering topics such land suitability; cost-effective building with nature; environmental regulatory compliance; climate change risks and mitigation; biodiversity and sensitive habitats; risks and return on investment; environmental certification. Relationships between private and government sectors must often be brokered for solutions that benefit environment and enterprise, permission must be secured, and community concerns and benefits addressed- these are areas in which she has a proven track record. The scale of her projects has ranged from ownerships of 23.5sq miles (66 km2), properties and entire small islands up to 11sq miles (28 km2), to individual properties with complex developments.

ISLANDS AND EMERGING NATIONS

Dr. Brosnan, a resident in the Caribbean maintains a specialized practice in islands.
Examples of work include:
Assessments, EIAs, Land and Marine use planning and development for private and public sectors spanning ecological, environmental, energy issues. (several islands)
Design and implementation of ecosystem-based solutions Assisted multi-sector clients on building with nature in a cost-effective way as part of their ethic, brand, solution to climate-change and hazard risks, and compliance. Project have spanned design to implementation and included e.g. entire beach length dune-restoration, coral reef restoration, site assessments e.g., hydrodynamic and biological analysis, building community relations, permitting etc. Numerous Islands include St Barthelemy, St Kitts and Nevis and adjacent state; and the integration of environment, natural resources and infrastructure for solutions in the Montserrat Volcanic crisis
Design and implementation of the Marine Reserve, St Barthelemy the first network-designed reserve in the Caribbean.

SOLUTIONS TO HAZARDS, DISASTERS AND CLIMATE CHANGE

Science and Technology for Resilience. As part of the leadership team with NASA and The Nature Conservancy, we have designed a state of the science GIS based resilience tool that is web accessible and can be used by the community in their evaluation and decision-making. (2014-present).
Tsunami Planning California. Evaluated risks and consequences to California and the national economy from distant-sourced earthquakes and tsunamis. As part of the leadership Dr. Brosnan led the scenario effort on impacts on ports, fisheries, endangered species, protected lands and coasts, evaluating ecological, economic and social impacts. Working with 6 teams of scientists from disciplines including economics to engineering, we provided forecasting on direct and cascading impacts.
Extreme Geohazards. As a member of the Geo-hazard team we evaluated the likelihood of extreme volcanic eruptions and their potential impacts on communities, trade and policy (project at the request of European Science Foundation).
Design and Implementation of New Town and Port Facility to mitigate Montserrat Volcano: Led the environmental assessment and planning the engagement of government and community and worked with the engineers and government to design an ecologically-sustainable new town and port facility that would provide necessary infrastructure, transportation, government and community services and natural resource and habitat basis for fisheries, tourism and farming. This proved vital when subsequently the eruption destroyed main town, transportation and services.

CAPACITY BUILDING AND MULTI-DISCIPLINARY ENGAGEMENT

Dr. Brosnan has developed and implemented innovative and cross cutting workshops and capacity building experiences including:

Integrating ecosystems, Disaster Risk Reduction and Climate Change in policy and actions for Organization of Eastern Caribbean States (11 nations) 2016.
Science in the Courtroom: Workshops and lectures for State Supreme Justices and US Justices.
Science Arbitration: Using science to resolve complex environmental disputes (Lecture and Workshop series for professionals and graduate students)
Marine science and Law: Course for environmental lawyers and students and practitioners.
Recent Presentations (2016-2017)
Upcoming Sustainable Infrastructure, Miami Green Infrastructure Conference March 2018.
TEDx Aligning with Nature: Sun Valley 2017
Green, Gray and Hybrid Solutions: Why they matter to you? American Society of Civil Engineers Sustainable Infrastructure Conference (Speaker and Session Convenor) Nov 2017.
Ports and Coasts: Evaluating Risks and Designing Solutions. World Ocean Council (Industry Group for Oceans and Maritime issues) Nov 2016 Rotterdam
Oceans – 3 Lectures in French Polynesia 2016
Workshop on New Sustainability: Incentives and Opportunities in Design and Legal Framework Florida Green Building Coalition Convention Miami Sept 2016
Innovations in ecosystem-engineering for disasters and climate Change (Workshop U.N. Bonn 2016)
In the heat of the moment effective use of science and scientists during crises and hazard events (Workshop San Francisco Dec 2016)

PUBLICATIONS
Over 50 publications in peer reviewed, reports and popular literature, including edited book
Frequent Expert Contributor to Huffington Post on science environment and disasters. http://www.huffingtonpost.com/author/brosnan-132 Articles and OpEds published to Washington Post, New York Times

BOARDS OF DIRECTORS AND ADVISORY BOARDS
Dr. Brosnan serves and has served on a number of Boards and Advisory Boards including:
President of the Board of Directors, Wild Geese Network of Irish Scientists- international diaspora of Irish scientists, engineers and technologists. 2014- present
Board of Trustees and Past Chair- University of California Davis, Wildlife Health Center, SeaDoc Society. 2000-present. A wildlife science and medicine program to restore and sustain ecosystem and human health.
American Society of Civil Engineers. Member of Committee on Sustainability. 2016-present
National Courts and Sciences Institute. Science Board Member 2014- Present. Education of justices in scientific practices and knowledge.
Board of Directors, PADI Project AWARE a global SCUBA diving conservation organization office in 8 Regions around the world 2011- Present
Science Advisor to The Environmental Agency St Barthelemy FWI. 2013-Present.
Commissioner IUCN Commission on Ecosystems 2014- Present.
Global Risk Forum, Davos, Board of Advisors 2014- Present. Comprehensive Disaster Risk Reduction globally
Conservation Committee, American Ornithological Society 2014-2016.
Joint USA- Italy Commission on hazards and disasters 2015-2016
BBC The World, Science Advisor 2006-2012 3BBC Radio Series.
Oregon Health and Sciences University, Board of Advisors, Coastal Oceans Monitoring Program 2005 to 2015. High-tech ocean observation and monitoring system for biological and physical aspects of the ocean including fisheries conditions and tsunami risks.
Public Trustee, Board of Directors, Oregon State University, College of Forestry, appointed by

