ENVIRONMENTAL IMPACT ASSESSMENT FOR

Port of Magical Belize

A proposed cruise terminal 6 kilometres south of the Sibun River, Belize District, Belize C.A.

PREPARED BY:

Sustainable Development Consulting Services

"Developing sustainably is a win-win for everyone"

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Glossary of terms

AD	Agriculture Department
ADD	Acoustic Deterrent Devices
AMSL	Above Mean Sea Level
AST	Above Storage Tank
BAS	Belize Audubon Society
BEL	Belize Electricity Limited
BERDS	Biodiversity and Environmental Resource Data System of Belize
BESR	Belize Education Section Reform project
BESST	Biological Engineered Single Sludge Treatment system
BHA	Belize Hotel Association
BMP	Best Management Practices
BOD	Biological Oxygen Demand
BSI	Belize Sugar Industries
BWSL	Belize Water Services Limited
BSWMA	Belize Solid Waste Management Authority
BSWMP	The Belize Solid Waste Management Project
BTB	Belize Tourism Bond
BTIA	Belize Tourism Industry Association
BWSL	Belize Water Services Limited
CARICOM	Caribbean Community and Common Market
CBA	Central Building Authority
CBOs	Community-based Organization
CD	Chart Datum
CEMO	City Emergency Management Organization
CEO	Chief Executive Officer
CITES	Convention on International Trade of Endangered Species of Wild
CZMAI	Belize Coastal Zone Management Authority and Institute
DEM	Digital Elevation Model
DO	Dissolved Oxygen
DOE	Department of Environment

DRM	Disaster Risk Management
ECP	Environmental Compliance Plan
EIA	Environmental and Social Impact Assessment
EPA	Environmental Protection Act
FCCA	Florida- Caribbean Cruise Association
FD	Forest Department
FFPA	Forest Fires Protection Act
FiD	Fisheries Department
FSTV	Fort Street Tourist Village
gal/H	Gallons per Hour
GDP	Gross Domestic Product
GPD	Geology and Petroleum Department
GOB	Government of Belize
gp/d	gallons per day
GSDS	Growth and Sustainable Development Strategy
IAC	Inter-American Convention for the Protection and Conservation of Marine Turtles
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IDF	Intense Duration Frequency
IUCN	International Union for Conservation of Nature
KHMH	Karl Heusner Memorial Hospital
LDC	Less Developed Country
LIC	Land Information Center
LLES	Limited Level Environmental Study
LNG	Liquified Natural Gas
LUA	Land Utilization Authority
LUC	Land Use Classification
MARPOL	International Convention for the Prevention of Pollution from Ships
mg/l	milligram per liter
MEAs	Multilateral Environmental Agreements
MMO	Marine Mammal Observer
MOH	Ministry of Health

MOU	Memorandum of Understanding
MOW	Ministry of Works
MSC	Mediterranean Shipping Company
NCL	Norwegian Cruise Lines
NDC	Nationally Determined Contributions
NEAC	National Environmental Appraisal Committee
NEMO	National Emergency Management Organization
NGOs	Non-Governmental Organizations
NHS	National Health Services
NICH	National Institute of Culture and History in Belize
NIWRA	National Integrated Water Resource Authority
NMS	Belize National Meteorological Service
NPSH	National Parks System Act
PA	Protected Area
PACT	Protected Areas Conservation Trust
PAM	Passive Acoustic Monitoring
PCB	Pesticides Control Board
PCQM	Point Centered Quarter Method
PIANC	Permanent International Commission for Navigation Congresses
PSWGIA	Philip S. W. Goldson International Airport
PTS	Permanent threshold shift
PUC (Act)	The Public Utilities Commission Act
ODS	Ozone Depleting Substances
OIC	Out Island Construction
SBR	Sabre Sequencing Batch Reactor
SPV	Special Purpose Vehicle
SOP	Standard Operating Procedure
SRSB	Sibun River Sub-Basin
SRSB 5th-2	Dry Creek Sub-Basin
SRSB 5th-2	Caves Branch Sub-Basin
SWaMA	Solid Waste Management Authority
TDS	Total Dissolved Solids

TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TOR	Terms of Reference
TSS	Total Suspended Solids / Temporary Threshold Shift
UNCBD	United Nations Convention on Biological Diversity
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCC	United Nations Framework Convention on Climate Change
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WMO	World Meteorological Organization
WPA	Wildlife Protection Act

Executive Summary

Background of the Project

Portico Enterprises Limited, a limited liability company registered under the Companies Act, Chapter 250 of the Substantive Laws of Belize, Revised Edition 2000, proposes to develop the Port of Magical Belize, a unique cruise ship port in Belize. The company was officially registered on the 28th day of August 2017. Portico Enterprises Limited will be owned by a consortium of local and international strategic investors.

In September of 2017 Portico Enterprises Limited signed an MOU with the Government of Belize through which the Government is supportive of the objective of Portico to develop a mainland cruise port. On May 11th, 2019, Portico signed a Joint Development Agreement with Royal Boskalis Westminster Contracting Ltd. – Abu Dhabi Branch (Boskalis). Boskalis is a Dutch dredging company with 110 years of engineering design and dredging experience. Boskalis is investing in development capital, providing engineering and design services, and is committed to taking an equity position in the corporate structure.

Portico and Boskalis propose to construct a cruise ship terminal situated along the coastline, some 8 miles south of Belize City. The development consists of the dredging of a navigational channel, reclamation of land from dredged materials, construction and operation of a cruise terminal, piers, and associated amenities and infrastructure including shops, restaurants, cabanas, etc. An information and booking center will also be created. A hotel with beaches and related facilities will also be built. The development will also include a roadway (including a bridge across the Sibun River) running parallel to the coastline connecting the project site to the George Price Highway in the vicinity of Old Belize.

The goal of the Management of the Port of Magical Belize is to provide a safe, secure and efficient cruise ship terminal which includes piers for the berthing of cruise ships. This will encourage current and new cruise lines to move a greater number of cruise passengers through the Port. The company aims to market and provide cruise ship services and facilities that will maintain and grow the cruise business in the Belize District area, while creating job security for those already engaged in cruise tourism, generating employment opportunities for many more stakeholders, and contributing significantly to the economic growth of Belize.

Justification of the Project

Cruise tourism commenced in Belize when in 1998 Norwegian Cruise Lines and Premier Cruises made their first visits. In 2001, Royal Caribbean Cruise Lines and Carnival Cruise Lines made their first calls and the Fort Street Tourism Village opened shortly thereafter as a tender port. However, the tender distance is 4 miles with travel time of approximately 20 to 30 minutes and this is partly responsible for the fact that only 85% of the total cruise passengers will come ashore while in Belize. Despite this, the industry has seen significant growth, but it has long been

established that Belize needs a proper Cruise Port facility if it is desirous of sustaining a viable Cruise tourism industry and accommodating the full potential of the industry's growth.

The development of an economically viable, strategically located cruise port would be a significant boost to the tourism industry as well as the economy of Belize.

In summary, Belize is fast approaching the critical juncture where a mainland docking facility will be the only long-term solution for a truly economically viable cruise industry. While there have been several proposals to develop a Cruise Port in Belize, for a myriad of reasons they have not met the requisite criteria. The Port of Magical Belize offers the most social and economic long-term benefits to the country and, perhaps of equal importance, it is projected to be the most environmentally and operationally efficient option for the cruise lines.

Location of the port

The port will be strategical located in the Belize District approximately 8 miles south of Belize City along the coastline. This particular site was chosen because it is considered to be sufficiently close to Belize City (short transport routes for stakeholders), free of any housing or roads (no displacement), and the local marine environment is considered by the local experts as not-sensitive. The project location has several advantages to the tourism industry compared to the present operating model. These are as follows:

- Safer navigation pathway to terminal location for cruise vessels, now and for future bigger vessels;
- Docking facility (eliminates tendering), safer disembarkation operations for passengers;
- Bypasses narrow streets in Belize City (prevention of congestion), safer, and improved access to tourist locations with more time available for full day tours;
- Location provides an opportunity for exciting and new shore excursions;
- Belize City will become an even better tour destination.

Description of Existing Environment

There are no protected areas within or directly bordering the project site. On the terrestrial side, the closest being Peccary Hills National Park located 5 km (3.5mi) west of the project and Burdon Canal Nature Reserve located about 9.5km (5.9mi) north of the property but less than 1km (0.6mi) from the point where the proposed road will join the George Price Highway.

On the coastal and marine side, Gales Point Wildlife Sanctuary and Manatee Forest Reserve are an estimated 10 km (6.2mi) south of the project at its closest point.

The immediate local environment (i.e. 2 km east of the coastline) can be characterized as being shallow, highly sedimented and turbid mainly from prevailing action from longshore current and

wave action along the coastline. The area is not a commercial fishing site and only subsistence fishing is known to occur in the area. No sensitive areas (i.e. coral reef and seagrass) for marine wildlife was identified within the project site. However, patch reef characterized as being already impacted (i.e. are bleached and sedimented) and sea grass beds were identified within the zone of influence. Depending on final access channel route selected, dredging for the proposed access channel will likely start in proximity (i.e. approximately 0.5 miles) away from the patch corals and sea grass beds and may potentially be impacted by dredging activities.

On the terrestrial side, based on ecosystem maps and terrestrial assessments, the project site and zone of influence is best described as consisting of 4 major ecosystems (i.e lowland broad-leafed moist forest, mangrove forest, littoral forest, and wetland). However, lowland broad leafed moist forest and mangrove and associated littoral forest are dominant within the property. While the terrestrial component of the project site is within the Sibun River Watershed and there are mangrove fringes along the coastline, no sensitive habitat for terrestrial wildlife was identified within the project site and zone of influence.

There are no communities immediate to the project site. The closest community is Ferguson Bank located some 7km (4.3mi) north of the project site.

Environmental Impact Assessment (EIA)

The main objective of this EIA is to carry out studies to determine both the adverse and beneficial environmental consequences of the proposed project on human health and the natural and socio-economic environment. Additionally, the EIA will ensure the development of mitigation measures to address the negative consequences during project development and operation and to develop measures to enhance the positive impacts.

Alternatives

Project alternatives that could result in a major change in the significance of the project's social and environmental impacts have been assessed in the EIA, as there is the no-project alternative, varieties on the shape of the development, approach routes, dredge techniques, disposal options, etc. Based on the alternative assessment the following is concluded:

- The "no project" alternative, if the project will not be developed, no impacts due to construction and operation (air and noise impacts, impact on water quality, etc.) will occur. However, the tourist industry will grow in other places as for instance in Belize City. If this is the case, the unsafe situation with the tendering of passengers and arriving in Belize City will continue to exist and will become even more a safety and security issue in addition to the nuisance due to congestion. Moreover, every new development needed for the increasing amount of cruise passengers that is projected for Belize will need developments involving dredging and construction of terminals leading to more or less the same impacts due to sensitivity of the receiving environment in other proposed locations. If the development will not be in Belize but

in neighbouring countries, the related economic benefits of future cruise tourism will not be for Belize as well. Considering the above the 'no project 'option is discarded.

- Several varieties on the shape of the development have been considered, ranging from a development completely on land, on a peninsula and a development totally on an island at sea. Basically, the peninsula shape (development partially on land and partially on reclaimed land in front of the coast) has been chosen on the best ratio between 'cut' and 'fill' of land (dredged material is used for the creation of the peninsula). Although financially driven, an optimal use of dredge spoil is also environmentally preferred as there is an optimal reuse of dredge spoil (less disposal and less additional raw material use). Some 50% of the dredged material will be reused in the area to be reclaimed. The other 50% will need to be disposed onshore.
- The disposal option as considered in this EIA is disposal on land. Although not preferred in Belize, disposal offshore could be an option as well and could be further assessed when for instance a disposal area on land is no longer available, or if the government allows for offshore disposal during ~~now and~~ the construction.
- In an early design phase several approach routes are considered, based, among others, on navigation possibilities and risks, and volumes to be dredged. Two preferred options are considered and assessed in the EIA. The most important conclusions of this assessment are that coral reefs (very small patches of) are located 600 to 700 m from the offshore onset of the access channel and although it can be expected that fines will be released, and under certain wind conditions be directed with the current towards the coral reefs, the associated sediment concentration is estimated to be limited. The impact is limited because the dredged material is disposed at minus 40 meter. However, the associated sediment concentration needs to be confirmed with an in-depth study once more in-situ data has become available and monitoring will be implemented.

Potential Impacts and Mitigation

The nature of the proposed project, field inspections and observations, concerns from stakeholder consultations and issues from relevant literature search formed the basis for the identified potential environmental issues and impacts associated with the project. A set of mitigation, monitoring, and institutional measures to be taken during planning and design, construction, operation and maintenance, of the works proposed under the development have been developed. The objective of these measures is to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels. The EIA includes practical actions needed to implement these measures.

The main potential positive impacts are related to the socio-economic conditions of the communities within the zone of influence and the economy of the country of Belize as a whole. The social assessment identified the following positive impacts of the proposed development:

- Increased foreign exchange earnings for Belize;
- Direct employment for workers during construction (building, etc.) and operations (shop owners, etc.) of the port;
- Indirect employment from supporting services (tour guides, catering, supplies, etc.)
- Business and training opportunities (training of employees, tourist events, vocational training, etc.);
- Prevention of fuel burning when vessels are parked in front of FSTV (in the no project scenario).

It is undeniable that a project this size will have negative impacts. However, the selected mitigation measures will reduce these to acceptable risk levels. Activities to monitor the effectiveness of the defined mitigation measures are defined. The following are considered the major areas of concern and their proposed mitigation measures.

- Impacts related to dredging and its sediment, mitigated by an optimal route selection and the application of Adaptive Dredging Management.
- Impacts related the reclamation, managed by replanting of mangroves and reforestation for coastline protection against storm surges and erosion.
- Impacts related to disposal of the dredge spoil, mitigated by disposal of dredge spoil on land (preferred by DOE) and the early rehabilitation of the dredge spoil area.

The following table gives an overview of the above described, including the residual impacts as a result of the implementation of mitigation measures developed for the specific potential impact.

Summary Impacts, Mitigation Measures and Residual Impacts – Construction.

Topic area	Mitigation /Enhancement	Residual Impact
Impacts on Marine Water Quality • Increased sedimentation • Increased turbidity	• Adaptive dredging management • Appropriate management of dredge spoil disposal area	**Minor**
Impacts on hydrological and bathymetric characteristics • Increased erosion • Changes to sediment transport	• Adaptive dredging management • Erosion control measures such as	**Minor**
Impacts on General Ecology • Loss of benthic habitat • Decreased productivity of mangroves	• Establishment and implementation of a biodiversity monitoring program • Replanting of vegetation	**Minor**

• Disturbance to marine fauna	• The establishment of a mitigation zone around the piling. • A pre-piling marine mammal search. • The implementation of soft-start and ramp-up procedures. • Timing of works	
Impacts on Nearshore Ecosystems • Reduced population of salt water fauna: crocodile, dolphin population, sea turtle and manatee	• Adaptive dredging management • Establishment and implementation of a biodiversity monitoring program. • The establishment of a mitigation zone around the piling. • A pre-piling marine mammal search. • The implementation of soft-start and ramp-up procedures.	**Minor**
Impacts on Economic Activity • Increase in jobs • Increase in commerce • Economic stimulation/GDP growth • Increased availability of foreign currency • Training	• Training: Employment of skilled labour from other parts of the country • Laborers are to be paid relative to skills and experience at competitive rates with pre-existing construction activities, and hotels and resort development. • Commerce/business opportunities for locals • Growth of passengers • Payments in USD by liners	**Positive**
Impacts on health and safety • Increased noise pollution • Increased health impacts	• Operators and local staff are to be trained in the proper operation of machinery and equipment as well as in safety procedures. • Proper equipment will be provided to workers	**Moderate**

Summary Impacts, Mitigation Measures and Residual Impacts – Operation.

Topic area	Mitigation	Residual Impact
Impacts on Marine Water Quality • Increased nutrients (nitrates and phosphates) • Increased fecal coliforms • Increased hydrocarbons • Increased solid wastes	• Appropriate solid and liquid waste management. Including a liquid waste treatment system. • Enforcement of the international and local laws and regulations regarding cruise ship waste management and operations while in Belizean waters. • Storm water drainage system will collect, convey, treat (where necessary) and discharge the storm water that will run off the port. • All storm water conveyance drainage infrastructure will be designed to handle peak flows resulting from rainy season. • Fuel sited and tanks housed in facility as per guidelines and requirement by relevant local authorities (DOE and BWMS)	**Minor**
Impacts on hydrobiological characteristics • Increased solid waste	• Appropriate solid and liquid waste management. Including a liquid waste treatment system. • Enforcement of the international and local laws and regulations regarding cruise ship waste management and operations while in Belizean waters.	**Minor**
Impacts on Economic Activity • Increased tour operations • Increased sports fishing activities • Increased jobs • Increased commerce • Infrastructure development • Foreign exchange • Economic stimulation/GDP growth	• The project proponent will develop employment criteria to assure fair labour practice and fair allocation of jobs (based on competences). For in-house jobs, much effort is to be expended in the training of unskilled and junior staff from the area.	**Positive**

Conclusions

Extensive studies were carried out and consultations were held with individual stakeholders and stakeholder groups as part of the information gathering on environmental and socio-economic issues, to create an open and transparent development process. There are genuine concerns regarding the negative impacts of the development such as: impacts related to dredging and disposal of the dredge spoil, damage to mangrove vegetation, and competition of the tourist sector with other sectors. However, in general the feeling towards the project is conceived as positive by the stakeholders consulted and the residual impacts are considered mostly minor after application of available mitigation measures.

PART A PROJECT DESCRIPTION AND PHYSICAL ENVIRONMENT

1 Project Description and Layout Plan

1.1 Company Background and Project Introduction

1.1.1 Company Background

Portico Enterprises Limited (Portico), a limited liability company registered under the Companies Act, Chapter 250 of the Substantive Laws of Belize, Revised Edition 2000, proposes to develop Port of Magical Belize (also referred to as the Port or the development) a one of a kind cruise ship port in Belize, Central America. The company was officially registered on the 28th day of August 2017. Registration documents are included in **Annex 4**. Portico will be owned by a consortium of local and international strategic investors.

In September of 2017 Portico Enterprises Limited signed a memorandum of understanding (MOU) with the Government of Belize through which the Government is supportive of the objective of Portico to develop a mainland cruise port. On June 14th, 2019, Portico signed a Joint Development Agreement with Royal Boskalis Westminster Contracting Ltd. - Abu Dhabi Branch (Boskalis). Boskalis is a Dutch dredging company with 110 years of engineering design and dredging experience. Boskalis is investing in development capital, providing engineering and design services, and is committed to taking an equity position.

Portico and Boskalis proposes to construct a cruise ship port situated along the coastline, 6 km (3.7mi) south of the Sibun River in the Belize District. The development consists of a cruise terminal pier and associated navigation channel (partly to be dredged), berths along a jetty and a reclamation area. The reclaimed area will be built using some of the dredged material potentially supplemented with material barged from the mainland and/or dredged from the mouth of the Sibun River. The road will connect the cruise ship docking facilities to the mainland. The reclaimed area will house several superstructures likely to include: a welcome centre, a retreat island, tourist amenities (e.g. shops, restaurants, information and booking centre, a hotel, cabanas, etc.) and beaches with facilities. The development will also include a roadway (including a bridge) running along the coastline connecting the project site to the George Price Highway in near Old Belize.

The goal of Port of Magical Belize is to provide a safe, secure and efficient cruise ship terminal which includes berthing docks for moorage of large cruise ships to encourage current and new cruise lines to move a greater number of cruise passengers through the Port. The company aims to market and provide cruise ship services and facilities that maintain and grow the cruise business in the Belize District area, while enhancing the economy of the Country, protecting jobs and providing a reasonable rate of return to the Port and all stakeholders.

1.1.2 Project Introduction and Justification

Cruise tourism commenced in Belize when in 1998 Norwegian Cruise Lines and Premier Cruises made their first visits. In 2001, Royal Caribbean Cruise Lines and Carnival Cruise Lines made their first calls and the Fort Street Tourism Village opened shortly thereafter as a tender port. However, the tender distance is 6.5 km (4 miles) with travel time of approximately 20 to 30 minutes and it is partly responsible for why only approximately 85% of the total cruise passengers come onshore in Belize. Despite this, the industry has seen significant growth, but it has long been established that Belize needs a proper cruise port facility if it is desirous of sustaining a viable cruise tourism industry in the long term.

The development of an economically viable, strategically located cruise port would be a significant boost to the tourism industry as well as the economy of Belize. While there has been significant growth over the years, the current status of the industry is not sustainable. From a national perspective, the economy has not grown at the pace required to meet debt obligations and employment demands. These trends certainly support the narrative that the future of cruise tourism and its related stakeholder economic benefits lies in the development of a strategically located cruise port.

The Florida-Caribbean Cruise Association Cruise Industry Overview – 2019 report (FCCA, 2019) indicates that the Caribbean retained its title as the leading market for tourist deployment, accounting for more than a third (34.4 percent) of the global deployment capacity market share in 2018. This equates to approximately 9.9 million passengers annually. The same report states that another record was broken in 2018, with approximately 28.2 million guests cruising globally – a 5.6 percent increase compared to 2017's previous high of 26.7 million. Directly quoting the 2019 FCCA report, "looking to the future, the industry sees a clear path to continuing full steam ahead by building onto its strong foundation that has only begun to tap the potential of overall tourism, as cruise tourism only represents about 2 percent of the world travel market. To support this, FCCA Member Lines have 72 ships on order between 2019-2027, which will add more than 240,000 lower berths and reflect an investment of $57.6 billion. While many of those ships are large in both features and capacity, with 16 ships to sail with 5,000 or more guests, they also show further differentiation and growth of sectors like luxury and expedition, with 14 ultra-luxury and expedition ships on order."

Accordingly, it is anticipated that, with the development of a cruise port, Belize would be able to benefit significantly from the increases cited above. This is due to the fact that the port would be able to accommodate visits from larger ships (tendering by more than 5,000 passengers is not an option according to the cruise liners) that cannot access the tender port currently available, as well as attract visits from cruise lines that do not currently have Belize on their itineraries. Furthermore, since the port is strategically located, it would be conducive to an increase in the number and quality of the tour products. All these additions would equate to increases in passengers, tours and

other direct and indirect supplier income. Of course, this would also translate to increases in the various government taxes and employment opportunities for the country.

In recent years, there have been discussions for the development of a cruise port in two additional locations, south and southeast of Belize City. While the locations have access to deep water, one requires construction of 8km causeway over an environmentally sensitive area and trafficking of hundreds of buses via Belize City, which would result in congestion on cruise ship days. Furthermore, in both instances these project sites are north of One Man Caye channel, a narrow and dangerous passage through which all ships must continue to pass if they were to access the proposed sites. This will not be an easy fit for the new generation of larger cruise ships that are being constructed and will be the fleet of the near future.

In 2014 Norwegian Cruise Lines (NCL) relocated its ships south of Belize City to the Harvest Caye, NCL ‘s purpose-built port. However, the Belize City region has a greater population base that is already involved in tourism. Furthermore, Belize City offers unique shore excursions that are not accessible from Harvest Caye due to time constraints. These excursions include signature Cave Tubing and access to four (4) Mayan Archaeological Sites.

To put the above in perspective it is worth mentioning comments quoted in a CentralAmericaData.com article entitled ― Cruise Ships Need Specialized Ports (*https://m.centralamericadata.com/en/article/home/Cruise_Tourism_Growing_at_15_a_Year_in_Central_America*). The article quoted Richard Sasso, President and chief executive officer (CEO) of Mediterranean Shipping Company (MSC) Cruises USA, who stated that “one of the main issues is having suitable docks so that cruise ships can dock directly, instead of using small boats to unload passengers in groups, as this causes many delays.” In addition, according to Sasso, when one of their cruise ships arrives at a destination it needs a lot of attractions for tourists. "I have 3,000 passengers on a ship, when I arrive, what to do? I need a lot of things inland." "I need a combination of a lot of things: the port, infrastructure, attractions, buses". The article also quoted Amilcar Cascias, Vice President of Tour Operations for Carnival Cruise Lines, who stressed that "success stories come from ports that have created segregated areas to cater to cruise ships.” The site location for the Port of Magical Belize addresses these concerns and many more.

In April 2017, a purchase agreement for a 250 acre (1 km^2) parcel of land located along the coastline approximately 6km south of the Sibun River in the Belize District. There is consensus that the proposed location is ideal for the construction of the Port of Magical Belize. Furthermore, it will attract visits from cruise lines that do not have Belize as a destination on their current itinerary and allow for port calls from the larger ships of all cruise lines. As can be seen from the **Table 1-1** below, the cruise passenger visits are far less in Belize than the other Western Caribbean Countries listed. These locations either have cruise terminals or a relatively short tender distance. It is strongly believed that the Port of Magical Belize will realize comparable or greater passenger visits for Belize, resulting in far reaching and long-term benefits to its many stakeholders. The

primary driver for this expectation is that Belize has the potential to provide a similar water excursion experience, as well as very popular excursions to world renowned archaeological sites.

This, and other unique inland excursions that Belize can offer, do not have comparable experiences in the other countries listed. In fairness, it must be mentioned that each country clearly has attractions that are in demand, but it is felt that Belize has a significant amount of untapped potential that would be realized with the proper cruise infrastructure in place.

Table 1-1. Cruise passenger visit - Western Caribbean '000.

Destination	2014	2015	2016	2017	2018	2019
Belize city region	**868**	**958**	**1,005**	**666**	**843**	**786***
Belize, Harvest Caye	-	-	-	237	365	356*
Cayman Islands	1,610	1,717	1,712	1,728	1,921	1,446*
Cozumel	2,700	2,972	3,600	4,110	4,296	Not available
Jamaica	1,422	1,568	1,653	1,923	1,846	Not available

*Estimate

The map below (**Figure 1-1**) provide a visual of the proposed location and its significant advantage when compared to the current and previously proposed locations.

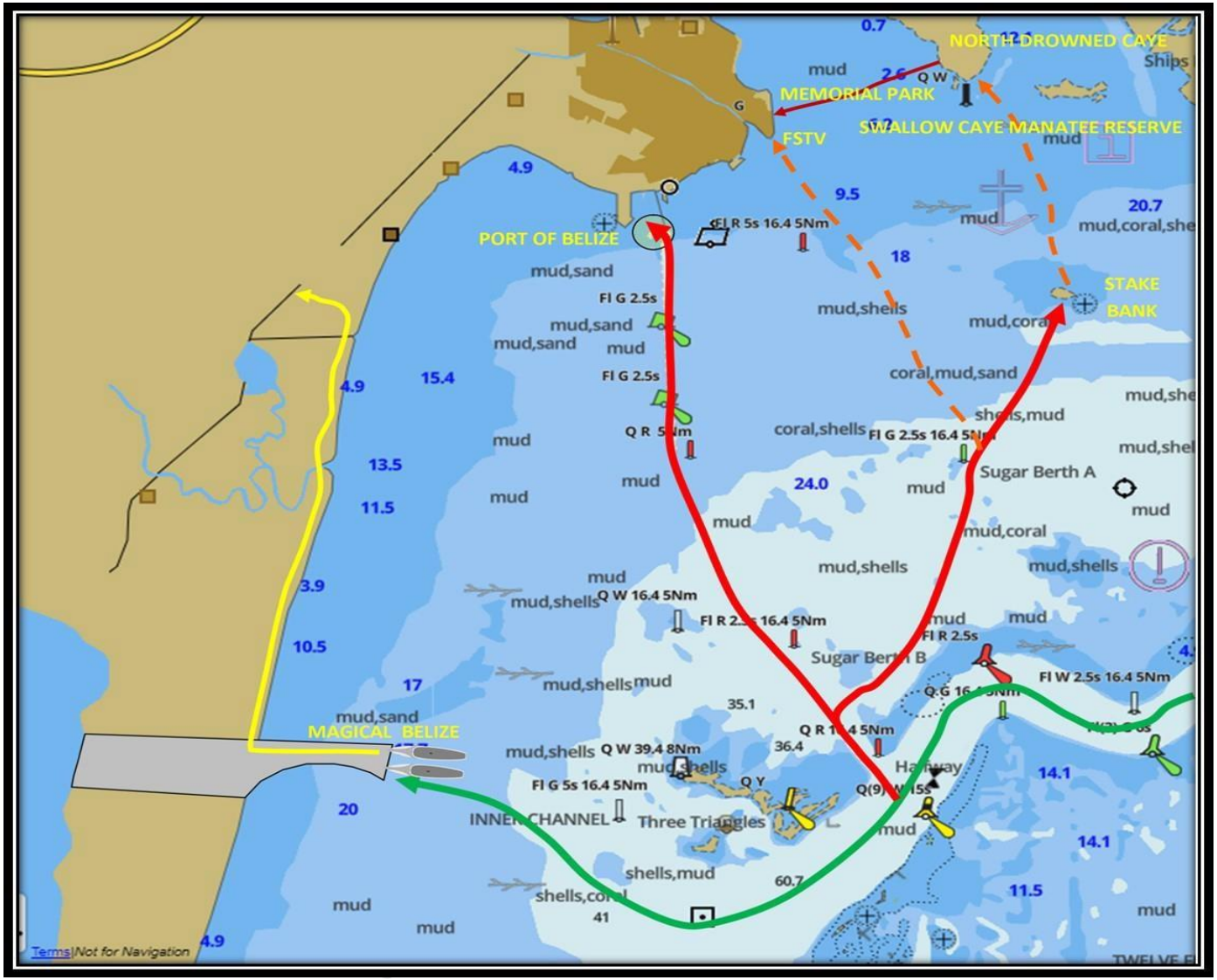


Figure 1-1: Map showing the location of the three proposed cruise ports.

In summary, Belize is fast approaching the critical juncture where a dedicated port will be the only long-term solution for a truly economically viable cruise industry. While there have been several proposals to develop a cruise port in Belize, for a myriad of reasons they have not met the requisite criteria. Port of Magical Belize offers the most social and economic benefits to the country and, perhaps of equal importance, it is projected to be the most environmentally and operationally efficient option for the cruise lines. Furthermore, Portico understands the importance of environmental consciousness in the development of its port as this type of activity may affect environmental elements including water, soil and air. With this in mind, the Port of Magical Belize is proposed to be sited at an area that has been corroborated by studies to be of reduced environmental sensitivity compared to other possible sites. Regardless of those factors, the developers understand the importance of obtaining environmental clearance for their development and will work along with the DOE to ensure that the Environmental and Social Impact Assessment Regulation and all other relevant environmental laws are followed and complied with in the development and operation of Port of Magical Belize.

1.2 Project Location

The Port of Magical Belize is proposed to be located in the Belize District approximately 6km (3.7mi) south of the mouth of the Sibun River and 14.2km (8.8mi) south of Belize City along the coastline (**Figure 1-2**). The proposed docking facilities are to be sited in approximately 185 acres (75 hectares) of reclaimed land. Port infrastructure will be sited both on the reclaimed land and on a parcel of land described by UTM NAD 1927 Zone 16N coordinates as seen in **Table 1-2** below:

Table 1-2: Port of Magical Belize Limited General Boundary Coordinates.

Corner	Easting	Northing
Northeast	364632.207	1920818.525
Northwest	361301.959	1920828.203
Southeast	364552.633	1920367.968
Southwest	361269.699	1920477.65

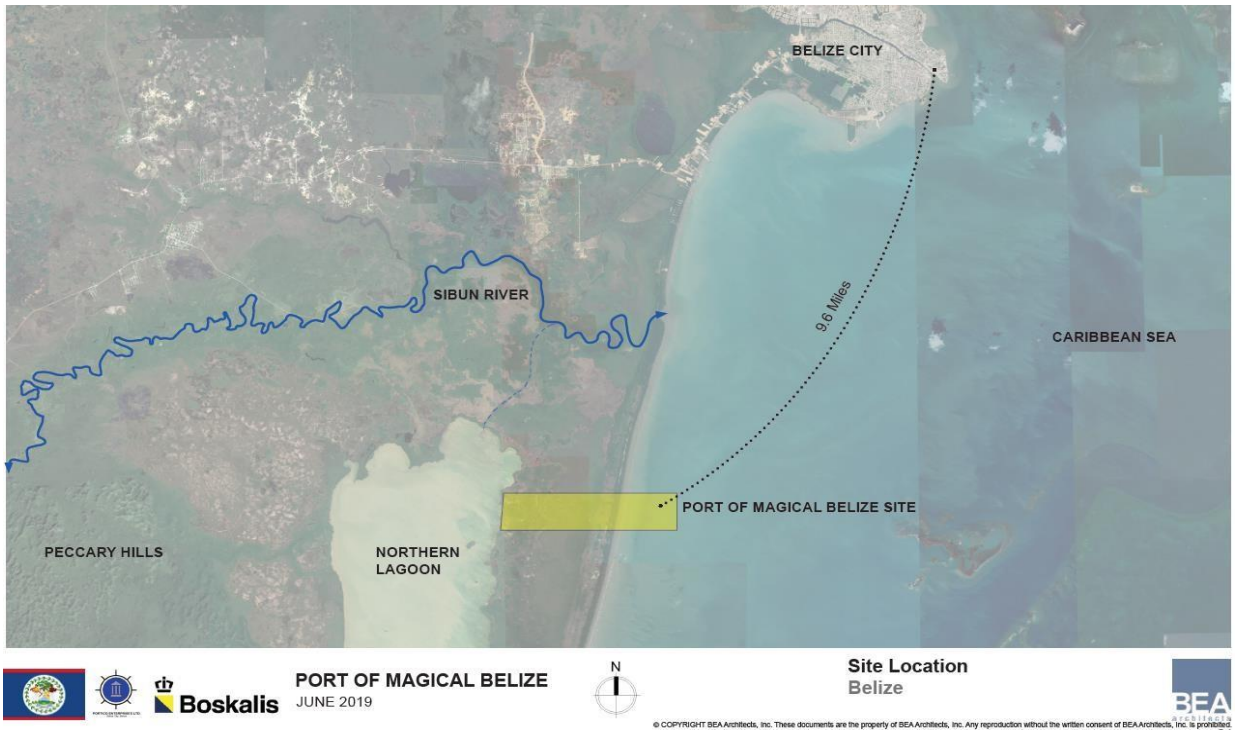


Figure 1-2: General Location of the Port of Magical Belize in Reference to Belize City

Other communities in the vicinity of the project site include Ferguson Bank, Freetown Sibun, Hattieville, Rockville, Watters Bank and Gales Point which are 7km (4.3mi) north, 16.6 km (10.3mi) south west, 22km (13.5mi) north west, 17.6km (10.9mi) west, 27.7km (17.2mi) south east and 21.4km (13.3mi) south west of the project site respectively (**Figure 1-3**).

Figure 1-3: Port of Magical Belize project site in relation to proximal communities.

The project site is strategically located within close distances and access to sites and activities that are popular with current cruise ship passengers (**Figure 1--4**).

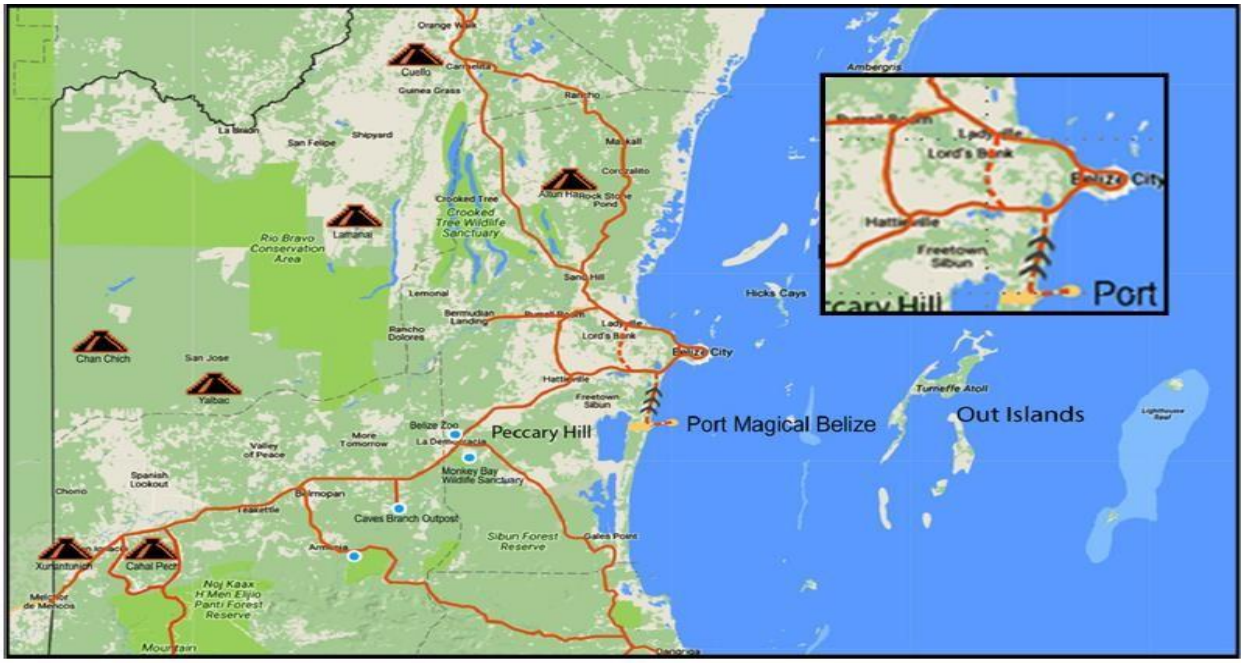


Figure 1--4: Access routes and commonly visited tourist destinations in in-land Belize.

Currently, the main access to the project site is by water either through the sea leaving from Belize City or through the Sibun River. However, once completed, the main access to the project site will be through an all- weather road connecting the project site to the George Price highway near Old Belize. The road will be built along the coastline as shown in **Figure 1-5**.

Figure 1-5: Access routes (road and navigation) to Port of Magical Belize.

The project location (**Figure 1-5**) has several advantages to the tourism industry compared to the present situation as follows:

- Safer navigation pathways to port location; avoids navigating through "One Man Caye channel" which features a 145 degree turn to starboard for access to Belize City area. This channel is narrow and cruise line executives have expressed concern about having their larger ships (6,000 passengers plus crew) sailing through this channel. Additionally, ships will consume less fuel to access new area.

- Provides mooring facilities (eliminates tendering); therefore, ships will be able to spend at least an additional hour or more in Port and it is safer for the passengers. This means more time for tours and other revenue generating activities for cruise passengers and crew.
- Bypasses narrow and congested streets in Belize City, which will result in faster access to traditional tour sites and more time spent by tourists in Belize and increases safety (less traffic and decreases air pollution (less traffic) in Belize City. Additionally, it avoids exposure to the overcrowded and developing parts of Belize City which would clearly be visible from the upper decks of ships
- Larger ships that are coming on stream will be able to access and dock directly at a port facility.
- Location provides an opportunity for exciting new shore excursions.
- With the building of a 6 km road and a bridge over the Sibun River, all existing attractions are more readily available as travel time through Belize City is avoided.
- Belize City will become a Tour Destination.
- According to experts with extensive cruise port development experience, a project in this location can be completed within approximately **36 months**. This assumes seabed reclamation and extension along the coast.

1.3 Project Phasing and Layout Plan

The Project will be undertaken in the two phases:

- Phase 1 - Site preparation, fencing, temporary routes, preparation peninsula, dredging access channel and turning basin back filling onshore part and peninsula (incl. pre-load), pre-loading, construction cruise jetties, construction buildings, construction road infrastructure, beaches, cabanas, termination, testing and commissioning
- Phase 2 - Construction of amenities and jetty 3.

If the project is successful construction of further amenities, for example marinas and onshore amenities, might be included, however this would be subject to a separate impact assessment and is not considered in this document.

The overall layout plan of the project is presented in **Figure 1-7**. The timing of the project is described in Section 1.6 (Project Timeline) in this chapter. It must be noted that these figures are included to give an overall picture of what could be expected to be developed. Further detailing will be done based on environmental, social, technical and financial considerations. The development broadly consists of a navigation channel (partly to be dredged), berths along a quay or jetty and a reclamation area of approximately 75 hectares (180 acres). Other major components of the project include a dredge spoils dewatering site, tourism amenities to be constructed on reclaimed land, the road construction (network within the property and access to the property) and other infrastructure associated with the project such as administrative buildings, hotels, restaurants, over-the-water structures, beaches with facilities etc.

Figure 1-6: Masterplan Layout

1.3.1 Nautical Layout

Boskalis in-house engineering department Hydronamic has determined the preliminary nautical design of the cruise terminal, see memo P34020-FJOL-3-0 in **Annex 7** based on the Oasis class cruise ship characteristics, see **Figure 1-7**. The principle horizontal and vertical dimensions are explained in the next sections. The preliminary design has considered recommendations following navigation simulations conducted by Simwave (2019).

Figure 1-7: Design ship characteristics.

Parameter	Unit	Phase 1
LOA	m	362
Beam, waterline	m	47.5
Max. draft	m	9.3

The design of the proposed channel is presented in **Figure 1-7** below.

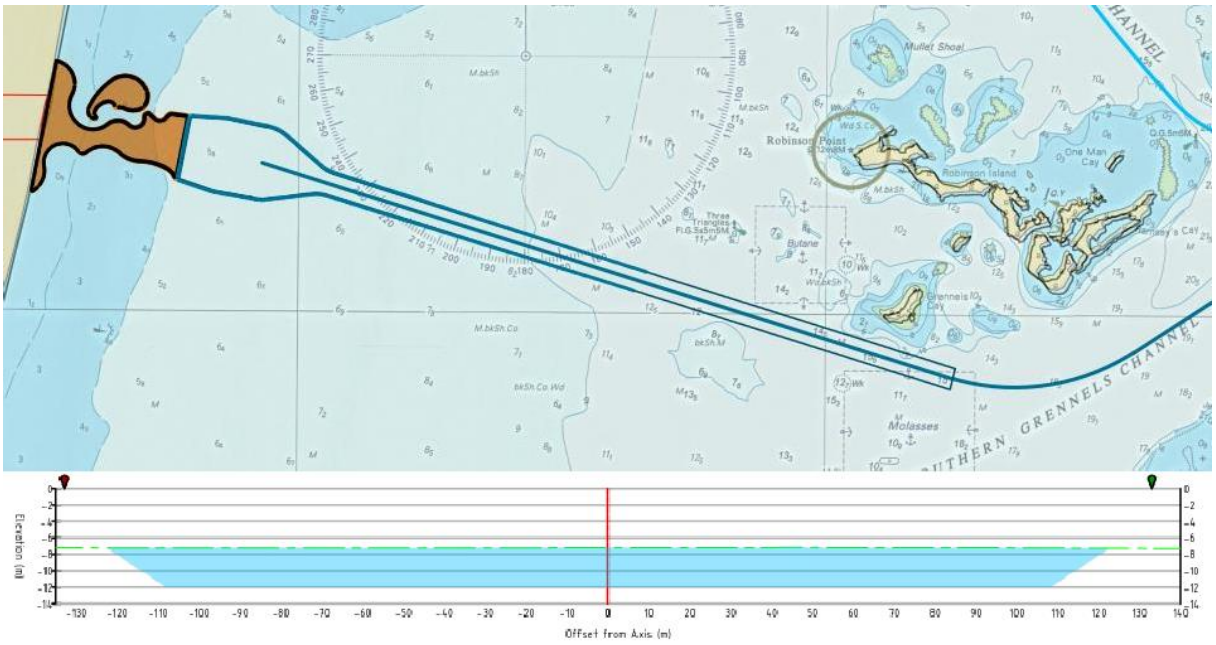


Figure 1-8: Proposed channel design for Port of Magical Belize (top view and cross-section).

Vertical Design

For the vertical design of the navigation channel Permanent International Association of Navigation Congresses (PIANC) guidelines are applied. At this stage, a nominal level of CD-12.0m is advised. This can be determined in more detail in a later stage considering allowable physical conditions, allowable downtime and sailing speed (higher speeds: longer stays, increased channel depth and width due to squat amongst others). PIANC 152 (**Section 2.5.2**) recommends a berth depth of draught + 2.0m, which would imply a depth of CD-11.3m. At this stage, the same depth is assumed as the navigation channel.

Horizontal Design

In **Figure 1-9** the principle horizontal dimensions are provided, distinguishing the access channel, turning circle and berthing area.

Access channel

Based on PIANC guidelines a width of 216m (4.6 beam (B)) is advised for a one-way straight channel, see Annex 7.

Turning circle

Following PIANC (MarCom report No. 121, 2014, Section 3.1.8.4) a turning circle diameter of 2 LOA is applied, i.e. 720m.

Berthing area

In **Figure 1-9** below, the estimated dimensions of a 3-pier layout is explained. The following is applied:

- interspace between ships of 2B is assumed, and 2B between ship and bank
- 0.5 B is assumed for bed clearance from bow
- dimensions are based on the beam at waterline, whereas maximum beam applies for hull-to-hull distance;
- Apron width of 20m based on 9.1m ship overhang, heel and safety
- This should be considered as a first, rough estimate, to be reconsidered in a later stage.

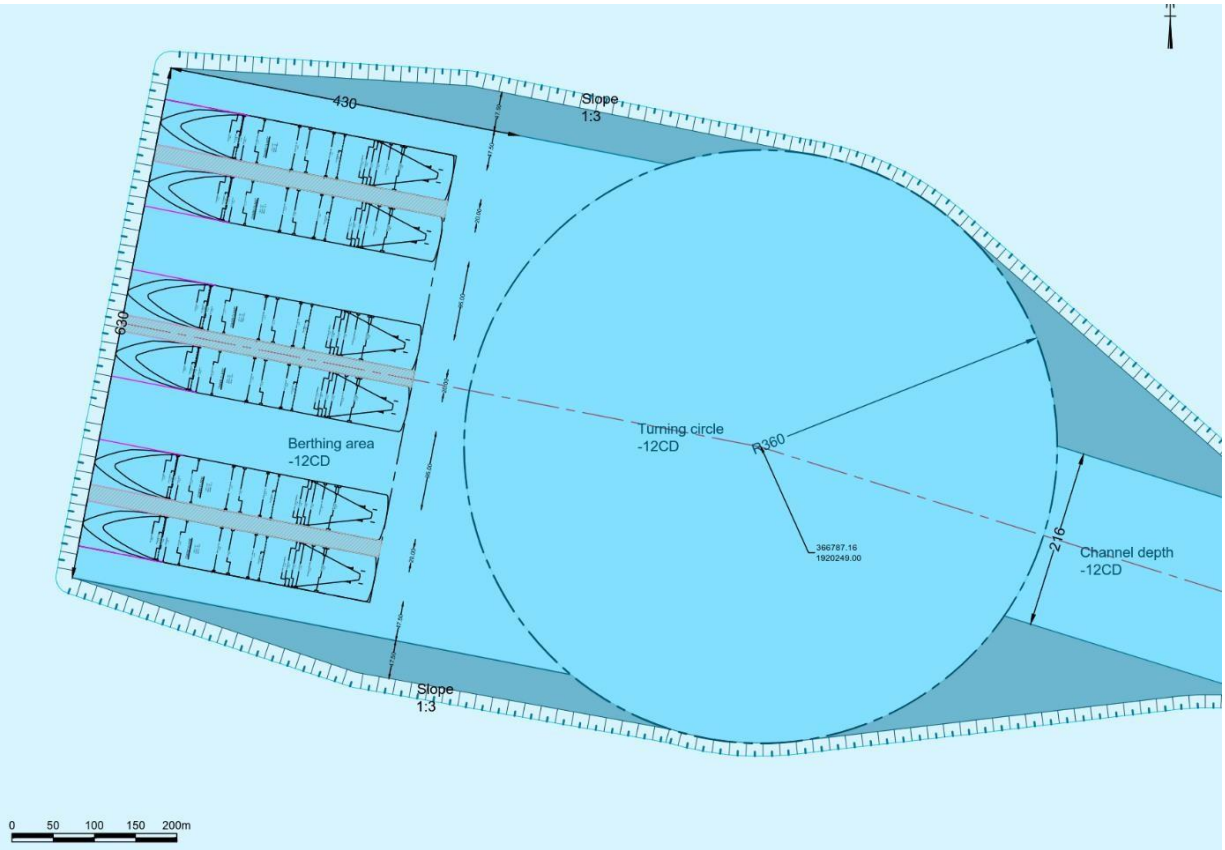


Figure 1-9: Minimal dimensions are a case of 3 parallel jetties.

Dredging slopes

At this stage, 1(v):3(h) side slopes are assumed for volume determination. This will be verified later considering the soil conditions, potentially leading to steeper slopes in the stiffer clay and gentler slope in the upper soft clays.