State as the Public Representative 1997-2005. State oversight and assistance for forestry research and practices.
Board Member of National Science Foundation Group to form the National Ecological Observatory Network (NEON) 2001-2004. Developed vision, organizational structure and legal entity, and set up the US NEON Observatory platform.
Chair, US Department of the Interior, Blue Ribbon Scientific Ethics Panel 2002.Led the effort to develop and review a code of scientific ethics adopted for the conduct of science by all the agencies under the US Dept. of Interior.

Other Fellowships and Awards
Inducted into Ireland 100 for services to US higher education and learning. 2015
Science-artist in residence Cill Rialig Ireland August 2015.
Senior Whiteley Fellow, University of Washington 2010, 2005
Red Cross Hero's Award for saving lives in 747-plane crash.

ADDITIONAL COMMUNITY WORK
Founded Tsunami Reef Fund (2005) linking international scientists, professional divers with local communities affected by the tsunami. Provided practical economic and scientific assistance locally in marine debris clean up and reef recovery, and re-engage communities with the ocean. Travelled throughout region to establish program and long-term linkages.

LANGUAGES
English, French, and Gaelic

ACADEMIC CREDENTIALS
Ph.D. Oregon State University. Effect of extreme events on marine community dynamics. 1994
M.S. National University of Ireland Fisheries Science: Thesis Experimental Fishery for Spider Crab Maia squinado 1982
B.S. honors in Zoology and Botany, University College Galway 1978

<u>EIA Role</u>: Dr. Deborah Brosnan has been project lead on the EIA and involved in all aspects of its preparation.

JOSH CHAPMAN
Project Manager

Mr. Chapman is Lead Project Manager for several U.S. and international efforts at Deborah Brosnan and Associates. Prior to joining Deborah Brosnan and Associates, Mr. Chapman worked for 12 years as a lead environmental specialist and project manager at Maryland Environmental Service. He brings extensive experience in large-scale environmental project management and compliance across a diversity of efforts for Maryland Department of Transportation business units. These include environmental compliance, mitigation and outreach projects related to Maryland Port Administration dredging and harbor development; and drilling, geotechnical investigation, transportation, and invasive species control efforts for the State Highway Administration. Mr. Chapman is a graduate of Virginia Tech where he received his B.S. in environmental policy and planning.

EIA Role: Mr. Chapman has been the project manager involved in all aspects of the EIA including baseline background research, synthesis of previous studies, environmental policy, and EIA management.

LAURA L. FLYNN
GIS Remote Sensing Analyst

Ms. Flynn specializes in GIS based platforms to spatially analyze ecological characteristics and develop user-friendly applications. With 20 years of background in coastal zone habitat management, she has successfully completed a diversity of projects to include mapping of species composition, distribution and health of marine habitats throughout the state of Florida and Caribbean. Her work in field assessments routinely incorporates spatial data that are used to create user friendly map products and provide end decision-makers and all users' accessible information for the long-term management of resource areas.

EIA Role: Ms. Flynn conducted several biological field assessment and evaluation for the EIA Specific efforts included field investigations (including vegetation assessment, bird community survey, and seagrass transect survey), GIS based spatial analysis and production of maps, species identification, and evaluating impacts and developing mitigation strategies for sensitive flora and fauna on site.

GENEVIEVE RENAUD-BYRNE
Field Manager and Scientist

Ms. Renaud-Byrne served as Field Manager/Scientist for several Caribbean efforts. Prior to her work at Deborah Brosnan and Associates, she worked as a project coordinator for the Department of the Environment in Antigua. Before moving to Antigua, she was the Climate Change communications officer with COINAtlantic for the Eastern Canadian Assessment on Climate Change. Ms. Renaud-Byrne brought experience in marine science, climate change resilience, communications, as well as design and implementation of climate change adaptation projects on Caribbean islands covering climate financing, protected areas, renewable energy, and ecosystem enhancement. She has a Masters in Marine Management from Dalhousie University, Canada, and a BSc Honors from the University of Guelph, Canada.

EIA Role: Ms. Renaud Byrne conducted environmental impact assessments for Cedar Tree Point, and helped to assess impacts develop mitigation strategies for marine species and habitats.

TORBEN ABBOTT, PE, LEED AP
Civil Engineer

Mr. Abbott is a Civil Engineer with 25 years' experience in designing development solutions for projects in the US, China and the Caribbean, specializing in site-grading, stormwater and utility engineering design. Mr. Abbott has worked on numerous, wide-ranging development projects, developing infrastructure systems that both serve the needs of the end-user and work with respect to and in tune with the local environment.

EIA Role: Mr. Abbott was the principle engineer assessing and calculating site infrastructure needs and providing recommendations for potable water, wastewater treatment, power, and stormwater management. Mr. Abbott also reviewed site grading needs and produced conceptual site plans.

MIKE JENKINS, Ph.D.
Principal Coastal Engineer

Dr. Jenkins is a Principal Coastal Engineer at Applied Technology and Management (ATM) specializing in coastal analysis and numerical modeling. With experience in beach nourishment design and permitting of environmental restoration projects around the world, he has a successful track record of reducing risk from storm surge and climate change in coastal resort developments. Dr Jenkins has worked throughout the Caribbean including as an associate partner of Deborah Brosnan & Associates on several projects in Antigua and Barbuda.

EIA Role: Dr. Jenkins and his team of coastal engineers at ATM completed the storm surge risk assessment and modeling efforts and developed recommendations for setbacks and elevations.

ANNEX 2 DECLARATION OF COMPLETENESS AND AUTHENTICITY

ANNEX 2 DECLARATION OF COMPLETENESS AND AUTHENTICITY

November 2, 2020

Mr. Frederick Southwell
Chief Town and Country Planner
Development Control Authority
Transportation Board, Factory Rd
St. Johns, Antigua

Dear Mr. Southwell,

We are pleased to submit this EIA for the proposed Cedar Tree Point Residential Construction, Plan Application #G04-2020.

This declaration of completeness and authenticity accompanies this EIA. The EIA was conducted according to the Terms of Reference provided to us (dated 29th September 2020).

Kind Regards,

D. M Brosnan

Deborah Brosnan, Ph.D.
President, Deborah Brosnan & Associates

ANNEX 3 Enclosures

GOVERNMENT OF ANTIGUA AND BARBUDA

September 29, 2020

Department of Environment
Ministry of Health and the Environment
#1 Victoria Park, Botanical Garden
P.O, Box W693
St. John's
Antigua, W.I.
Tel: (268) 462-6265
Fax: (268) 462-4625
Email: antiguaenvironmentdivision@gmail.com

Chief Town and Country Planner,
Development Control Authority
Transport Board Head Quarters
Herbert's Estate
P.O. Box 895
St. John's
Antigua

REF #D.o.E 9/6/Q6

Terms of Reference for Plan Application #G04-2020 – Private Residential

Dear Mr. Southwell,

The Department of Environment in is receipt of your letter dated September 25, 2020, in which you confirmed the legality of the lease for the developer.

Specifically, to the review of plan application G04-2020, dated July 6, 2020, to meet all environmental concerns the developer should seek to have prepared, for further consideration, an Environmental Impact Assessment (EIA) as guided by the Terms of Reference (TOR) attached, which shall include:

- Rapid Coastal Erosion
- Hydrology and Drainage
- Alteration to Wetland and Ecosystems Impacts
- Water Resources
- Energy-Solar PV
- Climate Change Impacts- Surge zone

Best Regards,

....
Chief Environment Officer
Department of Environment

TERMS OF REFERENCE
Environmental Impact Assessment (Cedar Tree Point)

Objective

The purpose of the Terms of Reference (TOR) is for preparation of the Environmental Impact assessment (EIA) to guide project proponents and consultants to execute the appropriate analyses and prepare a report with relevant project specific data, which are informative, compact and, easy to comprehend. The findings of the assessment as well as impacts of the development and mitigation measures to address these should be documented in an Environmental Impact Assessment (EIA) to be submitted to the Development Control Authority for onward submission to the DoE for review, comments and final recommendations.

The EIA process should result in the development of a refined land use plan for the development and specific recommendations for mitigation measures to guide phase one of the development. The subsequent phases of this development may require additional detailed environmental impact analysis once the plans for these phases are further advanced.

Executive Summary

This section should allow for a clear understanding of the project proposal and summarize the significant results of the EIA study, e.g. positive and negative environmental, social and economic impacts, options considered, reasons for selection of the proposed options for design and density, and the measures to be implemented to prevent or mitigate negative impacts or capitalize on positive impacts. This section should be reader friendly and include a tabular summary of main impacts and mitigation measures. The use of diagrams photos and maps to illustrate key findings is encouraged. The section should be capable of becoming a standalone section for presentation to policy makers or for public consultations.

1.0 Introduction

This chapter should cover the following:

- Profile of the project proponent, name and contact address, implementing organization, organizational chart, project consultants etc., should be mentioned clearly.
- Purpose of the project, brief description of the project- name, nature, size, location of the project, its importance to the country.
- Land description - Ownership, extent of the land and provisions for access.
- Description of national and local regulations and standards applicable to area development projects should be discussed.

2.0 Project Description

This chapter should cover the broader details of the basic activities, location, zoning plan and specific site plan for the houses as well as implementation schedule of the housing project.

- Include critical aspects of the social, and economic context of the project.
- Type of project - new, expansion, modernization, etc.
- Relevance of the project.
- Use of existing "infrastructure" or lack thereof – traditional uses of access foot paths (roads). Plans for water supply, electrical power, telecommunications, etc.

- Estimated water budget and sources for the proposed project - during construction/ operation stages.
- Estimated cost of development of the project (for the houses and projected for the entire project), environmental cost, funding agencies, etc.
- Estimated cost for creating access within the site.
- Details of any philanthropic and community development activities such as, rehabilitation of disrupted ecosystems, interaction with traditional users from surrounding villages, farmers and present status of such activities.
- Resources, manpower, timeframe, etc. – required for project implementation

2.1 Essential Maps to be provided with application

- A map of the project area, delineating the major topographical features such as land use, drainage, locations of habitats.
- Sea level rise and storm surge models.
- A map covering aerial distance of the proposed project to sensitive areas.
- Map of major constructions including, buildings, roads, trails and other facilities.
- Site layout plan of the proposed development, original layout and any proposed changes in response to the EIA.
- Land use master plan reflecting in particular management zones, biodiversity corridors, hydrological features, buffer zones etc.

2.2 Project benefits

This section details the improvements in physical infrastructure and social infrastructure if any. Also, it details any employment potential and other benefits that are accrued if the project is taken up.