Dredging footprint

As a result of the horizontal and vertical dimensions described above, a seabed area of approximately 570 acres (2.3km2) will be dredged.

Navigation aids

For safe navigation, leading lights and buoys will be installed. The latter will be green and red buoys demarcating the channel and the shallows of Grannel's Cay, see **Annex 9**. Further

detailed engineering of navigation aids will be done in a later stage according to international standards, such as IALA (2018).

1.3.2 Cruise Terminal Pier

After arrival at the terminal, the vessels will berth at the pier. The cruise terminal pier will accommodate 6 larges capacity cruise ships (e.g. Oasis, Carnival XL, MSC World Class, etc.). The pier consists of three 460m long jetties with dolphins which allow the berthing of two ships, one on each side. A 20m wide deck facilitates the (dis)embarkation of the passengers between the vessel and the terminal as well as the transfer of commodities and luggage and the provision of utilities. The jetty is equipped with bollards and fenders to facilitate safe berthing and mooring of the ships. Along the entire length, the jetties are equipped with safety ladders and lifebuoys.

The jetties will be constructed using reinforced concrete decks supported by pile foundations. Tubular steel piles are used which are filled with sand and a concrete plug from just below water level till the top of the piles. On top of the piles, concrete capping beams are installed which will support the deck and the fenders. The deck is constructed with concrete pre-stressed girders which are connected with a concrete top layer. The definitive dimensioning of the elements that make up the jetty will be made once the detailed geotechnical studies have been concluded and the definitive structural calculations have been made.

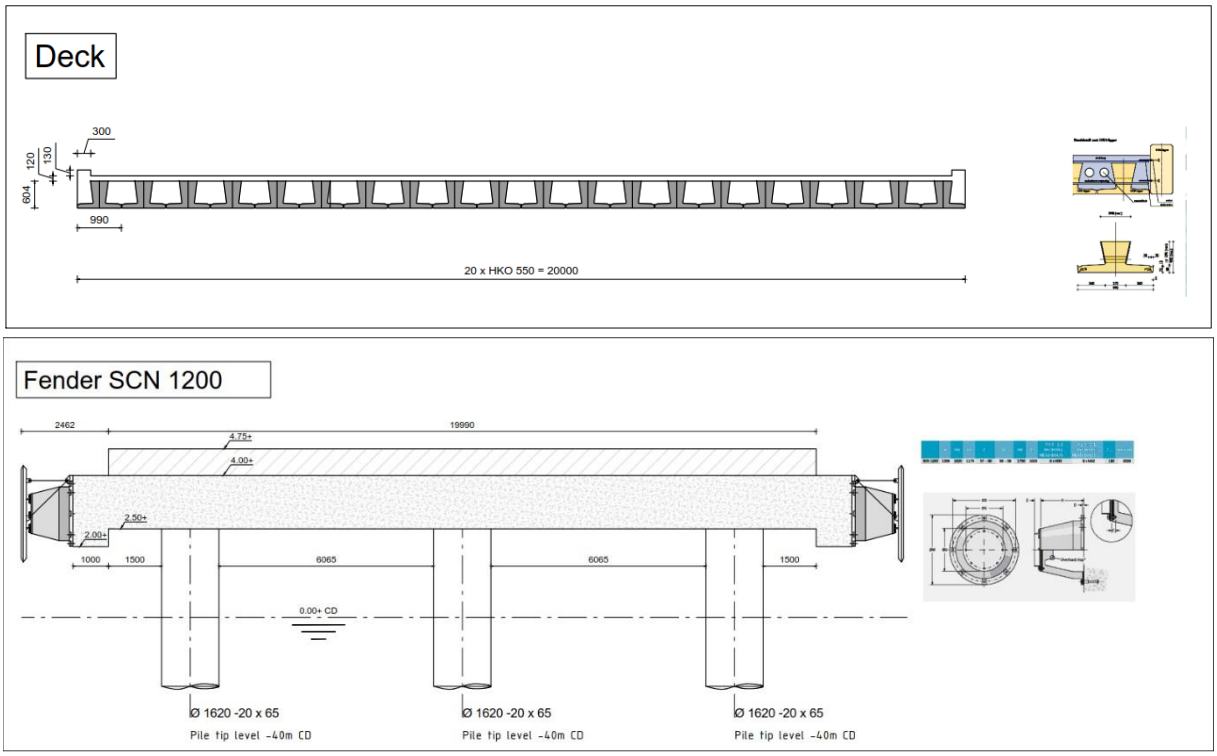


Figure 1-10: Principle cross section of jetty.

1.3.3 Land Reclamation/Artificial Peninsula and Associated Amenities

An estimated 185 acres (75 hectares) are proposed for reclamation. As a result of the slopes the total footprint is approximately 235 acres (95 hectares). "The reclaimed land/artificial peninsula and the terrestrial portion of the project site will accommodate several infrastructures/port amenities.

The Master Plan (see **Annex 8** for the full version) shows that a peninsula will be constructed with the reclamation materials from dredging of the canal supplemented with material sourced elsewhere. However, alternatives will be considered as well based on technical, financial and environmental criteria. The artificial peninsula will measure approximately 0.7km (0.4mi) wide by 1.4km (0.9mi) long. This peninsula will accommodate all the infrastructure to be constructed such as the cruise terminal to dock six cruise ship on one given day with a potential extension in the future with a third jetty for two additional cruise ships, associated amenities (as described in sections below). Water and electricity infrastructure will be run from the main line located on the George Price Highway. A 10.5km (6.5mi) road will be built from the main highway up to the peninsula in order to provide all weather access to the terminal. Below is a comprehensive summary of all infrastructures to be constructed in the peninsula.

Magical Belize Welcome Centre

A Welcome Centre facility will be built on the artificial peninsula. The Welcome Centre will be a concrete building of some 5,500m^2 (60,000sq. ft). The Welcome Centre will be a central place of the port and will be constructed in the shape of a Mayan Temple. This will be the first site that incoming cruise ships and passengers will see. The building will house, among others: a shopping mall, restaurants and bars, diving shop and several kiosks. The kiosks will be providing goods and services to visitors.

There will be a bus parking area in front of the welcome centre building providing easier and quicker boarding access of tourist to access different tour destinations. This will allow tourist to board directly from cruise ship to the buses. The cruise line will make direct arrangement with bus company and tour operators.

The construction of an aquarium for visitors to walk in and enjoy the different aquatic species such as the coral reef, fish, sea horse and other marine life is in the future plans of Portico.

Administration Building

The administration building will be located at the centre of the peninsula. The intended use of the administration building is for employees as well as for checking in and the provision of information based on the request of visitors. The security office of the securities will be stationed inside the building.

Pool Area

Several swimming pools will be constructed, each pool will include changing room, bathroom facilities and kiosks for food and beverages. Some of the pools will have water slides for children.

Magical Belize Beaches and Over the Water Bungalows

Artificial beaches will be constructed along the peninsula. As outlined in the Master Plan (see **Annex 8**), two beach areas will be established south of the peninsula with all-inclusive services. The beaches will be separated by the beach bungalows which will be constructed in the middle of the two beaches.

Some forty-double occupancy over the water beach bungalows will be constructed between the two beaches located on the southern part of the artificial peninsula. It will be constructed using treated pine timber with thatch roof and will be equipped with hammocks, beds, desk and chairs, bathrooms, jacuzzi, and food and bar services. The typical design of these over the water bungalows is shown in **Figure 1-11**. Water and Electricity will be connected from the main line which will be run from the George Price Highway to the peninsula. As shown in the Master Plan a wooden bridge will be constructed in the form of a "Y" for access and to connect to the port main facilities.

Figure 1-11: Typical over the water bungalows being constructed in Belizean resorts (Source: Pointconstruction.com)

Toucan Kids Area Facility

A kid's facility with the following amenities will also be sited in the artificial peninsula:

- Kid water pools,
- Kid water features.
- Kid water slides.
- Carnival pass area.
- Arcade centre.

1.3.4 Inland Area Amenities

The following amenities will be included in the inland section of the project:

Hotel and Casino

Port of Magical Belize proposes to construct a luxurious hotel as part of port. The hotel will house a casino. The hotel will consist of up to 300 luxurious rooms, a reception room, conference rooms, restaurant & bars and all other amenities that a hotel of this nature requires. The hotel will be constructed on mainland ground south of the peninsula as shown in the master plan. It is expected that approximately 180 persons will be employed during operation. Water and electricity for this facility will be from the main line which come from the George Price Highway.

Intermodal Centre

An intermodal centre will be sited within the inland portion of the project. The intermodal centre will serve as an area for receiving and moving containers and materials that will be used in the port.

Road

A 9.6km all whether road will be constructed connecting the project site to the George Price highway near Old Belize. The road will be built along the coastline as shown in **Figure 1-12**.

Figure 1-12: Road along the coastline.

1.4 Activities during the construction phase

1.4.1 Marine activities

The proposed area to be dredged and the land fill/reclaimed area for Port of Magical Belize are shown in **Figure 1-8**.

1.4.1.1 Dredge Volumes

The theoretical in-situ volume to be dredged is approximately 7.5Mm^3, see **Annex 9**. As a result of tolerances and uncertainties, the actual dredged volume is approximately 8.5Mm^3 of which approximately 5Mm^3 is anticipated to be suitable for a reuse during the port construction. The remaining dredged material which is considered not suitable for reuse (mostly soft clays) will need to be disposed of. During the dredging and transporting process water will added to the material which will result in an initial increase of the material volume up to 8Mm^3. Based on preliminary assessment of soil type soft silts and underlying stiff clays found in the proposed area to be dredged, it is recommended that the mouth of the Sibun River is to be dredged to source some of the required material for land reclamation proposed for the project (see **Annex 9**).

The geographic areas around the project area includes the Robinson Island, Mullet Shoal, Ramsey Caye and Grennels Caye to east at approximately 6 km out. Along the coast the closest development to the south is approximately 20km away, along the coast adjacent to Gale Point. The major current runs southwards, controlling deposition along the coastline. There is a 600m to 900m zone along the coast that generally remains turbid because of a shallow high energy environment. It is expected that the turbidity plume from dredging and land reclamation will end up in this zone, having minor to moderate impact on the receiving environment. The areas to the east are not expected to be affected.

1.4.1.2 Dredging equipment

Before describing the alternative and preferred dredging and disposal work methods, a general description is provided of the typical kinds of dredging equipment. Basically, the following type of equipment can be deployed:

- Backhoe dredgers (BHD).
- Cutter Suction Dredgers (CSD).
- Trailing Suction Hopper Dredgers (TSHD).

Below, the different types of dredging equipment are described. First a general description and work method is explained, followed by the specific equipment that is foreseen at this stage. More elaborate equipment sheets with technical specifications are provided in **Annex 10**.

Backhoe dredgers (BHD)

A BHD is basically a hydraulic excavator installed on a pontoon. Dredging is executed by the excavator which is mounted on a turntable at the front of the pontoon. The BHD is mainly used for dredging in shallow or confined waters. It is especially suitable for working in narrow areas

and in the near presence of obstacles (e.g. jetties, quay walls, pipelines etc.). Although a BHD is a stationary dredger it is a limited obstacle to shipping traffic, as it is relatively small and does not need anchors. An impression of a BHD is given in **Figure 1-13**.

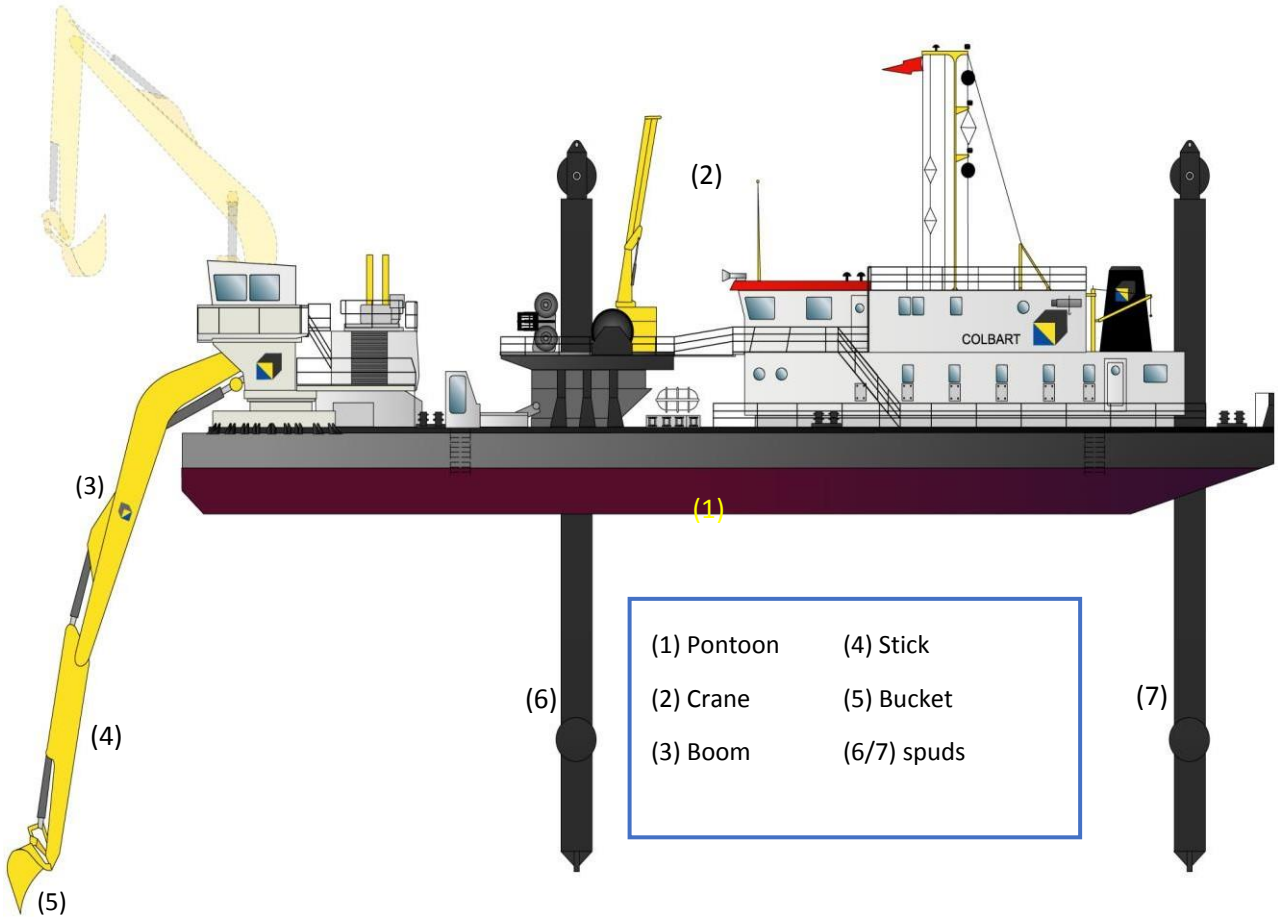


Figure 1-13: General layout BHD.

To start dredging operations, the BHD is towed to the location where excavation will take place. The BHD positions its spuds on the seabed. Dredging with a BHD is a cycle operated process, the bucket mounted at the end of the stick will excavate the soil from the seabed and will lift the material to the surface. The material in the bucket will be either side-cast or loaded into a hopper barge for further transport to the defined disposal area, see **Figure 1-14**.

Figure 1-14: Example of a BHD loading a barge.

At this stage the BHD 'Odin' (see **Figure 1-15**) loading the split hopper barge 'Terraferre 301', see **Figure 1-16**.

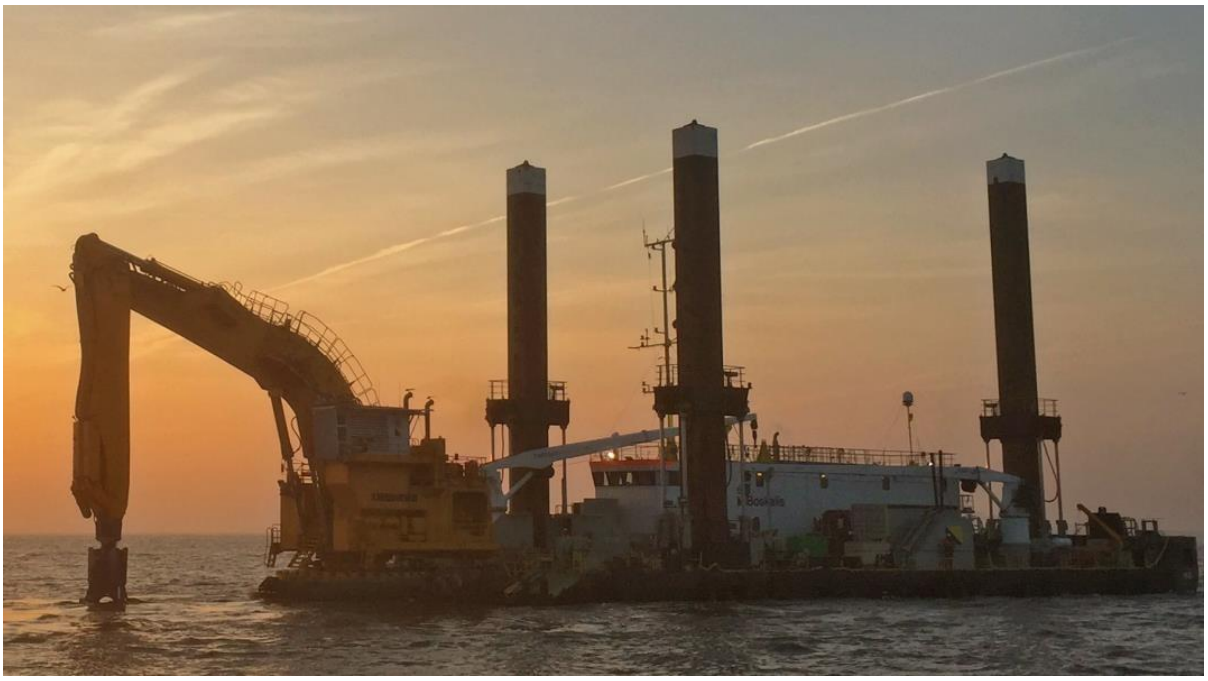


Figure 1-15: Backhoe Dredger 'Odin' with 6-22m3 buckets.

Figure 1-16: Non-propelled split hopper barge 'Terraferre 301' (2,300m3) with push boat.

Cutter Suction Dredgers (CSD)

A CSD is a suction dredger equipped with a rotating cutter head. The CSD is positioned on spuds and anchor wires during dredging operations. A CSD is suitable for dredging silts, sand, clay and rock. The dredging process consists of cutting the seabed (loosening the soil) with the cutter-head, then transporting a mixture of soil and water by the dredge pump through a discharge pipeline for further transport to a discharge location, or for loading barges.

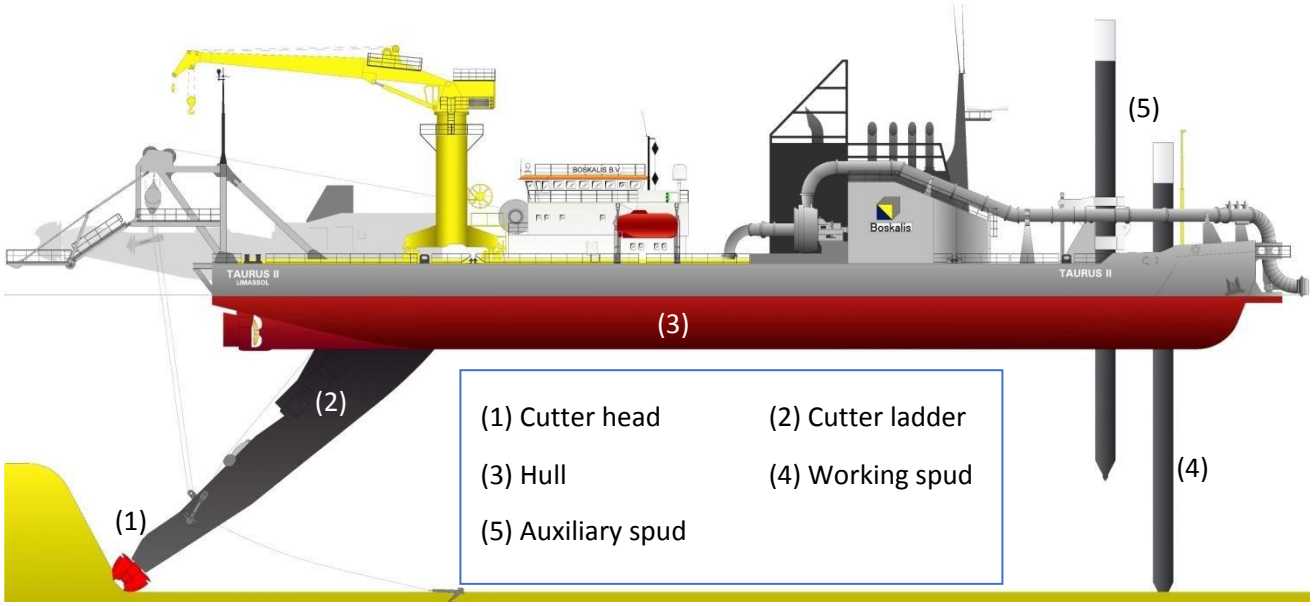


Figure 1-17: General layout of a Cutter Suction Dredger.

Before the start of dredging operations, the CSD will sail or be towed to the dredging location. The CSD maintains its position with its spud(s) and the two side wires. The working spud or main spud is dropped onto the seabed securing the stern of the dredger. During dredging, the CSD makes a pivoting movement around the main spud. To create the required swinging motion, the CSD deploys side anchors on both sides of the cutter ladder, these are connected by steel wires to the side winches onboard the CSD. By simultaneously reeling in one side-wire and reeling out the other side-wire the dredger pivots around its spud. Depending on the water

depth and the length of the CSD, a CSD can dredge a cut width varying between 5 and 120m wide. At this stage, the CSD 'Taurus II' is foreseen, see **Figure 1-18**, connected to discharge pipes, see examples in **Figure 1-19** and **Figure 1-20**.

Figure 1-18: Cutter Suction Dredger 'Taurus II'.

Figure 1-19: Examples of floating pipelines.

Figure 1-20: Examples of shore pipeline on a reclamation.

Trailing Suction Hopper Dredgers (TSHD)

A TSHD is a sea-going self-propelled free-floating vessel that loads dredged material into its hopper well. The TSHD's dredging process consists of a cycle of a loading (dredging), transporting (sailing) and discharging stage.

Dredging takes place by means of one or two suction pipe(s), installed alongside the vessel. The material is loosened and collected by means of the draghead(s), which are located at the lower end of the suction pipe(s). Dredge pump(s) in the vessel or integrated in the suction pipe, lift the mixture of soil and water into the hopper well. After dredging, the TSHD stops pumping, lifts the suction pipe and draghead on deck and sails to the discharge area, with a speed between 5 and 15 knots. At the discharge area the TSHD discharges the load of dredged material, this can be done in different ways, such as discharging through bottom doors, or by pumping options. These pumping options are rainbowing, pumping to a reclamation area, pumping to a spray pontoon or by pumping through the suction pipe. A typical TSHD during the loading process is shown Figure 1-25.

To start dredging operations, the TSHD will sail to the dredging (or borrow) area. Once in the dredging area, the suction pipe(s) are lowered to the seabed, the dredge pump(s) are started and dredging commences.

While dredging the draghead(s) scrape(s) over the seabed and loosen(s) the sediments. The sediment-water mixture is brought up through the suction pipe and pumped into the hopper well. During loading with its draghead(s) on the seabed, the TSHD sails fairly slowly. The trailing speed depends on local conditions and the material being dredged and will generally not exceed a few knots. The dredged material settles out in the hopper well and the excess transport water is evacuated through the overflow system. This overflow system can be adjusted, in order to optimise production and minimise losses of fine particles.

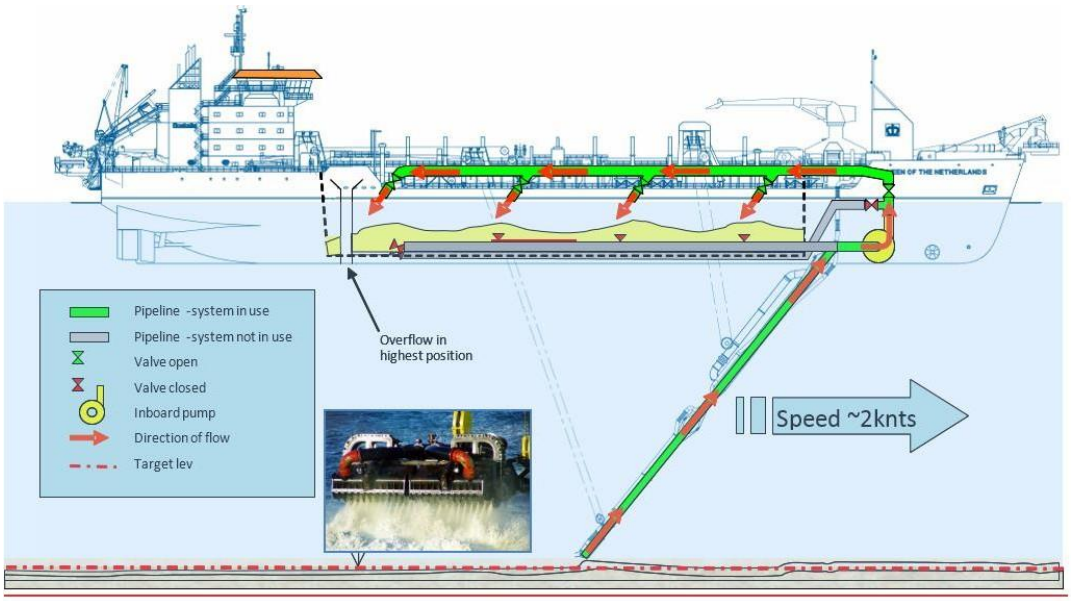


Figure 1-21: TSHD dredging principle (inserted photo: draghead with waterjets).

For discharging the dredged material from a THSD, there are several possibilities:

- Discharging by opening the bottom doors.
- Discharging by pumping through a nozzle over the bow, so-called rainbowing.
- Discharging by pumping through pipelines to a reclamation area.
- Discharging by pumping through pipelines to a spray pontoon.
- Discharging by pumping through the suction pipe.
- Discharging by loading barges.

For this project, deployment of TSHD 'Beachway' is foreseen, see **Figure 1-22**, two options of disposing were considered including offshore (by opening the bottom doors) or through discharging. The preferred option is disposal on land and this will be taken forward for the assessment. This TSHD require a minimum water depth of approximately 7m.

Figure 1-22: Trailing Suction Hopper Dredger 'Beachway' (7,350m3 hopper capacity).

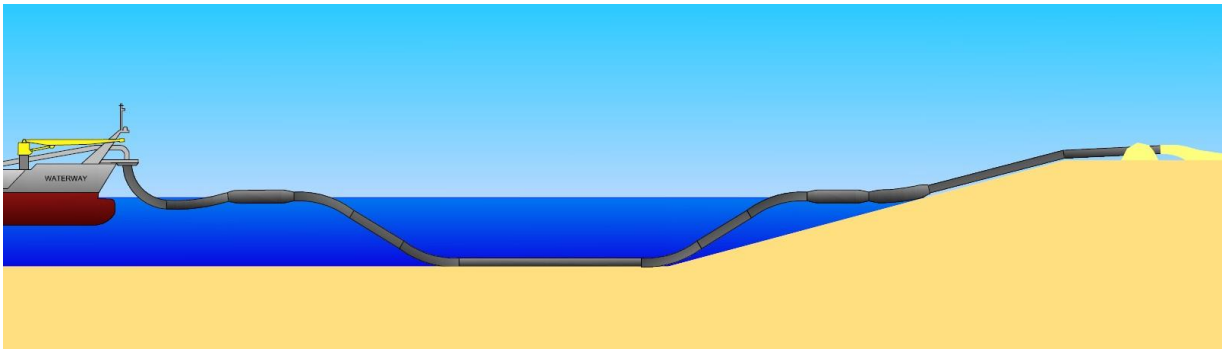


Figure 1-23: TSHD discharging via floating or partially submerged pipeline on land.

1.4.1.3 Dredging activities

The recommended dredging method strongly depend on the following:

- Soil conditions, basically divided in soft clay/peat and stiffer clay which determine the equipment, environmental impact and the possibility of reuse for construction.
- Ship draft: non-stationary equipment like Trailing Suction Hopper Dredgers (TSHD) require a minimum depth (approximately CD-7m), whereas stationary equipment like Cutter Suction Dredgers (CSD) and Backhoe dredgers (BHD) can dig in, creating their own floatation depth.
- Pumping distance: a CSD can dispose material using a floating pipeline, possibly attached to a sinker (fixed steel pipe laying on the seabed) and/or connected land pipes. The pumping distance is limited and depends on the dredged material and the number of additional pumps.

Basically, three far different work methods (combination of dredging and disposal) have been considered:

- offshore disposal and minimum reuse of material for the reclamation.
- sidecasting soft material and minimum reuse of material for the reclamation.
- onshore disposal of unsuitable material and maximum reuse of suitable material.

1. Offshore disposal

In this alternative, a backhoe (BHD) dredges all material above CD-7m, loading split hopper barges (see Figure 1-18) that are pushed to an offshore disposal site far outside the reef. A trailing suction hopper dredger (TSHD) dredges the softer material below CD-7m for to be disposed at the same offshore disposal site. The stiffer clays below CD-7m are first dredged by a BHD loading barges for bund construction. Once the perimeter bunds of the reclamation area are constructed a Cutter Suction Dredger (CSD) dredges the remaining stiff material which is pumped through in the reclamation area as fill material using a combination of fixed and floatation pipes.

2. Sidecasting

In this alternative work method, a CSD dredges the soft material, which is disposed approximately 1 km south of access channel using a floatation pipeline, see Figure 1-22. Once the soft material is removed, a BHD dredges the stiffer clay loading barges for bund construction. After bund construction, the CSD will pump ashore the dredged material in the reclamation area using a sinker and floating pipeline.

3. All onshore

In this alternative, a siltation pit is created on land first (approximate size of 2x2km, 2m high, volume approximately 8Mm^3). The CSD dredges the soft material first, which is disposed in the siltation pond using pipelines and additional pumps. Once the soft material is removed, a BHD dredges the stiffer clay loading barges for bund construction. After bund construction, the

CSD will pump ashore the dredged material in the reclamation area using a sinker and floating pipeline. To limit the pumping distance, the soft material below CD-7m is dredged using a TSHD that pumps ashore the material by connecting to a pipeline.

It is recommended that the softer materials will be disposed onshore or in the peninsula. The dredge spoil has time to dewater and settle. The harder material (clay) is to be used to form bunds and top layer reclamation will require sand.

The final placement of fill material will be pre-planned based on suitability, quality, and production rates as determined by a civil/coastal engineer and contractor. This will be accomplished through spillway management and a testing program to ensure fill volumes are distributed as intended. The developers have identified land to be used as potential disposal site for dredge spoils (Figure 1-24). The coordinates demarcating the available land is presented in Table 1-3.

Figure 1-24: Indicative area which can be used as dump site for the dredged materials for Port of Magical Belize.

Table 1-3. Coordinates demarcating proposed site for disposal of dredge spoils for Port of Magical Belize.

Description	Mark on Figure	Latitude	Longitude
Northwest corner (Block #1)	A	17°27'40.77"N	88°15'54.69"W
Northeast corner (Block #1)	B	17°27'31.51"N	88°15'27.71"W

Southwest corner (Block #1)	C	17°27'10.65"N	88°16'23.81"W
Southeast corner (Block #1)	D	17°27'8.19"N	88°15'32.15"W
Northwest corner (Block #2)	E	17°27'10.48"N	88°15'46.05"W
Northeast corner (Block #2)	F	17°27'7.53"N	88°15'36.98"W
Southwest corner (Block #2)	G	17°25'40.31"N	88°15'48.48"W
Southeast corner (Block #2)	H	17°25'44.50"N	88°15'42.97"W

1.4.1.4 Other marine activities

Other marine activities during construction consists of:

- Rockworks.
- Installation of navigational aids.
- Survey activities.

Rockworks

For stabilizing the revetments against erosion, a rock revetment is foreseen. This involves the following activities:

- Profiling of the revetment.
- nstalling a preamble geo-textile fabric preventing material from washing out.
- Rock supply and installation.

Scour protection at the berth pocket bed is required to prevent erosion.

Navigational aids

For the installation of the floating monitoring buoys or navigation buoys the following actions will be executed (location of the navigation buoys is presented in **Annex 9**, **Figure 9**):

- On-shore assembly of buoys at the work site.
- Testing the buoys before installation.
- Marking the mooring position of the buoys into the survey system.
- Loading of buoys onto installation vessel with positioning system.
- Placement of the buoys.

Survey activities

In addition to bathymetric work already done, during the marine construction activities regular bathymetric surveys will be undertaken to monitor progress of the work. On completion of the marine activities a final bathymetric survey will be undertaken to confirm sea bed levels. This information will be then submitted to the Belize Port Authority.

1.4.2 Civil works

The activities related to the construction of the jetties will be the following:

- Installation of steel tubular foundation piles with marine based equipment.
- Construction and installation of prefabricated capping beams with reinforced concrete.
- Construction of deck structure with pre-stressed concrete girders and concrete top layer.
- Installation of bollards, fenders, safety ladders and utilities, among others.

Installation of the foundation piles is performed with marine based equipment, where a choice can be made between floating equipment and jack-up platforms depending on local conditions. Depending on the soil conditions, and local environmental regulations and restrictions an installation method is defined. The options to be investigated are, pile driving with a hammer or vibrator or drilling with a rig. After installation of the pile the tubular sections are filled with sand and a concrete plug at the top.

Figure 1-25: Construction of a jetty with a crane barge.

When the foundation piles are finished the prefabricated concrete capping beams are installed on the top of the piles and connected with a wet-joint. This creates transverse supports for the deck structure which result in a free deck span of 15m. On top of the beams, the pre-stressed t-shape concrete girders are installed, which are then pored to one homogeneous deck structure with concrete. Expansion joints are located above the capping beams for absorption of longitudinal deformations in the deck.

When the deck is finished the jetty will be equipped with bollards and fenders for enabling the

mooring of the vessels. The fenders are located on both sides of the jetty and are mounted at the head of the capping beams. The bollards are positioned at the edge of the deck structure where 200 tons variant are located at the front and end of the vessels and 75 tons variants in between. Safety ladders are fitted on both sides of the jetty every 40m.

1.4.3 Terrestrial activities

On land, the following activities are foreseen during the construction phase:

- Vegetation clearance of maximum 18 hectares (44.5 acres) littoral forest / mangroves.
- Construction of access road (further details can be found in Section 2) and bridge over the Sibun River.
- Drainage and culvert works.
- Installation of utilities (potable water supply, data cables, power cables, sewage, firefighting systems, etc.).
- Construction of buildings (welcome centre, shops, restaurants, etc.).
- Construction of security systems (CCTV and perimeter fences).

1.5 Activities during the operational phase

1.5.1 Marine activities

The marine activities during the operational phase consist of:

- Cruise ship navigation;
- Maintenance dredging.

Tourist related activities (a.o. watersports, dive excursions, etc.) take place outside the project area and are not described further in this EIA.

Cruise ship navigation is limited to a maximum of 6 ships arriving and departing per day. Navigation will be through the English Cay Channel, the Southern Grennels Channel and the navigation channel to be dredged.

Maintenance dredging will most likely be done using the TSHD. The intensity and exact frequency (2 to 5 year interval) will be based on the initial overdepth (to account for infill), the infill rates and economic considerations taking into account mobilization costs. At this stage no sedimentation control measures are foreseen as the dredged area lies outside the morphological active zone (depth of closure is estimated to be 3m).

Bunkering will not take place in the port area. There no adequate waste receptor facilities to receive waste from cruise ships and therefore any waste will be disposed in other ports.

1.5.2 Terrestrial activities

The terrestrial activities during this phase will be associated with general port and tourist facilities operation for hotels, restaurants and transport activities. Those activities will require energy and will lead to waste creation. This will be described in detail in later sections.

1.6 Project timeline

The timeline for the implementation of the project, taking into consideration the development in phases, is tabulated below. Basically, the first phase of the development is expected to take approximately three years. A detailed schedule will be developed later.

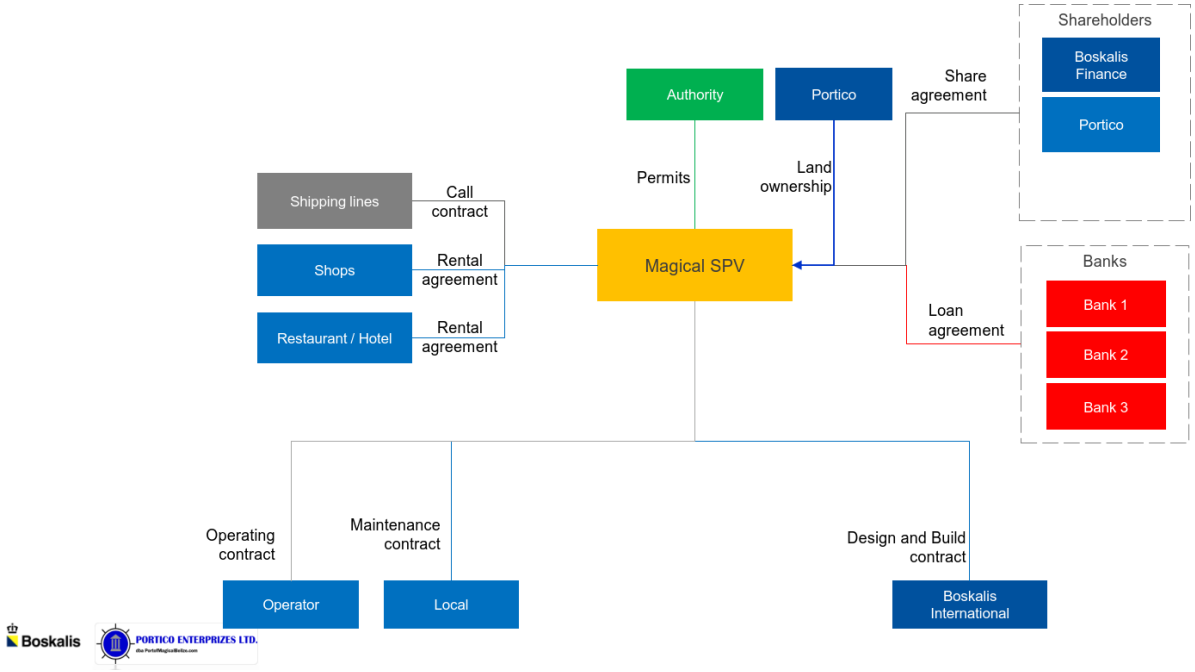
Table 1-3: Project timeline

Phase	Task	Year 1				Year 2				Year 3				Year 4 - 20
		Trimester				Trimester				Trimester				
		1	2	3	4	1	2	3	4	1	2	3	4	
Phase 1	Site preparation, fencing, temporary routes													
	Preparation peninsula													
	Dredging access channel and turning basin back filling onshore part and peninsula (incl pre-load)													
	Pre-loading													
	Construction cruise jetties													
	Construction buildings													
	Construction road infrastructure													
	Beaches, cabanas													
	Termination, testing and commissioning													
Phase 2	Construction of amenities													
	Construction jetty 3													

1.7 Overall Management Structure

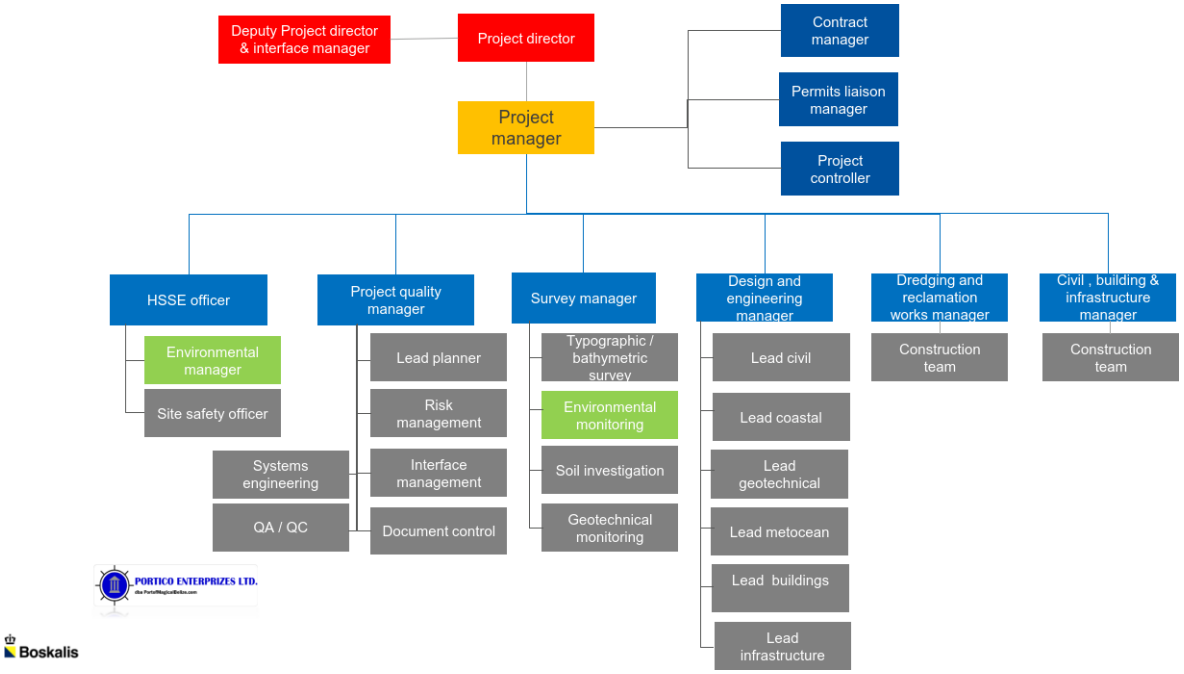
1.7.1 Overall management structure of the developer (SPV)

The management structure is presented in the Figure below.



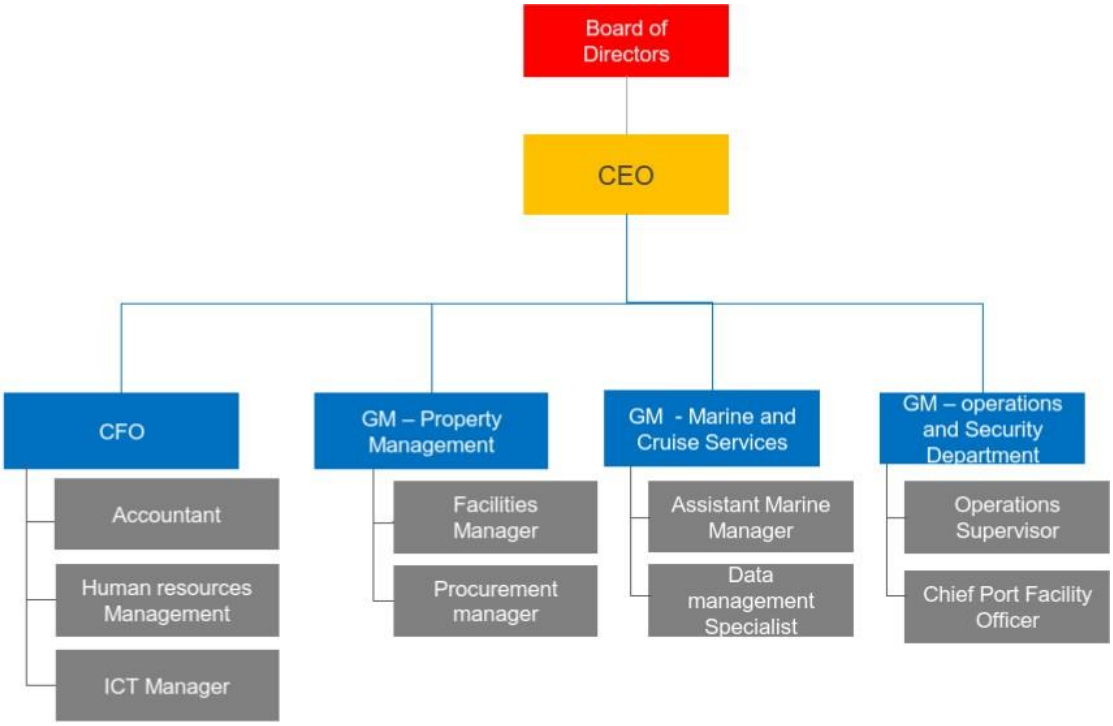
1.7.2 Overall management structure during construction

The management structure is presented in table below. There will be a dedicated Environmental Officer to supervise the construction.



1.7.3 Overall management structure during operational phase

Below is a proposed Organizational Chart for the Port of Magical Belize.com subject, of course, to final determination by the owners and Board of Directors.



The Office of the CEO will have responsibilities as a managing director, decision maker, leader, and executor. The Office will provide overall direction of the company as well as assist in maintaining strong relationships with key stakeholders such as the shareholders, key government departments and other partners. It will be responsible for the management and budget of the overall administration of the company and will ensure compliance to the procedures and policies of the company.

The Finance Department will provide the company with efficient and effective service using generally accepted accounting procedures and by ensuring emphasis on quality, service and satisfaction both internally and externally.

1.8 References

Boskalis, 2019, 'Port of Magical - preliminary nautical design', Hydronamic memo P34020-FJOL-3-0, December 2nd 2019

FCCA, 2019, '2019 Cruise Industry Overview'

IALA, 2018,' NAVGUIDE 2018 – Marine aids and navigation manual' 8th Edition by the International Association of Marine Aids to Navigation and Lighthouses Authorities, April 2018

PIANC, 2014, 'Approach channels – a guide for design, PIANC MarCom report No. 121, 2014

PIANC, 2016, 'Guidelines for cruise terminals', PIANC MarCom report No. 152, 2016

Simwave, 2019,'Port of Magical, Belize, Simulation Runs', Simwave Report v.1.0 October 28th 2019

2 The Physical Environment

2.1 Topography

The project site is located between the Northern Lagoon and the coastline south of the Sibun River and is within the extended coastal plain of central Belize. The Project site is generally flat to gently sloping towards the coast, it however has three distinct topographic regions, the elevated sand dune along the coastline in the east (60-90m or 200-300ft), the lower interior marsh section and an elevated area along the perimeter of Northern Lagoon in the west (450-600m or 1500-2000ft).

The sandy coastline forms a natural barrier (at approximately 2ft to 3ft above mean seal level) between the property interior and the sea. The sand ridges forming the beach acts as a natural barrier between the vegetated interior of the property and the sea. This sand ridge gently slopes downward to form a sandy surf zone in the sea in waters about 3ft or less below the sea surface. This surf zone extends approximately 240 to 300m (800ft to 1000ft) away from the shoreline this gentle downward underwater slope continues into the sea for about 450-600m (1500ft to 2000ft) to depths of approximately 5m (16.4ft) below the water surface. Thereafter, the slope flattens to a lower bathymetric declination in waters that gradually increase in depths ranging from approximately 5 to 12m (16ft to 40ft) between 600 to 5000m (2000ft to 16000ft) from the shoreline.

The lowland broad-leaf forests area that exist along the western boundary of the project site along the Northern Lagoon also sits about 0.6m to 0.9m (2ft to 3ft) above the lagoon water level. Google Earth terrain models places the surface elevation of the Northern Lagoon at 2m (7 feet) above sea level.

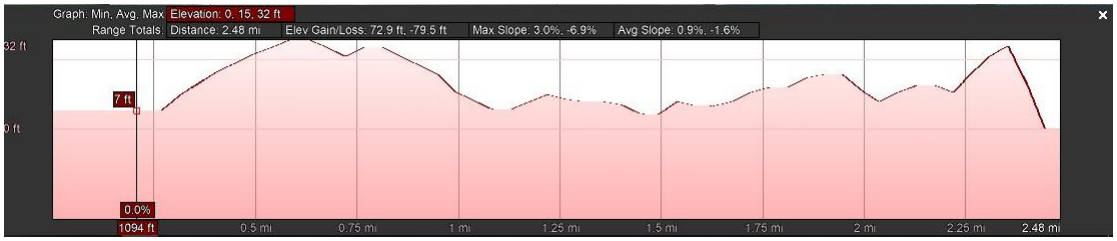


Figure 2-1: Elevation Profile along project area (source: Google Earth).

2.2 Climate and Meteorology

The climate at the site for the Port of Magical Belize, a proposed Cruise Terminal at the mouth of the Sibun River, Portico Enterprise Limited, hereafter 'the Cruise Terminal', is tropical maritime, typical of the islands and the coastal zone of the country. **Figure 2-2** is a Google map of the proposed Cruise Terminal site, in relation to the mouth of the Sibun River, the Port of Belize and Belize City. Climate records from the Port of Belize, St. John's College, Landivar, and the Philip Goldson International Airport weather observation stations can be used as representative conditions for the area at the mouth of the Sibun River, because of their proximity to the project site.