2.3 Analysis of alternatives (Technology & Sites)

The EIA may find that there is a need to develop alternatives to the original intent of the developer with respect to treatment of hydrological features, water sources (desalination?), transportation to site and within the site, energy and wastewater treatment. A clear description of each alternative, summary of the impact – adverse and positive – within the site as well as the cumulative impact when considering other inputs into the environment. ***Selection of alternatives are to be detailed out.***

3.0 Methodology

The EIA consultant is expected to outline the process used to collect information and data. The methodology may include publication research, interviews, surveys and other research techniques, and could include both present and historical information. The methodology section of a research paper answers two main questions: How was the data collected or generated? And, how was it analyzed? The provision of this information allows the DoE, DCA and any other interested stakeholder to critically evaluate the EIA's overall validity and reliability.

4.0 Environmental Baseline

Collect environmental data to establish a reference point as to the quality of environmental features prior to the execution of the project. Specific areas to be reported on:

a) land and ecosystems particularly wetland and coastal features;
b) freshwater resources;
c) climate and microclimate;

d) biological resources terrestrial and marine (birds, bats and other mammals, invertebrates, flora (all types) special reports on invasive species and endemic or indigenous species;
e) noise;
f) socio-economic environment,
g) roads. …

4.1 Land Environment

a. A detailed Land use plan is to be developed and analysed against the baseline
b. Topography (if applicable can include underwater topography)
   Slope form
   Landform and terrain analysis
c. Soil
   Type and characteristics
   Porosity and permeability
   Sub-soil permeability
   Inherent fertility
   Soil moisture content
d. Size of the sub-catchment in comparison to the project area

4.2 Air Environment

Climatological data are to be obtained from the nearest Meteorological Department (MD) station for one full year. Micro meteorological data should consist of wind speed, wind direction, temperature, cloud cover, (amount and height), humidity, inversions, rainfall (peak and average daily rainfall), and wind rose patterns should be collected.

4.3 Noise Environment

Construction equipment and road traffic are the major sources of noise. The mitigation of noise impact during construction and in operations phases will be particularly important. Baseline data of noise at the project area and the neighboring habitat areas are to be ascertained. Daytime and night-time data should be collected.

4.4 Biological Environment

An inventory, inclusive of lists and maps of ecosystems and species within the general zone of the project site, is to be prepared along with a description of the vegetation and coastal benthic features and processes. If there are any rare and endangered species in the study area they are to be clearly mentioned. Details for fauna and flora to be included are:

- General type and dominant species
- Densities and distributions
- Habitat value
- Historically /commercially important species (deer) or ecosystems
- Rare and Endangered species (location, distribution, conditions etc.)
- Specimen of scientific or aesthetic interest

The presence of invasive flora and fauna should also be documented in a similar manner.

4.5 Socio Economic & Health Environment

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.

5.0 Anticipated Environmental Impacts and Mitigation Measures:

5.1 Prediction of Impacts:

This should describe the likely impact of the project on each of the environmental parameters, methods adopted for assessing the impact such as model studies, empirical methods, reference to existing similar situations, details of mitigation, methods proposed to reduce adverse effects of the project, best environmental practices, conservation of natural resources; environmental management plan; integrated watershed and biodiversity management plan as well as post project environmental monitoring programme including budgeting for the expenditure proposed in the project cost.

5.2 Land Environment

Anticipated Impacts:

Some of the anticipated impacts, which need to be addressed, are

- Estimation of anticipated impacts of the overall land use plan for the development on the surrounding land use pattern, road network, watersheds, wetlands beaches and, other environmentally sensitive places etc. in doing this a carrying capacity rating is to be assigned to each zone
- Impact of the specific plan for the residential homes on the natural drainage system, sediment attenuation and soil erosion.
- Pollution due to improper handling of waste and other substances particularly with regards to the operations of the Wastewater Treatment, Reverse osmosis plant, as well as the power generation facilities if any.

Mitigation Measures:

Proper mitigation measures should be detailed and specific and should include measures on the housing site in consideration of the overall land use plans as well as measures. These could include but will not be limited to the following:

- Soil erosion mitigation.
- Improved flood and sediment attenuation mechanisms
- Forest and wetland ecosystem conservation zones.
- Watershed and biodiversity systems planning and implementation of alternatives.
- Waste removal and management.

5.3 Air Environment

Anticipated Impacts:

Impacts on air quality during the construction and operation phase should be predicted. The existing surrounding features of the study area and impacts on them should be addressed separately. It is necessary to predict the following if any:

- Prediction of potential sources of emissions.
- Prediction of possible types of pollutants and their impacts on people, flora, fauna (terrestrial and marine), the natural and, man-made environment.
- Identification of potentially hazardous substances.
- Health-related impacts.
- Water quality impacts (marine and inland)

Mitigating Measures:

Mitigation measures are to be proposed during the construction stage as well as the operational stage of the project. Detailed description of the measure and analysis of its function should be listed. The long-term impact of these measures on the risk to be mitigated should also be discussed. Measures could include but are not limited to:

- Mitigation measures during construction to reduce the amount and incidence of emissions.
- Recommendation of emissions standards.
- Greenbelt development and buffer zones.
- Dust mitigation.
- Estimation of any environmental implications from transportation (road) related emissions associated with the construction and operational phases and suggest suitable options.
- Recommended protective gear.

5.4 Noise Environment

Impact of project construction/operation on the noise level within the area includes:
Anticipated Impacts:

- Noise due to construction activities.
- Impact due to present and future transportation activities.
- Operation of Diesel Generator (DG) sets.
- Impact of noise due to work at night.
- Impacts on biodiversity.

Mitigation measures:
Identification and adoption of mitigating measures for noise abatement including noise barriers for point sources and line sources as also measures to minimize effect of vibrations due to demolition and while new construction.

- Land use Zone noise levels.
- Recommend noise reducing technologies.
- Recommend noisy activities take place at times less likely to affect others.

5.5 Water Environment

Impact of construction and operational phases on the surface and ground water on account of the development is to be estimated.
Anticipated Impacts:

- Impact on water sources due to shifting of watercourses, if any as well as the alteration of wetlands.
- Impact of water withdrawal on surface water / ground water resources.
- Impact on exploitation of surface/ground water.
- Water contamination.
- Wastewater generation.
- Information regarding how the wastewater is to be disposed of.

Mitigating measures:
Prediction of ground water contamination and suggested mitigating measures to minimize the pollution level.

- Water conservation.
- Rainwater harvesting.
- Pollution prevention techniques and technologies.
- Adequate measures to be adopted for water conservation during construction and operation stages.

5.6 Biological Environment

Impact of project during construction and operational phases on the biological environment on account of project activity is to be detailed.

Anticipated Impacts:

- Impact of construction and operational activity on fauna and flora (Marine and Terrestrial).
- Pre- and post- topography, soil and parent material conditions and their contribution to flora and fauna and.
- Aquatic (fresh water and marine) and terrestrial ecosystem diversity.

Mitigating measures:

- Mitigating measures to compensate the loss of vegetation cover / providing green belt development,
- Mitigating measures to prevent damage and, loss of ecosystem functionality in wetland ecosystems.
- Regeneration/Restoration of rare plants of economic importance including medicinal plants species which require protection and conservation
- Biodiversity management plan for the operational phase of the homes.

5.7 Socio-Economic Environment

Anticipated Impacts:

Predicted impact on the communities of the proposed activity is to be given. Impact on surroundings on socio-economic status is to be detailed. Present status of housing, public utilities, commercial structures and, transportation. Impact of the project in construction and operational phases on socio-cultural aspects is to be assessed. This should include beach access and current use of the coastal areas.

Mitigation measures:

Mitigation measures to reduce adverse effects are to be given.

5.8 Solid Waste

Solid waste from construction sector can be categorized into two phases i.e. during construction & during operation. Details of the following are to be given:

- Construction waste, i.e., massive and inert waste.
- Municipal waste, i.e., biodegradable and recyclable waste.
- Hazardous waste.
- E-waste.
- Earth movement

Details of authorized municipal solid waste facilities in the area should be included.

Anticipated impacts:

Impact of the project during construction and operational phases for generation of waste is to be assessed.

Mitigation measures:

Mitigation measures to reduce adverse effects. Options for minimization of solid waste and environmentally compactable disposal are to be given. Management and disposal of temporary structures made during construction phase are to be addressed. Recycling waste materials due to the project activity in the construction and operational phase of the project is to be discussed.

5.9 Sewage Treatment

Sewage treatment plant will be designed to treat the wastewater from the development. The wastewater is to be treated to a tertiary level and after treatment, reused for flushing of toilets in buildings and in gardening. Plans for the reuse of treated wastewater for landscaping, car washing etc. should be discussed.

5.10 Hydrology and Strom water management

A full hydrological analysis should be carried out. The objective would be to identify hydrological risk and present design options for hydraulic solutions. The study should consider the entire drainage basin/watershed affected by the development. The solutions recommended should be developed in the context of the government policies and laws related the treatment of wetlands and respect the conservation of these areas.

5.11 Infrastructure

Describe the project energy requirements, associated infrastructure and, other infrastructure requirements. Discuss the steps taken to integrate the needs of other stakeholders into the location and design of access infrastructure to reduce and manage overall environmental impacts from resource development.

6.0 Risk Assessment (ERA) and Disaster Management Plan (DMP):

This section should indicate a clear understanding of perceived risks to the development and to the environment and should feature a rating matrix (both positive and, or negative) prior to and after proposed mitigation to produce a residual impact rating. Impact risk rating analysis focuses on the severity of the impact and the likelihood of the impact or hazard happening. Alternatively, risk theories establish the theoretical formula where Risk = Vulnerability x Hazard. The chapter should seek to:

- Identify sources of impacts generated by the proposed development.
- Identify receptors of impacts to include, air, nearby residents, ecosystems and, water bodies all within the vicinity of the site.
- List stakeholders who may be a major recipient of impacts and host consultations to discuss impacts and mitigation measures. Concerns of stakeholders should be captured and annexed to the final report.
- Based on the identified impacts and sources, suggest mitigation measures to address these impacts as appropriate; efforts should be made to include ecosystem-based approaches for disaster risk reduction.
- Assessment and mitigation of the direct and indirect impacts during construction and post construction. Impacts should be scaled based on severity - low, medium, and high; and presented in a tabular format. The following table maybe used as a guide:

Likelihood of hazard/Impact	Severity of Impact		
	Low	Medium	High
	Medium	Low	High
	High	High	High

Table 2: Summary assessment and mitigation of environmental impacts

Area of Impact	Brief Description	Risk Significance High/Medium/ Low	Mitigation Measures	Residual risk High/Mediu m/Low
Water /Hydrology				
Drainage				
Air pollution				
Noise Pollution				
Residents/business es				
Plants				
Animals				
Aesthetics of the area				

Given the nature of the proposed development and the sensitive environment in which it is to be located, the investment is exposed to projected impacts of climate change, including increasing rainfall intensity, sea level rise, decreasing average annual rainfall and extreme temperatures. In order to ensure that the development is climate-resilient, potential impacts are to be assessed and mitigation measures proposed in the planning and assessment stage (See table 3 below as a guide).

Table 3: Summary of risks associated to climate change impacts and mitigation measures

Impact	Brief Description	Risk Significance High/Medium/Lo w	Mitigation Measures
Extreme rainfall event			
Extreme drought			
Extreme atmospheric temperatures			
Hurricanes			
Sea Level Rise			
Other			

Discuss emergency plans for any environmental risks such as earthquakes, hurricanes, surges, flooding, etc.