Figure 2-3 and **Figure 2-4** are climate charts for St. John's College, Landivar Belize City, and Philip Goldson International Airport (PGIA) for the baseline period 1970-2005.

The rainfall regime is bi-modal with peaks in June and September in the Belize City area at St. John's College, Landivar; and June and October at the PGIA, Ladyville. The rainfall maxima are separated by a characteristic mid-summer dry spell in early August (*maga season*). A marked dry season is evident from March through May. The cool transition period runs from November through February with its characteristic cool air incursion from the north.

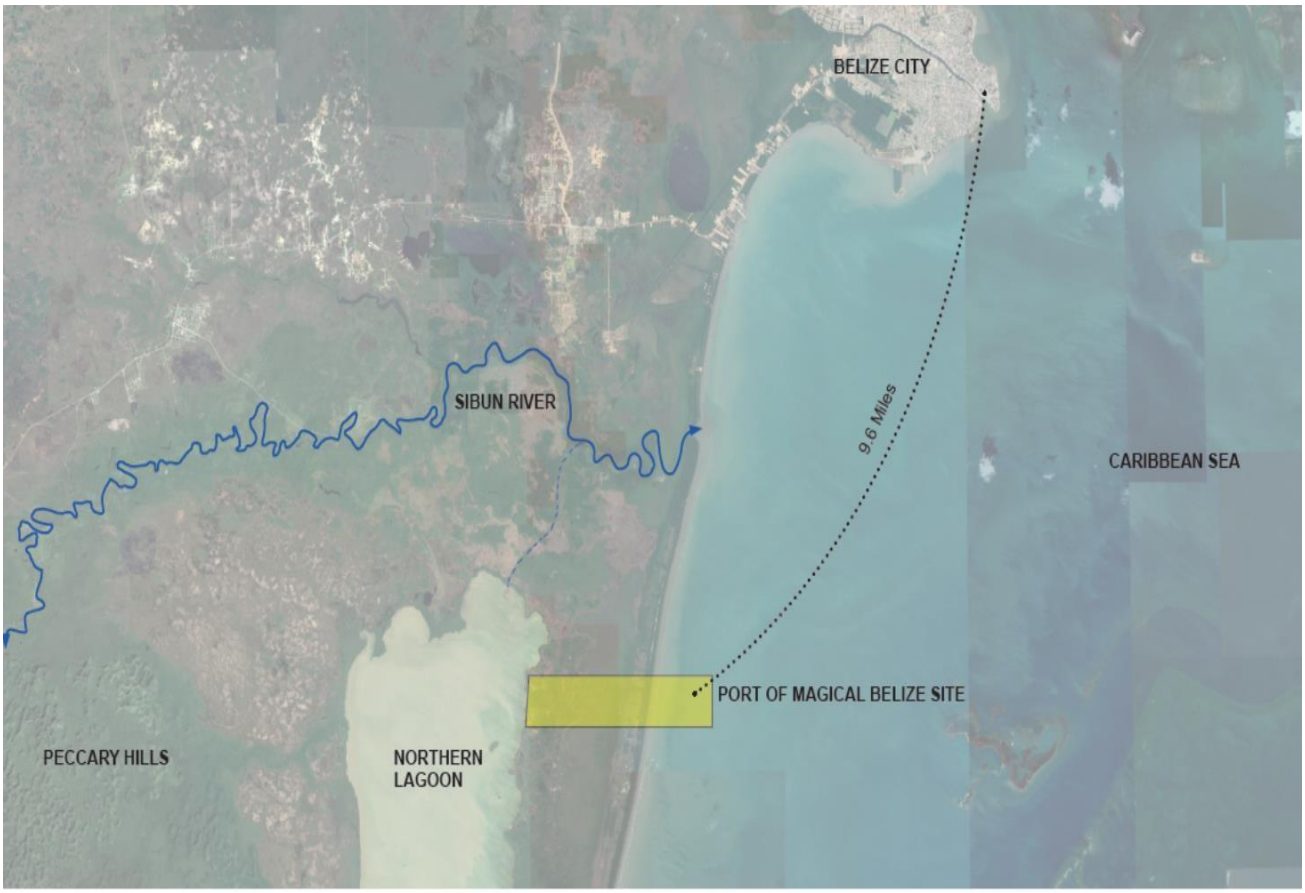


Figure 2-2: Port of Magical Belize site relative to the mouth of the Sibun River and Belize City.

Mean annual rainfall is about 1,963mm (77 inches) in the Belize City area and 1,892 mm (74 inches) at Philip Goldson International Airport. **Figure 2-2** shows the climate chart for St. John's College, Belize City based on the historical period 1970 – 2005.

Surface air temperature in the Belize City area and the project zone is strongly moderated by the fresh sea breeze, and the climate is less extreme than inland. The average annual temperature is 27°C (See **Figure 2-5**). The warmest months are April through September with daily average temperature of 28°C. The coolest month is January when the daily average temperature drops to about 24°C. The maximum or highest temperature record for Belize City is: 37.8°C and the lowest recorded was 7.8°C (NMS, 2010; WMO, 2016).

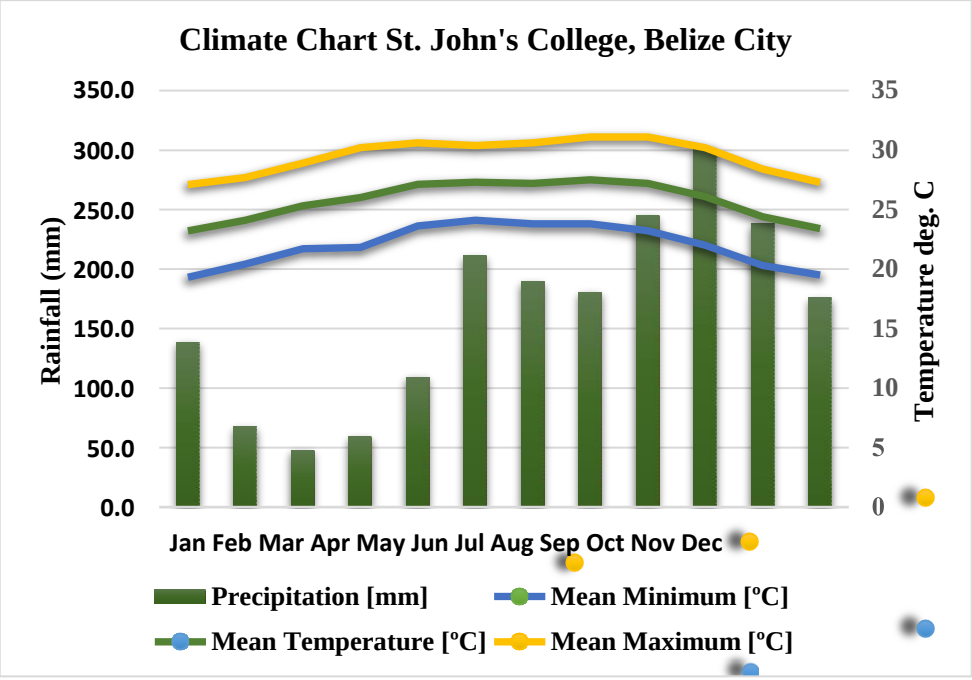


Figure 2-3: Climate chart for St. John's College, Landivar, Belize City.

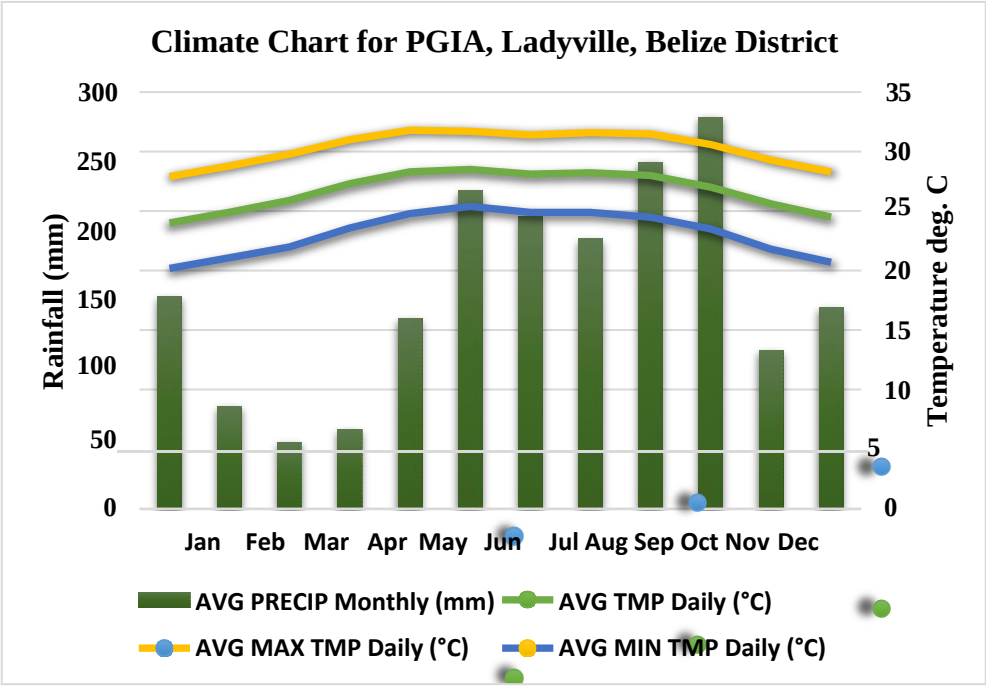


Figure 2-4: Climate chart for Philip Goldson International Airport, Ladyville

The monthly average mid-afternoon humidity at the Airport is about 65% during the dry season, and near 70% in the wet season (see **Table 2-1**).

Table 2-1: Climate records for the Philip S. W. Goldson International Airport (Source: Data - NMS, Belize. Table: R. Frutos, 2019).

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mid-afternoon RH %	69.0	66.0	65.0	65.0	66.0	70.0	70.0	70.0	70.0	70.0	69.0	70.0	68.0	26
Avg. Precip (mm)	152.6	73.7	47.8	57.2	136.9	229.0	210.1	194.4	249.4	281.9	113.9	144.7	1891.6	30
No. Rain days >1 mm	11.0	7.0	5.0	4.0	7.0	13.0	15.0	15.0	17.0	15.0	13.0	12.0	11.0	30
Avg Evapo Tot (mm)	135.3	109.4	148.6	167.1	172.3	141.0	149.0	139.1	115.4	102.3	87.4	83.7	129.2	30
Monthly Windspeed (kts	4.0	5.0	6.0	6.0	6.0	6.0	6.0	5.0	4.0	4.0	4.0	4.0	5.0	30
MonthlycWindDir	E	SE	SE	SE	SE	SE	E	E	SE	SE	N	E	SE	30
No. Days w/Thunder	1	1	1	2	4	9	11	12	14	8	4	1	6	30

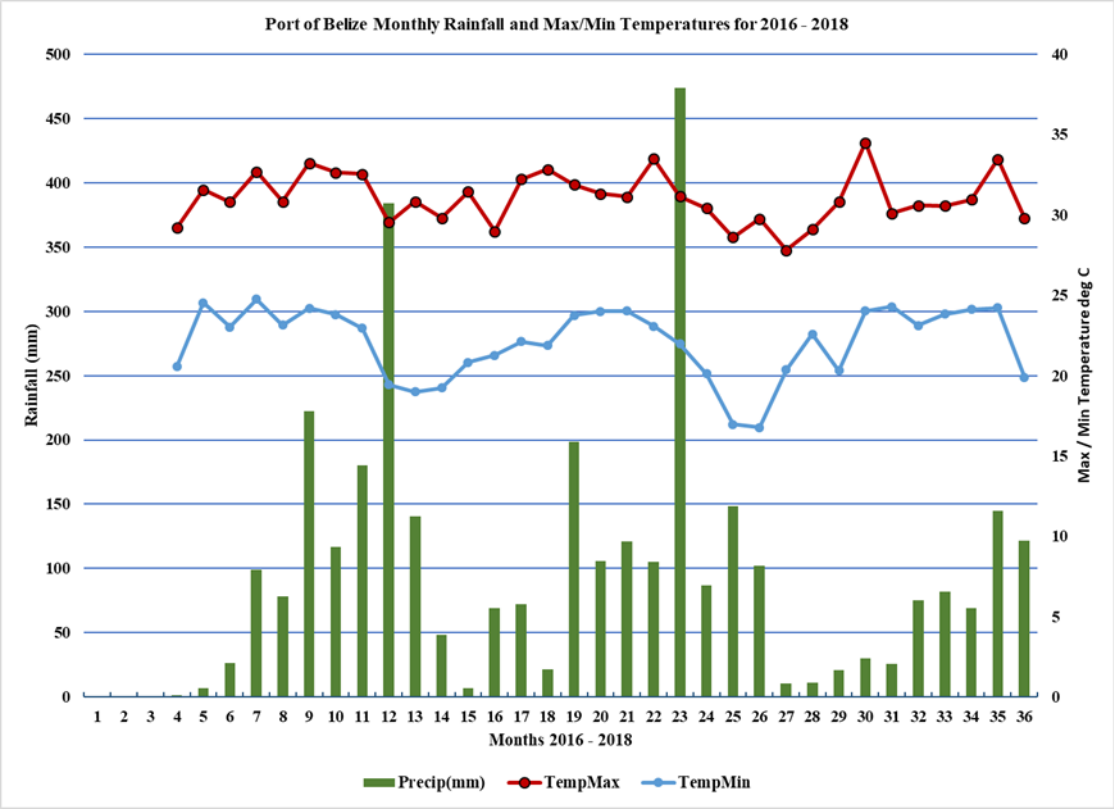


Figure 2-5: Monthly rainfall and temperature time series for the Port of Belize (2016-2018) (Source: Data – NMS. Analysis: R Frutos).

Figure 2-5 is a climate time series for the Port of Belize for the period 2016 – 2018, showing monthly rainfall (mm) and maximum and minimum temperature variation. Peak rainfall were recorded in December 2016, and November 2017, associated with late hurricane season disturbances. Highest maximum temperatures were recorded in October 2017, and July/November, 2018 (**Figure 2-5**).

2.2.1 Intensity-Duration-Frequency (12 year record for the Philip Goldson Airport)

Table 2-2 below is the result of frequency analysis on 1-day to 4-day annual maximum rainfall for PGIA and Towerhill based on 21 and 19 years of daily rainfall records. In the general

analysis the 1:100 year 1-day rainfall rainfall depth or intensity were estimated to 482 mm at PGIA, 340mm for Towerhill, 377mm for Chetumal and 220mm for Nicolas Bravo, Quintana Roo, Mexico. A comparison with information collected and reviewed during the study showed that:

1) The high 1:100 year 1-day value for PGIA was driven by the 457mm 1-day record observed on October 2, 2000 during Hurricane Keith. It was confirmed by similar records at neighbouring stations: 448mm on October 3rd 2000 at La Milpa, and 536mm on October 2, 2000 at St. John's College, Belize City. These values were significantly higher than the Miami (USA) 1:100 year 24-hour rainfall depth (361 mm), which was used by SSBN Ltd. And the University of Bristol (2016) which was used as a proxy for Belize.

2) The 1:100 year 1-day rainfall depth at PGIA is higher than the TYPSA (2010) 426mm PMP estimate. It is much higher than Germany GmnH (2014) estimate (approx. 78mm in 24 hours) at the Philip Goldson International Airport.

The IDF rainfall analysis for the Philip Goldson Airport is the most updated study for rainfall intensity based on reliable data for Belize, and is the closest representative hydrological analysis results that can be applied for the design of the proposed road and bridge crossing connected with the Cruise Terminal development in the Cozal Zone section of the Sibun River watershed.

Table 2-2: Frequency analysis on daily annual maxima rainfall records for PGIA and BSI(Source: Golder & Associates, 2017).

Return Period (years)	Rainfall Depth (mm) as a Function of the Event Duration (days)							
	PGIA Station (1990 – 2010)				Towerhill (1992-2010)			
	1 day	2 days	3 days	4 days	1 day	2 days	3 days	4 days
2	122	160	182	201	97	116	125	140
5	175	239	262	284	141	170	188	205
10	223	317	342	364	178	221	253	270
25	303	459	489	508	233	309	370	382
50	382	610	647	656	282	399	486	488
100	482	812	859	900	340	514	630	618

2.2.2 Winds

The prevailing winds along the coastal zone of Belize are predominantly southeast and east at about 5 – 15 knots, as can be observed from the historical mean wind-rose (**Figure 2-6**) for the Philip Goldson International Airport. In the Belize City area and the project site near the mouth of the Sibun River, the winds generally blow moderately from the east and southeast at about 8 – 18 knots during the dry season months of March, April and May. In the summer months (June through August), the prevailing wind is out of the east and northeast at about 8 – 16 knots. During the cool transition period from October through early March incursions of cool, continental air masses and associated frontal boundaries (cold fronts) move across the Gulf of

Mexico and spill into the north-western Caribbean, occasionally reaching the central Caribbean. The northerly winds associated with these cool air mass incursions are often gusty, generating turbulent seas and unfavourable condition for marine operations in exposed regions of Belize's coastal waters. Such events may persist for a day or two but may also extend for 3 to 4 days during intense cold air outbreaks from the north.

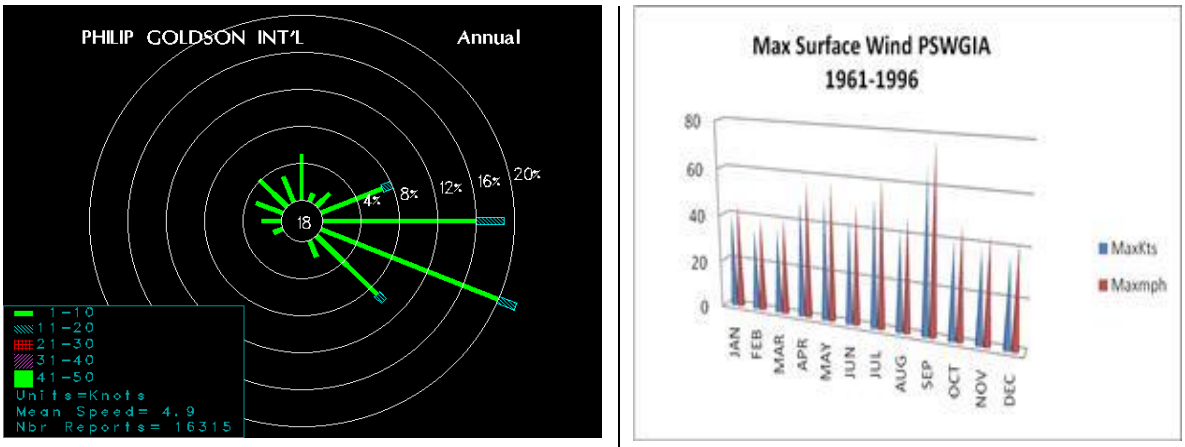


Figure 2-6: Annual mean wind-rose and wind record for Philip Goldson Airport.

Extreme wind speeds are associated with tropical cyclones and tropical disturbances that traverse the north-western Caribbean and impact the coastal zone of Belize. These events are more frequent during the hurricane season or summer months, but invariably are also associated with strong northerly airflow generated by cold air mass movement over the region during the cool transition period. **Figure 2-6** is a graph showing records of historical Daily Maximum wind speeds recorded at the Philip Goldson Airport for the period 1961 to 1996. As can be observed, September holds the record for the highest surface wind speed at the Airport with a value of 64 knots or 75 mph. September also marks the month with peak hurricane activity for the North Atlantic Basin. Recent landfalling hurricanes along the coast near Belize City (i.e. Richard in October 2010, and Earl in August 2016) had winds of near 90 mph as they came on shore.

Wind Characteristic

Wind and wave data was obtained from the Infoplaza database, containing 19 years of 3hr interval data (https://www.infoplaza.co.uk/zakelijk/data-en/). The location of offshore wind and wave data point used is shown in **Figure 2-7**. Monthly wind roses are provided in **Annex 11**.

Figure 2-7: *Location of offshore wind and wave data point.*

Wind roses and wind speed exceedance are shown in **Figure 2-8** and Figure 2-9. PIANC 121 strong cross-wind threshold is 33 knots (17.0m/s) which is exceeded 0.05% (including hurricanes) and 0.03% (excluding hurricanes). Navigation channel design is based on 'moderate' wind (Beaufort 4-7).

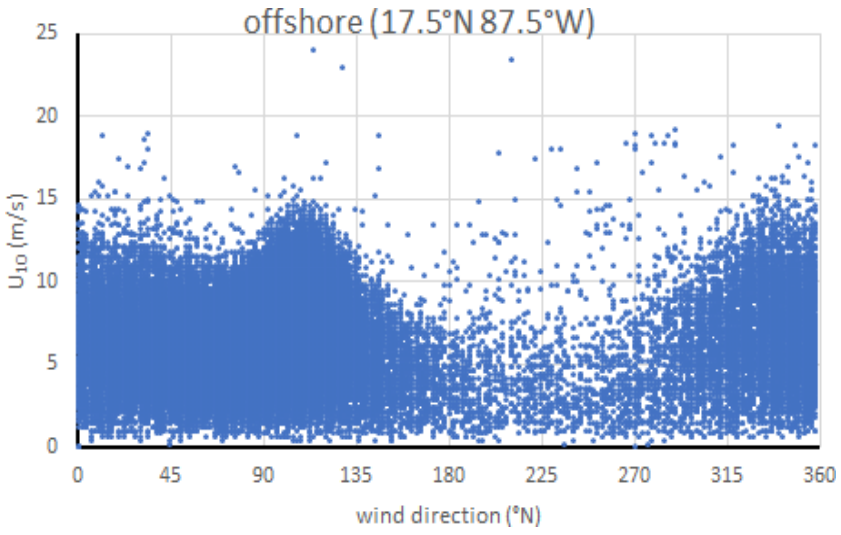


Figure 2-8: Wind speed – wind direction scatter (84,736 points).

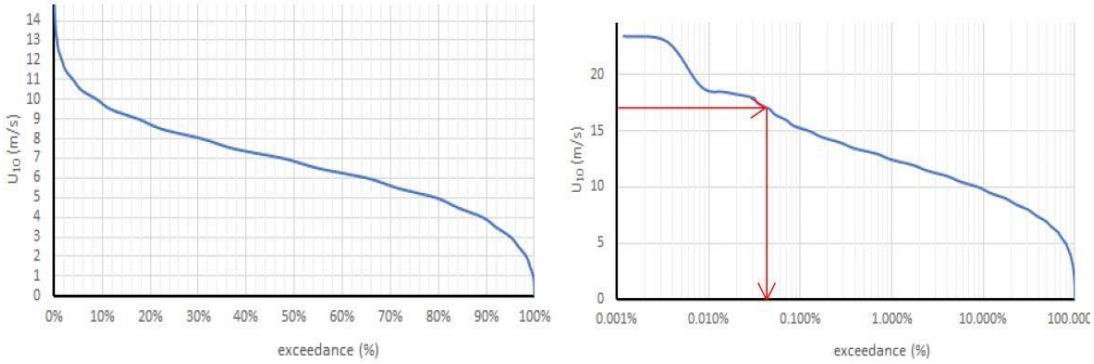


Figure 2-9: Offshore wind speed exceedance.

Based on the data gathered and analysed, the channel design and specifications will take into consideration that thirty three (33) knots (17.0m/s) is exceeded 0.05% (including hurricanes) and 0.03% (excluding hurricanes) based on offshore long term statistics.

Table 2-3: Monthly exceedance (%) of wind speeds using 1990 to 2018 for an offshore location 17°30'N 87°30'W.

U_{10} (m/s)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	all year
0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	100.0	100.0	100.0	100.0
2	99.7	99.7	99.8	99.8	99.6	99.7	99.9	99.7	99.3	99.4	99.8	99.6	99.7
3	98.8	98.9	99.1	99.2	98.3	98.7	99.2	98.4	97.1	97.0	98.6	98.3	98.5
4	96.3	96.8	97.0	97.1	95.6	96.9	97.3	94.7	91.7	91.7	95.1	95.3	95.6
5	90.9	92.1	92.6	92.1	89.9	93.2	91.9	86.5	82.3	80.8	87.0	88.7	89.2
6	80.7	82.8	83.5	82.4	80.0	86.4	80.3	72.7	67.0	65.3	72.5	75.9	77.8
7	64.6	67.6	69.2	66.6	64.8	74.5	62.9	53.9	47.9	46.8	54.9	57.6	61.4
8	46.7	47.2	50.5	48.0	44.8	58.5	42.8	35.2	30.4	31.6	37.1	37.7	43.0
9	29.5	29.3	32.8	30.3	26.5	39.7	25.7	20.5	16.3	20.1	23.3	22.2	26.7
10	16.6	16.2	19.4	16.2	13.2	23.5	13.2	10.5	7.7	12.1	14.1	11.5	14.7
11	8.3	8.5	10.6	7.5	5.5	11.5	5.4	4.5	3.3	7.1	7.4	5.5	7.2
12	3.9	4.0	5.0	3.4	1.9	4.7	1.7	1.7	1.0	5.1	4.1	2.4	3.3
13	1.9	1.7	2.1	1.3	0.6	1.5	0.5	0.9	0.3	3.6	1.9	0.8	1.4
14	1.0	0.8	1.0	0.2	0.1	0.4	0.1	0.5	0.1	2.5	0.8	0.1	0.6
15	0.4	0.2	0.3	0.0		0.1	0.1	0.3	0.1	1.9	0.5		0.3
16	0.1	0.1	0.1	0.0		0.1		0.2	0.1	1.4	0.2		0.2
17	0.1	0.0	0.0			0.0		0.2	0.0	1.1	0.1		0.1
18	0.1					0.0		0.2	0.0	0.7	0.0		0.1
19	0.0							0.0		0.2			0.0
20								0.0		0.1			0.0

Table 2-4: Frequency of occurrence (%) of wind speeds per 22.5° directional bin using 1990 to 2018 for an offshore location 17°30'N 87°30'W.

U_{10} (m/s)	0-22.5	22.5-45	45-67.5	67.5-90	90-112.5	112.5-135	135-157.5	157.5-180	180-202.5	202.5-225	225-247.5	247.5-270	270-292.5	292.5-315	315-337.5	337.5-360	0-360
0-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
1-2	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	1.4
2-3	0.3	0.3	0.4	0.5	0.4	0.3	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.2	3.2
3-4	0.4	0.6	1.0	1.2	1.0	0.5	0.2	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.2	0.2	5.8
4-5	0.5	0.9	1.7	2.5	2.0	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.4	9.8
5-6	0.6	1.0	2.5	4.2	3.5	1.0	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.3	0.4	14.3
6-7	0.6	1.0	2.7	5.4	5.0	1.2	0.3	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.4	17.4
7-8	0.6	0.9	2.1	4.9	5.9	1.4	0.3	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.4	17.0
8-9	0.5	0.6	1.1	3.1	5.7	1.3	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.4	13.3
9-10	0.3	0.4	0.5	1.4	4.1	1.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	8.7
10-11	0.2	0.2	0.2	0.5	2.5	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	5.0
11-12	0.1	0.1	0.1	0.1	1.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	2.4
12-13	0.1	0.1	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	1.0
13-14	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4
14-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.1
15-16	0.0	0.0	0.0	0.0	0.0		0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
16-17	0.0	0.0		0.0	0.0	0.0	0.0				0.0		0.0	0.0	0.0	0.0	0.0
17-18	0.0	0.0		0.0		0.0				0.0		0.0	0.0	0.0		0.0	0.0
18-19	0.0	0.0			0.0		0.0				0.0	0.0	0.0		0.0	0.0	0.0
19-20		0.0											0.0			0.0	0.0
23-24						0.0				0.0							0.0
Total	**4.4**	**6.3**	**12.4**	**24.1**	**32.2**	**8.7**	**2.0**	**0.7**	**0.4**	**0.3**	**0.3**	**0.4**	**0.6**	**1.2**	**2.6**	**3.5**	**100.0**

2.2.3 Natural disasters

The coastal zone of Belize is exposed and vulnerable to natural hazards such as hurricanes, coastal flooding and storm surge, and tsunamis, as a large proportion of its population and economic activity (such as fisheries, tourism, commerce and agriculture) is concentrated along the low-lying coastal zone and the flood plains of the main river systems.

2.2.3.1 Hurricanes

For an in depth look at hurricanes and their implications on the project see section 12.5 of chapter 12 (Disaster Prevention and Emergency Management) of this EIA. During the period 1960 and 2016 tropical cyclones and hurricanes, storm surges and floods affected more than 300,000 people, resulting in 69 deaths, and caused more than US$ 607.5 million in economic damage (**Table 2-5**). **Figure 2-10** shows tracks of recent tropical cyclones affecting coastal Belize and the Belize City area, including the proposed Cruise terminal project site just south of the Sibun River mouth.

Table 2-5: Estimated losses in US$ resulting from impacts of recent hurricanes in Belize.

No.	EVENT	Date	Sector	Direct Cost	Indirect Cost	Total Damage
			Impacted	**US $**	**US $**	**US $**
1	Hurr. Keith	Oct 1, 2000	All	204,779,630	0	204,779,630
2	TS Chantal	Aug. 22, 2001	All	8,737,005	11,771,000	20,508,005
3	Hurr. Iris	Oct. 8, 2001	All	107,841,500	53,250,925	161,092,425
4	Hurr. Dean	Sep. 21, 2007	All	50,279,000	45,350,000	95,629,000
5	TS Arthur	May 31, 2008	All	42,806,908	0	42,806,908
6	TD 16	Oct. 30, 2008	All	1,390,937	0	1,390,937
7	Richard	Oct. 24,2010	All	24,590,000	0	24,590,000
8	Earl	Aug. 4, 2016	All	56,750,000	0	56,750,000
Total						**607,546,905**

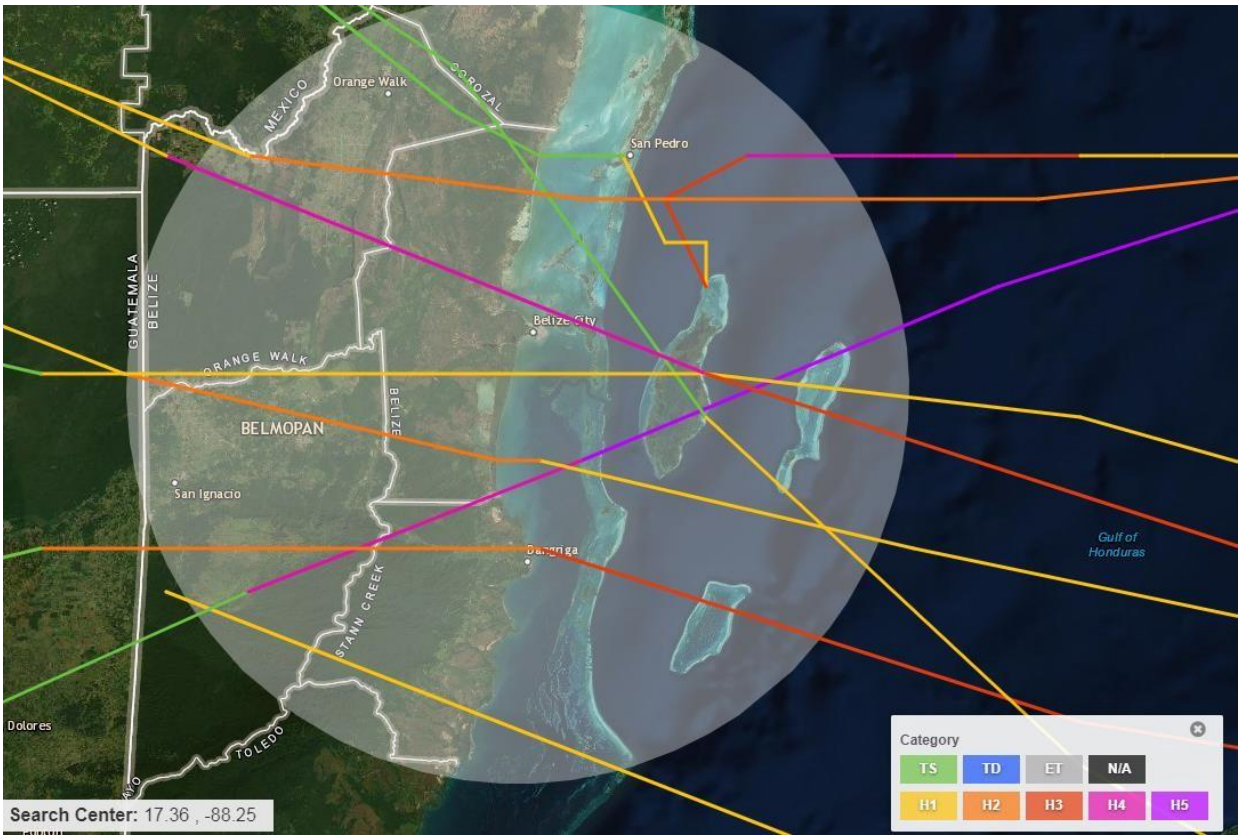


Figure 2-10: Tracks of 9 historical (1919-2019) tropical cyclones within 100km radius from the project site (source: https://coast.noaa.gov/hurricanes/).

As with any coastal development, the proposed Port of Magical Belize Cruise Terminal development will be vulnerable to the hazards of future, land-falling hurricanes near and over the central coastline of Belize. The bathymetry of this coastal area is shallow for a distance of several kilometres from the shoreline, and is strongly influence from sediment discharged by the Sibun River a short distance to the north. Updated analysis based on hurricane tracking maps and reports for the past three decades (1994-2018) showed that seven (7) hurricanes and six (6) tropical storms affected the country of Belize. This does not include the extensive floods across central Belize generated by Tropical Depression 16 in late October-November of 2008. Six of these tropical cyclones impacted the Belize City area with torrential rainfall, storm surge and sustained, hurricane force winds, resulting in much structural damage to property and assets, and extensive beach erosion. Mangrove forests in the Coastal Plain to the south of the Port of Belize suffered significant wind damaged. Consequently, over water structures and other buildings to be erected to accommodate the proposed cruise terminal should be in compliance with international standards for such infrastructure and Belize's building codes for hurricane force winds and storm surge impacts.

A review of historical storm surges associated with landfalling hurricanes are listed for in Table 2-6 below for reference.

Table 2-6: Storm surge generated by landfalling hurricanes relative to Belize City.

Year	Hurricane	Surge
1864	Un named Cat I	1.5m (5 feet) in Belize City
1931	Un named Cat III	3m (10 feet) in Belize City
1955	Janet Cat V	1.5m (5 feet) in Corozal Town, Demolished Chetumal Quintana Roo
1961	Hattie, Cat IV	4.0-4.5m (13-15 feet) in Belize City
1974	Fifi, Cat II	0.6-1.2m (2-4 feet) in Belize City, higher surge in Dangriga
1978	Greta, Cat II	0.6-1.2m (2-4 feet) in Belize City.
2000	Keith, Cat IV	1.5m (5 feet) Caye Caulker; 2.4-3.2m (6-8 feet) San Pedro; 1.2m (4 feet) in Belize City. Storm remained stationary for 24 hours some 40 km offshore
2001	Iris, Cat IV	3.2-4.5m (8-15 feet) Placencia Peninsula, Stann Creek District
2010	Richard, Cat I	0.6 – 1.2m (2-4 feet) northern Lagoon area
2016	Earl, Cat I	1.2 – 1.8m (4-6 feet) Belize City

These records underline the importance of and need for of a detailed hurricane and storm surge Assessment, including simulation in order to define the design conditions for the Project. The data gathered in this phase can be used as baseline data for this specialized study.

2.2.3.2 Coastal Flooding: TAOS Storm Surge Model

Flood hazard types

Belize is exposed to the three major types of flood hazard: river flooding (fluvial), surface water flooding from extreme rainfall (pluvial), and coastal flooding from storm surges (Trigg et al., 2016).

Fluvial flooding (River overtopping)

This relates to prolonged rainfall across catchments and extremes often associated with hurricane or tropical storms. For example, higher rainfall and steep slopes at the headwaters in the Maya mountains, leads to very rapid flood wave build and travel times, e.g. Macal River. When these flood waves arrive in the lower reaches of the river, where the terrain is very flat, bank overtopping occurs, leading to long duration ponded water flooding.

Pluvial Flooding (Intense rainfall)

The tropical context is associated with very high intensity, short duration rainfall events which results in rapid saturation, overland flow and localized ponding.

Storm Surge

Storm surges are generated by tropical storms and hurricane arriving at the coast. This leads to a 1-5 m water surge travelling inland, centred on the depression or the low pressure vortex (or the eye of a hurricane). In Belize the local tide range is small and timing with tide peaks is not an issue.

Hazards associated with land-falling hurricanes along the coast of Belize include torrential rainfall, tornadoes, storm surge and coastal flooding.

The TAOS storm surge model (OAS, 1995) projected a 1.8 meters surge in the Project site for a Category I hurricane, 5.2 meters for a category II hurricane, 7.2 meters for a Category IV hurricane and about 7 - 8 meters for a Category V hurricane making landfall around the Project site just south of the mouth of the Sibun River. Figure 4.13 below is a graphics of the storm surge result for a Category V hurricane crossing the central Belize District. The coastal zone in the Belize City area would be inundated by a storm surge in excess of 5.5m (18 feet) of water in a Category V hurricane, bearing in mind that such an extreme event has a return period of 50 to 100 years. The map in Figure 2-15 shows the extend of the coastal flooding associated with a storm surge produced by a land-falling Cat V hurricane in the vicinity of the project zone south of Belize City coastline, shaded in light brown.

The flood hazard map (**Figure 2-12**) shows flood hazards from storm surge generated by hurricane categories 1 to 5. It does not show results for a particular event but is a combined map showing flood risk for the coastal zone in the Belize City area and south to the Cruise Terminal project site, with a defined probability (World Bank Group, 2016).

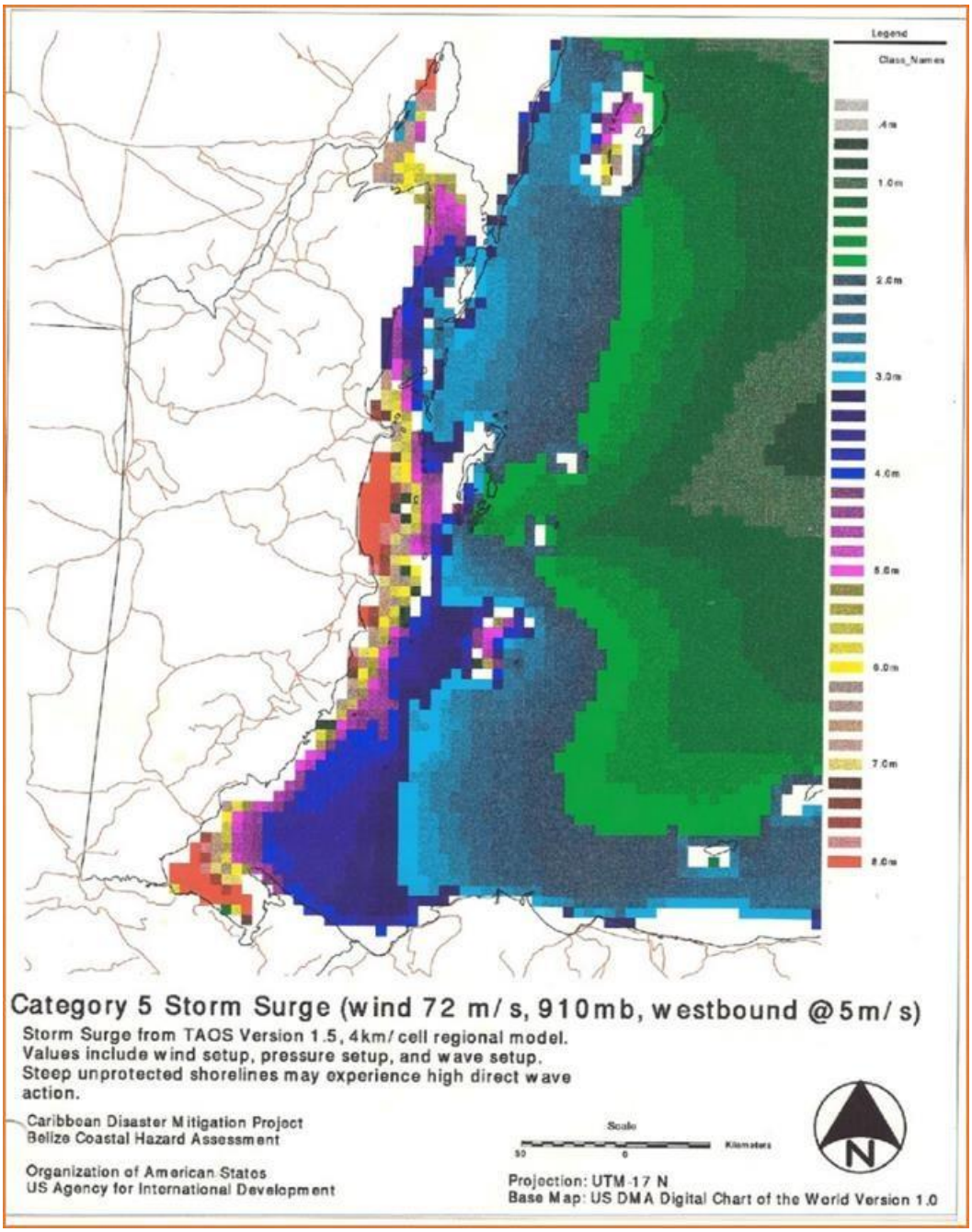


Figure 2-11: TAOS Storm Surge Model Projection for a Westward bound Cat V Hurricane moving at 11.2.

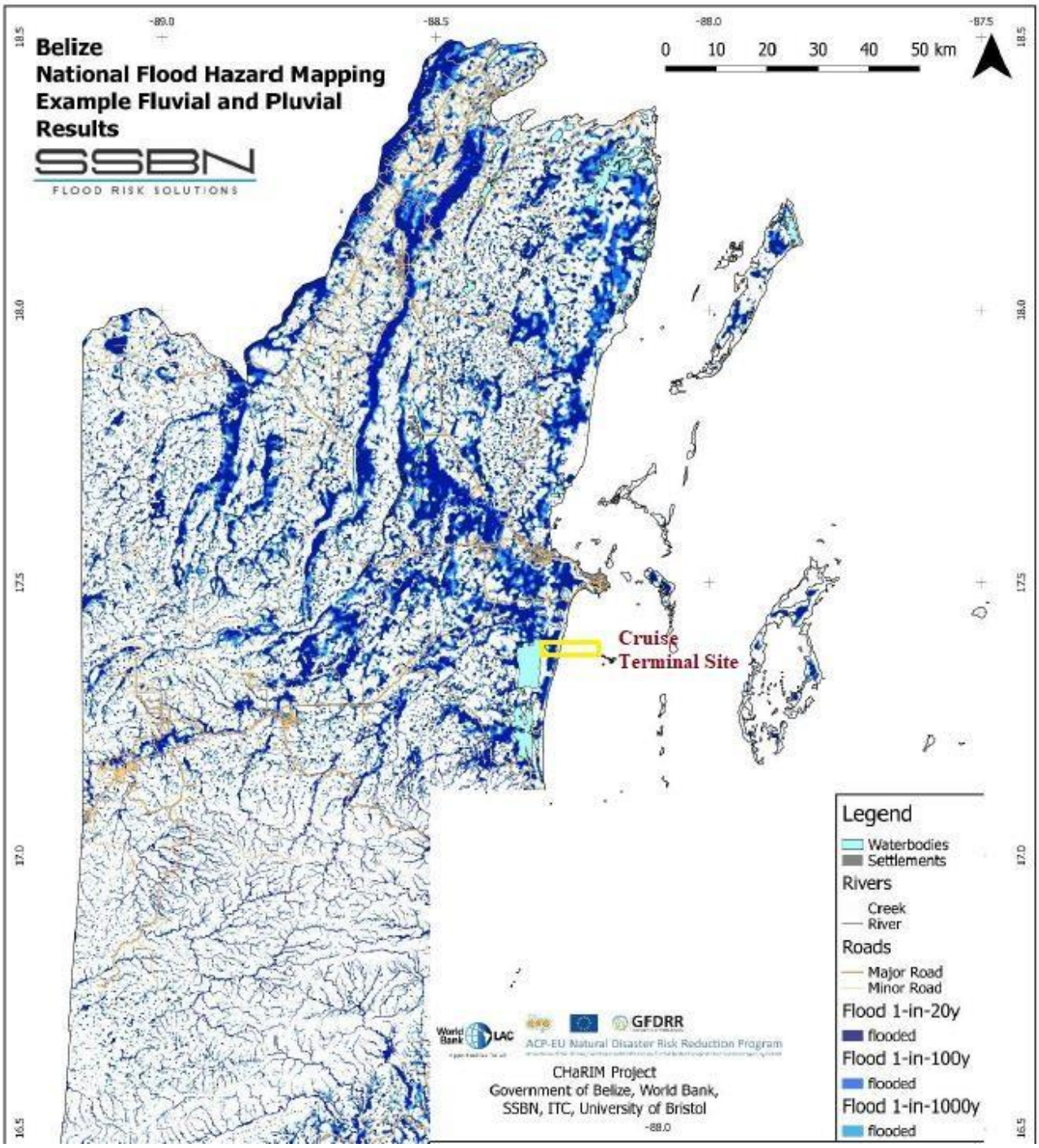


Figure 2-12: Flood hazard map showing a in 20-year coastal flood in the project site (Source: Trigg, et al., 2016 CHaRIM project).

2.2.3.3 Seismicity and Tsunamis

The country of Belize is close to the northern margin of the Caribbean plate and North American plate. Earthquake risk is concentrated in the south-eastern region of the country, away from the main population centres. The records show that large earthquakes do occur in the area offshore SE Belize where the Caribbean transform plate boundary runs, and these have damaging

potential for Belize City, Belmopan, San Ignacio/Santa Elena as well as other communities in Southern Belize (e.g. May 30, 2009 seismic event). **Figure 2-13** is a map showing locations and strength of historic seismic epicentres in the neighbourhood of Belize and its coastal zone (CCRIF, 2013). The proposed Cruised Terminal development near the mouth of the Sibun River is less exposed to seismicity than coastal areas farther south, however, like the rest of costal Belize, it is exposed and may be vulnerable to the impacts of tsunamis generated by marine earthquakes in the region.

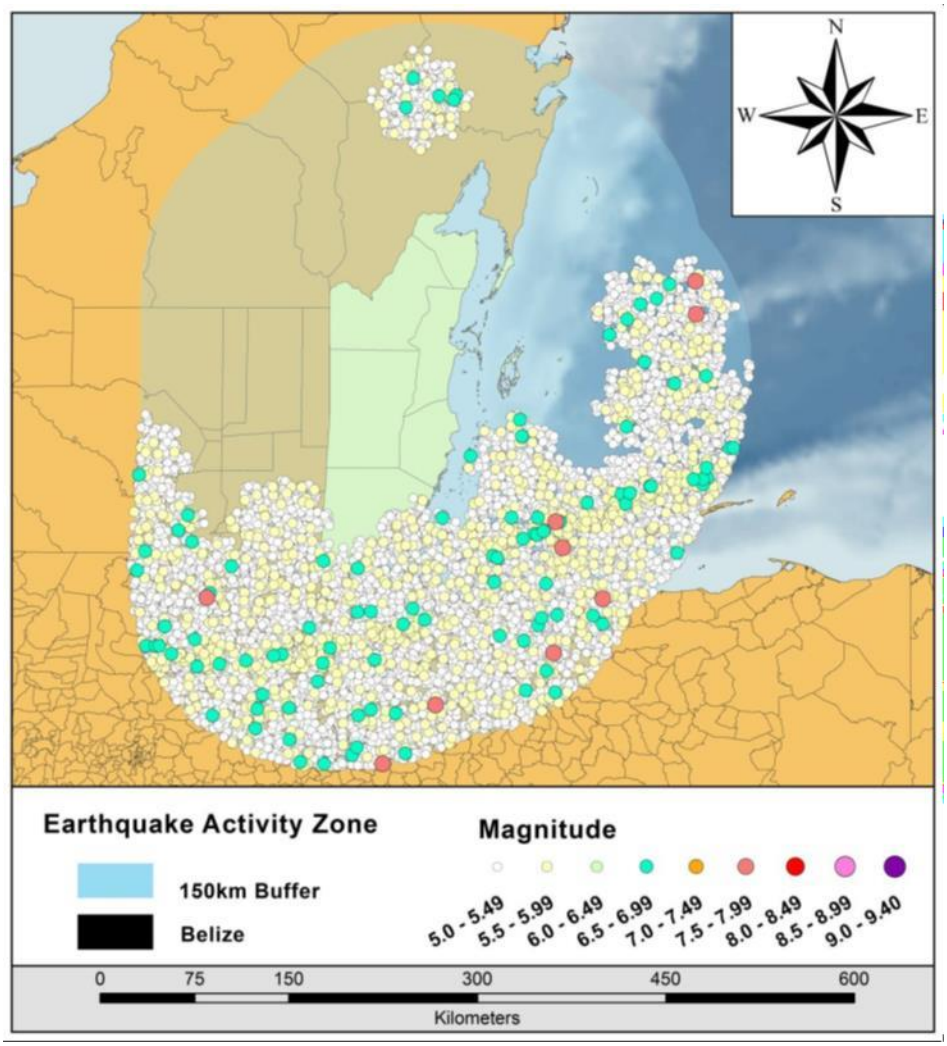


Figure 2-13: Caribbean Catastrophe Insurance Fund stochastic earthquake catalogue for the region of southern Belize, Honduras and Guatemala (CCRIF, 2013).

Tsunami Threats

Tsunamis are generated by marine earthquakes, massive underwater landslides and island volcano eruptions. Figure 2-18 is an illustration of the mechanics of a tsunami.

According to the Belize Development Trust (BDT, 2000), Belize has a 100% chance of experiencing five (5) earthquakes and 75% of seeing 10 in the next century. Source region for marine earthquake epicentres, according to the United States Geological Survey, are along the major fault lines across the Caribbean and the Gulf of Honduras.

Belize does not have a National Earthquake Information Center or seismic station, and all earthquake disaster preparedness rests with NEMO. Warnings from the US Pacific and National Tsunami Warning Centers (PTWC, Hawaii) are transmitted to the National Meteorological Service which is the National Tsunami Focal Point. The warnings are re-transmitted directly to the NEMO Headquarters in Belmopan. Unlike hurricanes that normally allow sufficient time to prepare, marine earthquakes and associated tsunamis strike suddenly, violently and without much warning.

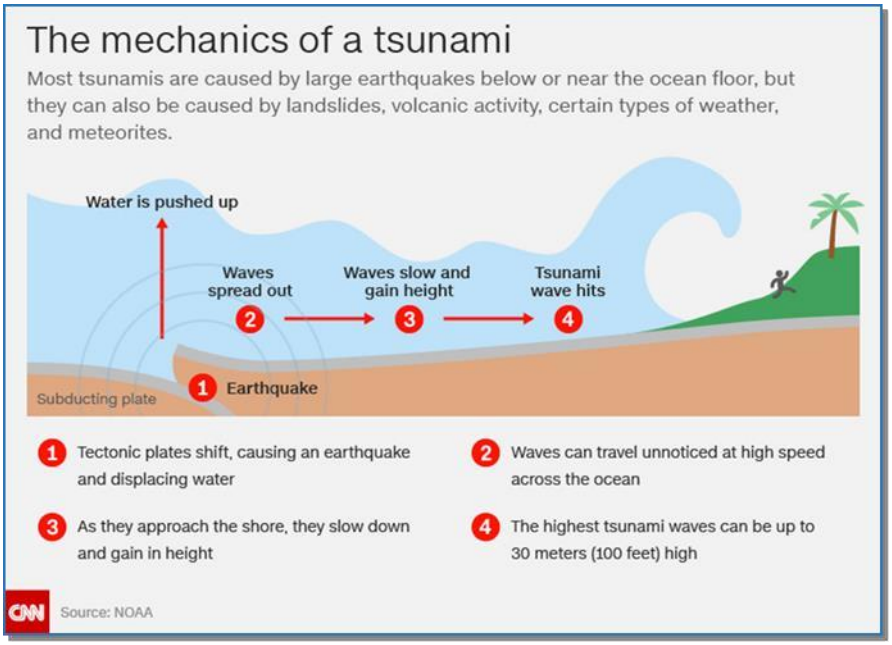


Figure 2-14: How a tsunami is generated (Source: NOAA 2016).

Earthquake preparedness depends to a great extent on the early measure taken to plan for these seismic movements by ensuring that the construction of building and other structures, particularly in the coastal zone, take these into consideration, and by identifying potential hazards associated with sudden earth movement ahead of time. Major hazards associated with marine earthquakes are tsunamis.

Historical records indicate that the Caribbean region have been affected by tidal waves or tsunamis generated by earthquakes. **Figure 2-15** is a map of historic earthquakes and tsunamis in the Caribbean/Central America sub-regions.

The map depicts the locations (green squares) and water heights of historic tsunamis in the Caribbean (gold and blue bars) and locations of significant earthquakes (circles). Red triangles mark significant volcanic eruptions.

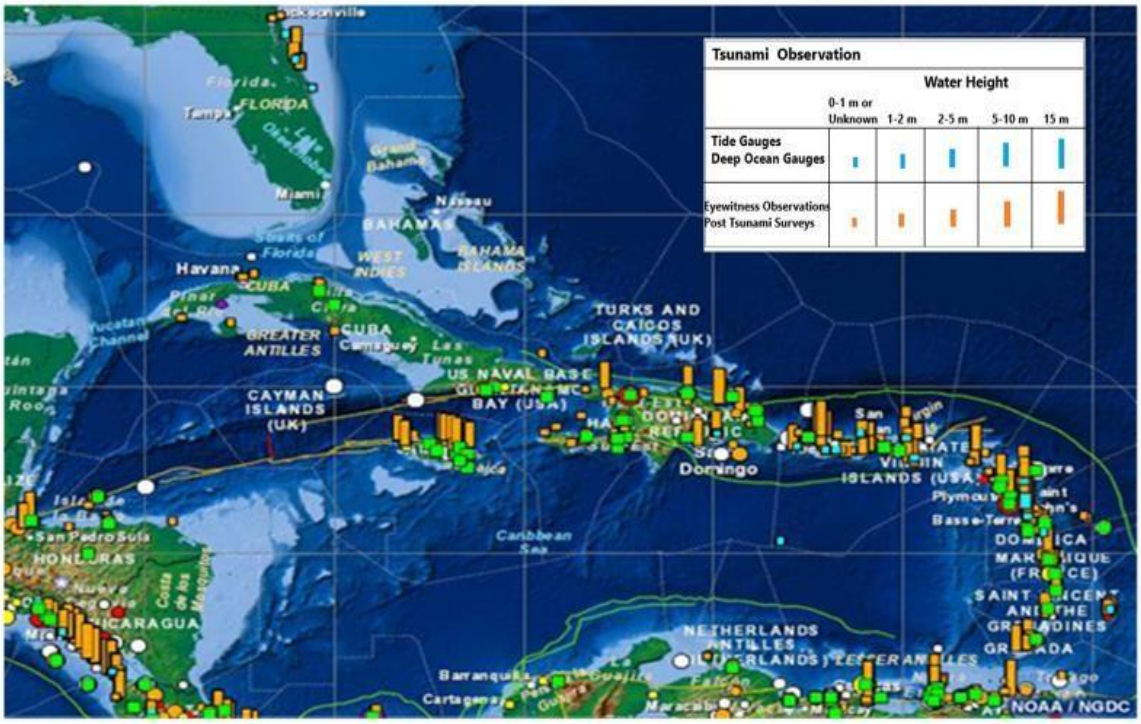


Figure 2-15: Historic Caribbean Earthquakes and Tsunamis (Source: www.meted.ucar.edu/tsunami/community/media_gallery.php)

2.2.4 Climate Change

For a look at climate change and its potential impacts on the project see section **Part B** of this EIA. According to newly released data from NASA, the first six months of 2019 finished up as the second warmest half-year on record. In addition, each of the last five January through Junes are now the five warmest such *spans* on record. Only 2016 started hotter than 2019 (Kaufman, 2019). NOAA (2019) reported that the month of June 2019 was characterized by warmer-than-normal temperatures across much of the world.

The global land-only surface temperature for June 2019 was 1.34°C (2.41°F) above the 20th century average. This was also the highest June temperature in the 140-year record, exceeding the previous record of +1.30°C (+2.34°F) set in 2015. Asia and the Caribbean region had their eighth and ninth highest June temperature in the 110-year regional record, respectively. Meanwhile, North America and Oceania had their coolest (or least warm) June since 2009 and 2012, respectively.

The global ocean-only temperature for June 2019 tied with 2016 as the highest June temperature on record at 0.81°C (1.46°F) above average. Junes 2016 and 2019 are the only June global ocean-only temperature departures from average that have surpassed +0.80°C (+1.44°F). June 2019 tied with August 2015, April 2016, and June 2016 as the 10th highest monthly global ocean temperature departure from average among all months (1,674 months) on record. The 10 highest global ocean monthly temperature departures from average have all occurred since September 2015 (NOAA, 2019).

The preceding climate update from NOAA indicates that Global Warming is a reality and is now impacting every continent and maritime ecosystem. Therefore, impacts of climate change and climate variability must be considered in any economic venture, particularly in high risk coastal zones in the Caribbean and Central America. According to the IPCC (2013), climate change is being manifested in form of increased in the mean averaged surface temperature and sea surface temperatures, increased rainfall variability, increased global seas level rise, and increased frequency of more intense hurricanes, such as the Atlantic Basin Cat 5 Hurricane Dorian (24 Aug. – 9 Sep., 2019).

Coastal Belize will remain vulnerable to rising sea level, increased temperature, and increased frequency of intense hurricanes with their associated hazards in the form of torrential rains, catastrophic winds and destructive storm surge under warmer environmental conditions. Hence, it is imperative that the proprietors of the Port of Magical Belize proposed Cruise Terminal project develop an effective hurricane/natural hazard plan for the establishment in coordination with CEMO and NEMO, and key partners operating in the tourism sector and the coastal zone.

2.2.4.1 Climate Change Projections

The impacts of climate change resulting from global warming are expected to threaten the sustainability of social, economic and ecological systems. Coastal zones in tropical regions are especially vulnerable (IPCC, 2007). Rising sea levels are expected to threaten low-lying coastal areas and islands, with increase evidence of beach erosion, coastal flooding, inundation, and salinization of surface and groundwater resources.

Global projections of future sea level rise range from 0.18 to 0.59 meters relative to the average for 1980-1999 by 2099, however sea level rise is not expected to be geographically uniform. Sea level rise in the Caribbean region by the end of the 21st century is expected to range from 0.44 m to 0.70 m for the high climate model scenario (IPCC, 2007).

Haites *et al.* (2002) estimated the economic impacts of climate change for CARICOM countries across a range of economic sectors including tourism. The authors cite a range of potential effects of climate change on tourism, including the loss of beaches due to erosion, degradation of ecosystems (e.g., coral reefs and littoral forests), inundation, and damages to infrastructure. The economic impact is calculated as the difference between a "low" and "high" climate scenario. In the low scenario, the temperature increases are 1.5 °C in 2050 and 2 °C in 2080, and the projected sea level rise is 0.08 m in 2050 and 0.13 m in 2080. In the high scenario, the temperature increase is 2.0 °C by 2050 and 3.3 °C by 2080, and the projected sea level rise is 0.44 m in 2050 and 0.70 m in 2080. Precipitation is projected to decrease in the low scenario, particularly in the rainy season; the high scenario projects an overall increase in precipitation.

The impacts of Climate Change are already being experienced across the productive sectors of Belize, affecting the livelihood of much of the population (GOB-NCCO, 2015). As a small, insignificant contributor to global greenhouse gas emissions, Belize has limited capacity to contribute to mitigation of global climate change. However, the country is committed to play

its part in support of the UNFCCC target to limit the increase of global average temperature to 1.5 °C compared to pre-industrial levels. In this respect, Belize's Nationally Determine Contribution (NDC) is guided by its commitment to strategically transition to low carbon development, while strengthening its resilience to the effects of Climate Change.

The future climate for Belize will likely be characterized by increasing temperatures and declining levels of precipitation possibly arising due to a shift in the rainy season and extended dry season. One study projected a median temperature increase of 2.0 °C (3.6 °F) for the Caribbean region and 3.2 °C (5.7 °F) for the Central American region, and they project a median decrease in annual precipitation of 12% for the Caribbean region and 9% for the Central American region (UNDP, 2009). Average annual temperatures are expected to increase 3.5 °C (6.4 °F) over the 90-year period, while average rainfall is expected to decrease by 100 mm (IPCC, 2007).

The coastal lowlands in northern Belize are vulnerable to sea-level rise (McSweeney, *et al.* 2012). The climate models project sea-level rise in the region by the 2090s, relative to 1980-1999 sea-level as follow: 0.18 to 0.43 m under SRES B1; 0.21 to 0.53 m under SRES A1B; 0.23 to 0.56 m under SRES A2 (McSweeney, *et al.* 2012). The damages to infrastructure resulting from sea level rise, coupled with increased frequency of intense tropical cyclones, and the economic effects on the tourism sector, the largest contributor to GDP, could negatively impact the sustainable development of Belize (UNDP, 2009).

In summary the effects of climate change will be in three forms, namely:

i) Increased ambient and sea surface temperatures;

ii) Sea level rise; and

iii) Increased frequency of more intense hurricanes (Cat III or stronger) in hurricane basins around the world (IPCC, 2013).

The impacts on the coastal zone of Belize, is increased seas level rise and tidal influence on flood conditions, stronger hurricane making landfall along the coast of Yucatan and Belize, provoking destructive storm surges and coastal flooding, and extensive coastal erosion (e.g. the on-going Monkey River village situation). Effective adaptation measure will have to be carried out to mitigate these impacts.

Summary Climate Change Model Projections for Belize

Figure 2-16 shows a summary of the regional climate change model projections for Belize.

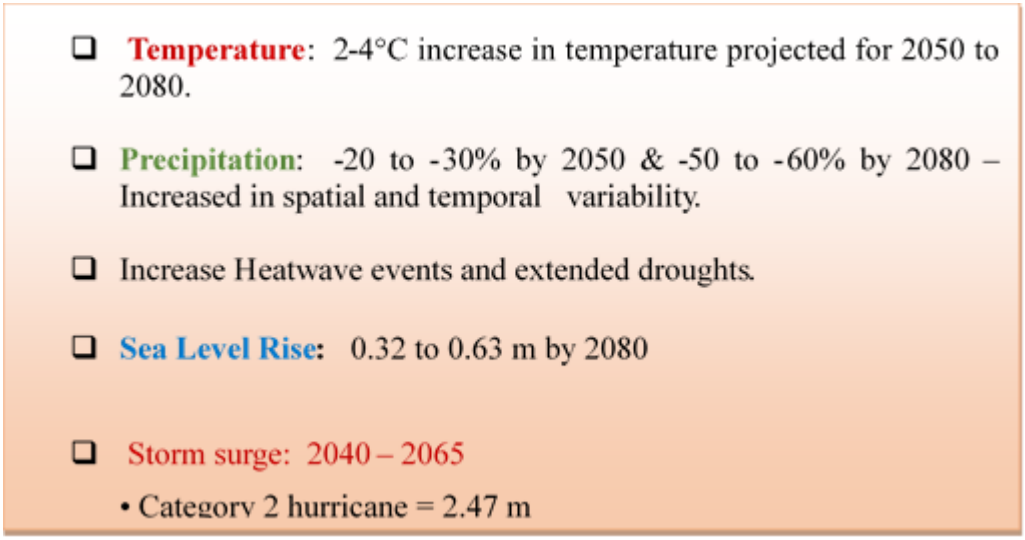


Figure 2-16: Regional Climate Model Projections for Belize (Source: NCCO-NAP, 2019).

2.3 Oceanographic data

2.3.1 Tides

The tides in Belize are semi-diurnal, meaning that two low and two high tides occur daily or in tide cycles that last about 24 hours and 50 minutes. The highest tide is followed by a low and lowest by a high, but not necessarily in the same sequence. The Earth rotates on its axis every 24 hours so that both sun and moon appear first on the eastern horizon and traverse the sky to the west. Likewise, the tidal bulge caused by the moon, and modified by the gravitational pull of the sun, also travels from east to west like a wave. For this reason, tides on the east coast of the Americas behave as expected, rising and falling twice every 24 hours. The tidal amplitude or range over coastal waters of Belize is of the order of 0.3 m to 0.5 m, but this may vary during strong northerly flow associated with cold front passage when the range may increase to around 0.8 m (Tunich Nah, 2004). Generally, in the project zone tidal fluctuations are on the order of about 0.31 m (1 foot) about MSL.

De Nul et al. (2018) cites local source (EIA for Stake Bank, 2006) on waves and tidal motion in the vicinity of the proposed Cruise Terminal project at the Port of Belize, indicating that the wave climate near Belize City typically features 1 meter waves from the east. However, during storm events, storm surge can cause water levels to increase dramatically, for example the 3.0m to 5.5m (10 – 18 feet) storm surge associated with Hurricane Hattie in October 1961.

Tides in the Caribbean are typically microtidal, with ranges less than 0.5 meters. In Belize city, the tidal range is typically 0.3 meters with the largest recorded range of 0.41 meters.

2.3.2 Currents

Ocean waters are constantly on the move. Currents flow is affected by wind, the water's salinity and heat content, bottom topography, and the earth's rotation on its axis or the Coriolis effect. The currents influencing the depositional and erosional processes are derived from both wind-

driven and tidal sources. The wind driven currents are greater in magnitude and are in general more influential in affecting the dynamics of the coastal ecosystems.

The prevailing water movement entering the Caribbean is the wind-driven Guiana Current (**Figure 2-17**) flowing from southeast to northwest; this becomes the Caribbean Current, flowing through the Lesser Antilles with the greater portion reaching the Yucatan Strait (Hanson & von Twistern, 1996; Gyory, J, et al. 2013). The current breaks at Rocky Point, northern Belize, to form a small gyre that drives the sea off Belize to flow from north to south as illustrated in Figure below (Perkins, 1983). While the prevailing current flow travels from north to south, powerful northerly winds during cold fronts or other storm events may generate temporary strong currents that may carry materials such as sediments as far as the Mesoamerican Barrier Reef System (MBRS). Fresh water discharge from the Belize and the Sibun Rivers, especially during flood stage influence the longshore currents offshore Belize City and the proposed Cruise Terminal site.

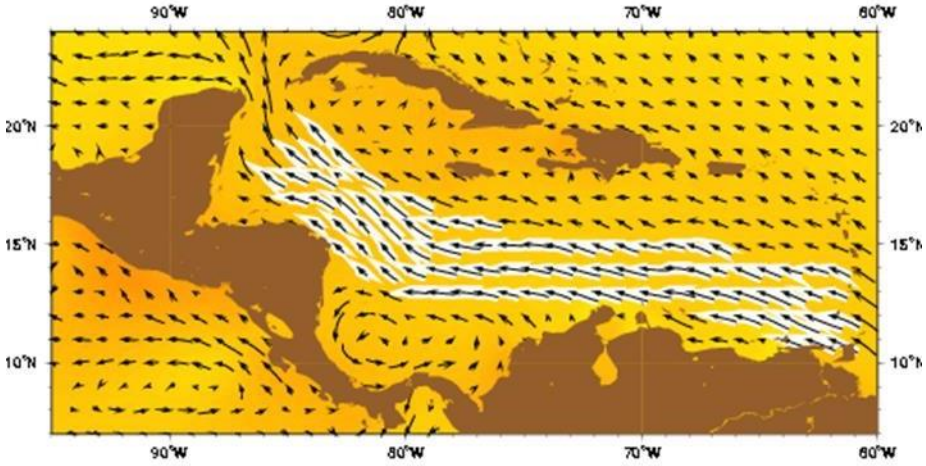


Figure 2-17: Caribbean current originating from the wind-driven Guiana current (Source: Hanson & von Twistern, 1996).

These currents do not only affect sediment transport but also the distribution of sessile organisms including seagrasses (e.g. sargassum) and algae. These currents vary seasonally and, though charted in general, have not been studied in detail (Hanson & von Twistern, 1996).

Localized flows off the central coast of Belize are influenced by longshore currents, and discharge from the Belize River to the north and the Sibun River. The trajectory and strength of the currents off Belize City and the proposed Cruise Terminal project site is influenced by the prevailing north-south flow in the Inner Lagoon, surface winds and tidal effects. Prevailing winds are the main driving force for waves and surface currents in coastal waters of Belize.

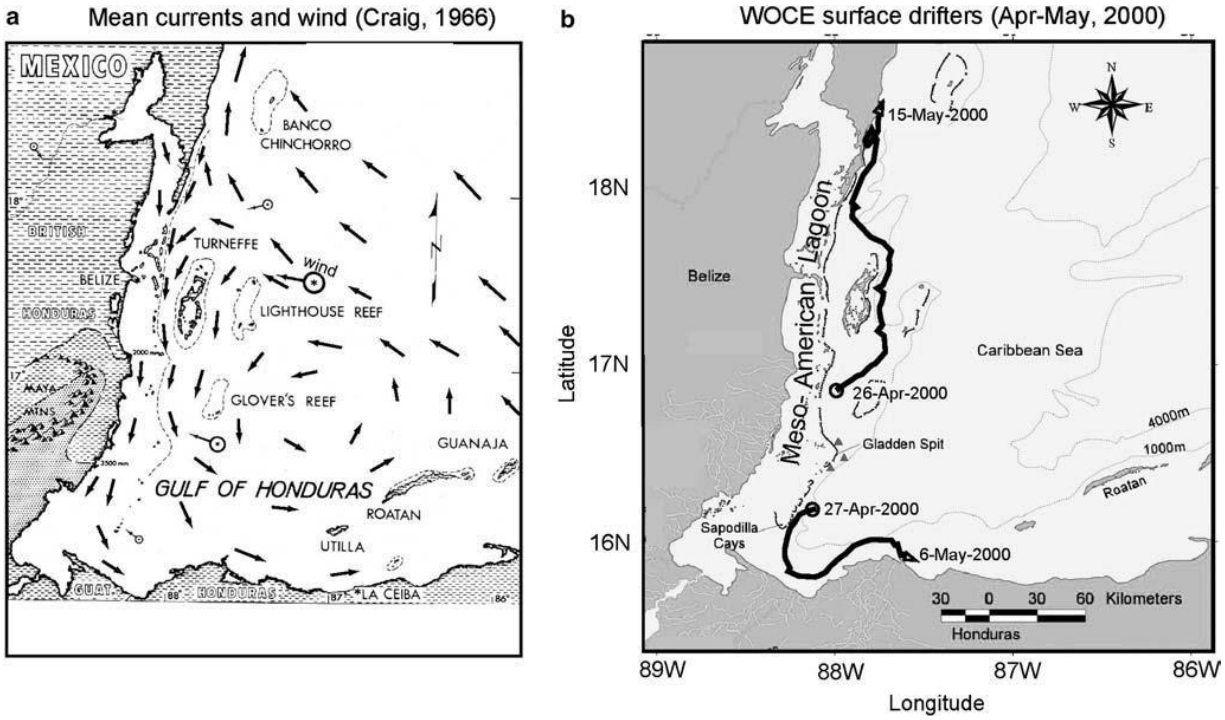


Figure 2-18: Observed flow field near the MBRS. (A) Mean currents (arrows) and wind (arrows with circles as composed from various observations (based on a larger map from Craig, 1966). (B) Two WOCE drifters at 15 m depth (launched on April 2000 at locations indicated by circles) (Perkins, 1983).

The prevailing winds also result in marine wave action moving predominantly towards the South and Southwest. **Table 2-7** and Figure below shows the results of drogue drifts a short distance south of the project zone as observed on the showery morning of 29 June 2019.

Table 2-7: Drogue displacement just south of the Port of Belize on 29 June 2019.

Date	Drogue	Start Time	Eastings	Northings	End Time	Eastings	Northings	Time (s)	Dist. (m)	Velocity (m/s)
29 June 2019	D1	9:00 am	0367370	1926877	12:02 pm	0368896	1925139	10920	2277.9	0.209
	D2	9:01 am	0367283	1926880	11.55 am	0368558	1925454	10440	1881.9	0.180
	D3	9:03 am	0367178	1926893	11:52 pm	0368246	1922561	10140	4332.5	0.427

As can be seen, the surface drift on that occasion was south south-eastwards, influenced partially by the receding tide and the river discharge. Superficial currents range from around 0.18 m/s to near 0.43 m/s (see **Table 2-7**).

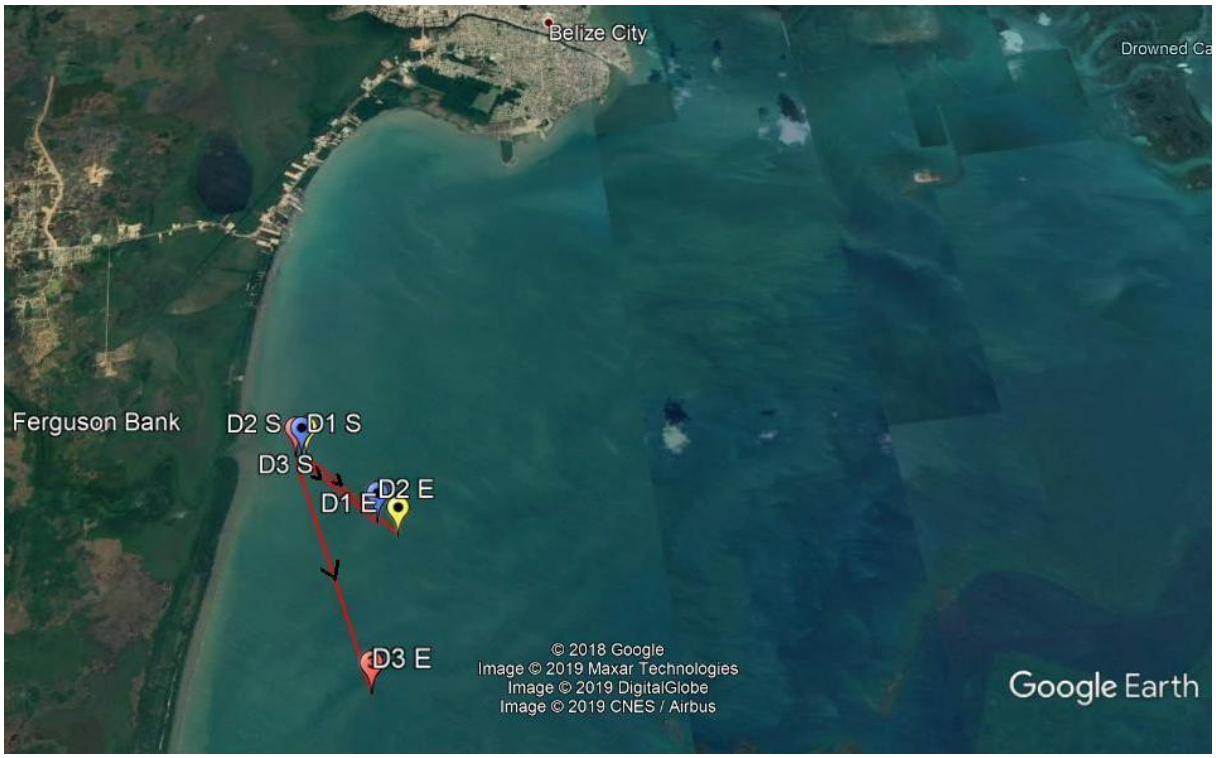


Figure 2-19: Drogue displacement near coast east of the Sibun River mouth and just north of the Cruise Terminal site on 29 June, 2019.

The literature indicates that wind driven currents in the Belize City areas have been recorded at 0.51 – 0.77 m/s (1.0 - 1.5 knots) at the immediate sub-surface depths and 0.10-0.30 m/s (0.2-0.6 knots) at a depth of 1.8 meters (FAO/UNDP unpublished report, 1983; EIA Stake Bank 2006). In the vicinity of Drowned Caye, the currents varied throughout the hydrographic profile from 0.09 m/s to 0.22 m/s. The direction of the current was generally from the Northeast towards the Southwest (BET, 2012) or in a southerly direction.

Historical records on currents in the vicinity of the Port of Belize based on field measurements by Ocean Surveys Inc. during the period July 14-23, 2004 showed that the maximum 6-minute current was 0.62 m/s (1.2 knots) near the surface, which was observed on July 23, 2004 around 3:18 pm (Tunich Nah, 2005). The direction was 356 degrees (true north). The maximum hourly current recorded was 0.44 m/s (0.85 knots) near the surface on July 16th, 2004 around 10:00 am. The measurements were taken using a current meter anchored in 5.5 meters of water approximately midway between the existing Deepwater Port pier head and the ESSO offshore fuel mooring buoys.

Tunich Nah (2005) also asserted that Intersea Research Corporation (Jan. 1976), which was associated with the design of the existing Deepwater Port of Belize, indicated that currents as high as 0.514 m/s (or 1 knot) were recorded near the existing turning basin site. Southwest currents driven by the wind and stream runoff were the strongest. Intersea Research Corporation also indicated that the weaker northeast currents during calm nights and early morning appeared to be driven primarily by tidal forces.

The 2001 Environmental and Social Impact Assessment for the dredging of the Deep Water Port and the mouth of the Haulover Creek stated that currents resulting from tidal amplitude on the Yucatan Shelf generally varied from 0.15 to 0.22 m/s (0.30 to 0.42 knots). Consequently, for normal currents a speed of 0.77 m/s (1.5 knots) can be used. The design features for the existing pier and other sea-based infrastructure associated with the proposed Belize Cruise Terminal at the Port of Belize shall be based on the 100-year flood and a Category V Hurricane landfall, according to the EIA (Tunich Nah, 2005).

Boskalis set up a numerical model to assess the wind driven currents, see Boskalis (2019) memo in Annex 12. For relatively high wind speeds, wind driven currents are dominant over tidal current. Calculated maximum depth-averaged velocities are approximately 0.6 knots.

In summary, wind driven currents in the Belize City area have been recorded at 1-1.5 knots at the immediate subsurface and 0.2-0.6 knots at depth of 1.8m. The net direction of surface currents in the shelf lagoon and the Cruise Terminal project area near the mouth of the Sibun River is in a southerly direction (EIA Stake Bank, 2006).

2.3.3 Waves

Waves conditions at various depths in the vicinity of the proposed cruise port are determined using the Infoplaza database, containing 19 years of 3hr interval data and a numerical wave transformation model (SWAN), taking into account all physical processes and the local bathymetry. **Figure 2-20** depicts the scatter between significant wave height and peak period and wave direction, clearly illustrating the dominance of wind waves from easterly directions.

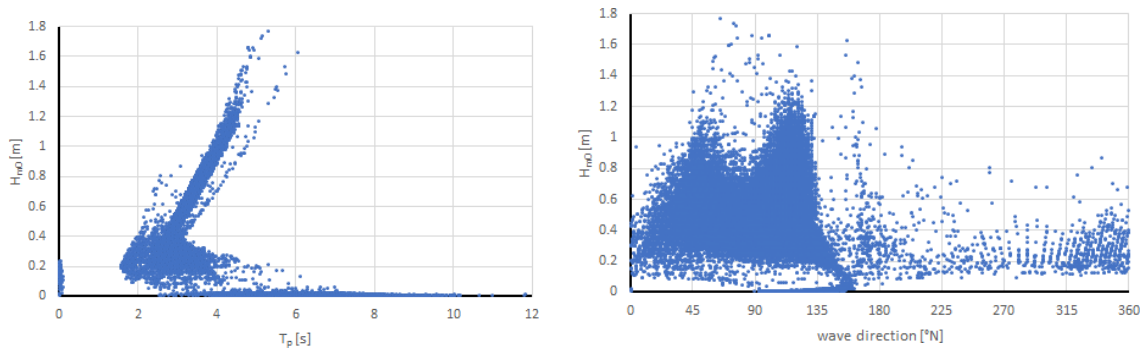


Figure 2-20: Scatter plots of calculated wave height, -period and -direction.

Based on the nearshore time series of 84,736 wave conditions, the monthly exceedance is computed and summarized in Table 2.7.

Table 2-8: Monthly exceedance (%) of significant wave height range (in metres)

H_{m0} (m)	Jan.	Feb.	Mar.	Arp.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	year
0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
0.1	98.5	98.8	99.1	99.2	99.2	99.1	98.5	98.7	98.7	98.4	98.4	98.2	98.8
0.2	98.2	98.6	98.9	99.1	98.8	98.9	98.4	98.5	98.0	96.8	98.0	97.8	98.4
0.3	96.3	96.9	97.4	97.7	96.9	98.0	96.3	95.0	93.9	90.3	94.4	95.4	95.9
0.4	86.6	88.1	88.9	88.1	86.2	91.4	82.3	75.1	73.8	71.2	79.0	83.0	83.6
0.5	71.0	71.4	74.3	73.3	69.1	80.5	64.1	55.9	53.2	53.1	57.2	61.3	66.6
0.6	48.7	50.1	56.4	55.6	49.8	62.1	42.5	37.5	33.9	35.9	35.7	38.1	46.9
0.7	27.5	30.7	38.5	38.6	31.1	41.0	23.5	22.2	18.3	22.4	19.6	19.3	28.9
0.8	14.2	17.4	24.7	24.1	17.6	23.0	11.4	10.7	9.4	13.5	8.9	10.1	16.3
0.9	5.9	8.6	13.6	13.7	9.1	10.9	4.4	4.8	4.0	8.4	3.6	3.8	8.1
1.00	2.7	3.6	6.7	6.5	3.3	4.5	1.7	2.0	1.3	5.6	1.8	1.4	3.6
1.1	1.0	1.7	3.2	2.7	1.1	1.7	0.5	0.8	0.6	4.2	0.9	0.4	1.6
1.2	0.2	0.4	1.0	0.8	0.4	0.5	0.1	0.4	0.0	3.4	0.5	0.0	0.6
1.3	0.2	0.2	0.2	0.1	0.0	0.1	0.1	0.2	0.0	2.9	0.2	0.0	0.3
1.4	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.2	0.0	2.3	0.1	0.0	0.2
1.5	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.2	0.0	1.4	0.1	0.0	0.1
1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.0	0.0	0.0	0.1
1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0

2.4 General Geology

Belize is situated the southern margin of the North American Tectonic Plate and forms part of the south-eastern edge of the Yucatan Peninsula where it is bordered to the east by the Caribbean Sea and sits on the eastern margin of the Greater Petén sedimentary basin. Northern Belize consists generally of low-lying Tertiary limestone and Quaternary Deposits with topographic relief of less than 60m. The coastal plains of northern Belize consist mainly of low swampy areas that are bordered along the Caribbean Sea by mangrove swamps, and beach barriers comprised of accreted beach sand ridges behind which several small isolated lagoons exist.

The project area is vegetated consisting of marshes, mangroves and littoral forests with no distinguishing surface geological features. The geology and geological assessment were inferred to by the use of publish work and the Provisional Geology Map of Belize (Cornec, 2010).The project area is situated with in the coastal plain of northern Belize. The project area and its marine extent forms part of a modern day siliciclastic-carbonate depositional system that has been well documented by Ferro, Droxler and Anderson, 1999. From the project site and its extended area of interest the Belize River & delta is 18.5 km to the north, the Sibun River is 6.2 km to the north, and the a Lagoon forms the western boundry. Both the Belize River and the Sibun River (and other smaller tributaries) act as drainage for the northern and eastern flanks of the Maya Mountain, depositing sediments (siliclastic muds, silts and sands) sourced

primarilty from Paleosoic rocks and granites of the Maya Mountain uplift within an area of influence on the project location.

A buried fluvial system also exists within the region of the proposed dredged access channel to the project site. This buried fluvial system consists of unconsolidated clays, silts and sands as described by Droxler and Anderson, 1999. This subsurface condition was further verified by sub-bottom profiling (-17m depth of investigation) geophysical surveys done by (Deltares, 2019) on behalf of the project developer, Boskalis. The results of the bottom profiling revealed a layer of soft silt with inclusions of sand, clay, shells, and peat. These soft unconsolidated sediments were underlain by stiff to hard mottled red clays. Depth to hard rock was not substantiated due to the inability to ground truth beyond the stiff clays (Refer to appendix for Sub Bottom Profiler investigation for the access channel Magical, Belize report). Lithologic logs from oil exploration wells and seismic sections as published by Purdy el al, suggests that these modern clastic deposits within the project area sits on Pleistocene limestone.

A combination of wave action and a Southward directed longshore current rework these sediments by transporting them along the coast. This forms a series of beach barriers comprised of accreted beach ridges and sand ridges in the surf zone - as evident in and around the project area and visible on Google Earth images. These longshore currents confines clastic sedimentaion along the coast allowing a marine carbonate evironment to persist to the east.

The provisional Geology Map of Belize (Cornec, 2010) describes the sediments to be of Quaternary Age (recent sediments) consisting of alluvium, river terraces, sand bars, calcareous sands and muds overlaying Late Tertiary marls and limetsones of the Orange Walk group in some areas and variagated mottled clays of the Red Bank Group in other areas. This is consistent with the investigations carried out by Out Island Construction where stiff and resistant red to gray mottled clays were encountoured in all boreholes at depths greater than 1.8m (6ft).

Further work done by Purdy, Gischler and Lomando suggests that the modern clastic deposits with in the project area sits on Pleistocene limestone. The Cornec provisonal Geology map of Belize (1998) was ammended by Purdy, Gischler and Lomando to include the structural fabric of Belize – faults, surface structures and other structural trends. The lack of physical observation of limestones or marls in the project site and along the road alignment is due to the depth of investigation of hand core, however the due to the required depth of excavation for the channel and the competent nature of the clays, no deeper investigations were required for the project at this stage. Deeper borings and soil testing with more detailed engineering/geotechnical work is recommended for the foundation design of the buildings or other structures.

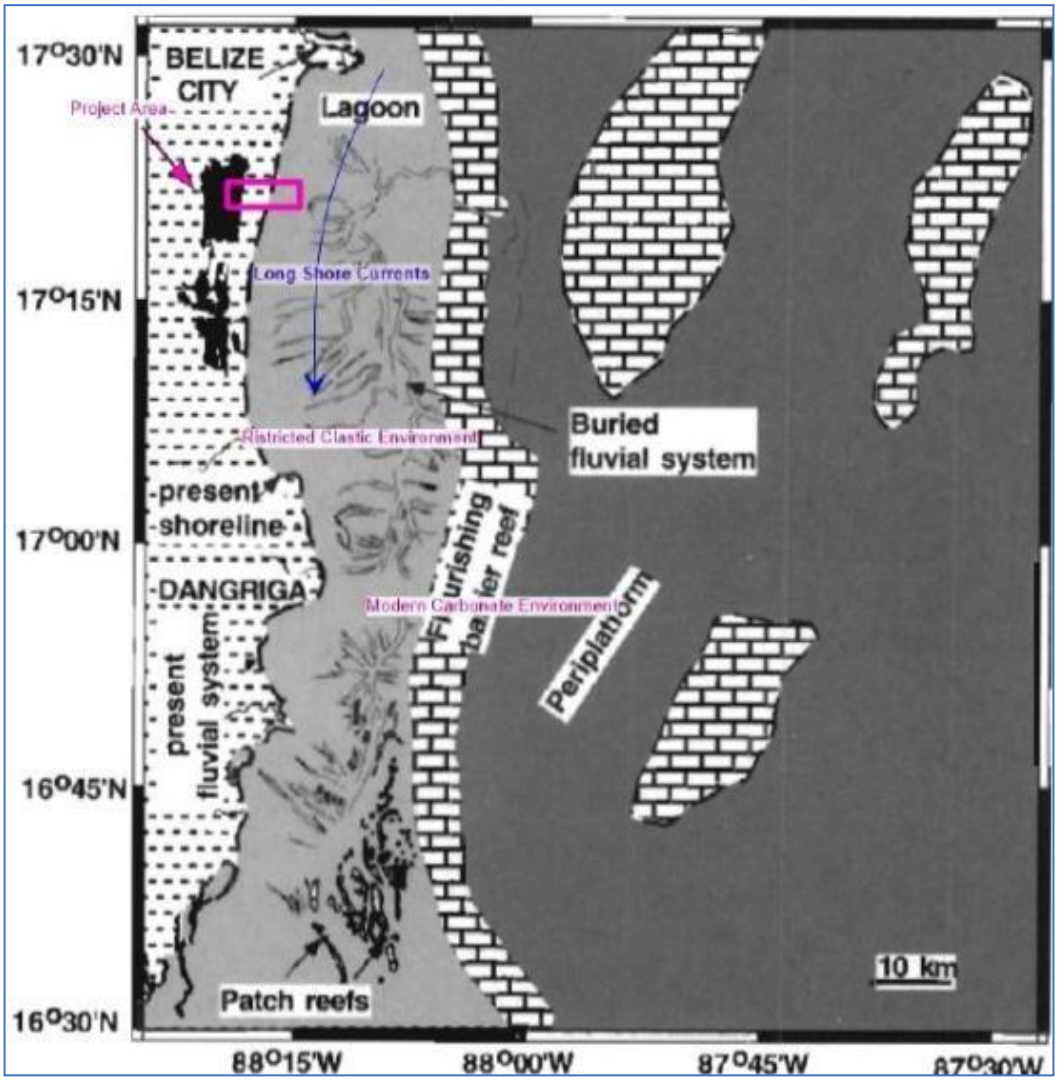


Figure 2-21: Longshore currents and Depositional Systems in Project Area (Amended from Ferro, Droxler, and Anderson, 1999).

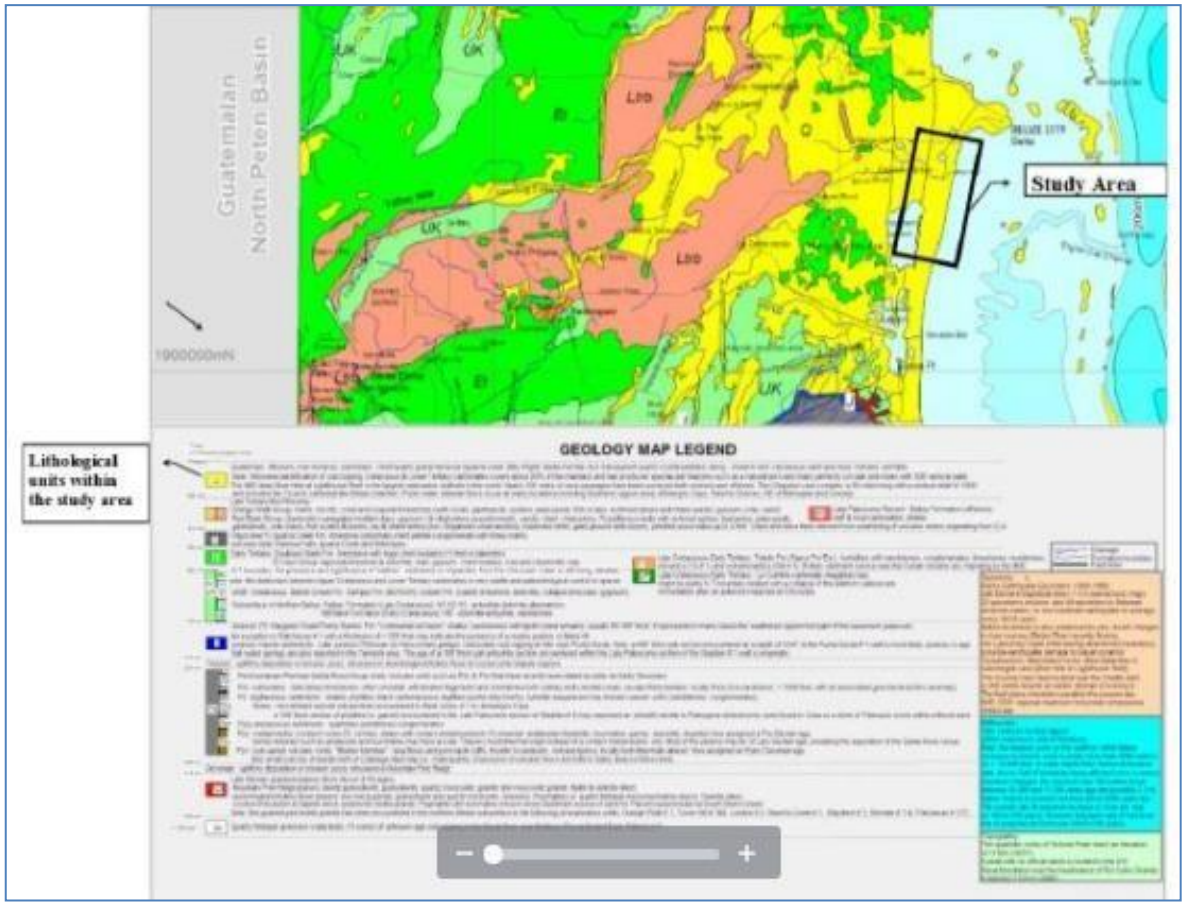


Figure 2-22: Extract from Provisional Geology Map of Belize (Cornec 2010).

Geological Structures and Tectonics

Belize lies close to the margin of the Caribbean Plate boundary and is influenced by its interactions with the North American and South American tectonic plates. Belize lies on the southern margin of the North American Plate which is separated from the Caribbean plate by a Transform Plate Boundary which moves in a strike slip motion (see Figure 2-23). The region is susceptible to earthquakes of varying strength.

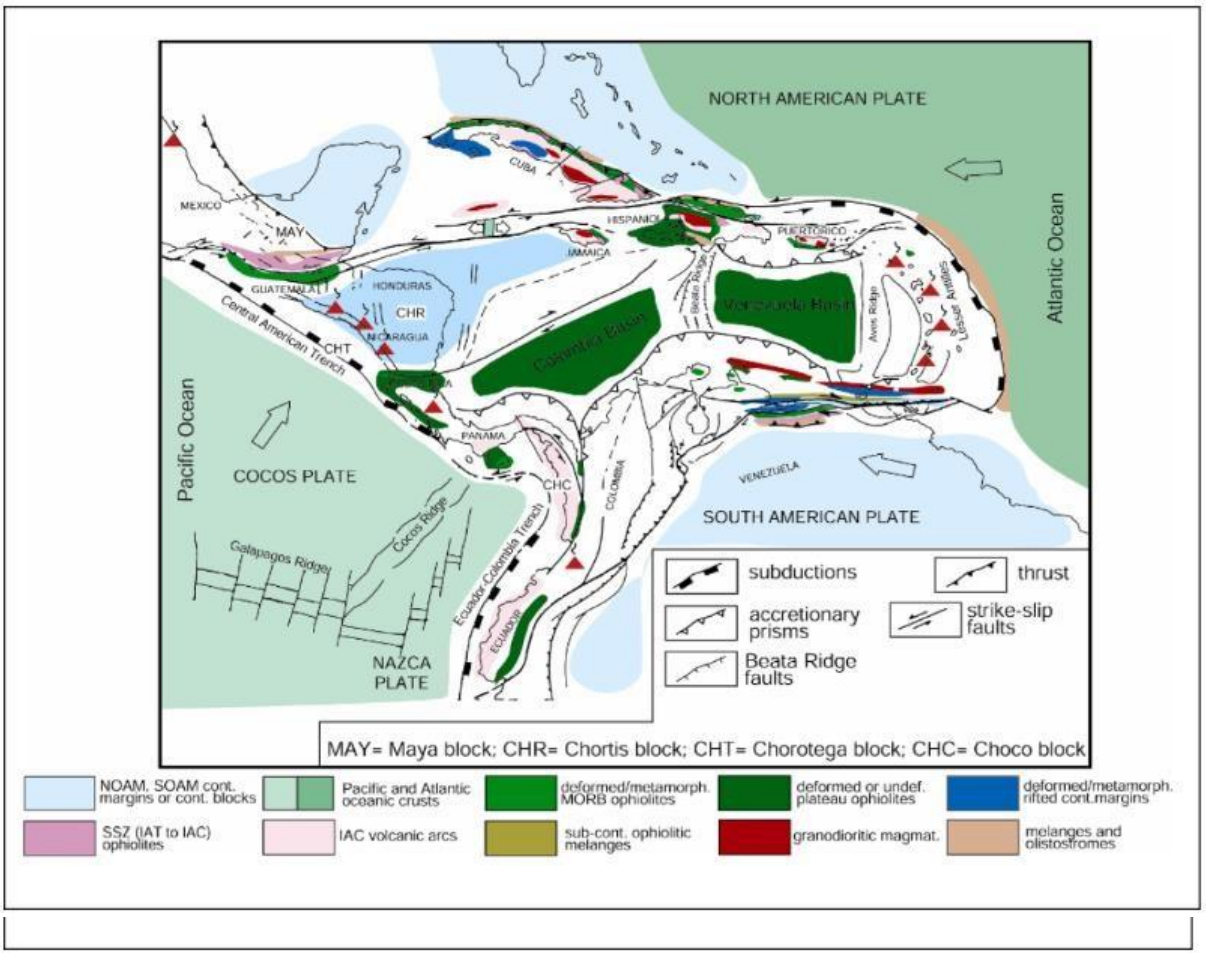


Figure 2-23: Caribbean Plate Tectonics after Guinta and Orioli, 2010.