- Types of Emergency; internal and external origin.
- Emergency evacuation plan.
- Emergency Procedures.

7.0 Environmental Monitoring and Management Plan (EMMP)

A draft environmental monitoring and management plan must be developed which will detail the monitoring requirements for pre-, during- and post- construction and during the operational phases of the project. This will include recommendations to ensure the documented implementation of mitigation measures and long-term minimization of negative impacts and maximization of positive impacts.

For the construction phase the following is required:

- Frequency, location, parameters of monitoring.
- Summary matrix of environmental monitoring, during construction and operation stage.
- Requirement of monitoring facilities.
- Compilation and analysis of data and reporting system
- Detailed parameters should be extracted from the EIA findings.

For the operational phase the following is required:

- Administrative and technical set-up for management of the environment.
- In-built mechanism of self-monitoring of compliance of environmental regulations.
- Institutional arrangements proposed with other organizations/ Govt. authorities for effective implementation of environmental measures proposed in the EIA.
- Safeguards/mechanism to continue the assumptions/field conditions made in the EIA, for arriving the site suitability.
- Provisions should be kept for the integration of solar water heating system and other energy conservation methods.

Detailed EMMP may be formulated to mitigate the residual impacts. Budgeting of the EMMP may be included in the EIA.

8.0 Summary & Conclusion

This section should summarize the significant findings of the EIA report. The summary must describe each significant environmental issue and its resolution in sufficient detail so that its importance and scope, as well as the appropriateness of the approach taken to resolve it are well understood. Wherever possible, the summary should make use of base maps, tables and figures given in the report. The following should be addressed in the summary if applicable:

- Impacts on lands used for traditional practices such as farming and fishing.
- Potential interruption or limitation of accesses to the coast.
- Alteration of sensitive wetland and coastal ecosystems

ANNEX 1 Disclosure of consultants engaged

This chapter shall include the names of the consultants engaged with their brief resume and nature of consultancy rendered.

ANNEX 2 Declaration of Completeness and authenticity

This section is to be in the form of a letter from the EIA consultant containing an indication of the completeness of the work and the authenticity of the information reported.

ANNEX 3 Enclosures

Conceptual plan / Questionnaire / Photos/ Maps/ Full Technical studies

Gmail

Joshua Chapman <chapman@deborahbrosnan.com>

G-Application #4-2020 -- Update following site visit

Joshua Chapman <chapman@deborahbrosnan.com> Wed, Sep 16, 2020 at 3:08 PM
To: clement.antonio@ab.gov.ag, Frederick Southwell <southwellfred@gmail.com>, Frederick Southwell <Frederick.Southwell@ab.gov.ag>
Cc: Arry Simon <arry.simon@ab.gov.ag>, Deborah Brosnan <brosnan@deborahbrosnan.com>

Good afternoon,

I am contacting you to update the subject G-Application to avoid issues identified by DoE during a 29 June 2020 site visit.

The location of one structure (known as the "Eloise Residence" on the original submission, now known as "Abercorn Residence") has been changed. Please see the attached document showing this change.

The location of the other structures on site has not changed.

Please let me know if you have any questions.

Thank you,

--
Josh Chapman
Project Manager

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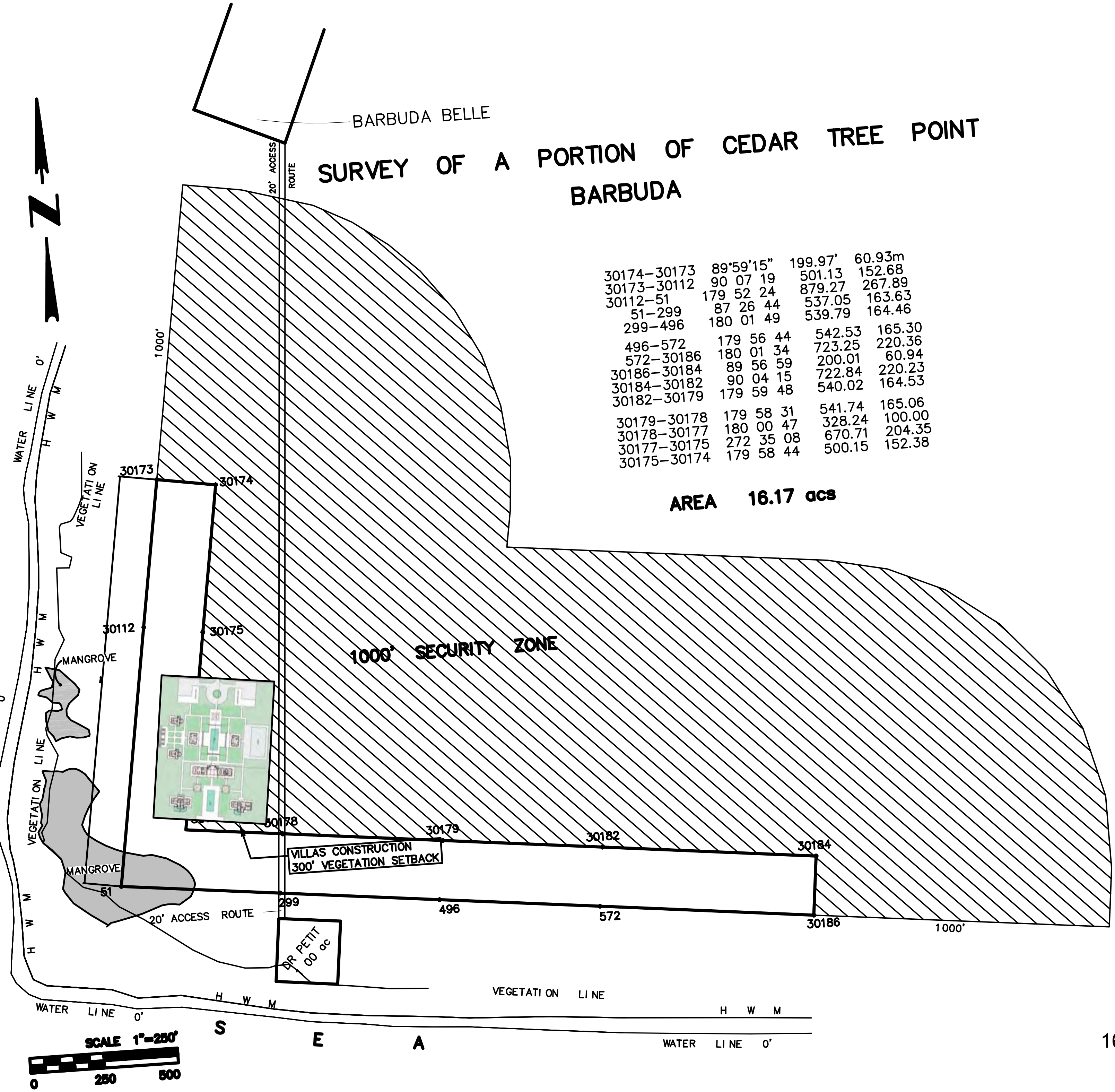
DEBORAH BROSNAN & ASSOCIATES