This Belize Structural Fabirc map of Purdy, Gischler and Lomando suggests that the project site sits on the hanging wall side of trust faults that splays off a major thrust fault system that forms the northern boundary of the Maya Mountain and extends into the marine province. This splay fault system while parallel to the plate boundary it is distally away from the the active boundary and recorded data does not show any seismic activity along this fault. Geological observations also do not indicate any "recent" movement along this splay fault. This is a good indication that the area near the project site is relatively quiet tectonically, this conclusion is consistent with several authors such as Purdy, Gischler and Lomando.

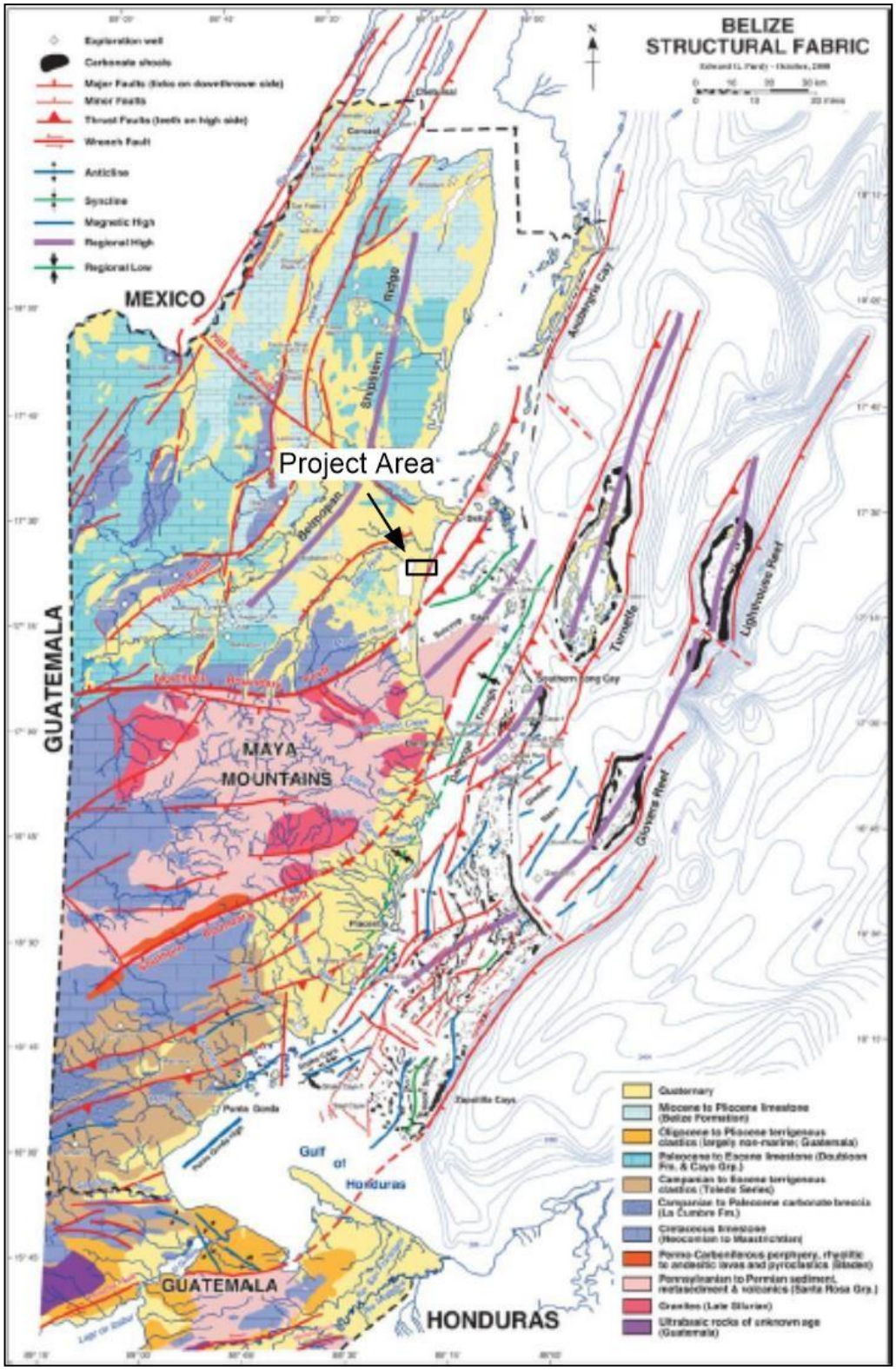


Figure 2-24: Major Faults within Project Region, Amended from Purdy, Gischler, and Lomando.

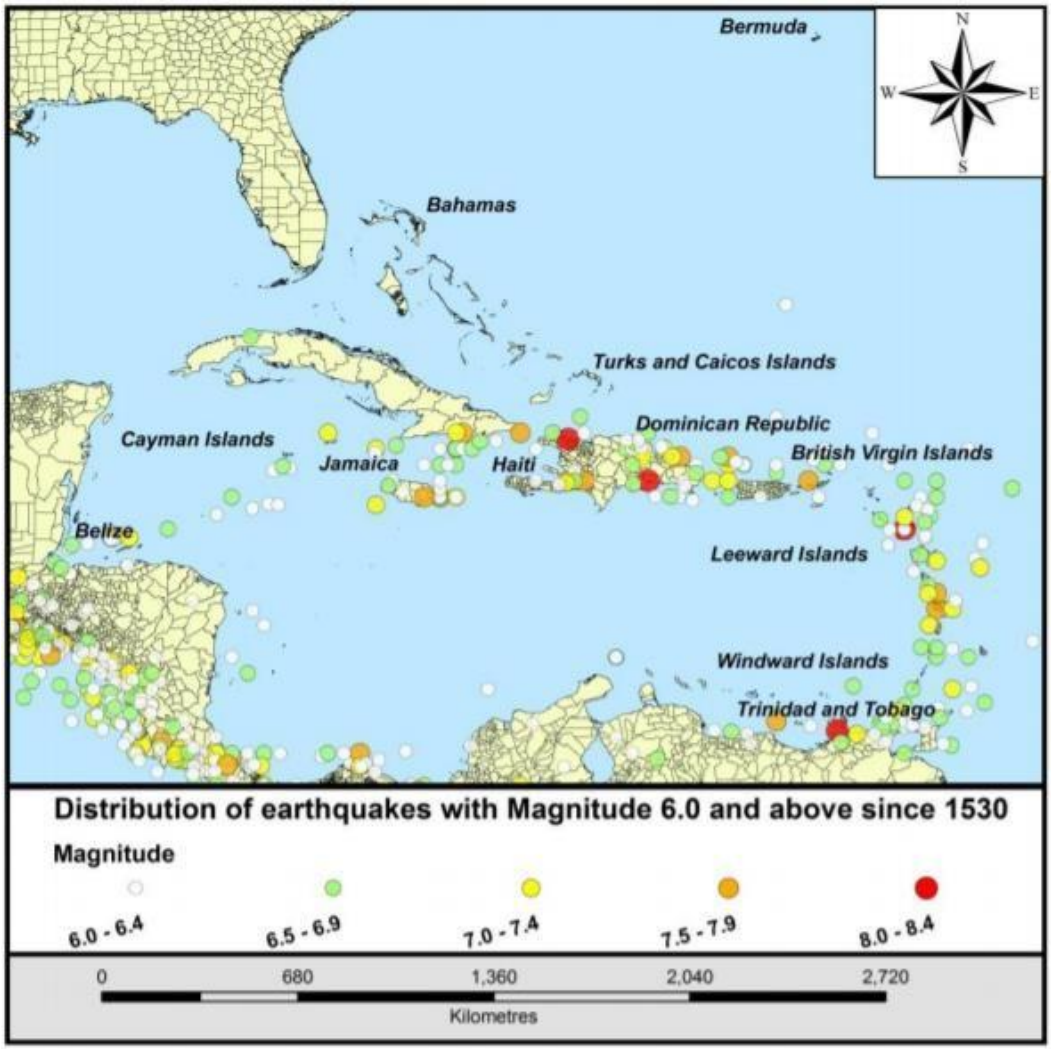


Figure 2-25: Earthquake Distribution Map for the Caribbean, Magnitude 6.0 and above since 1530.

Data published by the (The Carribbean Catastrophic Risk Insurance, 2013) shows that most of the Earthquakes assosicted with Belize are along the Motagua fault line system and the Cayman trough, south of Belize. A 50 year data plot from the USGS Database using a minimum representation criteria of seismic activity greater than a 2.5 magnitude on the Ritcher scale for the Belize geological province also supports that earthqukes in or near Belize are centered along the Motagua Fault zone. The earthquakes along that fault zone are triggered by strike slip movement and tend to be shallow and less intense than deeper earthqaukes, with some of the strongest recorded earthquakes ranging from 7.0M to 7.6M (within last 10 years). The southern part of the country is more sucspetible to impacts from earthquakes as it closer to the Motagua Fault System and the coastal regions sits on extended alluvial sands which are vulnerable to liquifaction from seismic loading. The project site however is away from the southern region and the sands within the site are shallow and sit ontop of dense stiff clays which would impeded or dampen the attentuation of sesimic waves.

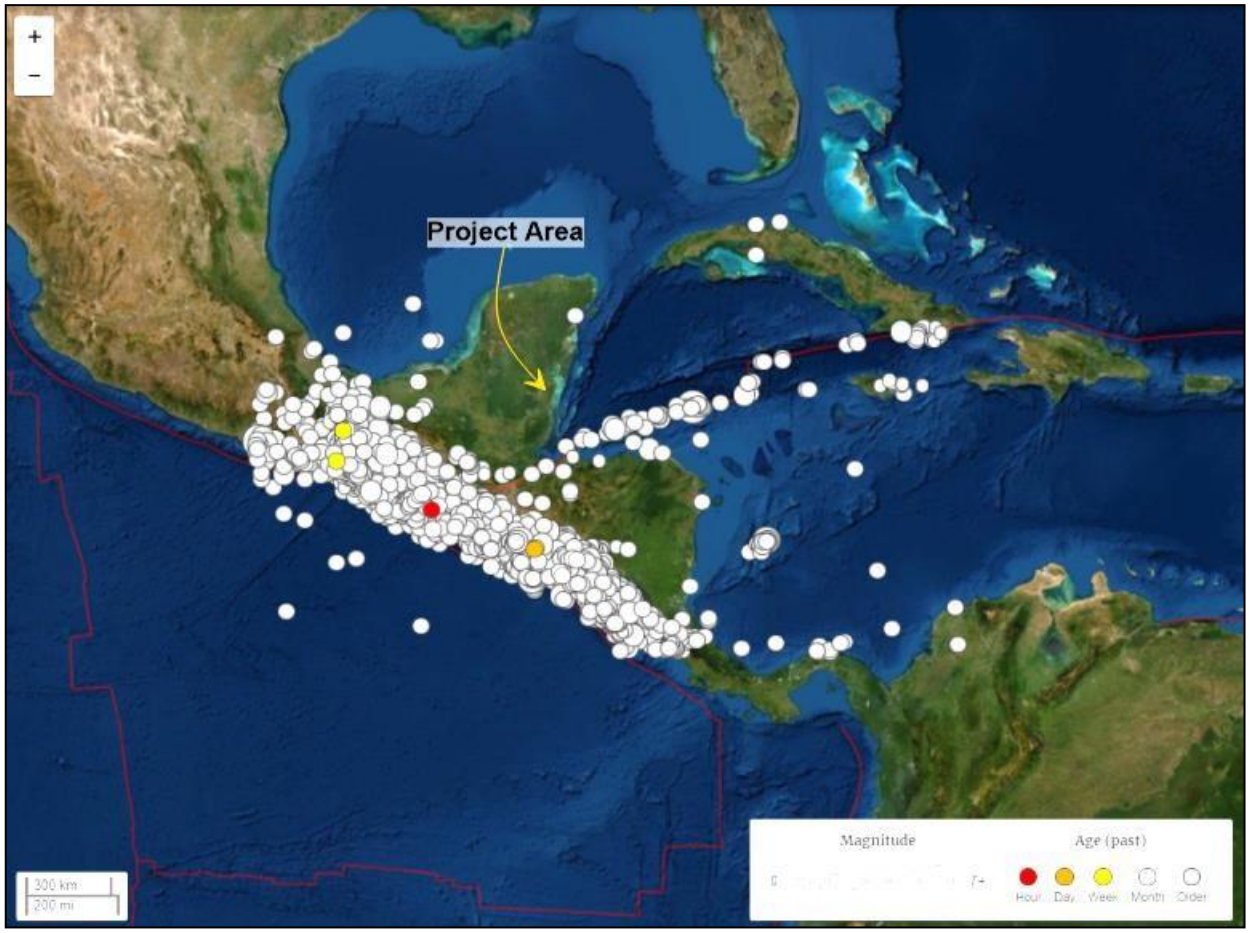


Figure 2-26: Earthquake activity map from USGS for the Belize-Central American Region, showing earthquake activity centred on Motagua Fault Zone.

2.5 Hydrology and Groundwater

2.5.1 Sibun River

The Sibun River, originates at a maximum elevation of 960 meters or 2,600 feet AMSL on the extreme north-eastern Maya Mountains (Boles, 1999). These elevations are typical of the north-eastern Maya Mountains, particularly within the headwaters of the Caves Branch. Some 491 km^2 or 42 % of the total area of the Sibun River watershed is at or less than 40 m elevation. The low elevated section is characteristic of the Coastal Plain through which the Lower Reaches and the Coastal Zone section of the Sibun River meanders to the sea. This river is well developed with a main tributary, the "Caves Branch" joining the Sibun around 33m AMSL. This is a medium size river that rapidly descends the Maya Mountains via well-developed channels onto the coastal plains. The total drainage area of the Sibun River watershed is about 1,170 km^2. Although the river travels a little over 80 km (50 miles) from source to mouth, the many twists and turns translates to near 160km (100 miles) of actual river. **Figure 2-27** is a map the Sibun River and a view of the mouth in the Coastal Zone section just north of the proposed Cruise Terminal development site.

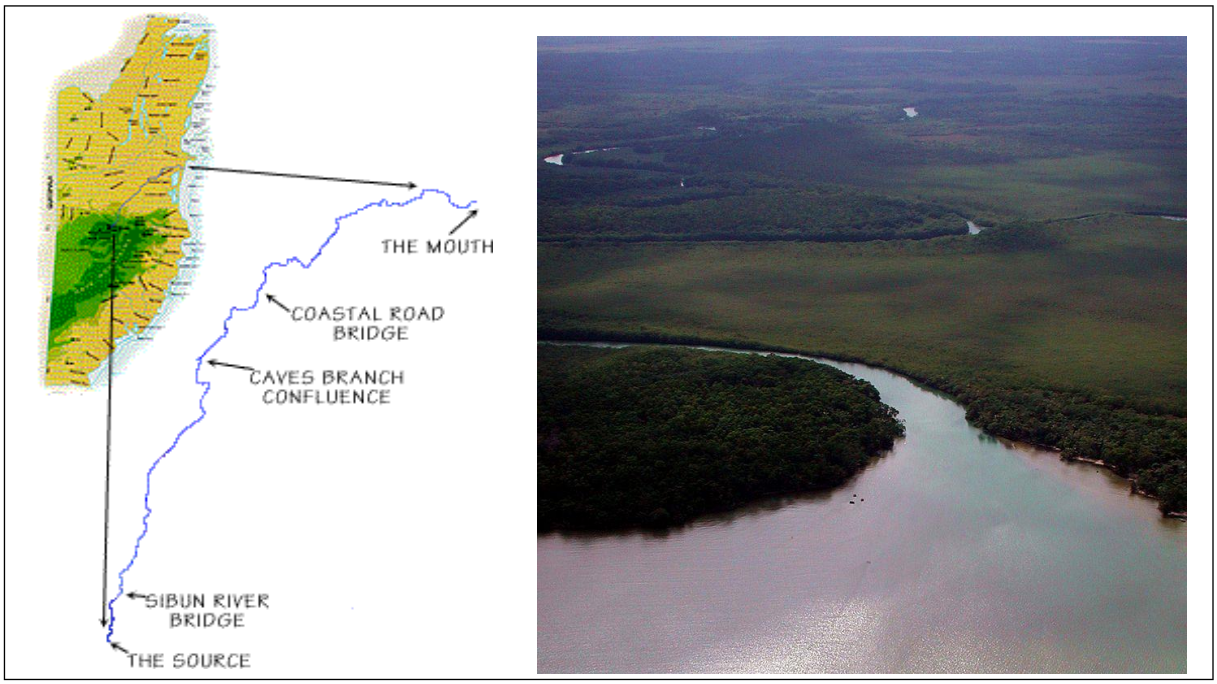


Figure 2-27: The Sibun River channel from the northern Maya Mountains to the Caribbean Sea

Figure 2-28: Lower headwater section of the Sibun River from the Hummingbird Highway.

Most of the rivers that drain the eastern Maya Mountains originate at elevations of a 1000 m or less AMSL. The western fringe of these basins conforms to the main divide of the Maya Mountains. The river systems are well branched and descend rapidly the relatively short, steep slopes of the eastern Maya Mountains onto the coastal plains, where they tend to become sluggish as they meander toward the coast. The Sibun River watershed is one of Belize's major river systems. Along with the Caves Branch River and Dry Creek, the Sibun River drains a major portion of the north-eastern section of the Maya Mountains. **Figure 2-29** is a DEM map

of the Sibun River Watershed. The river has many attributes as it finds its way from deep within the interior of the country to the mouth just south of Belize City.

Where the river leaves the mountains, farms grow a variety of crops on the wide flood plains and highly rich limestone soils. Once past the bridge on the Hummingbird Highway near Sleeping Giant Resort and Chanona's Farm, the Sibun River flows through limestone hills that are pockmarked with caves. Few recent settlements have grown along the banks of the Sibun, though development is now on the increase. The mouth of the river is constantly mined for sand.

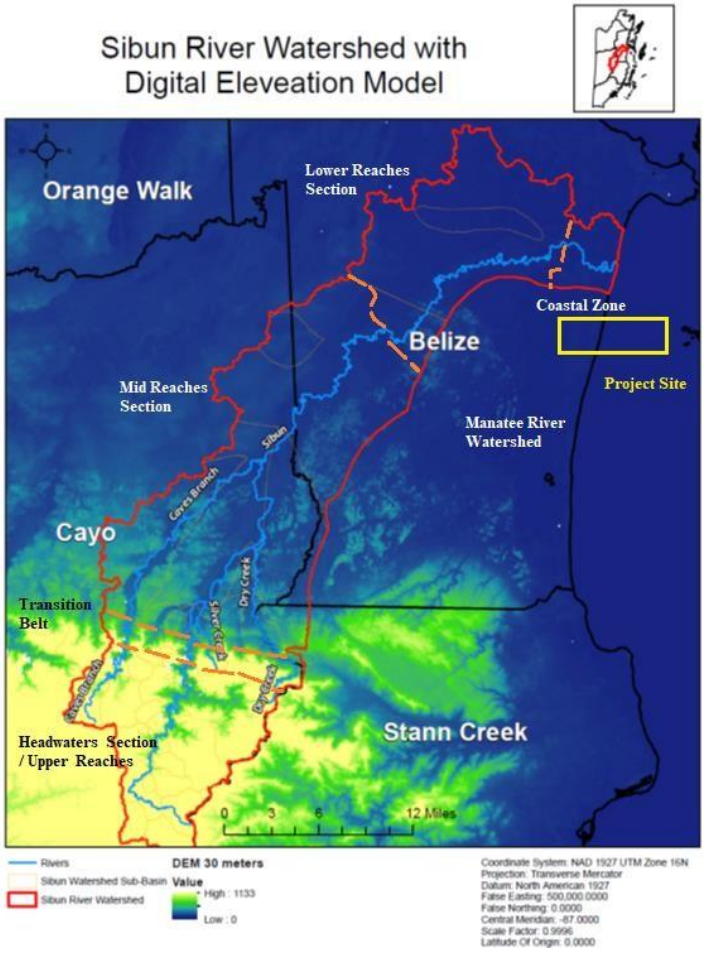


Figure 2-29: Sibun River watershed and tributaries (Source: BET, 2018).

There is evidence that the Sibun River exerts a strong influence on the regime of the Belize River. This problem occurs mainly in the area near the mouth of both rivers from the Rockville-Hattieville area along the George Price Highway to Burton Canal area near the coast, south of Belize City. Wet lands with permanent mangrove lagoons, fed from the Sibun River, exists between the two rivers. During periods of extreme rainfall, the joining of the two rivers' flood plains create a serious flooding problem along that stretch of the George Price Highway. Hence the reason this stretch of the highway was elevated with high-capacity culverts and several ferro concrete crossings. Recharge for the rivers of Belize is mainly from high rainfall and surface runoff during the rainy season. In the dry season the recharge is mainly from groundwater and lagoon systems.

Headwaters Section

The Headwaters Section or Upper Reaches consist of four principal ecological groups, based on similarities in geology, soils, and vegetation. The eastern sub-basins and the upper reaches all share the same geological formations and are characterized by transitional broad-leaf forest poor in lime-loving species. The cluster of small basins on the left bank of the Sibun River are covered with varying degrees of both upland pine forest without lime-loving species and transitional broadleaf forest poor in lime-loving species (Boles, 1999). The lower portion of the headwaters may be characterised by larger stream habitats and surrounded by broadleaf forest poor in lime-loving species. The fourth ecological cluster is the headwater sub-basins of the Cave Branch, which are almost covered by upland pine forest without lime-loving species, and may likely have more acidic waters than the rest of the headwaters section.

The Transition Belt

A transition belt lies in an east-west direction across the Sibun River watershed between the headwaters section and the mid-reaches section. Cutting through the transition belt is a fault line dividing the Santa Rosa Group from carbonate formations and alluvial deposits. The belt area has scattered patches of granite on tis eastern side surrounded by metamorphic rocks. Soils on the eastern side of the transition belt consist of mixed patches of quartzite, granite, and shale-based early semi-mature soils, interspersed with colluvial soils forming valley floor of the larger rivers, including Caves Branch, Sibun River, St. Margret's Creek, and Dry Creek. Vegetation of the transition belt consists of broadleaf forest poor in lime-loving species. Sub-basins and river sections within the transition belt include, from east to west, the upper Indian Creek, two sub-basins of Dry Creek (St. Margret's Creek and upper Dry Creek), Silver Creek, and a similar sized un-named creek, the section of the Sibun, the upper section of the Cave's Branch, and the hanging streams of the Cave's Branch.

The Mid-reaches Section

The Mid Reaches section extends from the transition belt to around Royal Point on the Sibun River and includes the lower half of Cave's Branch, Dry Creek and most of the Indian Creek basin. The elevations in this Section ranges from 400 to 40 meters. The upper end of this Section is mainly karst area divided by valleys of colluvial soils. Indian Creek on the extreme eastern side flows through the Sibun-Manatee karts region. The western edge of the section contains limestone and chert deposits from the Palaeocene-Eocene ages. The north-western edge also has mixed deposits of limestone, marl, clay, sand and gypsum. Early sub-mature alluvial soils have formed along the Sibun River in the lower end of the Mid-reaches section. The main vegetation in this section consists of broadleaf forest rich in lime-loving species reaching 21 – 30 m (70 – 100 feet) in height on the karst hills and broadleaf forests with occasional lime-loving species on the colluvial soils within the principal river valleys.

The Lower Reaches Section

The transition between the Mid-reaches section and the Lower Reaches section is less obvious than between the headwaters and mid-reaches. It begins roughly around Royal Point. The Sibun

River meandering pattern is more apparent in this section compared with the relatively straighter character in the mid-reaches. Finer alluvial sediments, along with colluvium are characteristic of the coastal plain.

Large areas of none-saline organic soils are found on the western and northern sides of the Sibun River watershed, and support large expanses of lowland pine forest and tropical savanna that begin near upstream boundary of the lower reaches section. According to Boles (1999), the lower reaches has *oxbow lakes* (lakes formed when river meanders are cut off from the main river), marshes, and several abandoned channels (old river channels cut off over geologic time from the main channel), very typical of the lower end of the coastal plain.

The Coastal Zone Section and Northern Lagoon

The Sibun River Mouth (Coastal Zone Section) lies within the coastal zone and is characterized by saline organic soils, marshes, and mangrove forests. This area of the main river channel is a **salt-wedge estuary** (formed when heavier sea water moves up the river beneath the lighter fresh water flowing down to the sea), typical of many coastal estuaries. It is evident that the salt water wedge can migrate at least as far upstream to Freetown Sibun during the dray season, especially with during neap tides.

The man-made Burdon Canal joins the Hawlover Creek to the Sibun, which in turn joins the Northern Lagoon, on the western edge of the Port of Magical Belize, a proposed Cruise Terminal property. This area forms a part of the Burdon Canal Forest Reserve. The project property and surrounding coastal area lie within the Manatee River watershed and is characterized by mangrove wetland forests, shallow lagoons, with elevation less than 1.8m (6 feet) AMSL. The Northern and Manatee Lagoon systems are natural reservoirs that attenuate the floods of the lower reaches of the Sibun and Manatee Rivers, and discharge into the rivers at low stage during the dry season.

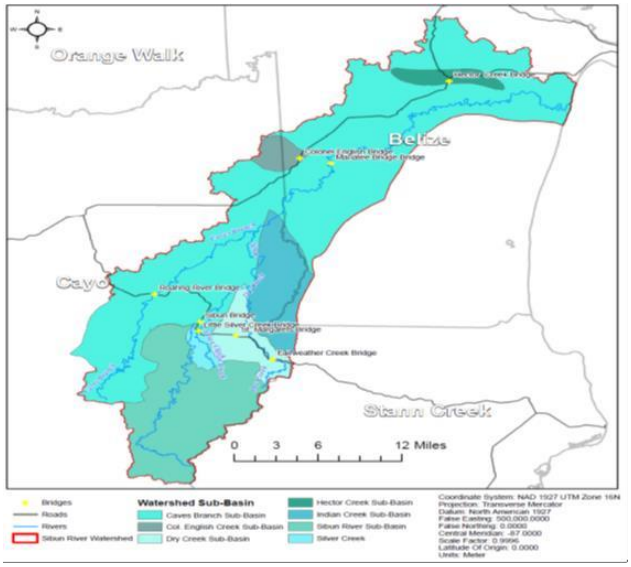


Figure 2-30: The Sibun River watershed. (Source: BET 2018).

The sub-basins of the Sibun are classified in accordance to its main tributaries, namely: Sibun River sub-basin (SRSB); Dry Creek Sub-basin (SRSB5th-2); Caves Branch Sub-basin (SRSB5th-3).

The main sub-basins in the upper and mid-reaches of the watershed are: the Sibun River sub-basin itself, Caves Branch, Dry Creek and Silver. **Table 2-9** list the main sub-basins of the Sibun River, estimated drainage area, elevation at origin and discharge point, the mean annual discharge and land use.

Table 2-9: Watersheds and sub-catchments of the Sibun River Basin (Source: R. Frutos, 2015).

Sibun River Sub-basins	Area (km^2)	Lc (km)*	Hmax (m)**	Hmin (m)***	Mean annual flow m^3/s	Landuse
Main Sibun River (1)	238	160.0	960	0	45.1	Forest Reserve citrus, pastures, mining
Caves Branch (2)	864	54.5	800	32	15.6	Forest, mining, citrus, pasture
Dry Creek (3)	63	29.8	600	49	10.8	Citrus & pasture
Silver Creek (4)	17	21.4	500	21	12.4	Citrus, crops, pastures

* Mean length of channel; ** Maximum elevation at source; *** Minimum elevation near mouth

(Source: BET -GIS, National Hydrological Department, 2013)

Sibun River Catchment

Figure 2-31 shows the Belize country map containing the main watersheds and 5-year deforestation rates from 1980 to 2010. The Sibun watershed has seen its share of deforestation during this period, particularly in the mid-reaches, with which the project site is located.
The majority of the Sibun River Watershed is broadleaf forest, especially above the Hummingbird Highway. The other principal vegetation types in the catchment is summarized by percentage cover of catchment in **Table 2-10**.

Table 2-10: Major vegetation types of the Sibun River Watershed (Source: Boles, 1999).

Vegetation Type	% of Catchment
Broadleaf forest	64.6
Savannah	11.6
Mountain Pine Ridge	9.7
Thicket	6.7
Savannah/thicket	2.4
Riparian forest	2.1
Mangrove	1.6
Scrub	1.3

The vegetation/land use type in the upper to mid reaches of the watershed based on the 1995 Land Information Centre map, consist of: Broadleaf hill forest over limestone; Lowland Needle-leaf moist open forests over poor soil; Seasonal swamp forest (Marsh forest) of Northern Belize, Coco Plum Variant; Fire induced vegetation and Hills; Agriculture (e.g. pastures and crops); Urban areas.

In the mid and lower reaches of the Sibun Watershed, the main vegetation/land use types include: fire-induced scrub over poor soils; Disturbed scrub; Mountain inland well-drained over poor soils; permanent waterlogged freshwater scrub; seasonally waterlogged scrub with abundant Miconin (Maya) species; mixed mangrove and scrub; and coastal beach and scrub.

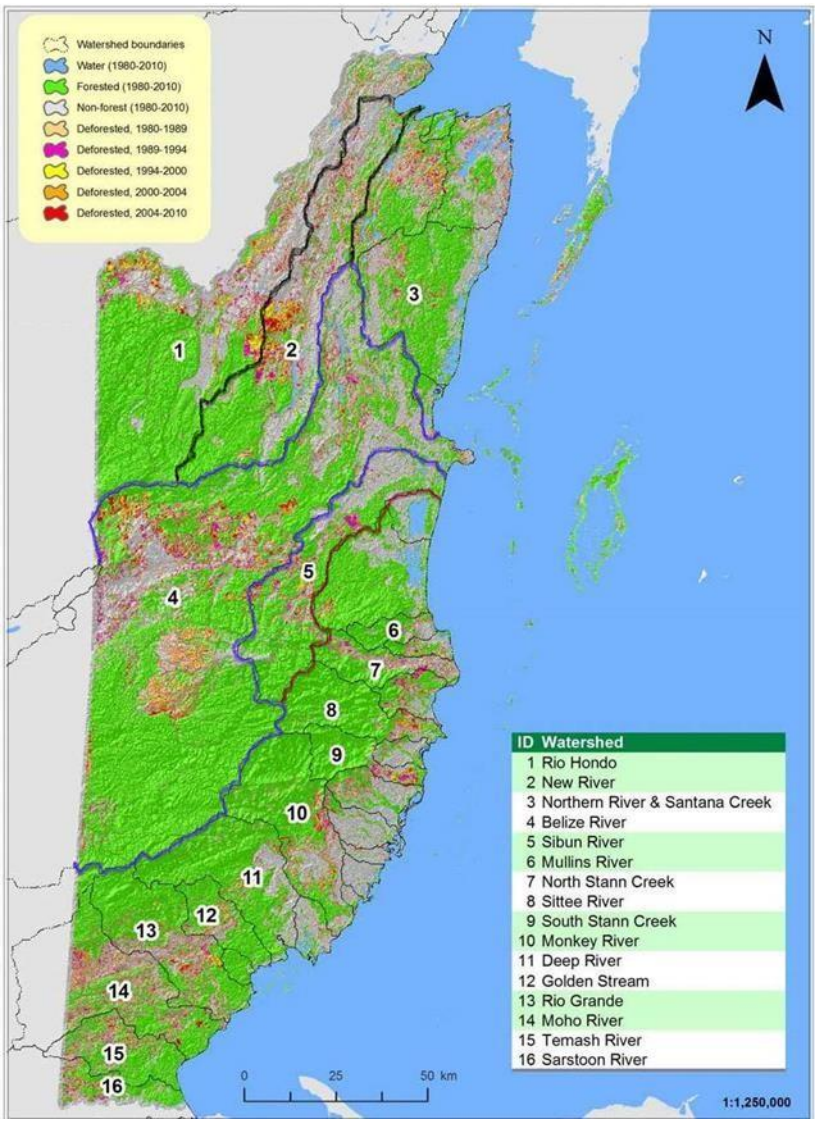


Figure 2-31: Forest cover and deforested areas in the main Watersheds (Source: Cherrington, 2012).

2.5.2 River Stage and Flow Discharge in the Sibun River

Monthly average river level records and monthly average evaluated flow records for the Sibun River at Freetown Sibun, Belize District are presented in figures below, respectively. The Sibun River is at maximum stage and river flow in July and November. Lowest stage and base flow are normal in April, the driest month across central Belize.

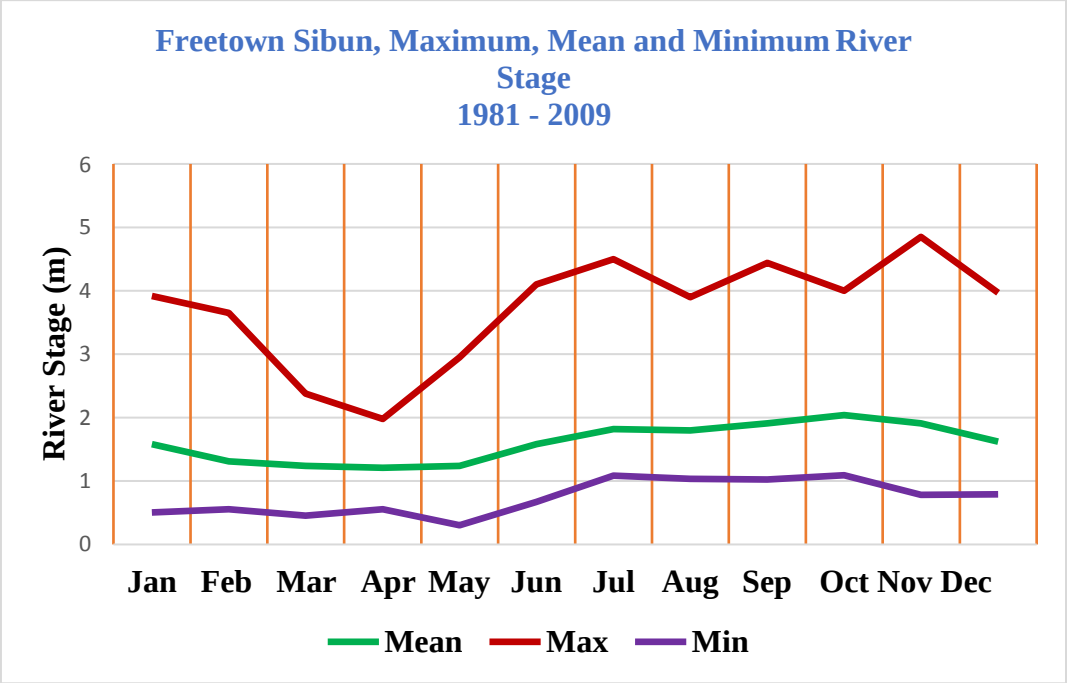


Figure 2-32: Freetown Sibun hydrologic station historic average stage records (1981-2009). (Source: Hydrological data courtesy of the NHS; Analysis - R. Frutos 2015)

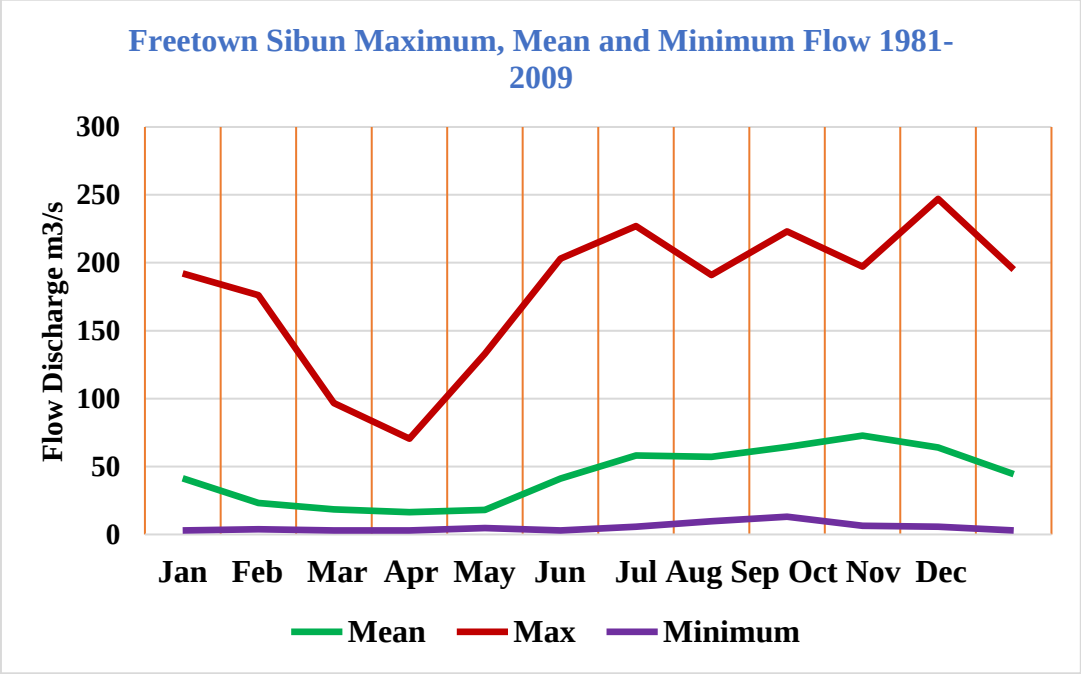


Figure 2-33: Freetown Sibun hydrologic station historic average flow records (1981-2009) (Source: Hydrological data courtesy of the NHS; Analysis - R. Frutos 2015).

Table 2-1 shows a summary of recent and historic flow discharge in the Sibun River and tributaries.

Climate change will have an impact on future runoff and monthly flows in river systems such as the Sibun River watershed and adjacent watersheds and wetlands of central Belize

(Cherrington et al. 2014, IPCC 2013). Rainfall variability will increase as the influence of ENSO events become more significant across central America and the western Caribbean under warmer climatic conditions, as was the case with the intense long drought that impacted Belize in 2019. This could have long term effects on the volume of freshwater and sediment discharge to the coastal zone, and increase the displacement of the saline wedge upstream with impending sea level rise.

Table 2-11: Stream discharge measurements of the Sibun River and some tributaries.

Site / 6 April, 2015	Eastings	Northings	Flow (m^3/s)	Date	Remarks
Sibun River at Sleeping Giant Resort	0322401	1890290	24.8	9 Aug-18	Strong current at narrow crossing. Evidence of river rising after heavy rains in hills; by mid-afternoon the Sibun was at about 1.2-1.5m (4-5 feet) above normal flood level for August
Main Creek in the Sleeping Giant Resort	0322389	1890296	0.11	9-Aug-18	Creek draining the low low-lying flood prone area of east end of orange orchard. Low flow for August
Caves Branch	0318180	1890843	5.50	24-Aug-18	Mod to low flow for Sep.
Dry Creek	0322559	1890320	3.80	28-Aug-18	Low flow
Silver Creek	0322580	1890345	3.20	28-Aug-18	Low flow
Spring Sleeping Giant Resort	0322393	1890285	0.02	28-Aug-18	Spring feed small pond and creek in the main Sleeping Giant Resort. Spring is perennial.
La Democracia			9.71	19-Mar-07	R. Frutos river flow measurement near the La Democracia bridge
Freetown Sibun			247.0	30-Nov-96	Computed value from rating curve
Gracie Rock			6.40	21-May-70	± 2 Walker, 1972
Gracie Rock			214.46	17-Jul-70	Flood condition
Gracie Rock			114.11	20-Oct-70	Flood condition
Gracie Rock			28.70	6-Jan-71	Into the New Year, Walker, 1972

2.5.3 Runoff

General runoff from the property will run towards the main water bodies (west and east) bordering the project area (lagoon and sea), there will also be movement of runoff waters in the interior of the property in a north south direction, with water moving parallel to the shoreline

within the marsh areas. This trend of the runoff waters is due to difference in elevation going from approx. 3m (10ft) above msl in the west near the lagoon to a height at msl in the interior and approx. 0.9-1.2m (3-4ft) above msl along the sandy ridge in east along the coastline.

The runoff of waters to the lagoon and the sea as well as the movement within the interior of the property would add to an increased water turbidity in all the receiving water bodies in the project site. During the rainy season, the waters in these two main bodies are known to be typically murky with poor visibility.

Given the permeable nature of the near-surface sandy soils, water-borne contaminants can also be transported in the groundwater by percolation. Lateral movement of these waters is then possible along the interface of the sands and the underlying clays resulting in water-borne contaminants eventually entering the marine environment.

2.5.4 Groundwater

Generally, groundwater is available throughout the less mountainous areas of Belize. In the northern half and extreme south of the country the soils have relatively high permeability and groundwater yields. Shales and slates are naturally less permeable, however, these may develop secondary permeability when fractured and weathered. Freshwater lens and wedges exists on the Cayes and along the coastal zone.

Belize is divided into seven groundwater provinces namely the Campur province, the Coastal Shelf province, the Coastal Plain and Shelf province, the Vaca Plateau province, Savannah province, the Maya Mountain province, and the Toledo province (King *et al*.,1992, Bukalew et al., 1998, DOE/USAID 1996). Figure 4.14 is a map showing the geographic extent of the groundwater provinces of Belize as described by King, et al. (1992).

The lower Sibun River watershed lies within the boundary of the Campur groundwater Province. The Campur Province coincides with the outcrop of the Campur limestone north of the Maya Mountains extending eastward to the Belmopan area and the coast, and in a northward direction to the boundary of the Coastal Plains and Shelf Provinces of the Belize, Orange Walk and Corozal districts. The area includes the northern Cayo and southern Belize districts.

This Campur groundwater province is characterized by semi-confined and perched aquifers primarily of quaternary alluvial deposits and Miocene-Pleistocene sedimentary materials that overlie the porous and fractured Palaeocene-Eocene limestone formations, under alluvial overlain in the coastal zone region of the watershed. These aquifers are recharged directly from infiltration and runoff from the Maya Mountains. Natural springs originating from the karst limestone hills in the Mid-reaches sections of the watershed are evidence of the sub-surface discharge of these semi-confined and perched limestone aquifers. Wells drilled in the Green Tropics agriculture development and another at the Belize Sustainable Agriculture Ltd. around Cotton Tree Village produced artesian water, with the latter having a projected flow rate of over 2,000 gpm from a 0.5m (20-inch) production well (Tunich Nah, 2014). No well water is being used at the current time in the Coastal Zone section of the Sibun River watershed.

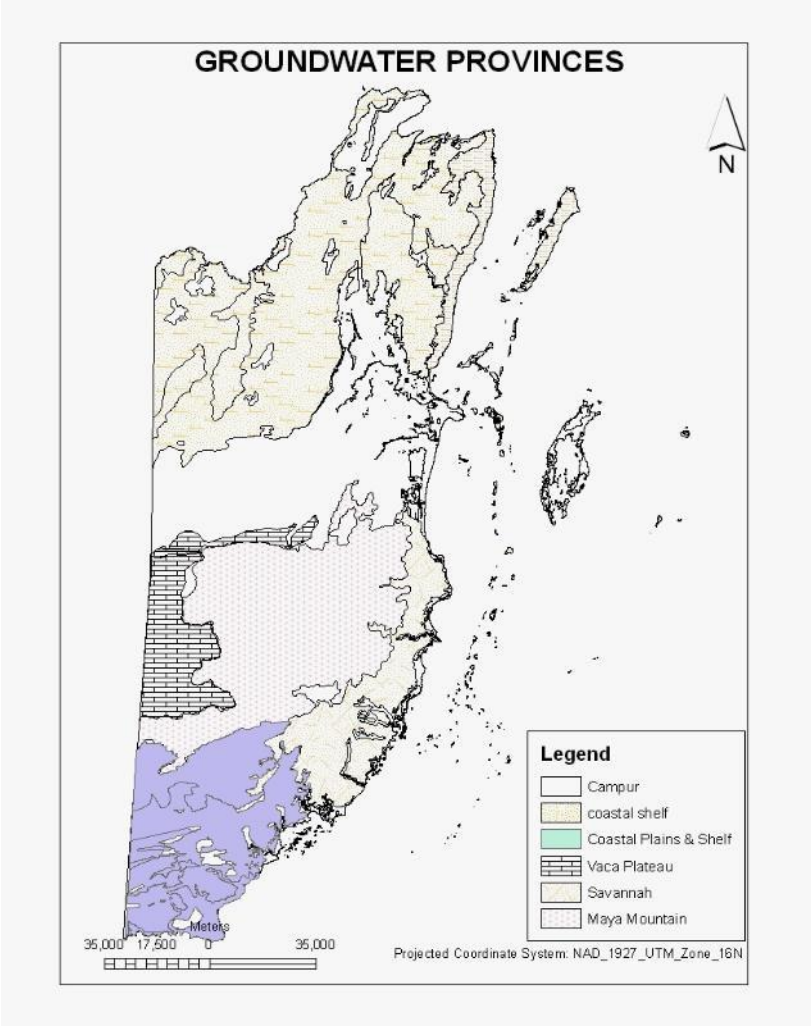


Figure 2-34: Groundwater provinces of Belize (Source: King et al., 1992; Bukalew et al., 1998).

2.6 Soil and Seabed Sampling

A series of soil exploration testing was conducted between Velquest Engineering (**Figure 2-35**) and associates as required by the Terms of Reference to assist in the development of the Environmental Impact Assessment. These surevey were later complement additional studies done by Boskalis using hand augers (1m) in the terrestrial areas and vibro-cores in the marine areas.

2.6.1 Methodology for the Investigation of the soils within the Project Site

The following outlines the services carried our for the analysis of soil exploration testing conducted between Velquest Engineering (Figure 2-35) and associates as required by the Terms of Reference:

1. Reviewed the available topographical/bathymetric, hydrological/oceanographic data, soil coring results, and other pertinent studies performed by others for the EIA development.
2. Digitized bathymetric data extracted from the "Belize City and Approaches" nautical map published by the UK Hydrographic Office.
3. Perform limited soil/sediment sampling within 3m (10 feet) of the ground surface and/or the mudline of the sea bed to:

    1) Verify soil sediment conditions,

    2) Describe and develop predictions concerning the impacts of ocean activity on the project.

4. Visually classified collected soil sediment samples using the Unified Soil Classification System (USCS). Identified soil conditions at each sample location and form an opinion of the site soil stratigraphy. Laborotary tests are being performed on selected soil samples to confirm the visual analyses of the collected soil samples. Laboratory testing being performed include:

    1. Grain-Size Analyses. The grain-size analyses are conducted in general accordance with the AASHTO test designation T-088 (ASTM test designation D-422).
    2. Atterberg Limits - The liquid limit and the plastic limit tests ("Atterberg Limits") are conducted in general accordance with the AASHTO test designations T-089 and T-090, respectively (ASTM test designation D-4318).
    3. Natural Moisture Content - The moisture content tests were conducted in general accordance with the AASHTO test designation T-265 (ASTM test designation D-2216).
    4. Specific Gravity

Preliminary studies performed by Professional Engineering Services and (Out Island Construction (OIC), 2018) (Figure 2-36) on the coastline and offshore indicates that firm soils

are located typically within 3m (10 feet) of the mudline, see **Annex 6**. As such it was anticipated that deeper cores may not be feasible without the use of barges and larger offshore drilling equipment.

Prior to the commencement of our services, a boring location plan was developed based on a design concept that was provided to us along with soil studies performed within the footprint of the design concept. The borings were laid out in a manner to verify work previously completed by others prior to 2019 and to develop an independent assessment of the subsurface site conditions. The borings were then located in the field utilizing hand-held GPS units. Generally, the borings were performed at the proposed boring locations. Actual boring locations within the accuracy of the hand-held GPS units are shown in **Figure 2-35**.

Soil testing methods included: vibra-coring, hand augering, and rod probing. Rod probing was also performed to assess the nature of the near surface soils to determine the relatively nature of the density of the near surface soil strata. These rob probes were advanced typically within 3.0-3.6m (10 to 12ft) below the ground surface by manual methods. Rod probes were performed by Wade as referenced in Table 2-13: Summarized Results of Soil Survey.

The sediment sampling was performed using vibro-coring and hand auger methods to advance a sample tube of sufficient length into the unconsolidated sediments. Pneumatic vibra-coring and hand augering soil borings were performed to sample and evaluate the near-surface soils within the footprint of the proposed project area. These borings were performed within the initial 3m (10ft) of the ground surface and/or the mudline of the sea and lagoon. These soil borings were performed to evaluate the near surface soil sediments, and to assess the general topology of the project area.

The areas investigated included the project property, marine area in front of project area and along the coastline up to and beyond the Sibun river, the coastline from the project area and beyond the Sibun, and the Lagoon that borders the project property to the west. The locations of the soil explorations performed are presented in **Figure 2-35**.

A supplemental independent study was also performed using hand augers (1m) on land and vibro-cores in the marine areas by Boskalis.

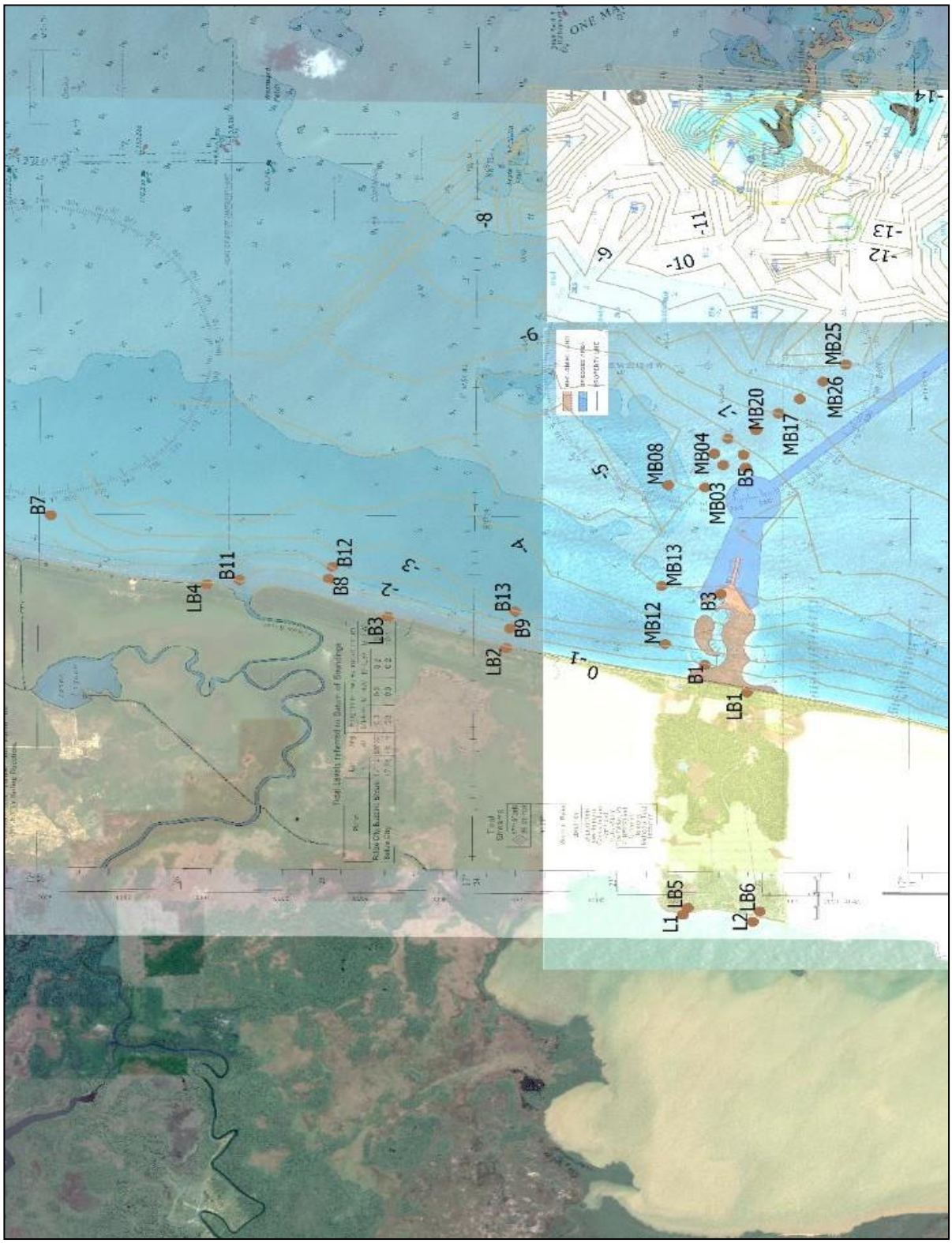
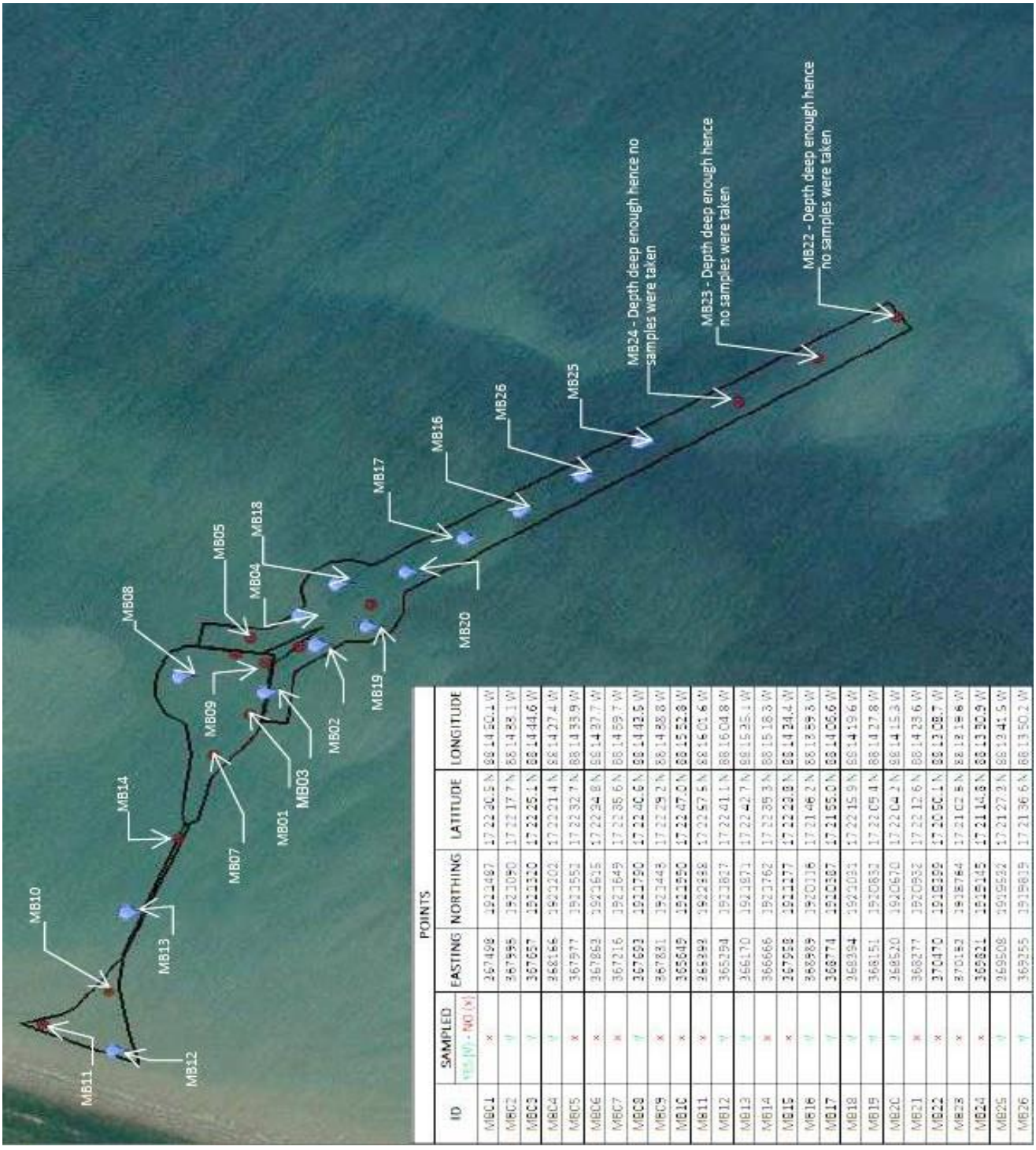


Figure 2-35: Boring Location Map for soil profile bores and selected offshore vibro-cores.



POINTS					
ID	SAMPLED (Y) - NO (X)	EASTING	NORTHING	LATITUDE	LONGITUDE
MB01	X	367498	1921487	17 22 30.5 N	88 14 50.1 W
MB02	Y	367995	1921090	17 22 17.7 N	88 14 33.1 W
MB03	Y	367657	1921310	17 22 25.1 N	88 14 44.6 W
MB04	Y	368166	1921202	17 22 21.4 N	88 14 27.4 W
MB05	X	367977	1921551	17 22 32.7 N	88 14 33.9 W
MB06	X	367863	1921615	17 22 34.8 N	88 14 37.7 W
MB07	X	367216	1921649	17 22 35.6 N	88 14 59.7 W
MB08	Y	367603	1921790	17 22 40.6 N	88 14 46.5 W
MB09	X	367831	1921448	17 22 29.2 N	88 14 38.8 W
MB10	X	365645	1921860	17 22 47.0 N	88 15 53.8 W
MB11	X	365392	1922498	17 23 07.5 N	88 16 01.6 W
MB12	Y	365284	1922867	17 23 41.1 N	88 16 04.8 W
MB13	Y	366170	1921871	17 22 42.7 N	88 15 25.1 W
MB14	X	366686	1921762	17 22 39.3 N	88 15 18.3 W
MB15	X	367908	1921177	17 22 20.8 N	88 14 34.4 W
MB16	Y	368089	1920116	17 21 46.2 N	88 13 59.3 W
MB17	Y	368774	1920387	17 21 55.0 N	88 14 05.6 W
MB18	Y	368394	1920891	17 22 15.9 N	88 14 19.6 W
MB19	Y	368151	1920694	17 22 05.4 N	88 14 27.8 W
MB20	Y	368520	1920670	17 22 04.2 N	88 14 15.3 W
MB21	X	368277	1920932	17 22 12.6 N	88 14 23.6 W
MB22	X	370470	1919389	17 21 20.1 N	88 13 08.7 W
MB23	X	370153	1918764	17 21 02.5 N	88 13 19.6 W
MB24	X	369831	1918945	17 21 14.6 N	88 13 30.9 W
MB25	Y	369508	1919584	17 21 27.3 N	88 13 41.5 W
MB26	Y	369255	1919819	17 21 36.6 N	88 13 50.2 W

Figure 2-36: Location Map for seafloor boreholes/cores (Out Island Construction (OIC), 2018)

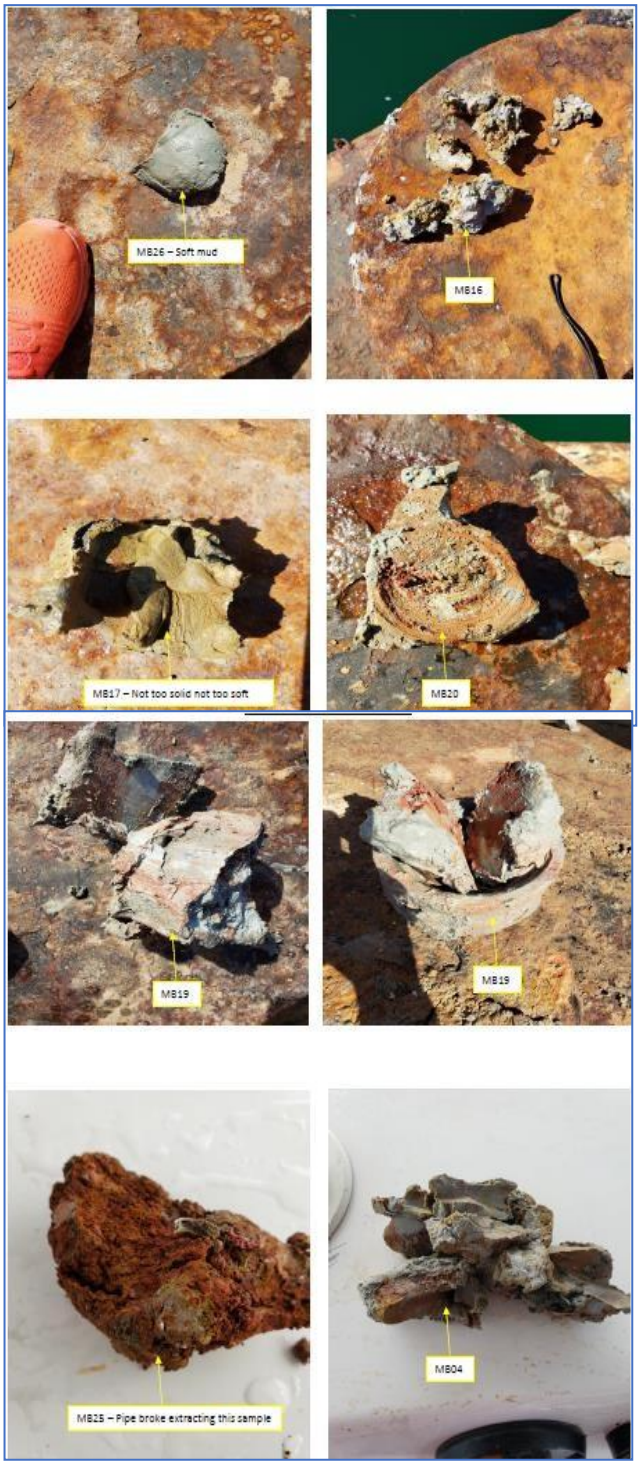


Figure 2-37: Soil Samples taken from various seafloor borings shows the variation of clays that grade from soft grey clays to stiff mottled red and grey clays at depth.

2.6.2 Description of Soils & Subsurface Geology within the Project Site

Information presented are based on the results of soil conditions encountered at the test locations as carried out by Velquest Engineering and associates and rapid assesments done by Professional Engineering Services and Out Island Construction. Variability in soil conditions between test locations are inherent and should be expected.

In general:

1. Soils along the coastline between Sibun River and the project site are generally sandy within the initial 0.3 – 2.1m (1 to 7 feet). These sandy soils were encountered on land within 60m (200ft) west of the shoreline out to about 300m (1000 feet) from the shoreline. The sandy soils within the 300m (1000ft) zone of the shoreline forms a Surf Zone that acts as a natural wave breaking area. This zone is visible on Google Earth imagery. Water depths in this area ranges from at the ground surface to about 3 feet below the sea surface.

2. Further out from coastline the seabed gradually dips downwards at depth ranging from about 3.0 to 11m (10 to 35 feet) within the proposed project dredged area. Generally, a stiff grey marine clay is encountered at the sea bed level closer to the shoreline that then dips downward. This clay stratum is typically overlain by unconsolidated soils consisting of silt and clay, sand, and shells; ranging in thickness from 0 to about 4.5 m (15 feet). In boring B5, a thin crust was encountered at approximately 7.5m (24ft) below the water surface in the initial 15 to 30 cm (6 to 12 inches) of the mudline. Thereafter, very soft unconsolidated soils were encountered to a depth of approximately 4m (13 feet) below the sea bed where soft light-grey clayey sands with shell was encountered to about 4.5m (15 feet) below the mudline. These sandy clays were underlain by mottled light grey and red clays at approximately 12m (40 feet) below water surface. These soil conditions appear consistent with the buried geologic fluvial system indicated in Ferro, Droxler and Anderson, 1999. These observations are similar to interpreted geophysical cross-sections done by Deltares in the Sub Bottom Profiler investigation for the access channel Magical, Belize (see the subsequent section).

3. Borings within the project area along the eastern coastline of Northern lagoon encountered silty/clayey sands within 0.75-0.9m (2.5 to 3 feet) below the lagoon mudline. This stratum was underlain by stiff mottled grey and red clays. On land, brown sands were encountered within 0.75 – 0.9 m (2.5 to 3 feet) below ground and was underlain by stiff mottled grey and red clays to depths ranging from 1.5 – 2.5m (5 to 8 feet) below ground.

The soil types encountered during site investigations have been assigned a stratum number. Each stratum group exhibits a range of engineering properties related to suitability for general

construction. The stratum numbers and soil types associated with this project are listed below in Table 2-12.

Table 2-12: Soil Description and Classification

Stratum Number	Typical Soil Description	USCS Classification
1	Water	N/A
2	Fine SAND to Fine SAND with Silt and/or Clay	SP, SP-SM/SP-SC
3	Silty/Clayey SAND	SM/SC
4	Grey Sandy SILT/CLAY	ML/MH/CH
5	Mottled Light Grey and Red CLAY	CH
6	Peat	PT

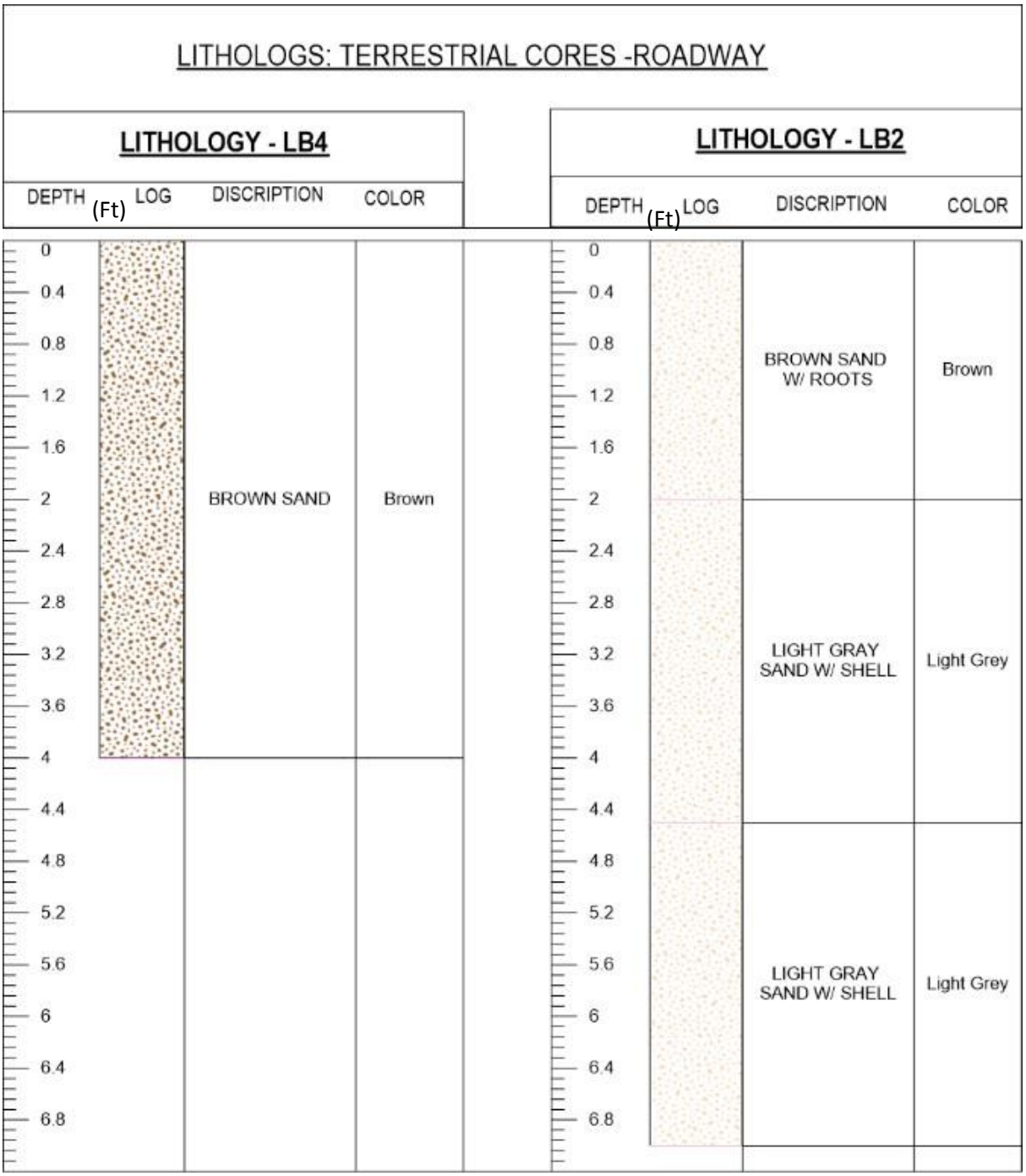


Figure 2-38: Cores along the proposed road way along the coast line shows predominantly sands with some peat (depth in feet).

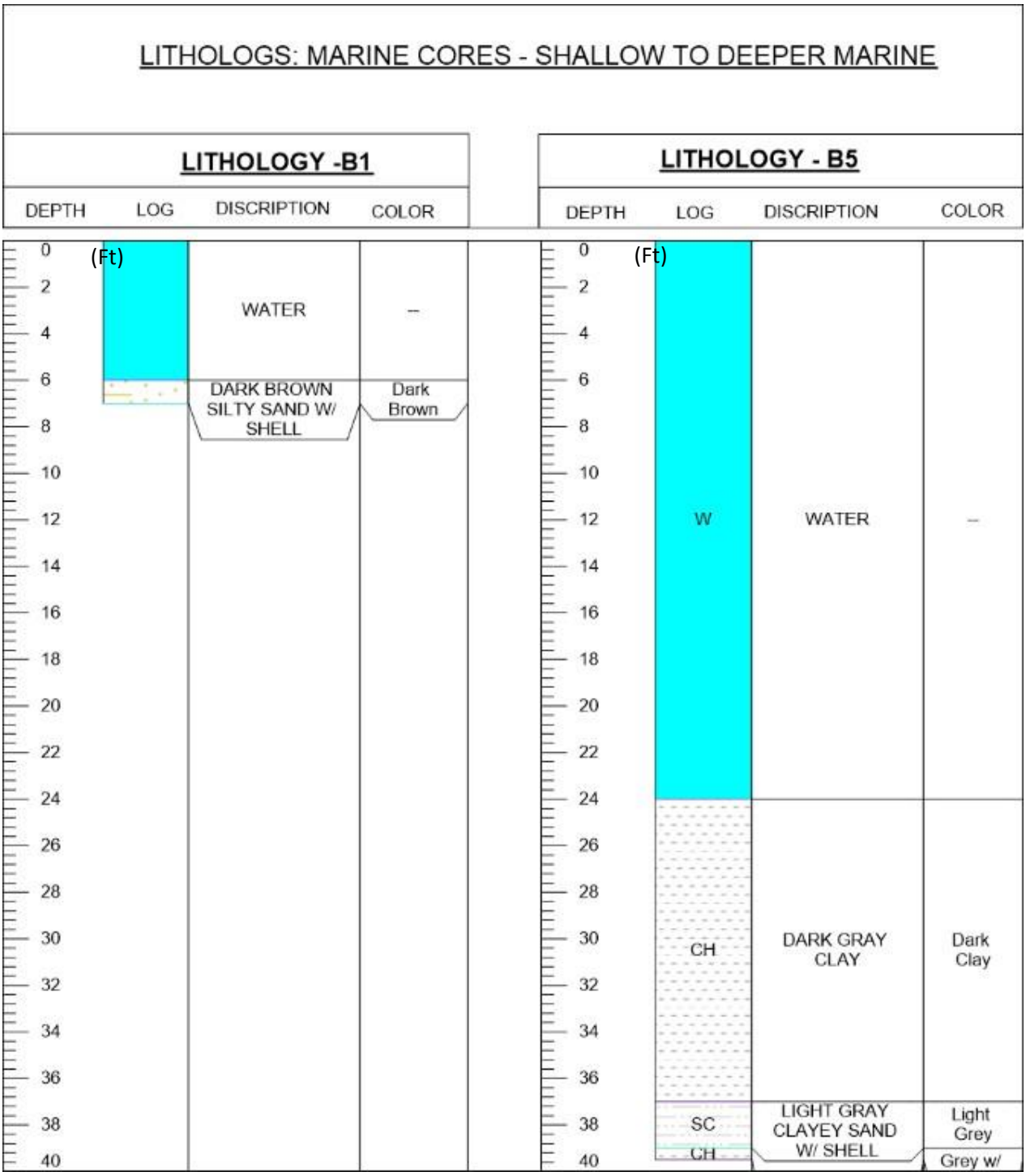


Figure 2-39: Cores for shallow to deep marine shows a transition from a sandy coast line to clays in the deeper marine areas (depth in feet).

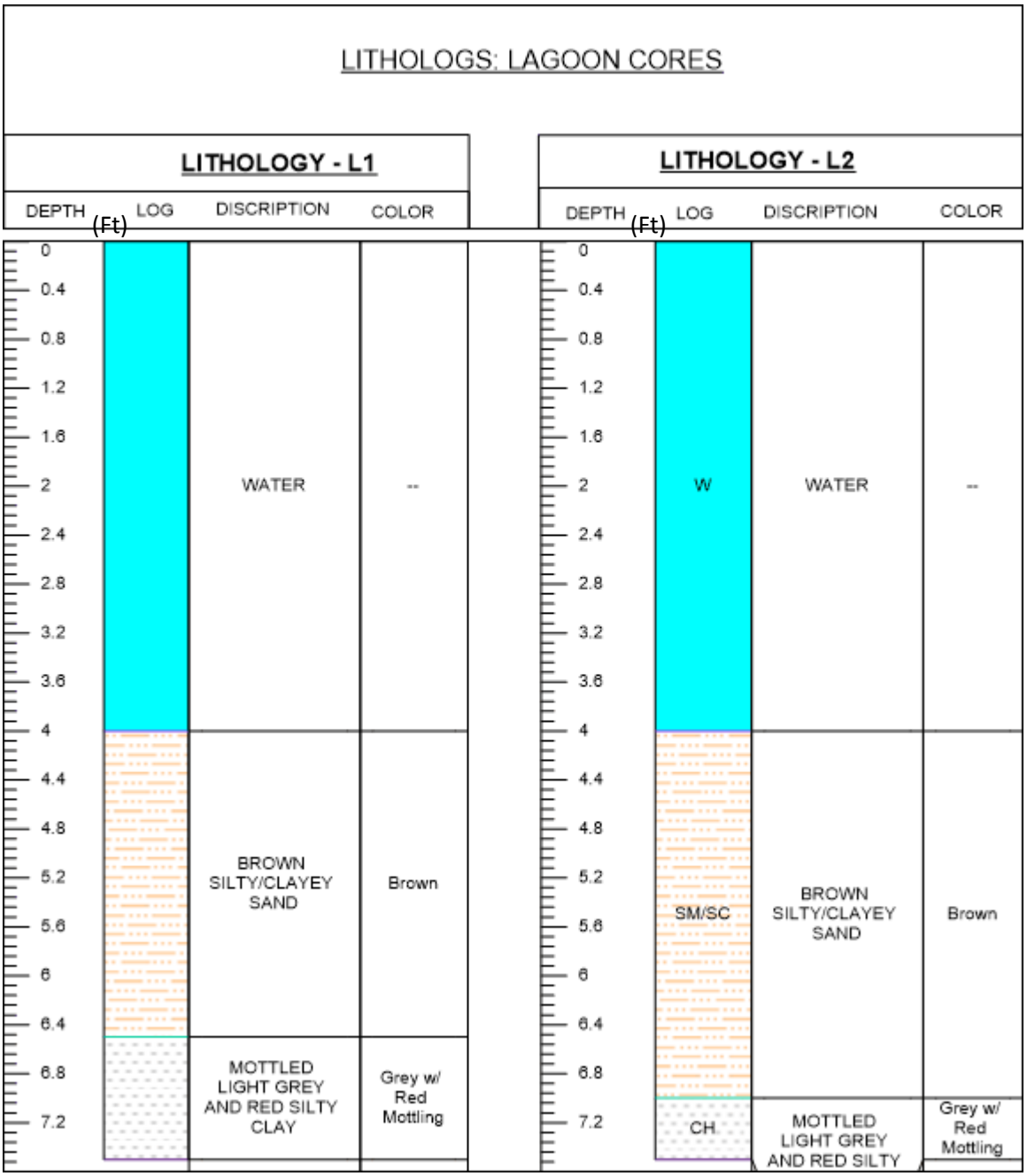


Figure 2-40: Lagoon cores showing sandy clays overlaying still light to creamy clays with red mottling (depth in feet).

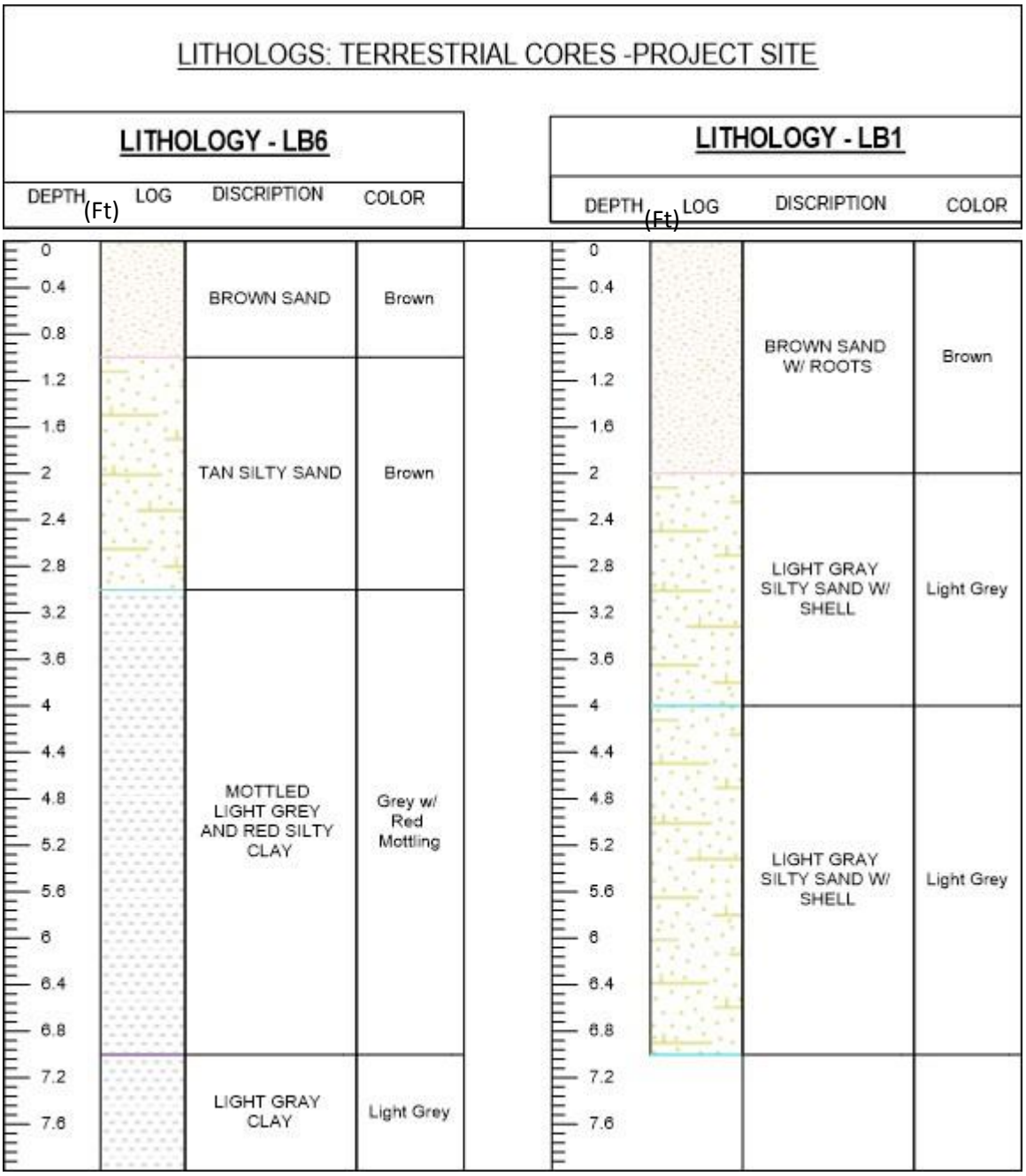


Figure 2-41: Cores on the terrestrial part of the project areas shows sands over laying clay (depth in feet).

From a geotechnical engineer basis, the soil stratification was conducted based on a visual review of the recovered samples, laboratory testing and interpretation of the subsurface conditions encountered at the boring locations. The boring stratification lines represent the approximate boundaries between soil types of significantly different engineering properties; however, the actual transition may be gradual.

The location coordinate and lithological description of the bores are presented in Table 2-13: Summarized Results of Soil Survey. A geologic cross section interpretation of the near surface stratigraphy in the project region is presented in **Figure 2-42** and **Figure 2-43**.

The results of laboratory testing used to verify the visual classification of collected soil samples are summarized in Table 2-14: Summary of Soil Laboratory Testing Results.

Ferro, Droxler and Anderson (1999) reports of modern reefs (approximately 21km or 13 miles) due east of the project area (around the entrance of the English Channel) have developed on Pliostocene limestone. Limestone also ourcrops in the northwestern part of the Lagoon. While not encountered in cores drilled it is expected that these limestone (competent rock) would be encounterd around 9 to 12m (30ft to 40ft) – referencing the Stake Bank EIA proding encountered bedrock at around 6 – 8 m (20ft-27ft).

Table 2-13: Summarized Results of Soil Survey

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
R5	WADE	360022	1918843	-8	-2.4	WATER	--	MEASURED DEPTH TO LAGOON BED	1	WATER BORING	E. SHORELINE N. LAGOON
R5	WADE	360022	1918843	-19	-5.8	GREY CLAY W/ MINOR PLANT REMAINS	ML/MH/CH	SOFT	4	WATER BORING	E. SHORELINE N. LAGOON
R6	WADE	360555	1922462	-6	-1.8	WATER	--	MEASURED DEPTH TO LAGOON BED	1	WATER BORING	E. SHORELINE N. LAGOON
R6	WADE	360555	1922462	-12.5	-3.8	GREY CLAY W/ MINOR PLANT REMAINS	ML/MH/CH	SOFT	4	WATER BORING	E. SHORELINE N. LAGOON
R6	WADE	360555	1922462	-13.5	-4.1	MOTTLED LIGHT GREY AND RED CLAY	CH	STIFF	5	WATER BORING	E. SHORELINE N. LAGOON
R4	WADE	360809	1919587	-3	-0.9	WATER		MEASURED DEPTH TO LAGOON BED	1	WATER BORING	E. SHORELINE N. LAGOON
R4	WADE	360809	1919587	-12	-3.7	GREY CLAY W/ MINOR PLANT REMAINS	ML/MH/CH	SOFT	4	WATER BORING	E. SHORELINE N. LAGOON

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
L2	VELQUEST	361096.71	1920509.4	-4	-1.2	WATER	--	MEASURED DEPTH TO LAGOON BED	1	WATER BORING	E. SHORELINE N. LAGOON
L2	VELQUEST	361096.71	1920509.4	-7	-2.1	BROWN SILT	ML/MH/CH	DENSE SOILS	4	WATER BORING	E. SHORELINE N. LAGOON
L2	VELQUEST	361096.71	1920509.4	-7.5	-2.3	MOTTLED LIGHT GREY AND RED SILTY CLAY	CH	DENSE SOILS	5	WATER BORING	E. SHORELINE N. LAGOON
L1	VELQUEST	361200	1921398	-4	-1.2	WATER	--	MEASURED DEPTH TO LAGOON BED	1	WATER BORING	E. SHORELINE N. LAGOON
L1	VELQUEST	361200	1921398	-6.5	-2.0	BROWN SILTY/CLAYEY SAND	SM/SC	DENSE SOILS	3	WATER BORING	E. SHORELINE N. LAGOON
L1	VELQUEST	361200	1921398	-7.5	-2.3	MOTTLED LIGHT GREY AND RED CLAY	CH	DENSE SOILS	5	WATER BORING	E. SHORELINE N. LAGOON
R3	WADE	361204	1921133	-3	-0.9	WATER		MEASURED DEPTH TO LAGOON BED	1	WATER BORING	E. SHORELINE N. LAGOON
R3	WADE	361204	1921133	-5	-1.5	MOTTLED LIGHT GREY AND RED CLAY	CH		5	WATER BORING	E. SHORELINE N. LAGOON

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
LB6	VELQUEST	361252.42	1920421.7	-1	-0.3	BROWN SAND	SP/SP-SM	DENSE SOILS	2	LAND BORING	E. SHORELINE N. LAGOON
LB6	VELQUEST	361252.42	1920421.7	-3	-0.9	TAN SILT	ML/MH/CH	DENSE SOILS	4	LAND BORING	E. SHORELINE N. LAGOON
LB6	VELQUEST	361252.42	1920421.7	-7	-2.1	MOTTLED RED AND LIGHT GREY CLAY	CH	DENSE SOILS	5	LAND BORING	E. SHORELINE N. LAGOON
LB6	VELQUEST	361252.42	1920421.7	-8	-2.4	LIGHT GREY CLAY	CH	DENSE SOILS	5	LAND BORING	E. SHORELINE N. LAGOON
LB5	VELQUEST	361305	1921335	-1	-0.3	BROWN SILTY SAND	SM	DENSE SOILS	3	LAND BORING	E. SHORELINE N. LAGOON
LB5	VELQUEST	361305	1921335	-2.5	-0.8	LIGHT BROWN CLAYEY SAND	SC	DENSE SOILS	3	LAND BORING	E. SHORELINE N. LAGOON
LB5	VELQUEST	361305	1921335	-5	-1.5	MOTTLED TAN AND RED CLAY	CH	DENSE SOILS	5	LAND BORING	E. SHORELINE N. LAGOON
LB1	VELQUEST	364556	1920585	-2	-0.6	BROWN SAND W/ ROOTS	SP/SP-SM	GROUNDWATER AT 4FT BGS, MEDIUM DENSE SOILS	2	LAND BORING	SEA SHORELINE

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
LB1	VELQUEST	364556	1920585	-4	-1.2	LIGHT GREY SANDY SILT/CLAY W/ SHELL	ML/MH/CH	MEDIUM DENSE SOILS	4	LAND BORING	SEA SHORELINE
LB1	VELQUEST	364556	1920585	-7	-2.1	LIGHT GREY SILTY SAND W/ SHELL	SM	MEDIUM DENSE SOILS	3	LAND BORING	SEA SHORELINE
LB2	VELQUEST	365228	1923641	-2	-0.6	BROWN SAND W/ ROOTS	SP/SP-SM	GROUNDWATER AT 3FT BGS, LOOSE SOILS	2	LAND BORING	SEA SHORELINE
LB2	VELQUEST	365228	1923641	-4.5	-1.4	LIGHT GREY SAND W/ SHELL	SP/SP-SM	LOOSE SOILS	2	LAND BORING	SEA SHORELINE
LB2	VELQUEST	365228	1923641	-7	-2.1	LIGHT GREY SAND W/ SHELL	SP/SP-SM	MED DENSE SOILS	2	LAND BORING	SEA SHORELINE
LB3	VELQUEST	365700	1925142	-0.5	-0.2	BROWN SAND W/ ROOTS	SP/SP-SM	GROUNDWATER AT 6IN BGS, LOOSE SOILS	2	LAND BORING	SEA SHORELINE
LB3	VELQUEST	365700	1925142	-5	-1.5	BROWN SILTY SAND W/ SHELL	SM	VERY LOOSE SOILS	3	LAND BORING	SEA SHORELINE
LB3	VELQUEST	365700	1925142	-7	-2.1	GREY-BROWN SANDY SILT/CLAY	ML/MH/CH		4	LAND BORING	SEA SHORELINE

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
LB4	VELQUEST	366191	1927442	-4	-1.2	BROWN SAND	SP	GROUNDWATER AT 6IN BGS	2	LAND BORING	SEA SHORELINE
R2	WADE	364885	1920572	-6	-1.8	WATER		MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
R2	WADE	364885	1920572	-7	-2.1	DARK GREY SILTY/CLAYEY SAND	SM/SC	SOFT TO STIFF	3	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B1	VELQUEST	364975	1921119	-6	-1.8	WATER	--	MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B1	VELQUEST	364975	1921119	-7	-2.1	DARK BROWN SILTY SAND W/ SHELL	SM	BORING TERMINATED DUE TO REFUSAL CONDITIONS IN DENSE SOILS	3	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
C2	WADE	365139	1921393	-9.85	-3.0	WATER	--	MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
C2	WADE	365139	1921393	-19.45	-5.9	DARK GREY CLAY	DARK GREY CLAY	ROD PROBE ADVANCED TO REFUSAL	4	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
MB12	OIC	365287.73	1921623.5	-11	-3.4	WATER	--	MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
MB12	OIC	365287.73	1921623.5	-19.5	-5.9			MATERIAL RETREIVED WAS SOFT AND SLUSHY MUD	3	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B9	VELQUEST	365523.55	1923591.5	-7.5	-2.3	WATER	--	MEASURED DEPTH TO SEABED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B9	VELQUEST	365523.55	1923591.5	-7.75	-2.4	BROWN SAND	SP		2	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B9	VELQUEST	365523.55	1923591.5	-8.5	-2.6	DARK GREY SANDY SILT/CLAY W/ SHELL	ML/MH/CH	BORING TERMINATED DUE TO REFUSAL CONDITIONS IN DENSE SOILS	4	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B13	VELQUEST	365778.53	1923525.9	-14	-4.3	WATER	--	MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B13	VELQUEST	365778.53	1923525.9	-14.25	-4.3	DARK BROWN SILTY SAND W/ SHELL	SM		3	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B13	VELQUEST	365778.53	1923525.9	-15	-4.6	DARK GREY SANDY SILT/CLAY W/ SHELL	ML/MH/CH	BORING TERMINATED DUE TO REFUSAL CONDITIONS IN DENSE SOILS	4	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
B3	VELQUEST	366040.89	1920915.3	-18	-5.5	WATER	--	MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B3	VELQUEST	366040.89	1920915.3	-23	-7.0	DARK GREY CLAYEY SILT W/ SHELL	ML/MH/CH	VERY SOFT TO FIRM SOIL CONDITIONS	4	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
MB13	OIC	366163.73	1921667.5	-18	-5.5	WATER	--	MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
MB13	OIC	366163.73	1921667.5	-24	-7.3		ML/MH/CH	PRESUMED SILT/CLAY	4	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
MB13	OIC	366163.73	1921667.5	-24.42	-7.4			GREY AND RED CLAY AT BOTTOM	5	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
C1	WADE	365935	1926934	-8.6	-2.6	WATER				RIVER BORING	
C1	WADE	365935	1926934	-9.9	-3.0	PEAT	PT	SOFT TO STIFF	6	RIVER BORING	
C1	WADE	365935	1926934	-14.85	-4.5	CLAYEY SAND	SM/SC	STIFF	3	RIVER BORING	

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
B11	VELQUEST	366256.51	1927029.5	-4	-1.2	WATER	--	MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B11	VELQUEST	366256.51	1927029.5	-5	-1.5	BROWN SAND	SP	BORING TERMINATED DUE TO REFUSAL CONDITIONS IN DENSE SOILS	2	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B8	VELQUEST	366269.54	1925894.4	-5	-1.5	WATER	--	MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B8	VELQUEST	366269.54	1925894.4	-6	-1.8	BROWN SAND	SP	BORING TERMINATED DUE TO REFUSAL CONDITIONS IN DENSE SOILS	2	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B12	VELQUEST	366451.94	1925846.8	-11	-3.4	WATER	--	MEASURED DEPTH TO SEA BED	1	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER
B12	VELQUEST	366451.94	1925846.8	-12	-3.7	DARK GREY CLAY W/ SHELL	ML/MH/CH	BORING TERMINATED DUE TO REFUSAL CONDITIONS IN DENSE SOILS	4	W/IN 1500M FROM SHORELINE	5M MAX DEPTH OF WATER

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
B7	VELQUEST	367234.34	1929426.7	-17	-5.2	WATER	--	MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
B7	VELQUEST	367234.34	1929426.7	-18	-5.5	DARK GREY CLAY	CH	BORING TERMINATED DUE TO REFUSAL CONDITIONS IN DENSE SOILS	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB03	OIC	367650.73	1921116.5	-21	-6.4	WATER	--	MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB03	OIC	367650.73	1921116.5	-27.5	-8.4		SM/SC	PIPE PENETRATED 6.5FT THEN BROKE. MUD AND SAND FOUND	3	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB03	OIC	367650.73	1921116.5	-28	-8.5			DENSE SOILS	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB08	OIC	367686.73	1921586.5	-20	-6.1	WATER		MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB08	OIC	367686.73	1921586.5	-28	-8.5		SM/SC	PRESUMED MUD AND SAND	3	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
MB08	OIC	367686.73	1921586.5	-28.25	-8.6		CH	SOLID RED AND GREY CLAY	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
B5	VELQUEST	367950	1920597	-24	-7.3	WATER	--	MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
B5	VELQUEST	367950	1920597	-37	-11.3	DARK GREY SILT/CLAY	ML/MH/CH	VERY SOFT UNCONSOLIDATED SOILS W/ THIN CRUST AT TOP, CORE BARREL DESCENDED UNDER OWN WEIGHT	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
B5	VELQUEST	367950	1920597	-39	-11.9	LIGHT GREY SILTY/CLAYEY SAND W/ SHELL	SM/SC	SOFT SOILS	3	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
B5	VELQUEST	367950	1920597	-39.5	-12.0	MOTTLED LIGHT GREY AND RED CLAY	CH	DENSE SOILS	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB02	OIC	367988.73	1920886.5	-22.75	-6.9	WATER		MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB02	OIC	367988.73	1920886.5	-26.75	-8.2		ML/MH/CH	PRESUMED SILT/CLAY	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
MB02	OIC	367988.73	1920886.5	-27	-8.2		CH	SOLID RED AND GREY CLAY	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB19	OIC	368144.73	1920628.5	-24	-7.3	WATER	--	MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB19	OIC	368144.73	1920628.5	-40	-12.2		ML/MH/CH	PRESUMED SILT/CLAY	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB19	OIC	368144.73	1920628.5	-40.8	-12.4		CH	GREY AND RED CLAY AT BOTTOM	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB04	OIC	368159.73	1920998.5	-22.25	-6.8	WATER		MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB04	OIC	368159.73	1920998.5	-26.25	-8.0		ML/MH/CH	PRESUMED SILT/CLAY	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB04	OIC	368159.73	1920998.5	-26.5	-8.1		CH	SOLID RED AND GREY CLAY	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB18	OIC	368387.73	1920827.5	-24	-7.3	WATER		MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
MB18	OIC	368387.73	1920827.5	-40	-12.2		ML/MH/CH	PRESUMED SILT/CLAY	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB18	OIC	368387.73	1920827.5	-40.8	-12.4		CH	SOLID RED AND GREY CLAY	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB20	OIC	368513.73	1920466.5	-26.25	-8.0	WATER	--	MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB20	OIC	368513.73	1920466.5	-40	-12.2		ML/MH/CH	PRESUMED SILT/CLAY	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB20	OIC	368513.73	1920466.5	-40.25	-12.3		CH	GREY AND RED CLAY AT BOTTOM	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB17	OIC	368767.73	1920183.5	-30	-9.1	WATER		MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB17	OIC	368767.73	1920183.5	-39.5	-12.0		ML/MH/CH	MEDIUM DENSE SILT/CLAY	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB17	OIC	368767.73	1920183.5	-40	-12.2		CH	GREY AND RED CLAY AT BOTTOM	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M

ID	FIRM	EAST.	NORTH.	DEPTH (FT)	DEPTH (M)	DESCRIPTION	USCS SOIL CLASS.	COMMENT 1	STRATA	COMMENT 2	COMMENT 3
MB16	OIC	368982.73	1919912.5	-32	-9.8			MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB16	OIC	368982.73	1919912.5	-40.5	-12.3		ML/MH/CH	MEDIUM DENSE SILT/CLAY	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB26	OIC	369248.73	1919615.5	-35.5	-10.8	WATER		MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB26	OIC	369248.73	1919615.5	-41.5	-12.7		ML/MH/CH	SOFT SILT/CLAY	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB26	OIC	369248.73	1919615.5	-42	-12.8		CH	SOLID RED AND GREY CLAY	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB25	OIC	369501.73	1919328.5	-34	-10.4	WATER	--	MEASURED DEPTH TO SEA BED	1	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB25	OIC	369501.73	1919328.5	-40.83	-12.4		ML/MH/CH	SOFT GREY CLAYS	4	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M
MB25	OIC	369501.73	1919328.5	-41	-12.5		CH	HARD CLAYS	5	BEYOND 1500M FROM SHORELINE	DEPTH OF WATER >5M

Table 2-14: Summary of Soil Laboratory Testing Results.