Washington DC St. Barthelemy FWI Antigua BWI

21992 Abercorn - Site Plan (300 ft. Vegetation Setback) 8-18-2020.pdf
556K


SURVEY OF A PORTION OF CEDAR TREE POINT
BARBUDA
BARBUDA BELLE
20' ACCESS ROUTE
30174–30173 89°59'15" 199.97' 60.93m
30173–30112 90 07 19 501.13 152.68
30112–51 179 52 24 879.27 267.89
51–299 87 26 44 537.05 163.63
299–496 180 01 49 539.79 164.46
496–572 179 56 44 542.53 165.30
572–30186 180 01 34 723.25 220.36
30186–30184 89 56 59 200.01 60.94
30184–30182 90 04 15 722.84 220.23
30182–30179 179 59 48 540.02 164.53
30179–30178 179 58 31 541.74 165.06
30178–30177 180 00 47 328.24 100.00
30177–30175 272 35 08 670.71 204.35
30175–30174 179 58 44 500.15 152.38
AREA 16.17 acs
1000'
30173
30174
30112
30175
1000' SECURITY ZONE
MANGROVE
VEGETATION LINE
WATER LINE 0'
H W M
S E A
30178
30179
30182
30184
VILLAS CONSTRUCTION
300' VEGETATION SETBACK
MANGROVE
51
299
496
572
30186
1000'
20' ACCESS ROUTE
DR PETIT
1.00 ac
VEGETATION LINE
H W M
WATER LINE 0'
S E A
SCALE 1"=250'
0 250 500

Pre-Construction and Planning Guidelines for Sea Turtle Management

The pre-construction phase is an important phase for environmental planning and establishing a clear commitment to BMPs for biological monitoring. Pre-construction measures should achieve environmental goals and prevent excess impacts, including proper design, planning, scheduling (e.g. avoiding sea turtle nesting and hatching seasons during heavy beach construction), and operational (e.g. proper beachfront lighting and protocols) considerations for the project.

<u>Construction Setbacks</u>

Many sea turtles prefer to select wide, obstacle-free beaches for nesting. Coastal beachfront development can reduce the quality of this type of habitat, and it is therefore important to consider the setback of physical development, including construction, to promote continued sea turtle nesting.

Setbacks have been discussed in the EIA as a means of reducing coastal risk and storm damage to habitable structures. Coastal setbacks will need to be implemented not only for permanent structures, but for equipment storage and landscaping so as not to deter sea turtle nesting during the construction phase of this project. Sea turtle nesting should be incorporated into the design of native plant and dune restoration, which will further help to stabilize the beach.

Dune restoration will also prevent light from reaching the shoreline which can disorient nesting females and hatchlings. This is covered in more detail in the next section.

<u>Beachfront Lighting</u>

Lighting along beachfront properties and hotels strongly affects sea turtle hatchlings, misdirecting them inland and leading them away from the sea. Hatchlings immediately orient themselves toward the brightest horizon, which in unlit conditions is the open horizon of the sea (Choi & Eckert, 2009). Light from a variety of sources, direct and indirect, can combine and create a cumulative "sky-glow" that emanates from lights inside and outside buildings, street lights, and recreational facilities that could be several miles away. Proper light management can drastically reduce the disorienting effect on sea turtle hatchlings. Figure 1 illustrates three approaches to beachfront lighting ranked for their effect on sea turtles. "Poor" lighting can be seen from the beach and can cause disorientation. "Better" lighting allows for light to be directed and shielded, reducing stray light reaching the beach. "Best" lighting, such as louvered step lighting, prevents a majority of the light from reaching the dune or beach.