ID	DEPTH (FT)	DEPTH (M)	DESCRIPTION	MOISTURE (%)	SPECIFIC GRAVITY	FINE SAND #40 SIEVE (%)	FINES #200 SIEVE (%)	D_{85} (MM)	LIQUID LIMIT	PLASTICTIY INDEX	STRATA	USCS SOIL CLASS.
L2	-6	-1.8	BROWN SILT			10.7	84.2	0.083			4	ML
L2	-7	-2.1	BROWN SILT		2.51	94.9	65.1 TO 84.2	0.1842	28	5	4	ML
L2	-7.5	-2.3	MOTTLED LIGHT GREY AND RED SILTY CLAY	27.9		43.4	50	0.204			5	CH
LB6	-3	-0.9	TAN SILT	7.6		14.5	84.4	0.0782			4	ML
LB6	-8	-2.4	LIGHT GREY CLAY			16.2	82.5	0.0875			5	CH
LB5	-5	-1.5	MOTTLED TAN AND RED CLAY	18.7		8.8	88.7	0.09			5	CH
LB1	-4	-1.2	LIGHT GREY SANDY SILT W/ SHELL	34.6		36	62.5	0.1372			4	ML
LB1	-7	-2.1	LIGHT GREY SILTY SAND W/ SHELL	30							3	SM/SC
LB3	-5	-1.5	BROWN SILTY SAND W/ SHELL			33.4	22.5	0.6543			3	SM

ID	DEPTH (FT)	DEPTH (M)	DESCRIPTION	MOISTURE (%)	SPECIFIC GRAVITY	FINE SAND #40 SIEVE (%)	FINES #200 SIEVE (%)	D_{85} (MM)	LIQUID LIMIT	PLASTICTIY INDEX	STRATA	USCS SOIL CLASS.
LB3	-7	-2.1	GREY-BROWN SANDY SILT	41.4		34.5	50.5	0.4253			4	MH
LB4	-4	-1.2	BROWN SAND	24.5		39.3	6.3	0.7047			2	SP
B3	-23	-7.0	DARK GREY CLAYEY SILT W/ SHELL			15.9 TO 18	69.7 TO 75.4	0.3156	66	30	4	MH
B9	-8.5	-2.6	DARK GREY CLAYEY SILT W/ SHELL			20.1	77.8	0.174				MH
B11	-5	-1.5	BROWN SILTY SAND	22		54.5	22.5	0.6077			2	SM
B12	-12	-3.7	DARK GREY SILT/CLAY W/ SHELL	40.8		10 TO 18.7	69.4 TO 83.9	0.1101			4	MH/CH
B13	-15	-4.6	DARK GREY SILT/CLAY W/ SHELL			22.2	69.1	0.2102			4	MH/CH
B5	-39	-11.9	LIGHT GREY SILTY/CLAYEY SAND W/ SHELL		2.36	45.5	23.8	1.18			3	SM/SC

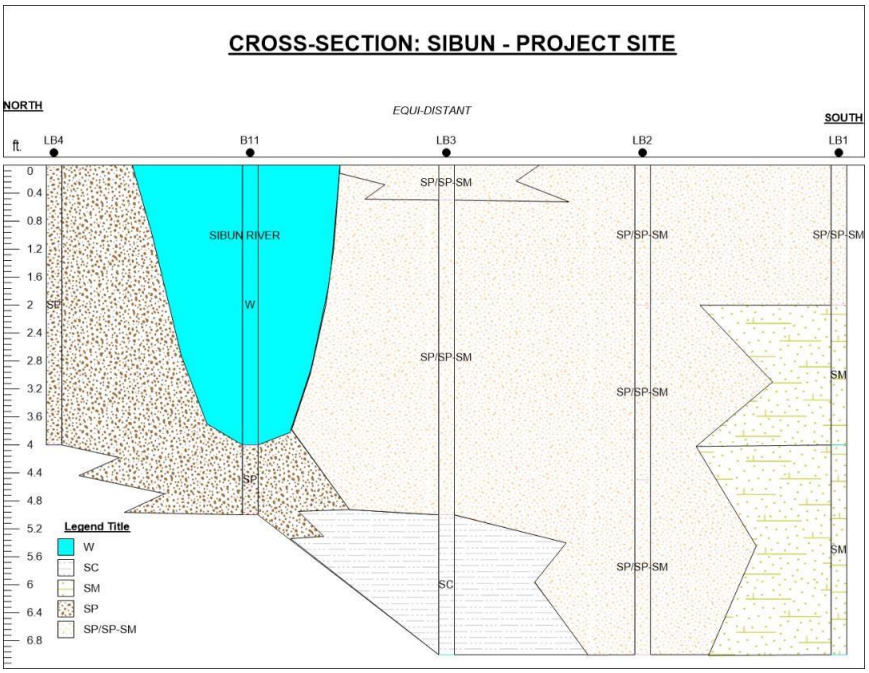


Figure 2-42: Stratigraphic cross section from Sibun River to the project site shows mainly sand deposits overlaying clays.

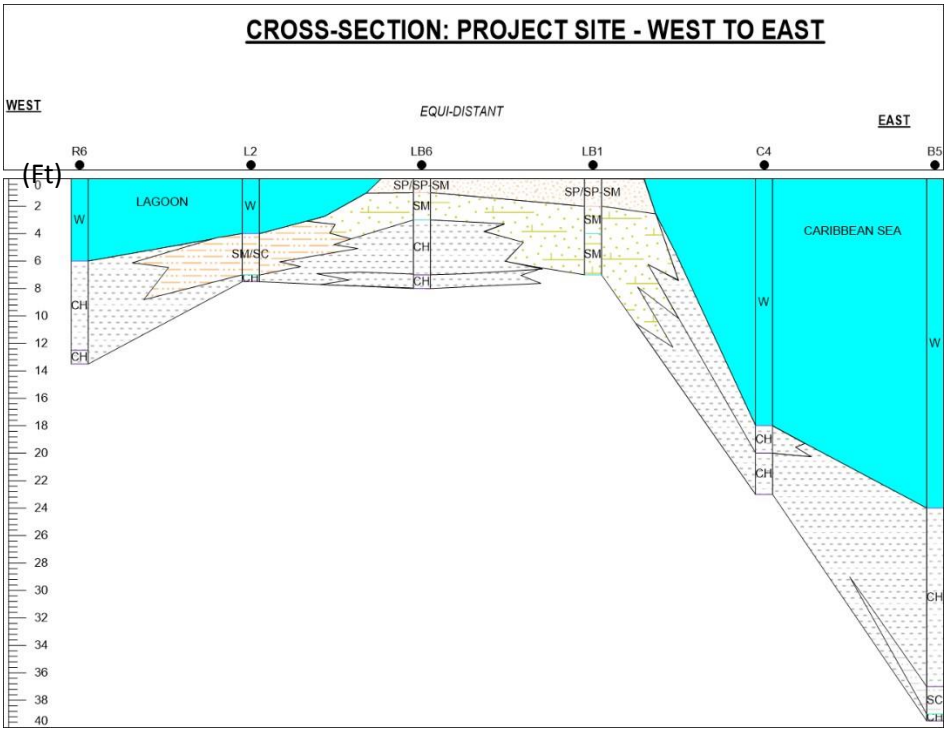


Figure 2-43: Stratigraphic section west to east from the Lagoon to the marine environment shows sands on clays that transitions into mainly clays in the marine environment.

2.6.3 Further Detailed Seabed Study

Based on acoustic and bathymetric survey as sailed in October 2019 and vibrocores performed in October 2019 a preliminary soil interpretation has been done by Boskalis' senior geologists, see **Annex 6**.

General remarks:

- The used vibrocorer was a pneumatic one with a diameter of 70 mm; it did not penetrate very deep in the lower, more dense material and we strongly have the impression in did not sample the very soft top layer very well. It is therefore not used to determine the thicknesses of the soil layers. The retrieved samples could however be used very well for describing the soil and for further lab analysis.
- At the moment of writing this memo only a part of the lab-results are available. These are the PSD's and shear strengths of the hard clay. Other tests as water content, hydrometer, Atterberg Limits, situ-density, $CaCO_3$ and organic content are outstanding.
- On the acoustic data (live) coral and reefs were visible. This was confirmed by the diving operations as performed by the Royal Haskoning survey

Interpretation:

Based on the vibrocores the soil consists of 2 layers; a very soft silt or clay on top of a stiff to hard clay. Locally sand layers are present on top or within the very soft silt/clay. Furthermore peat layers are present. The different soil layers are described at the end of this paragraph

The acoustic data show a very nice structure in which the subsoil (stiff clays) is cut in by rivers (Figure 2-28). The deeper parts of these previous rivers are filled with clay and clay with peat (Figure 2-29). This whole packet is covered by a layer of soft clay. On the locations of the previous rivers the thickness of the soft clay can be more than 5 meters. On the other locations this thickness is a lot less. Significant sand deposits were not recognized on the acoustic data. Coral and reefs could be recognized especially on those locations where the hard clay is present at the seabed; good substrate for growing reefs.

A deeper reflector (harder/rock layer) is visible but this is always located below -12.5 meters. As there are no boreholes or vibrocores available penetrating this depth ground proofing is not possible.

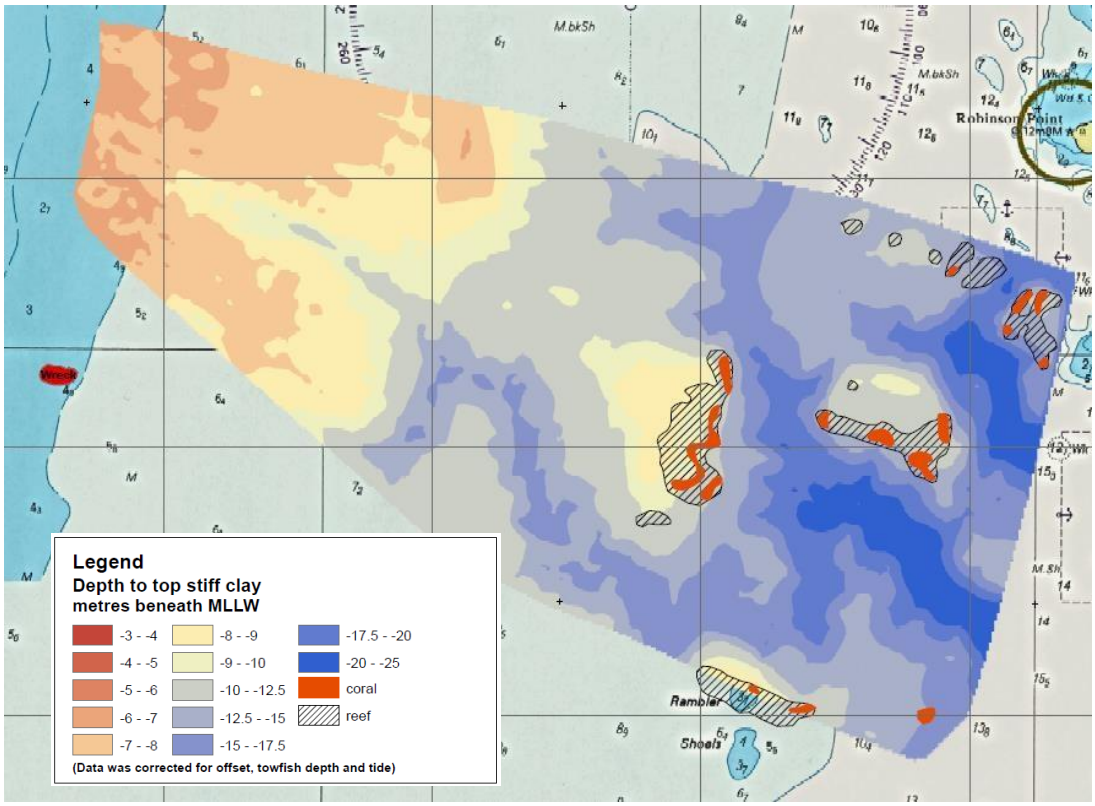


Figure 2-44: depth of the stiff clay. In the south there is a an old channel visible; it is located more or less at one of the possible channel to dredge (source: Deltares 2019).

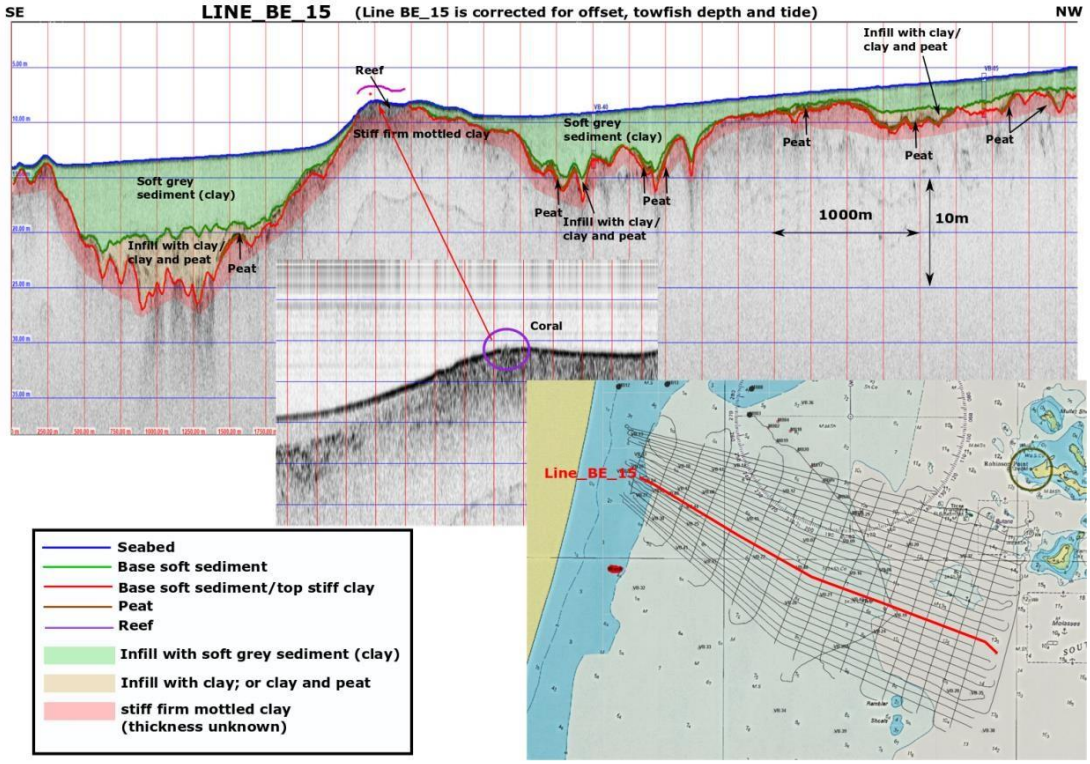


Figure 2-45: An acoustic section showing the top of the stiff to hard clay and overlying soft clay and channel infills (source: Deltares, 2019).

Very soft silt/clay

In the vibrocores it is described as grey, very soft to soft, silty, occasionally sandy clay with shells and/or shell debris. In the logs it is described as a clay; the acoustic data show a silt character.

Stiff clay

This most likely is a completely weathered rock. Based on the vibrocores samples it is described as red, yellow, orange and grey mottled, dry, firm to very stiff/hard with occasionally organic material (root fragments). Hard nodules (possibly rock fragments) can be present. It can also feel quite sandy.

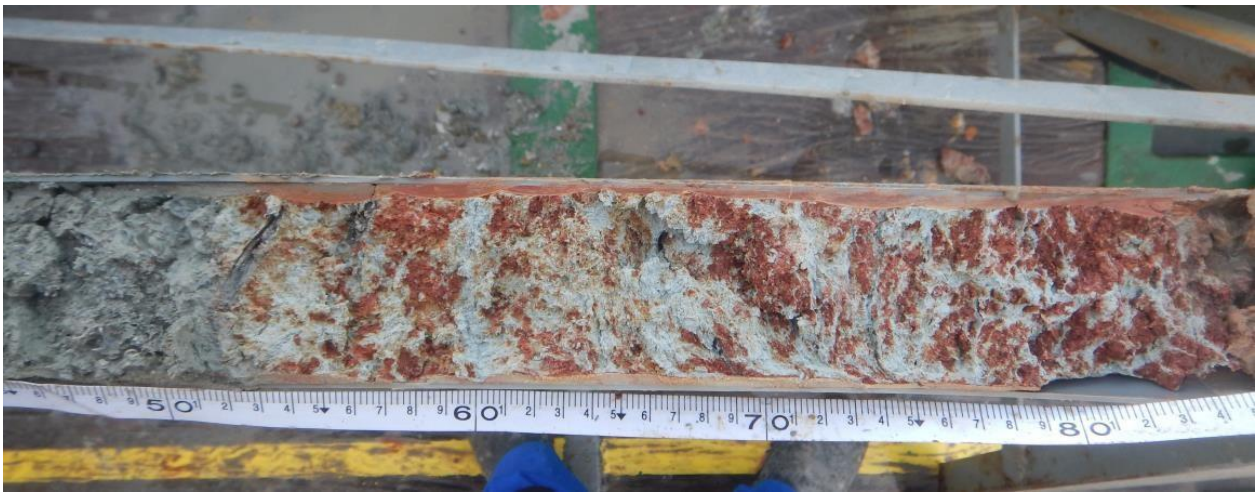


Figure 2-46: A picture of the very stiff to hard clay.

In the laboratory 5 vane tests on more or less undisturbed samples were performed giving values varying between 52 kPa (firm clay) and more than 260 kPa (very stiff to hard clay). The average is around 150 kPa.

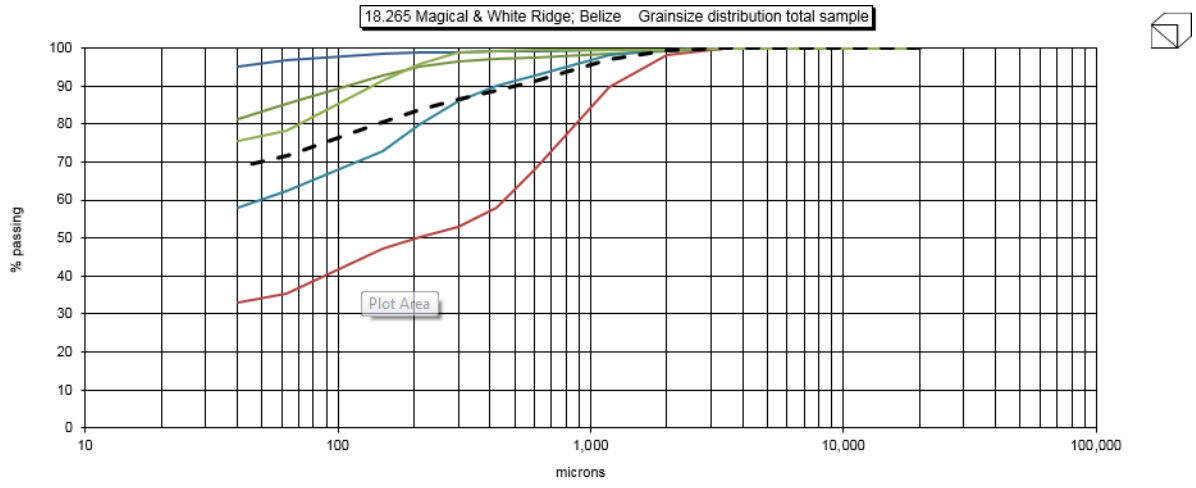


Figure 2-47: PSD's of the stiff clay in the Magical Port of Belize area.

5 PSD's tests on samples from the stiff clay are performed as shown in **Figure 2-47** above showing an average D_{50} of 36 mu (max 210 mu), 70% fines and about 1% coarse. The DMF_{tot} is 99 mu, the DMF_{sand} is 196 mu.

Sand

The sand is found very locally in 8 of the 45 vibrocores with an average thickness of 35 cm (max 70 cm) on or below the soft clay. It is described as grey, silty/clayey, fine to medium and occasionally very gravelly. It can contain a lot of shells and coral fragments but it can also be a very nice coarse angular sand (river deposit).

There are 4 PSD's performed as shown in Figure 2-32. On average the D_{50} is 301 mu, with 19% fines and 13% coarse. The DMF_{tot} is 678 and the DMF_{sand} is 196 mu.

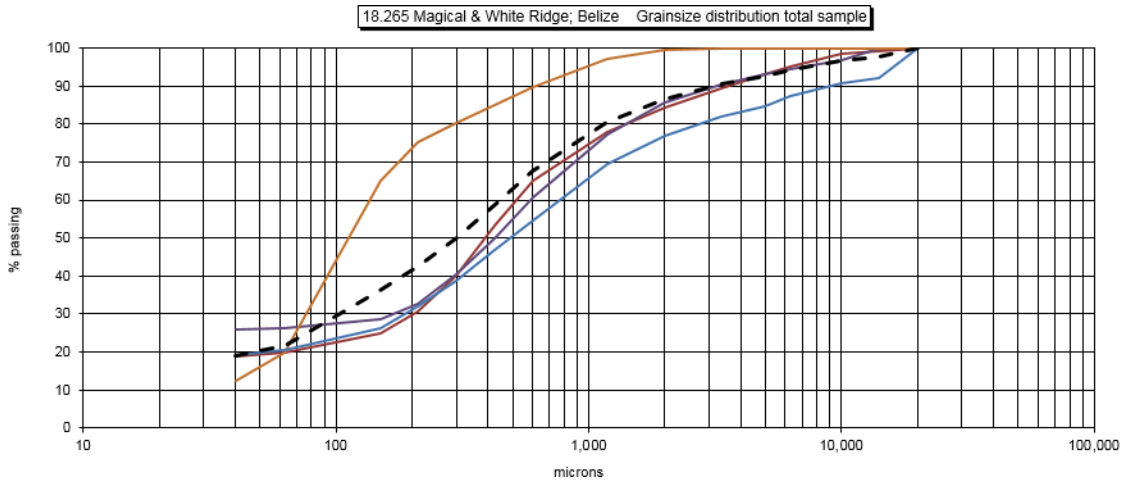


Figure 2-48: PSD's on the sand samples in Magical Port of Belize

Peat

The peat layers are found in 10 of the 45 vibrocores and have an average thickness of 45 cm with a maximum of 90 cm. It is in general described as dark brown.

2.6.4 Chemical characterisation of sediment samples

To assess the analytical results of the sediment samples, comparison with local legislation and/or international reference criteria is required.

With respect to dredging the National Marine Guidelines (2009) of Belize state:

''5.5.20 If dredged material is suspect of possible contamination with heavy metals or persistent organic pollutants, sampling and analyses of the intended dredged spoils will be carried out prior to commencement.

5.5.21 Contaminated dredged spoils will need to be disposed inland in a contained area approved by the Department of the Environment. ''

The guideline document, however, does not state reference values or standards that can be used to assess the sediment quality. As there are no national guidelines, the assessment of the results is carried out using the internationally applied OSPAR guidelines.

The following guidelines and standards are used to assess the sediment quality:

- UK Centre for Environment Fisheries & Aquaculture Science (CEFAS) Action Levels in Dredged Material Assessments[1], and
- Canadian Sediment Quality Guideline for the Protection of Aquatic Life.

The above guidelines are in accordance with the requirements in the OSPAR Guidelines for the Management of Dredged Material at Sea.

CEFAS Action Levels are presented in **Table 2-15**. Contaminant levels in dredged material which are below Action Level 1 are of no concern. When contaminant levels are above Action Level 2, material is unsuitable for disposal at sea. When contaminant levels are between Action Level 1 and 2 dredged material requires further consideration and testing.

The Canadian Sediment Quality Guidelines involved the derivation of Interim marine Sediment Quality Guidelines (ISQGs) or Threshold Effect Levels (TEL) and Probable Effect Levels (PEL) from an extensive database containing direct measurements of toxicity of contaminated sediments to a range of aquatic organisms exposed in laboratory tests and under field conditions. These values were designed specifically for Canada and are based on the protection of pristine environments therefore the findings should be treated with caution. In the absence of suitable alternatives, however, it has become commonplace for these guidelines to be used by regulatory and statutory bodies around the world as part of a 'weight of evidence' approach in assessing the potential ecological effects of disturbed sediment. Given the location of the potential development in Belize, the use of these standards is considered legitimate.

The lower level is referred to as the TEL and represents a concentration below which adverse biological effects are expected to occur only rarely (in some sensitive species for example). The higher level, the PEL, defines a concentration above which adverse effects may be expected in a wider range of organisms. The Canadian standards are summarized in **Table 2-16**.

Table 2-15: Action levels in mg.kg dry weight (ppm) for dredged material assessment defined by CEFAS

Contaminant/compound	Action Level 1	Action Level 2
Arsenic	20	100
Mercury	0.3	3
Cadmium	0.4	5
Chromium	40	400
Copper	40	400

[1] CEFAS, https://www.gov.uk/guidance/marine-licensing-sediment-analysis-and-sample-plans accessed on 7 January 2020

Contaminant/compound	Action Level 1	Action Level 2
Nickel	20	200
Lead	50	500
Zinc	130	800
Organotins; TBT, DBT, MBT	0.1	1
PCBS, sum of ICES 7	0.01	none
PCB's, sum of 25 congeners	0.02	0.2
*DDT	*0.001	

*levels were set in 1994

Table 2-16: List of interim marine sediment quality guidelines (ISQGs)/threshold effect levels (TELs), probable effect levels (PELs)(dry weights) and incidence (%) of adverse biological effects in concentration ranges defined by these values

Substance	Units	ISQG/TEL	PEL
Metals			
Arsenic	mg.kg-1	7.24	41.6
Cadmium	mg.kg-1	0.7	4.2
Chromium	mg.kg-1	52.3	160
Copper	mg.kg-1	18.7	108
Lead	mg.kg-1	30.2	112
Mercury	mg.kg-1	0.13	0.7
Zinc	mg.kg-1	124	271
Polychlorinated biphenyl (PCB)			
PCBs: total PCBs	mg.kg-1	21.5	189
Polyaromatic hydrocarbons (PAH)			
Acenaphthene	µg.kg-1	6.71	88.9
Acenaphthylene	µg.kg-1	5.87	128
Anthracene	µg.kg-1	46.9	245
Benz(a)anthracene	µg.kg-1	74.8	693

Substance	Units	ISQG/TEL	PEL
Benzo(a)pyrene	µg.kg-1	88.8	763
Fluorene	µg.kg-1	21.2	144
2-Methylnaphthalene	µg.kg-1	20.2	201
Naphthalene	µg.kg-1	34.6	391
Phenanthrene	µg.kg-1	86.7	544

2.6.4.1 Results

Fieldwork Execution

Samples for environmental purposes were taken with the aim to establish a spatial variation throughout the investigation area, as well as a variation in soil layers and depths. The boreholes of which the environmental samples were taken are summarized in table below, also indicating the soil characteristics and sample depths.

In the table below, the lithology and depths of the layers that were encountered during drilling have been summarized in the table below.

Table 2-17: Sampling results.

Sample point	Type	Sample depth (m)	Lithology
vb01	grab sample	0-0.10	soft silty clay, grey, shells, light brown top layer.
vb03	grab sample	0-0.10	soft silty clay, grey, shells, light brown top layer.
vb05	vibrocore	0-0.30	soft silty clay, grey
		0.30-0.65	soft silty clay, grey, more stiff
		0.65-1.10	soft clay, grey, lots of small shell remains
		1.10-1.75	soft clay, dark grey, little shell remains
		1.75-2.60	organic material, peat, dark brown, slight clayey
		2.60-2.85	sandy clay, grey, with root remains
		2.85-3.40	hard sandy clay, grey, includes nodules: hard stone like fragments, red and brown patches
vb06	vibrocore	0-0.70	sand, grey, many shells, coral pieces, organic material at 50 cm. Sponges at the top. Last 20cm more clayey
		0.70-1.40	hard sandy clay, light grey, with yellow/red patches, organic material in the top. To the bottom more dark red clay.
vb07	vibrocore	0-0.35	soft sandy clay, grey, shell remains, from 20-35 more sandy, whole shell
		0.35-0.70	hard sandy clay, light grey, red and light brown patches of sandy clay.
vb09	vibrocore	0-0.65	soft silty clay, grey, last 20cm more sandy and stiff, around 45-65cm more shell remains including whole shells
		0.65-1.10	very hard sandy clay, red and brown patches

Sample point	Type	Sample depth (m)	Lithology
vb12	vibrocore	0-0.50	hard sandy clay, red and brown patches, shells in the top
vb19	vibrocore	0-0.20	soft silty clay, grey, some shells
		0.20-0.45	grey sand, shell remains, organic material (peat), the layer goes from grey sand to grey sandy clay,
		0.45-1.05	hard sandy clay, grey, with brown patches of clay, very hard. last 20 cm becomes more sandy
vb22	vibrocore	0-0.35	soft clay, grey, some shells
		0.35-1.35	stiff clay, light brown and red patches, softer on the top, more clayey than similar layer in other boreholes.
vb26	vibrocore	0-0.50	soft clay, grey, some shells
		0.50-1.00	hard clay, light grey, light brown and red patches, much harder than VB22. 185kPa.
vb34	grab sample	0-0.25	soft grey clay, with shells and coral remains
vb36	vibrocore	0-1.25	sandy clay, grey, top more sandy, from 90-110cm more organic material, large shells till 60cm.
		1.25-2.10	hard sandy clay, grey, red and brown patches, organic material inclusion
vb37	vibrocore	0-0.95	soft silty clay, grey, shells, big pieces of coral, last 10 cm organic material (peat)
		0.95-1.10	sand, grey-dark grey, shells
		1.10-1.60	sandy clay, grey, red and light brown colouring, very hard
vb37A	vibrocore	0-0.95	soft silty clay, grey, shells, big pieces of coral, last 10 cm organic material (peat), appears like roots
		0.95-1.10	sand, grey-dark grey, shells, organic material (wood remains)
		1.10-1.60	sandy clay, grey, red and light brown colouring, very hard, organic material, like roots
vb38	grab sample	0-0.10	Soft sandy clay, some shell remains,
	vibrocore	0-0.25	soft sandy clay, grey, with shells, last 5 cm more sand.
		0.25-0.80	stiff clay, grey, stiff, red and light brown spots, top 20cm clay bit more soft.
vb39	vibrocore	0-0.40	soft clay, grey, shells, around 40cm distinct shell layer. Bottom part more sandy
		0.40-0.70	silty sand, light brown, contains hard pieces. Possibly limestone or iron
		0.70-1.30	hard clay, grey, with red and light brown patches
vb39A	vibrocore	0-2.60	clay, grey, from soft to harder, some shells
		2.60-2.70	organic material, peat layer, with 5 cm layer of shells and coral pieces
vb48	grab sample	0.25	soft clay, grey, in top 10 cm coral remains, shells, worms, from 10-25cm shell remains
Sib1	grab sample	0-0.05	dark grey sand, brown top layer. Shell particles

Sample point	Type	Sample depth (m)	Lithology
Sib2	grab sample	0-0.05	very fine black silt with a thin brownish top layer. Plant remains, rotting smell
Lag1	grab sample	0-0.10	soft silty clay, grey, top layer light brown. No plants or shells
Lag2	grab sample	0-0.05	soft silty clay, grey brown, some sand and shells, little red stones which is also seen on the shores of the lagoon.

Analytical Results

All samples were sent to the ISO 17025 accredited laboratory of Eurofins Analytico in Barneveld, the Netherlands[2] and analysed on a suite of metals, polycyclic aromatic hydrocarbons (PAH), chlorobenzenes, suite of pesticides and total petroleum hydrocarbons (TPH). Additionally, dry matter, organic matter and lutum (the percentage of soil particles smaller than 2 µm) have been determined.

All samples were stored in a refrigerator during the execution of the sampling activities (vibrocoring) until the sampling campaign was finalized. After that they were directly taken to DHL and transported in specially prepared boxes with ice packs, provided by the laboratory, to keep the samples cool. The temperature of the samples is kept low in order to prevent any possible biological degradation prior to being analysed.

Interpretation

The baseline assessment performed at the sediment in the area of the future Magical Belize site has provided a substantial dataset with regards to chemical content of the sediment.

Analytical results show that for the parameters PAH (Polycyclic Aromatic Hydrocarbons), chlorinated hydrocarbons, and pesticides no elevated concentrations (above laboratory detection limits) have been observed. CEFAS or Canadian standards are not exceeded.

Mineral oil concentrations have been reported above the laboratory detection limit in 4 samples (out of 29). It is believed that these elevated mineral concentrations can be attributed to the presence of peat in the sediment, in which case the concentration can be referred to as naturally occurring oil.

With respect to metals fluctuating concentrations were observed. The variety of concentrations partly has to do with the depth of the sampled material. It is observed that the deeper samples consisting of hard clay and peat layers contain relatively higher concentrations of metals than other layers. This is best shown in below graph, presenting the results of 4 samples of different depth from sediment sample vb-05.

- The sample depths are as follows:
- Vb-05-1 0 - 0,65 metres below sea bottom

[2] to conduct the chemical analysis the samples were transported from Belize to the Netherlands by courier service. Due to the duration of the sample shipment, travel time could potentially affect the quality of the samples. This could potentially result in lower results due to biological or chemical processes. To overcome this, the laboratory protocol prescribes that the samples must be cooled during the transportation. The samples were therefore packed in (laboratory provided) insulated boxes with ice packs.

- Vb-05-2 0,65-1,75 metres below sea bottom
- Vb-05-3 1,75-2,60 metres below sea bottom
- Vb-05-4 2,60-3,40 metres below sea bottom

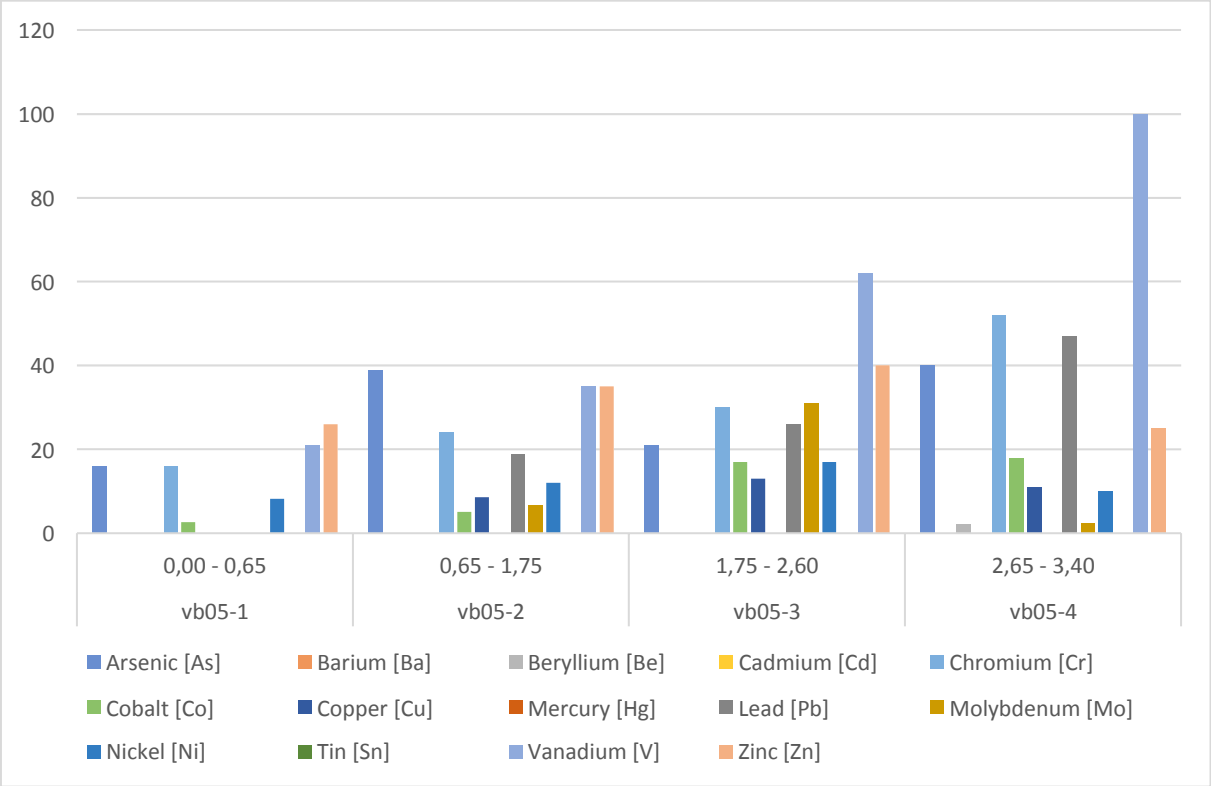


Figure 2-49: Sediment results vb-05

A few sediment samples show exceptional results, such as vb26, for Cobalt (170 mg/kgdm) and Nickel (38 mg/kgdm), which are far above other results in the area. There are no specific CEFAS or Canadian for Cobalt, however, the Cobalt concentration exceeds the CEFAS action level 1. It was observed however that this layer is much harder than comparable clay layers. Although the exact cause cannot be determined, it is not believed to be due to anthropogenic influences and related to natural background values. Also other, deeper samples from harder clay layers show relatively higher metal concentrations, although not as substantial as in vb-26. It would therefore be useful to perform some additional testing in this area to understand the spread in concentrations and assess of these results are reproducible or one-off.

For arsenic and lead the Canadian TEL levels are exceeded in a limited number of samples. However, also in this case, it is not believed that this is due to anthropogenic influences, but nearly related to natural background levels.

2.6.5 Additional Soil Survey

Soil sampling onshore was conducted in order to provide baseline data for the EIA, with the main purpose to:

- Record the current soil conditions in and around the area of the proposed project.

- Enable assessment of the chemical quality of the soil.

The results are presented in **Annex 6**. Based on the results of the chemical analysis of the soil samples it can be concluded that all concentrations of metals, polycyclic hydrocarbons, chlorinated hydrocarbons, pesticides or mineral oil (total petroleum hydrocarbons) are either below he laboratory detection limit or in line with natural background values.

2.7 Surrounding environment

Please refer for the physical description of surrounding environment, including terrestrial and marine environment, including seagrass beds, mangrove, lagoons, etc to Part B.1.

2.8 Hydrography

A hydrographic survey has been performed from October 7 to October 12, 2019, see **Figure 2-50**. In **Annex 9** this hydrographic survey map is provided as well, including additional information.

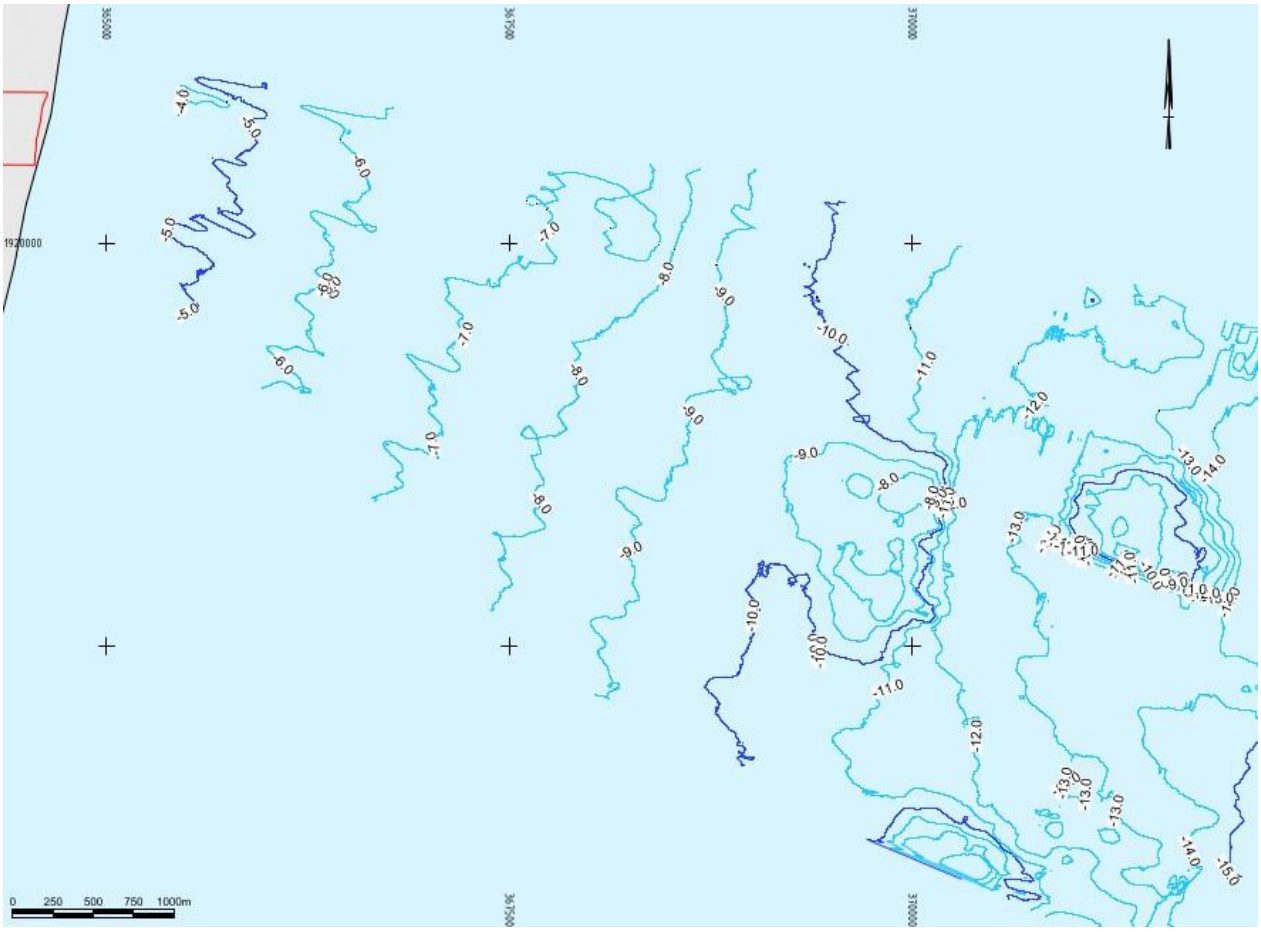


Figure 2-50: Hydrographic survey (October 2019)

2.9 Navigational routes

The Admiralty Sailing Directions (UKHO, 2019, section 5.37) describes the following approaches to Belize City, see **Figure 2-51**:

1. East approach: From the Pilot Boarding Place, between Turneffe Islands and the Belize Barrier Reef, this approach runs through the English Cay Channel. Thence the

route continues through One Mand Cayy Channel to a position north of Frank Knoll Light to enter the harbour or one of the anchorage areas

2. South approaches: From a position ESE of Rambler Shoals, this route leads through Southern Grennels Channel and One Man Channel to a position north of Frank Knoll Light Beacon towards the harbour or one of the anchorage areas. The route west of Grennels Cay is not recommended without local knowledge.

The proposed navigation route leads through English Cay Channel and Southern Grennels Channel. After passing the Molasses and Butane anchorage areas, the route continues west of Grennels Cay towards the dredged channel.

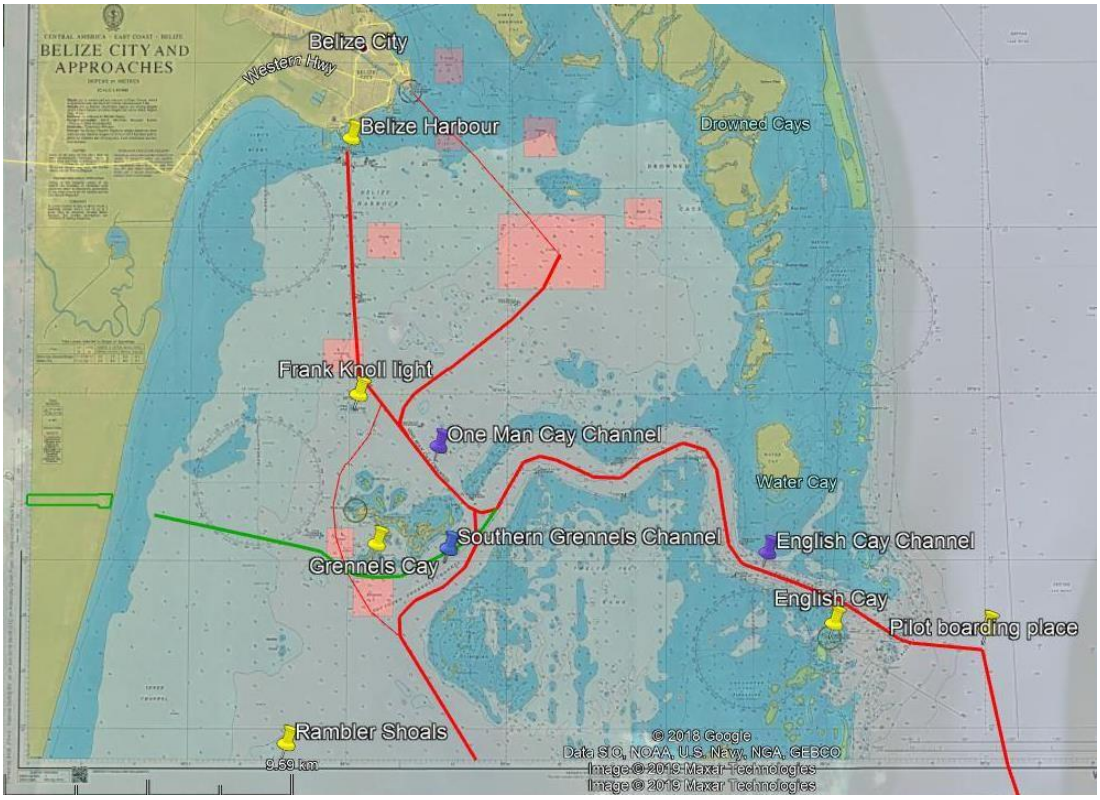


Figure 2-51: Navigation routes, existing (red) and proposed (green); red patches represent anchorage areas (background Admiralty Chart 522)

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3 Policy, Legal and Administrative Framework

3.1 Policy

Belize's long-term vision as expressed in its 20 years development plan, Horizon 2030, is that "Belize is a country of peace and tranquillity, where citizens live in harmony with the natural environment and enjoy a high quality of life. Belizeans are an energetic, resourceful and independent people looking after their own development in a sustainable way." Under the theme "Care for the natural environment," an important stakeholder view highlighted that "the natural environment is valued and protected as the basis for all economic activity and therefore development planning is based on the principles of environmental sustainability."

Belize's vision towards sustainable development is reflected in the country's medium-term plan, Growth and Sustainable Development Strategy (GSDS) which also integrates the 2030 Agenda on Sustainable Development being promoted at the global level. The GOB's commitment is therefore to sustainably explore its natural resources while ensuring fair and equitable distribution of the benefits derived from these resources to as many Belizeans for as long as possible. The Government, in its effort to improve the quality of life for its citizens, continues to seek new investment projects as well as the expansion of existing ones with the view of sustainably developing the country.

The GOB, through its Department of Environment (DOE), evaluates these projects to make an initial assessment of the environmental risk associated with them. Depending on factors such as project size, project type, and location, these projects may or may not be required to undertake an EIA. Supporting the DOE and its overarching legislation, the GOB has established numerous environmental laws, regulations, guidelines and standards governing the wise use and enjoyment of its natural resources. Several Government Departments have responsibility over one or more pieces of legislation that protect air, water and soil quality and its associated flora and fauna. While the DOE is the primary environmental regulatory agency in Belize, other government agencies with responsibility over some aspect of environmental/natural resources protection include the Fisheries Department (FiD), Forest Department (FD), Coastal Zone Management Authority and Institute (CZMAI), National Institute for Culture and History (NICH), Geology and Petroleum Department (GPD), Land Utilization Authority (LUA) and Central Building Authority (CBA). Some of the legislations being implemented by these Departments include: National Parks System Act (NPSA), Wildlife Protection Act (WPA), Forest Fires Protection Act (FFPA), Fisheries Act (FA), Environmental Protection Act (EPA), NICH Act, CZMAI Act, and CBA Act also contribute to the balance between development and environment.

To strengthen the EIA process and its relevant supporting institutions, the DOE has created guidelines for all its stakeholders with the view of facilitating knowledge of the requirements for any development. In the case of this project, the relevant guidelines directly relevant and considered in this EIA are the Overwater Environmental Guidelines of January, 2010, the Marina and Berthing Facilities Guidelines of 2009 and Final Service Station Guidelines of 2016.

Outside the government realm and supporting the GOB in its quest to environmental

sustainability are Non-Governmental Organizations (NGOs), Community-based Organizations (CBOs) and local communities that provide management, monitoring and active participation through various instruments of cooperation.

3.2 Legal Framework

Every aspect of the proposed development of Port of Magical Belize is guided and regulated by laws and/or regulations that intend to guide the sustainable use of Belize's Natural Resources, both marine and terrestrial. The proponents will be sensitive to the surrounding environment and apply the best available technologies including state of the art water and wastewater treatment facilities, natural lighting, green technologies in building such as motion sensors, solar etc. and recycling and conservation programs. In addition to environmental consideration, the developers want to contribute to the country's economic sustainability by utilizing local labour and skilled trades for construction, locally sourced construction materials and products, and locally designed and built furniture and interior finishes. Once the development enters in operations these practices should continue by employing local workers, local products and services vendors, artisans, and local food and beverage producers already involved in the cruise tourism industry.