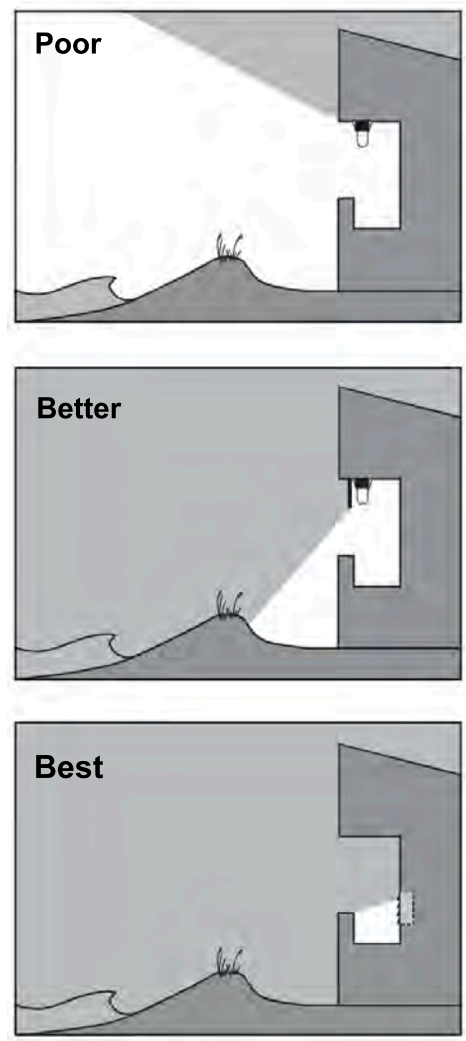


Figure 1: Poor, better, best examples of beachfront lighting for residential balconies, adapted from FWRI, 2014

The following are priority lighting recommendations for beach front development to be incorporated into site plans:

- **Alternative light sources**. Sea turtles are less sensitive to certain types and colors of lights, which should be incorporated into project design and planning. Metal hyalite lights and high-pressure sodium vapor lights can strongly affect turtles and should therefore only be sued in areas not visible on the beach. Low-pressure sodium vapor lights (LPS) in a monochromatic yellow color are the least detrimental to sea turtles due to their long wavelengths, which sea turtles do not detect as readily. If light is absolutely necessary on the beach, LPS lighting is the best choice.
- **Lower placement of lights**. The most visible lights from the beach are those mounted high on poles or upper stories of buildings. In many cases, lowering the placement of lights can direct it more precisely where it's needed and can be more functional, aesthetically-pleasing, and more cost-effective in the long run.
- **Directional fixtures**. Directional fixtures (unlike carriage lights or globe lights) focus the light downwards and away from areas visible from the beach.
- **Shield light**. Shielding light sources can be an effective way to keep light from reaching the beach. Screens such as aluminum flashing and vegetation (such as native dune vegetation and hedges) can provide effective shielding that works with the aesthetics of the resort design.
- **Moon-sensitive lights**. Installing motion-detecting lights (rather than lights that stay on throughout the duration of the night) reduce the detrimental effect on turtles because of their brief duration of illumination. These lights are also more energy efficient and cost effective.
- **Remove unnecessary lights**. Lighting inspections can help determine where lights are unnecessary and redundant, which benefits both the energy budget of the project as well as the impact to sea turtles.
- **Time restrictions**. The restriction of lights during peak sea turtle nesting and peak hatching hours (typically 7:00-11:00pm) can reduce the disorientation of emerging sea turtle hatchlings.
- **Area restrictions**. Limited beach lighting to areas not used by sea turtles, with the understanding that even distant light sources can influence hatchling orientation.
- **Window treatments.** The brightness of interior lights can be dulled by using black-out draperies or heavy, opaque curtains, shade-screens, and using tinting on windows. If window tinting is pursued as an option, they should be tinted to meet 45% light transmittance from inside to outside to reduce light leakage and decrease energy loss/cooling costs.
- **Vegetation**. Vegetation can be used both as habitat for nesting sea turtles and as a means of blocking light between the buildings and beaches.

Protocol for Sea Turtle Monitoring During Construction

Antigua and Barbuda legislation prohibits the taking of sea turtle eggs and prohibits disturbance to any sea turtles found onshore. Development supervisors and contractors are required to comply with this national legislation and international CITES agreement. Construction supervisors should adhere to the following Best Management Practices during construction to ensure that sea turtle species are protected and to remain in compliance with environmental laws and policies.

1. All personnel associated with the project should be instructed as to the presence of sea turtles and nesting behavior on site. All personnel must be made aware that they are responsible for complying with the law and must avoid collisions with or damage to sea turtles and their nests. Under Antigua and Barbuda Fisheries Regulations Statutory Instrument, Regulation 43 the take, capture or disturbance of a sea turtle or nest is subject to a maximum fine of EC$50,000.

2. Best practices involve the use of construction barriers. Construction barriers to prevent sea turtles from entering the construction zone and to prevent hatchlings from coming further inland due to lighting. These barriers include siltation fences that should be made of material in which sea turtles cannot become entangled and should be regularly monitored to avoid species entrapment.

3. If any sea turtles or hatchlings are observed within 100 yards (300 feet) of the active construction area, operations should cease and not resume until the animals have departed the project area of their own volition. This includes the operation of motorized vehicles in the vicinity of the active construction area.

4. Any nests should be clearly marked and protected. No disturbance to nests or poaching of eggs is permitted. In some cases, best professional judgement should be used when marking nests for protection from poaching. No adults or hatchlings are to be interfered with by any personnel.

5. Any collision with and/or injury to sea turtles should be immediately reported. The compliance government agency (Department of Environment, Fisheries Division) should be immediately informed to provide the appropriate protocols.

6. Lighting appropriate for the nightly work and safety of workers may be used. Lighting should be low-voltage, directed at the work site and not seaward to avoid disrupting marine life nearshore.

These BMPs should be used in conjunction with the regular sea turtle monitoring program, with close cooperation between the construction supervisor and the sea turtle patrol team, detailed later in the Sea Turtle Monitoring Program Patrol Team Protocol.