This section of the EIA aims at reviewing and presenting relevant environmental resource and planning legislations to ensure that this project is in full compliance at the different phases of the development, and that the necessary requirements are considered into the project design and implementation. Port of Magical Belize recognizes the importance of abiding by Belize's environmental laws, regulations, guidelines and standards and has secured the guidance the EIA preparers from the onset. Information on the environmental laws, regulations, guidelines and standards were obtained by consulting the DOE website at www.doe.gov.bz.

It is also important to note that this legal and regulatory framework is influenced by various multilateral environmental agreements (MEAs) Belize has signed on to, and includes national legislations and regulations that address issues of environmental management including pollution control and prevention, natural resource management, biodiversity conservation, protected areas management, preservation of historic and cultural resources, chemicals management and integrated water resources management.

In implementing its proposed project, the developer ensures adherence to Belize's environmental laws and permitting requirements. Below is an overview of Belize's environmental legal and regulatory framework, which highlights those legislations, regulations and institutions governing the activities associated with the proposed development.

Table 3-1: Legislation, their Description, and Applicability to the Proposed Project.

Legislation	Description	Applicability
ENVIRONMENTAL AND HEALTH RELATED LAWS		
Environmental Protection Act No 22 of 1992; Chapter 328 Revised Edition, 2000 (EPA) *http://www.belizelaw.org/lawadmin/PDF%20files/cap328.pdf*	Under section 3 (3), the Department of Environment (DOE) has the responsibility to monitor the implementation of the Act and Regulations, and to take necessary actions to enforce the provisions of the Act and its Regulations. This enabling legislation provides the Government and the Department with the comprehensive environmental protection authority it needs in order to address modern environmental management issues. The Act also grants the Department of Environment broad regulatory and enforcement authority for the prevention and control of environmental pollution, conservation and management of natural resources, and regulating Environmental and Social Impact Assessments (EIAs). The EPA entrusted the DOE with a broad range of functions relating to the protection of the environment including the assessment of water pollution, the coordination of activities relating to the discharger of wastes, licensing of activities that may cause water pollution, the registration of sources of pollution and the carrying out of research and investigations as to the causes, nature and extent of water pollution and the necessary prevention and control measures. A number of regulations including the Environmental and Social Impact Assessment Regulations (SI 107 of 1995), Pollution Regulations (SI 56 of 1996), the Environmental Protection (Effluent Limitation) Regulations (SI 94 of 1995), and the Hazardous Regulations are under the responsibility of the DOE and are being enforced. Under the Act, no person, installation, factory or plant shall, unless specifically permitted by the Department, emit, deposit or discharge or cause emission of any pollutant or contaminant into the atmosphere or environment in contravention of the permitted	All development in Belize requires environmental clearance from the DOE. Port of Magical Belize proposes the development of a cruise port and therefore had to apply for clearance as per the EIA Regulation under the EPA No. 22 of 19

Legislation	Description	Applicability
	levels: "Every person, installation, factory or plant emitting air pollutants is required to maintain and submit to the Department, records of the type, composition and quantity of pollutants emitted." Furthermore any person or undertaking exploiting the land, water resources, seas or other natural resources shall ensure the protection of the environment against unnecessary damage or from pollution by harmful substances; and no person shall emit, import, discharge, deposit, dispose of or dump any waste that might directly or indirectly pollute water resources or damage or destroy marine life.	This applies to ballast waters of cruise ships. It is totally prohibited to discharge these or any grey waters form sewage or kitchen into Belize's waters.
Environmental and Social Impact Assessment (Amendment Regulations, 2007) *http://www.doe.gov.bz/documents/legislation/Environmental%20Impact%20Assessment%20%28Amendment%29%20Regulations,%202007.pdf*	The EIA Regulations details the process one must follow in the application, preparation and evaluation of the Environmental and Social Impact Assessment. Screening is the first step of the process wherein programs/projects/activities with the potential to significantly impact the environment are required to do an EIA if they fall under Schedule 1. This is one of three categories under which projects may be classified under the screening process. The EIA Regulations also requires drafting of a TOR that outlines the level of focus of the EIA Report, it establishes minimum content and format for the EIA Report, establishes the National Environmental Appraisal Committee (NEAC) and identifies when public hearings/consultation are required. Consultation with the public and other interested bodies or organizations are required under section 18 (1) while section 26 require that projects, programmes or activities be assessed with the view to protect and improve human health and living conditions and to ensure reproductive capacity of ecosystems and secure diversity of species. Amendments to the EIA Regulations in 2007 instituted the	The EIA regulations outline the environmental clearance process from screening, scoping, pubic consultation, public hearing, report format, composition of NEAC, considerations for revision of EIA, possible outcomes, ECP etc.. Since the scope of the proposed project requires an EIA, the EIA regulations guides the process for this project.

Legislation	Description	Applicability
	Environmental Compliance Plan (ECP) for approved projects, a **Limited Level Environmental Study (LLES),** reconstituted the NEAC Membership, outlined the Appeal Process (established a tribunal), established an environmental application fee for projects and improved the Schedules for screening of projects in different categories.	
The Environmental Protection (Effluent Limitations) Regulations, (SI 94 of 1995) AND The Environmental Protection (Effluent Limitations) (Amendment) Regulations (S.I. 102 of 2009) *http://www.doe.gov.bz/documents/legislation/Effluent%20Limitations%20Amendment%20Regulations%202009.pdf*	The Effluent Regulations of 1996 was enacted to control and monitor discharge of effluents, into any inland waters or the marine environment of Belize, from industrial activities. Importantly, this regulation prohibits the discharge of effluents from new and altered point sources and establishes a licensing system for discharging effluents under specific conditions. The main objective of this licensing system is to ensure that industries improve their treatment of effluents before discharging into the environment. It also established the requirements for the treatment of effluents and set standards for physical and chemical parameters to be monitored for various industries. The Environmental Protection (Effluent Limitations) (Amendment) Regulations (S.I. 102 of 2009) were amended to primarily include provisions for the treatment of domestic wastewater and the categorization of Class I and II Waters that differentiate waters with unique ecological characteristics that are sensitive to impacts of domestic wastewater from those that are less sensitive to the impact of domestic effluent. The said amendment also allowed for greater consistency with the Cartagena Convention and the Aruba Protocol on land based sources of marine pollution.	The proposed development includes physical infrastructure such as restrooms, giftshops, restaurants, cabanas etc. which will produce effluents. An effluent license would be required and proper technology would be used to meet effluent standards.
The Environmental Protection (Pollution Regulations) (SI 65 of 1996)	These Regulations address issues of air, water and soil pollution, including noise pollution. Part III – 6 (1) deals generally with the emission of contaminants into the air where the proposed	This applies to any form of pollution from waste generated from dredging, land reclamation, road construction, landscaping etc..

Legislation	Description	Applicability
AND Pollution (Amendment) Regulation SI 60 of 2002 AND Pollution (Amendment) Regulation SI 101 of 2009 *http://www.doe.gov.bz/index.php/services/doc_download/87-pollution-amendment-regulations-2009*	development shall cause, allow or permit contaminants to be emitted or discharged either directly or indirectly into the air from any source. Other prohibitions are: • Regulation 31 provides that the proposed development shall not pollute the land so that the condition of the land is so changed as to be capable of making the land noxious or harmful to animals; • Regulation 32 provides that the proposed development shall not cause any seepage or leaching contamination of the adjacent soil, groundwater or surface water; • Regulation 33 empowers the DOE to issue directions to the proposed development where it is operating a site for the elimination of waste or a solid waste treatment plant and disposal system; and • Regulation 35 prohibits the depositing of waste in a place other than a site approved by DOE for the storage or elimination of waste or operation of a waste treatment plant or waste management system. The 2002 amendments included primarily issues related to the commitments made under the Montreal Protocol on Ozone Depleting Substances (ODS). It prohibits imports of equipment using ODS and establishment of a licensing system for importation of these substances. In 2009, this regulation was further strengthened with a requirement of the Montreal Protocol related to the licensing system for the importation of refrigerants into Belize for data gathering purposes only and complemented the Act in addressing the petroleum industry inclusive of refinery.	Applies to construction waste and other solid waste generated from offices and service areas This applies to cooling systems such as ACs, refrigerators, coolers etc.. and the need to use environmentally friendly freons..
Hazardous Waste Regulations (SI 100 of 2009)	With increasing concerns on trans-boundary movement of hazardous waste, both in-country and abroad, the Hazardous Waste Regulations was developed by the DOE. The Regulations which	This applies to the use of vehicle/bus batteries, regular batteries for gps and other equipment. Also,

Legislation	Description	Applicability
http://www.doe.gov.bz/index.php/services/doc_download/80-hazardous-waste-regulations-2009	was passed in August of 2009 addresses the overall management of hazardous wastes including the importation, storage, transportation, treatment and prohibition of these and a list is provided in the Regulations. Any hazardous waste such as waste oil (from motors and machinery), spent batteries, containers of antifouling agents and expired antibiotics and their containers will need to be properly stored in accordance with these requirements and taken to the mainland for final disposal in the mile 22 sanitary landfill site's specially designated cell for disposal of hazardous waste.	any acids, coolants etc.. used for servicing of equipment.
The Forest Act; Chapter 213, Revised Edition, 2000 and Forests (Mangrove Protection) Regulations, SI No. 52 of 1989 http://faolex.fao.org/docs/pdf/blz2737.pdf Forests (Protection of Mangroves) Regulations, 2018	Provide for the protection and conservation of all mangrove forests on both private and national lands, any alterations to which require evaluation and a permit by the Forestry Department; The newly passed mangrove regulations increases the fees for mangrove permits and updates the license permitting system to improve on the management and protection of mangrove. For example, all applications for mangrove permit require a site inspection as part of the process.	This applies to the need for cutting of mangroves and littoral forests found within the inland area intended for the project development.
Wildlife Protection Act; Chapter 220, Revised Edition 2000; Chapter 220s, Revised Edition 2003. http://www.belizelaw.org/lawadmin/PDF%20files/cap220.pdf	Seeks to control hunting, research, and trade in wildlife, protecting species from hunting, killing, and harassment, including two species of crocodiles, the manatee, all birds with the exception of six species, whales, dolphins, and the Caribbean monk seal; and prohibits the hunting of endangered species such as cetaceans, freshwater turtles and crocodiles. The ecological assessment does record sightings of manatees, crocodiles among other species of interest.	This applies to species of conservation concern documented in the project area during the EIA development.

Legislation	Description	Applicability
Fisheries Act (SI210 of 2000) http://www.belizelaw.org/web/lawadmin/index2.html	Under 6(1) of the Act, no person shall use or employ any boat in commercial fishing unless there is in force in respect of such boat a "license to fish" issued under the provisions of any regulations made under this Act. (7) No person shall engage in commercial fishing or be engaged or employed in or on any boat while in use for commercial fishing unless he is the holder of a valid "fisherman's license" issued under the regulations made under this Act (2 of 1972). (8) No person shall conduct or be engaged or employed in any scientific or research operations in any water or waters to which this Act applies which involve the taking, killing or capturing of any fish, or any interference or disturbances of fish, or with the seabed, unless there is in force in respect of such operations a license granted under the regulations made under this Act (2 of 1972). 9.-(1) No person shall export, attempt to export or purchase with a view to export any fish unless he is the holder of a valid fish exporter's license issued under the regulations made under this Act (2 of 1972,1 of 1983 &19 of 1989). Penalties for breach of the regulations are also included in the Act. The Fisheries Amendment Regulation also provides complete protection for the marine turtles of Belize. This i s aimed at bringing Belize in line with the Inter-American Convention for the Protection and Conservation of Marine Turtles (IAC), which Belize ratified in February 2003, these Regulations prohibit: • fishing in the waters of Belize or the purchase, sale or possession any marine turtle;	This applies to the development as there have been cases where employees of developments engage in commercial fisheries. Any research or monitoring of marine ecological quality needs to receive proper permitting.

Legislation	Description	Applicability
	• the take of any turtle found on land; the disturbance, take, purchase, sale or possession of any turtle or turtle eggs; and the interference with any turtle nest, except under written permission by the Fisheries Administrator; and • The import into, transit through or export from Belize of any turtle or turtle products. While there are no marine protected areas in the immediate vicinity of the proposed project, all employees should adhere to the Fisheries Act and its Regulations during construction of the facilities and during operations of the project. Moreover, any activities related to recreational/sports fishing derived from this Port must be familiar with local fishing and tourism activities.	
The Coastal Zone Management Act; Chapter 329, Revised Edition 2000 *http://www.belizelaw.org/web/lawadmin/index2.html*	Established the Coastal Zone Management Authority and Institute which conducts scientific research used to provide technical advice, recommendation of zoning schemes and the provision of guidelines for coastal development within Belize. This agency, while not regulatory in nature, is important in its monitoring activities of the marine waters.	This applies as the CZMAI conducts research and coastal development within the coastal zone. Issues of concern for CZMAI would be manatee killings from boat accidents, research on water quality etc.
Solid Waste Management Authority Act; Chapter 224, Revised Edition 2000; Chapter 224s, Revised Edition 2003. *http://www.belizelaw.org/lawadmin/PDF%20files/cap224.pdf* *http://www.belizelaw.org/lawadmin/PDF%20files/cap22*	This Act establishes the Solid Waste Management Authority (SWaMA) who is charged with the responsibility to deal with all matters pertaining to and conducive to the management of solid waste management. The Authority shall devise ways and means for the efficient collection and disposal of solid waste employing methods and techniques and exploring the possibility of recycling waste material. The Act, defines solid waste and gives responsibility to the SWaMA for the designation of "service areas", (with the approval of local authorities), to arrange for the collection and disposal of solid waste within a service area, (through contractual services or	To the extent the proposed development generates solid waste, this legislation would be directly relevant.

Legislation	Description	Applicability
4s.pdf	otherwise), and to enact and implement policy and guidelines conducive to adequate solid waste management throughout the Country. Under the Act "construction waste material" includes building materials from construction, alteration & remodeling building or any structure, such as lumber, concrete, steel roofing, etc.	
Mines and Minerals Act, Chapter 226, Revised Edition 2000; Chapter 226s, Revised Edition 2003. http://www.belizelaw.org/lawadmin/PDF%20files/cap226.pdf http://www.belizelaw.org/lawadmin/PDF%20files/cap226s.pdf	Addresses the extraction of all non-renewable resources except petroleum. The Government owns all minerals under public and private lands, and, minerals are reserved from all future grants of state lands. The Mines and Minerals (General) Regulations provide a general framework for the implementation of the Mines and Minerals Act. These Regulations cover a range of topics such as application, duties, terms and conditions and failure to comply with the conditions of a mining license. Under the Act "land" includes land beneath water, dredging and sand mining, which is essential in avoiding destruction to coastal habitats such as seagrass beds and the coral reef and requires that any application of a mining license (includes dredging) should be accompanied by a proposal for the prevention of pollution, the treatment of wastes, the safeguarding of natural resources and the minimization of the effects of mining on surface and underground water. The Act provides for licenses and royalties for the taking of minerals, and prohibits the pollution of any river, stream, or watercourse. A quarry permit allows for the extraction of volumes up to 16,000 cubic yards. A mining license will be required by the development since the volume to be extracted is greater than 16,000 cubic yards.	This applies to the project as maritime dredging works will be required for as part of the project works.
National Integrated Water Resources Act, 2010. http://www.hydromet.gov.bz/	Section 16 of the Act establishes the requirement for a license for the abstraction of water resources. An application for a License to abstract water must be submitted to the National Integrated Water	A project of this magnitude should not discredit the possibility of a well for water abstraction in the future.

Legislation	Description	Applicability
downloads/National_Integrated_Water_Resources_Act.pdf *http://www.doe.gov.bz/documents/services/Water_Industries_Info.pdf*	Resource Authority (NIWRA) for approval.	
Pesticides Control Act, Chapter 216, Revised Editions, 2003. *http://www.belizelaw.org/lawadmin/PDF%20files/cap216s.pdf*	This Act establishes the Pesticides Control Board (PCB) that addressed the placement of pesticides on the local market. The PCB issues licenses for the import of pesticides and provides certification for users of pesticides. The Act provides a list of restricted pesticides. This is important in the tourism industry as landscaping requires extended use of fertilizers and pesticides.	This is applicable for the project as landscaping can require herbicides, insecticides etc. to control pests.
Public Health Act (Chapter 40) Revised Edition 2000; Chapter 40s, Revised Edition 2003. *http://www.belizelaw.org/lawadmin//PDF%20files/cap040.pdf* *http://www.belizelaw.org/lawadmin/PDF%20files/cap040s.pdf*	This legislation addresses liquid and solid waste disposal and issues relating to general public health. The Ministry of Health is given a mandate for addressing public health issues and related complaints, monitoring of sewage and solid waste, and prosecution of public health offenders. In addition, all persons handling food for public consumption are required to have a food handler's certificate. The act also grants the Ministry of health responsibility for general public health issues which have incidence on the control, and prevention of pollution, including those pertaining to "Drains and Water Supply, Infectious Diseases, Mosquito Destruction, Offensive Trades and Sanitation and Prevention of Nuisances from Factories and Miscellaneous Trades. The revised Act authorizes the Ministry of Health, to issue regulations to prevent, control, or reduce contamination of the air, soil or water, and prohibits improper disposal of medical or infections wastes. The Act sets minimum standard of sanitary facilities for workers. Public Health Officers have the power to	Applies for restaurants being proposed as part of the project.

Legislation	Description	Applicability
	inspect water supply and sewage works. Furthermore, the act empowers the Minister to make regulations with respect to the safety of buildings being constructed or renovated with the objective of ensuring the health and safety of its occupants.	
The National Lands Act; Chapter 191, Revised Edition 2000; Chapter 191s, Revised Edition 2003. *http://www.belizelaw.org/lawadmin/PDF%20files/cap191.pdf*	According to the act, national lands mean "all lands and sea bed, other than reserved forest within the meaning of the Forests Act, including cayes and parts thereof not already located or granted, and includes any land which has been, or may hereafter become, escheated to or otherwise acquired by the Government of Belize." Hence, any person desirous of building or construction a pier, berthing facility of marina is required to obtain a permit from the Lands and Survey Department for the lease and construction of such erections over any water body (national lands). According to Section 29 of the National Lands Act there is the requirement of sixty-six feet reserve measured from high water mark along all water frontages which shall be reserved for Government or public purposes. Furthermore, Section 4 states "Access shall be provided from all surveyed lands to any public road, navigable river, creek, lake, or sea shore contiguous thereto." In Section 28 the National Lands Act states that in any "grant, lease or other document where the sea, or any sound, bay, or creek or any part thereof, affected by the ebb or flow of the tide, is described as forming the whole or part of the boundary of the land to be disposed of, such boundary or part thereof shall be deemed and taken to be the line of high water mark at ordinary tides". These sections of the National Lands Act are important to consider when planning and obtaining permit for the development and construction of any pier, road and overwater facilities.	Applies to over the water structures and the need to secure a permit from Lands department to use lands leading out of the coast.

Legislation	Description	Applicability
Crown Land Rules SI 60 of 1939	Under Crown Land Rules (Statutory Rules and Orders 66 of 1939), a 66 ft wide strip of land along all water frontages, measured from high water mark, is designated as public easement, but lands titles prior to 1930 included the land to the high water mark and in some cases, below the high water mark.	This applies to any land along permanent water ways which remains in public domain.
Land Tax Act, Chapter 58, 2000. *http://faolex.fao.org/docs/pdf/blz26335.pdf*	The Land and Surveys Department is responsible for the administration of the Land Tax Act, mainly through its valuation and taxation functions. The unimproved values determined by valuation prior to 2004 form the basis for the land taxes levied previously whereas the declared unimproved values, acreage and land type are considered for the levying of taxes as of 2004 (MNREI, 2004).	Yearly land taxes will be paid for both the existing ~ 250 acres (100 hectares) and the reclaimed land once applied for.
Ancient Monuments and Antiquities Act, SI 330/2000	Under section (4) of the Ancient Monuments and Antiquities Act, "all ancient monuments and antiquities however situate, whether upon any land or in any river, stream or watercourse, or under territorial waters of the country and whether or not before the date of the commencement of this Act in private ownership, possession, custody or control, shall absolutely vest in the Government." Under section (12), if any person finds any ancient monument or antiquity, he shall within 14 days of such finding report the details of the finding to the Minister.	Applies only in the event any antiquities or suspected Maya monuments are withing the property. Considering the topography this should not be ruled out.
HOUSING AND UTILITIES RELATED LAWS		
Housing and Town Planning Act (SI 182 of 2000)	Part II of the Act gives general powers of the Central Authority. Under the Completion of Schemes and Consequential Powers and Duties of the Central Authority 31 (2) the Central Authority may, in connection with any scheme, authorize the laying out and construction of roads	This applies to the road being proposed as part of the project.

Legislation	Description	Applicability
	and services upon the land acquired by it, and all roads and services as laid out and constructed, if situated within the jurisdiction of a local authority, shall thenceforth be public roads and services maintained by the local authority.	
Belize Building Act (No. 7 of 2003), Belize Building (Amendment) Act, No. 2 of 2005. *http://www.cbabelize.org/wp-content/uploads/2014/04/Belize- Building-Act-2003.pdf*	This Act established the Central Building Authority (CBA) with responsibility for approving and monitoring the construction and alteration of buildings to ensure that they meet standards for construction, electrical etc.	Applies to all building being proposed and requiring approval from CBA since it is outside city limits.
Water and Sewage Act, Chapter 222, Revised Edition, 2000 *http://www.belizelaw.org/web/lawadmin/index2.html*	This Act deals with controlling disposal of wastes generated from sewer treatment. The Act makes new provisions with respect to the supply and control of water and sewerage services in Belize. It also establishes the responsibility of private entities to provide facilities for the final disposal of sewerage taking into consideration 36 of the Environmental Protection Act 1 of 2001.	Applies to the proposed sewage system for the proposed project.
The Hotel and Tourist Accommodation Act, Chap. 285, R.E. 2003 *http://www.belizelaw.org/web/lawadmin/index2.html*	This Act empowers the Belize Tourism Board to receive applications for registration in respect of any premises used or proposed to be used for the business of a hotel or tourist accommodation, grant licenses to deserving applicants, and sets the minimum standards to be observed by hotel and tourist accommodations. Subject to the provisions of the Act, Part IV (22(1) states that "there shall be levied and paid a tax at the rate of seven per centum of all the accommodation charges in regard to lodging."	This legislation applies to the project as it relates to the tourism at the port and to accommodations situated therein (hotel and over the water cabanas)

Legislation	Description	Applicability
	Part V (General) sets out Offences and penalties as well as regulations prescribing standards for hotels and tourist accommodation. The Hotels Act and the Housing and Town Planning Act complement each other, since they both address tourism and residential developments in coastal areas.	
The Dangerous Goods Act, Chap. 134, R.E. 2003	This Act regulates the import, production, transportation, storage and distribution of dangerous goods (explosives and petroleum products) including the transportation and safe keeping of explosives and other dangerous goods, liquefied petroleum gases and gunpowder, dynamite, nitro-glycerine, gun cotton, blasting powders, fulminate of mercury or of other metals, coloured fires and every other similar substance.	This legislation applies to the project as it relates to the marina and refuel facilities (fuel). Additionally, it applies to ammunition that might be kept for security reason or dynamite for any mining of aggregate supplies.
OTHERS		
The Belize Port Authority Act, Chaps. 233 and 233S, R.E. 2000 and 2003 *http://www.belizelaw.org/web/lawadmin/index2.html*	At the heart of this development is the construction of a port which falls under Part III Sec. 23 (1).The Minister may, after consultation with the Authority, grant in writing a license to any person, corporation or other body to construct and operate a private port subject to such terms, conditions and restrictions and on the payment of such fees as the Minister may consider appropriate (Private ports 15 of1989). Under part III 19(3) -and in particular and without prejudice to the generality of the provisions of subsections (1) and (2), it is the duty of the Authority- *(a)* to operate the ports as appears to it best calculated to serve the public interest; *(b)* to regulate and control navigation within the limits of ports and their approaches; *(c)* to maintain, improve and regulate the use of such ports and services	This legislation is directly relevant to the port and its operations as it allows construction and operation of private ports. The Belize Port Authority licences boats and captains, enforces navigational safety etc…

Legislation	Description	Applicability
	and facilities therein as it considers necessary or desirable; *(d)* to provide for such ports and the approaches thereto such pilotage services, beacons, buoys and other navigational services and aids as it considers necessary or desirable; *(e)* to exercise the duties and functions relating to shipping and navigation exercisable under the provisions of any other law. Regulates air and water pollution via discharge from ships such as sanitary sewage, gaseous liquids and solids, carcasses, gasoline, oils, ballasts, butchers offal, garbage, residuum of gas, tar or refuse, trade waste or any other material that is capable of producing floating matter on the surfaces of water, sediment or obstruction on the bottom of the sea or odors of gas of putrefaction; and makes regulations relating to anchorage or obstruction of turning basis and channels, unauthorized movements of ships and lights and mooring or maneuvering in the territorial waters of Belize.	
The Customs and Excise Duties Act; Chapter 48, Revised Edition, 2000 *http://www.belizelaw.org/web/lawadmin/index2.html*	This regulates the importation or exportation of any goods which for the time being is subject to any number of conditions or restrictions and applies to the importation of all groups of metals.	This applies to any imports for the construction and operation equipment during the project construction and operation.
Labour Act, Chapter 297, 2003 and Labour (Amendment) Act, Chapter 297s, 2011. *http://www.belize.org/bcci/labour-law*	This Act regulates the conditions of employing workers, for example the minimum wages, overtime payment, period of notice and severance pay.	This legislation is applicable as local labour is expected to be employed and therefore compliance of local labour laws will have to be adhered to (e.g Minimum wages, overtime, termination, social security, vacation, etc.).
Social Security Act, Chapter	Every person who becomes an employer shall, within seven days	All persons employed by the project are expected to

Legislation	Description	Applicability
44s, Revised Edition 2003. *http://www.belizelaw.org/lawadmin/PDF%20files/cap044s.pdf*	of employing his first employee, present to the Manager (appointed pursuant to section 35), on the appropriate form an application for registration as an employer. Only workers with a valid social security card are to be employed. The employer must make monthly contributions to the Social Security Board on behalf of the employee.	contribute to the national social security scheme for Belize.
Protected Areas Conservation Trust Act (PACT); Chapter 218 of 2000	The Protected Areas Conservation Trust Act (PACT) establishes a fund for the financing of all protected areas, including marine reserves and all other protected areas on the coast.	Legislation applicable as all tourists visiting Belize must pay a conservation fee of $3.75US per person.
Belize Tourism Board Act; Chapter 275	The Belize Tourist Board Act indirectly encompasses most of the other Acts, since it contains provisions for the development of tourism policies, which would need to consider the effects and roles of all sectors in the development of tourism.	BTB has as its legal mandate to "develop all aspects of the tourist industry of Belize and to promote the efficiency of the industry" inclusive of cruise tourism.

3.3 Administrative Framework

In the process of development, it is indispensable that investors inform themselves on the relevant legislation and agencies that are responsible to enforce these. Below is a list of the most relevant agencies relevant to this development and their respective responsibilities (**Table 3-2**).

Table 3-2: List of Agencies in Belize Responsible to Enforce Laws and Regulations that are in place to safeguard and ensure Sustainable use of Belize's Natural Resources.

AGENCY	RESPONSIBILITY
Ministry of Agriculture, Forestry, Fisheries, Environment & Sustainable Development	This Ministry encompasses four important government departments with responsibility of primary environmental legislation. These four departments include the Department of the Environment (DOE), Forest Department (FD), Agriculture Department (AD) and the Fisheries Department (FiD). This Ministry also has oversight of the Protected Areas Conservation Trust (PACT), the Coastal Zone Management Authority and Institute (CZMAI) as well as the Office of Sustainable Development in the Minister's Office.
Department of the Environment	The Department of Environment was established through the Environmental Protection Act. The Department has wide responsibility over the environment including guiding development in all sectors, encourage adoption of best available and environmentally friendly technology, control and prevent pollution, implementation of the EIA process, surveillance of Environmental Compliance Plan fulfilment, and the sustainable utilization of Belize's Natural Resources.
Forest Department	The Forest Department is the primary agency that deals with Belize's Forest Resources. It has responsibility for the implementation of the Forest Act, 1960, the National Parks Systems Act, 1981, the Wildlife Protection Act, 1981 and the Forest Fires Protection Act. Important to note is that the FD also administers the enforcement and implementation of wildlife protection functions mandated under the Wildlife Protection Act, 1981.
Pesticides Control Board (PCB)	Is a statutory body under the Ministry of Agriculture, mandated with the regulation of pesticides in the country of Belize. PCB is responsible for registering of pesticides, licensing of pesticides imports & manufacture, provide authorization for sale of restricted pesticides, registration of premises for sale of restricted pesticides, provide authorization for use of restricted pesticides, classify pesticides, and; all other aspects of pesticide manufacture, importation, packaging, preparation for sale, disposal and use.
Ministry of Natural Resources	This newly formed Ministry (previously Ministry of Natural Resources and Agriculture) is responsible for the Land and Survey Department which administers lands in Belize and the Mining Unit among others.
Department of Mines and Minerals	Regulates licenses and permits for mining and extraction of soils and minerals, among other responsibilities. A mining permit is required for the execution of the dredging works and may be required to abstract material during construction of the retention ponds.

3.4 Environmental and Social Impact Assessment Process

In Belize, the Environmental Protection Act no 22 of 1992 is the primary environmental legislation that has been enacted to safeguard the three major environmental compartments namely air, water and soil. The most important regulation under this act that safeguards these compartments by bridging development with environmental conservation is the Environmental and Social Impact Assessment (EIA) Regulation. This assessment is the most important planning tool for sustainable development and is required for any project or activity that may significantly affect the environment. The EIA Regulations specify projects that are required to carry out an EIA through the establishment of Schedule 1 and Schedule 11 projects. Schedule 1 projects automatically require an EIA based on the nature of the project while Schedule 11 projects may require and EIA or Limited Level Environmental Study (LLES) based on the interpretation of the filled out environmental checklist describing the planned operations. For further clarification below is a list of projects falling under each Schedule that are relevant to the proposed port project:

Schedule I:

(a) A trading port, an inland waterway which permits the passage of vessels or a port for inland waterway traffic capable of handling such vessels.

Schedule II:

i. Land Reclamation - coastal reclamation involving an area of more than 10 acres (4 hectares)
ii. Resort and Recreational Development - construction of coastal resort facilities or hotels
iii. Resort and Recreational Development - ***development of tourist or recreational facilities on small islands***

3.5 Permits and Licenses - Compliance

Various activities included in the construction and operations of Port of Magical Belize will require the granting of permits or licenses for the construction and during the operation phase (**Table 3-3**).

Table 3-3: Permits, Licenses and Responsible Agency

Activity	License/Permit/Instructions Required	Permitting Agency
Pre-construction		
Commence Development	**Environmental Clearance.**	**Dept. of Environment**
Survey and Subdivision	Approval to survey lands created through the project's reclamation of beach and those existing to create hotel and cabanas.	Land utilization Authority

Activity	License/Permit/Instructions Required	Permitting Agency
Dredging/Excavation, and Land Filling	Extraction of Material Permit	Minister of Mining, Geology & Petroleum Units.
Mangrove alteration	Mangrove Alteration Permit	Forestry Dept.
Construction of breakwater facilities and walkways	Purchase or long term lease for use of seabed; permit to address navigational issues	Lands and Survey Dept. / Port Authority
Pier Construction	Permit to construct seawall, pier, marina etc.	Land Utilization Authority
Boat transportation	Boat License/Captain's License	Port Authority
Importation of building/household material, furniture, etc.	Import Permit	Ministry of Finance - Customs and Excise Dept.
Construction of all buildings to be used for tourism, staff quarters and housing of equipment/material	House Permit	Central Building Authority (CBA)
Road and Bridge construction to access site	Permit	Ministry of Works and Transport
Food preparation for workers	Food Handlers Certificate	Public Health Department
Foreign employees	Workers Permit	Labour Department
Operations of gift shops, restaurant, bars, tours, etc…	Trade licenses, liquor license	Belize City Council
Operation/construction of Casino	Gambling License	Ministry of Trade and Investment
Disposal of Hazardous Waste (batteries, waste oil etc)	Permit	Solid Waste Management Authority and DOE
Post-construction		
Water Abstraction	Water extraction license-Well construction and use Water Service Area	Hydrology Department Public Utilities Commission

Activity	License/Permit/Instructions Required	Permitting Agency
Operate Hotel/Cabanas	Hotel License - Establishment and operation of the hotel	Belize Tourism Board
Tour Operation	License to conduct tours, fishing trips, etc.	Belize Tourism Board
Hiring foreign workers	Work Permit	Labour Dept.
Effluent Discharge	Effluent Discharge for grey water and effluent from waste treatment plant	Department of the Environment
Food handling and Safety certificate	Food handlers certificate for persons working in the hotel kitchen or in the restaurant	Public Health Department
Solid waste disposal	Permission needed from the SWaMA for the use of the Regional Sanitary Landfill at Mile 24, George Price Highway.	Solid Waste Management Authority (SWaMA)
Excavation of drainage channels for both facility and road construction and extraction of material for road fill	Quarry Permit	Mining Unit
Import, application and disposal of chemicals	Certificate of Pesticide Users	Pesticides Control Board & Department of the Environment
Storage of fuel	Permit	DOE, Fire Department, Police Department.
Hiring of employees	Social Security	Social Security Board (SSB)
Transportation of guests with buses	Road Permits	Ministry of Works and Transport

3.6 International Conventions (Multilateral Environmental Agreements)

Belize has signed on to various Multilateral Environmental Agreements (MEAs) with other nations in a concerted effort to conserve and sustainably use earth's natural environment. In fulfilling their requirements, some MEAs have directly influenced the development of national environmental legislations and institutions; while others find some expression in existing national environmentally related legislations and institutions. Some MEAs Belize has signed on to which it influences Belize's environmental policies and programmes relating to the construction and operation of Port of Magical Belize, include:

Table 3-4: Multilateral Environmental Agreements and their objectives.

Multilateral Environmental Agreements	Objectives.
Convention on Biological Diversity. Rio de Janeiro 1992. Ratified 1993 (UNCBD)	To conserve biological diversity, to promote the sustainable use of its components, and encourage equitable sharing of benefits arising from the utilization of natural resources.
Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) of 1981	Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild
United Nations Framework Convention on Climate Change (UNFCC). 1992	The ultimate objective of the treaty is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system.
Convention for the Conservation of Biodiversity and Protection of Priority Areas of Central America, 1992	To conserve biological diversity and the biological resources of the Central American region by means of sustainable development.
Inter-American Convention for the Protection and Conservation of Sea Turtles (December 21, 1997)	To promote the protection, conservation and recovery of sea turtle populations and of the habitats on which they depend.
Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region and its three Protocols: Protocol on the Cooperation to fight oil spills in the wider Caribbean; Protocol on Areas and Wildlife; and Protocol on Pollution from Land-based sources and Terrestrial activities in the Wider Caribbean Region. (Cartagena de Indias, Colombia, 1983)	To protect the marine environment of the wider Caribbean region for the benefit and enjoyment of present and future generations.

Multilateral Environmental Agreements	Objectives.
Convention for Nature Protection and Wildlife Preservation in the Western Hemisphere (1940)	To establish in parties' territories national parks, national reserves, nature monuments, and strict wilderness reserves.
UN Convention on the Law of the Sea (LOSC), August 1983	To legally regulate law and order in the world's oceans and seas establishing rules governing all uses of the oceans and their resources.
1992 Protocol to the International Convention on Civil Liability for Oil Pollution Damage (1972) & 1992 Protocol to the Convention Establishing the Fund for Compensation for Oil Pollution (July 1991)	To ensure that adequate compensation is available to persons who suffer oil pollution damage resulting from maritime casualties involving oil-carrying ships.
International Convention for the Prevention of Pollution from Ships and the 1978 Protocol MARPOL (August 25, 1995)	To prevent pollution of the marine environment by ships from operational or accidental causes.
Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (BASEL) (April 21, 1997)	To reduce the movements of hazardous waste between nations, and specifically to prevent the transfer of hazardous waste from developed to less developed countries (LDCs).
London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (year)	To control pollution of the sea by dumping and to encourage regional agreements supplementary to the Convention.

3.7 Environmental Guidelines

3.7.1 Overwater Environmental Guidelines

With a changing tourism sector, Belize has seen an increase in developments requesting approval for the construction of overwater structures such as overwater cabanas, villas, restaurants, bars, spas, etc. mainly proposed in coastal areas such as offshore cayes, riverbanks and lagoons. While most applications are proposed primarily for tourism, there are a few requests from private residential waterfront areas. The DOE and NEAC are cognizant that these types of development are sensitive in nature and should be conducted in a prudent and regulated manner and have therefore developed guidelines intended to assist in determining where, how and what type of structures can be allowed throughout the country.

For several years, the Department of the Environment (DOE) and the National Environmental Appraisal Committee (NEAC) has received numerous applications for the construction and operation of overwater structures, specifically, overwater cabanas, villas, restaurants and bars. These structures have been proposed primarily for tourism purposes and are located in the coastal areas such as the offshore cayes, riverbanks and lagoons. The DOE and NEAC recognize that developments of this nature should be conducted in a prudent and regulated manner and have developed guidelines for "National Environmental Guidelines for Overwater Structures" intended to assist in determining where, how and what type of structures can be allowed throughout the country.

3.7.2 Marina Environmental Guidelines

Similar to the overwater structures, the country has experienced an increased demand for marina services where tender vessels, yachts and other boats could moor and be offered safe harbourage and other supporting services, especially with the growth of the tourism industry. Again, the DOE has developed guidelines for "Marinas and Berthing Facilities" (2009) to regulate these types of activities thereby mitigating the potential adverse environmental impacts. The operational standards established will ensure safe and environmentally sound operations of service stations in Belize. It will ensure the proper location of these facilities, proper design and properly equipped facilities with safety of the public, staff and environment.

3.8 References

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PART B- ENVIRONMENTAL ISSUES PORT OF MAGICAL BELIZE

As specified in the TOR for this EIA (**Annex 1**), Part B of the EIA targets the environmental issues of critical concern associated with the proposed development of the Port of Magical Belize. This section presents the results of studies performed to identify potential impacts of concern associated with the development and operations of the proposed activities.

4 Flora and Fauna

4.1 Terrestrial Component

4.1.1 Field and Desktop Study Methodology

A two-part study was performed to collect data required to determine the type of ecosystems, habitats, fauna and flora within and adjacent to the project site. The first part involved a desktop study in which a range of resources including remote sensing data, past Environmental and Social Impact Assessment reports, and information held by local entities (e.g. BERDS) was consulted to gather information. It also included a site reconnaissance (walkover) to establish basic information on the current site conditions. The second part included field surveys in which field data collection was carried out during several field visits made to the project site during the month of June, July and October of 2019. Detailed data collection methodology is outlined below for both flora and fauna. Also, an active search was employed to locate reptiles (turning over logs, rocks and searching on trees) and opportunistic sightings. Mammals were surveyed using active search for track, burrows, markings and sightings plus individuals confirmed through vocalization. Bird diversity was monitored by employing a combination of belt transects and point counts, plus recording of opportunistic sightings of species of conservation concern. Vegetation/Ecosystem was assessed using available satellite imagery, ecosystems maps and validation through field visits. The path of the transect and sampling points used to collect data are shown in **Figure 4-1**.

4.1.1.1 Methodology: Flora

Two standard vegetation assessment methods, determined based on the site's ecosystems, were used to assess vegetation communities within and in the vicinity of project site. Point-Centered Quarter Method (PCQM, Pool et al. 1977) was used to sample coastal ecosystems (mangroves and associate littoral forest) and Strip/ Belt Transect for broad-leaved forest since this habitat was compose mostly of sparse trees and a tangled understory of grasses and shrubs less than 1.5 m in total height. Field data was collected during two pulses (12-15 June and 28-30 June 2019).

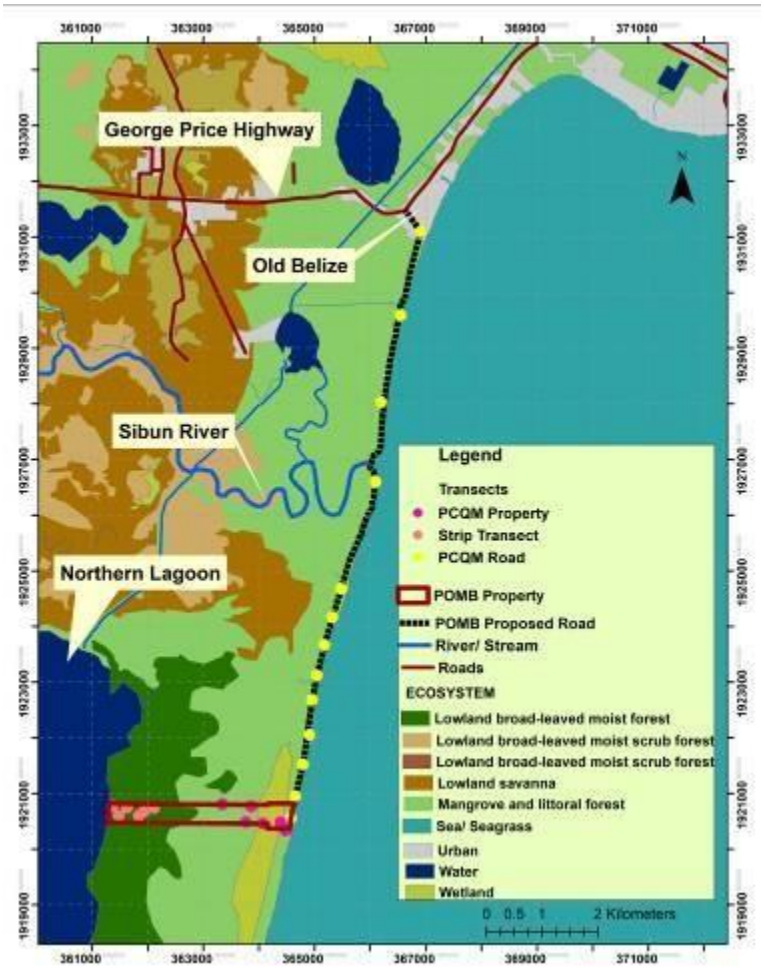

Figure 4-1: Spatial distribution of vegetation sampling sites overlaid on an ecosystems map of Belize.

Coastal vegetation was characterized using thirteen 50m length PCQM (used to asses vegetation along proposed road, starting at the coastline and oriented east to west covering most of the vegetation potentially impacted by the project) and six PCQM of 100m in length (length increased, justified to increase chances of capturing habitat variability) were established within the property boundaries. Centre points were 10m apart to avoid measuring the same tree twice. 50m transect had five centre points, since starting at point zero would have arisen to the issue of the first centre point not having trees in two quarters due to the sea. Hundred-meter PCQM had 11 centre points as the first point started at distance zero. At each centre point, four quadrants were defined by the transect line and a perpendicular line crossing through this point. At each of the four quadrants formed by these intersecting lines, the following measures of the tree closest to the centre point with diameter at breast height (dbh) greater or equal to one cm were recorded: species, distance from the centre point to the tree trunk (m), dbh (cm, standardized at 1.30 m from ground level and for trees with prop roots, dbh was recorded at 10cm above the last prop root, and estimated total height).

Figure 4-2: Setting transect line for a PCQM (left) and measuring dbh of a Red mangrove (right).

Six strip/ Belt Transect of dimensions10 x 100m were surveyed, covering most of the broad-leaved forest within the property. Within each transect all trees with dbh greater or equal to10cm was measured and the following information recorded: species, dbh (cm), and estimated total height (m).

Data Analysis

Raw data was summarized using descriptive statistics and by calculating absolute density and absolute basal area per species, see **Annex 18**. Absolute density and basal area per species from PCQM data was calculated following Cottam et al. (1953) and Cintrón & Schaeffer-Novelli (1984). The absolute density (D) of trees is the number of trees per unit area. Since absolute density is most easily estimated per square meter and since a hectare is 10,000m^2, D is often multiplied by 10,000 to express the number of trees per hectare.

Methodology: Fauna

Terrestrial fauna surveys were focussed on assessment bird assemblages within the project site. However, other fauna taxa were documented via opportunistic sightings while conducting the vegetation assessments. The emphasis on birds was mainly for the fact that taxa responds quickly to changes and disturbances in the natural environment. Bird assemblages were assessed using eight 100m transects on which 6 standard 25m radius point counts each 200m apart were surveyed during early (6:00 a.m. - 8:00 a.m.) and evening (4:00 p.m. - 6:00 p.m.) hours of the day (Ralph et al. 1996). Point counts are the most used survey techniques for determining avian species composition and abundance. Each point count was surveyed for 5 consecutive minutes allowing a 2-minute rest period after arrival, giving time for birds to

normally redistribute within the environment after a disturbance. All birds seen or heard within the 25m radius were documented, excluding for analysis all birds that flew overhead but such events were recorded and noted in results. Because point count observers are sedentary, they may be more likely to detect shy species that would otherwise hide and escape detection. Field data was collected during two pulses (12-15 June and 28-30 June 2019).

4.1.2 General Physical Description of the Terrestrial Flora and Fauna

4.1.1.2 Protected Areas

No protected area is directly bordering the project. The closest site is Peccary Hills National Park located 5km west of the project. Gales Point Wildlife Sanctuary and Manatee Forest Reserve are located approximately 10 km south, while Burdon Canal Nature Reserve is about 9.5km north of the project but less than 1km from the point where proposed road will join the George Price Highway. On the marine side, Swallow Caye Wildlife Sanctuary is located 19km north east of the project site at its closest point.

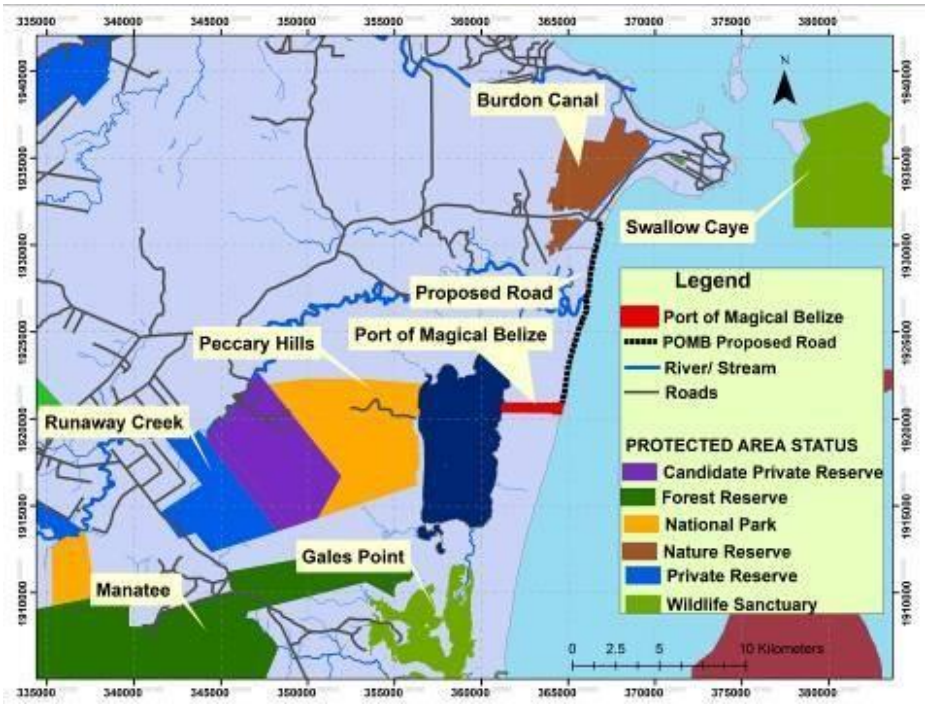

Figure 4-3: Protected areas network around the Port of Magical Belize project site.

4.1.1.3 Terrestrial ecosystems and Flora

The terrestrial component for Port of Magical Belize is relatively small (250 acres or 100 hectares), located between the Caribbean Sea on the east and the Northern Lagoon on the West. The proposed road will extend an estimated 9km north along the coastline connecting to the George Price Highway just south of Old Belize. A spatial analysis of the Ecosystem Map of Belize (Meerman and Sabido 2001) identifies 4 major ecosystems within and around the project site (see **Figure 4-4**). Lowland broad-leave moist forest and Mangrove and associated littoral forest are dominant within the property (**Table 4-1**).

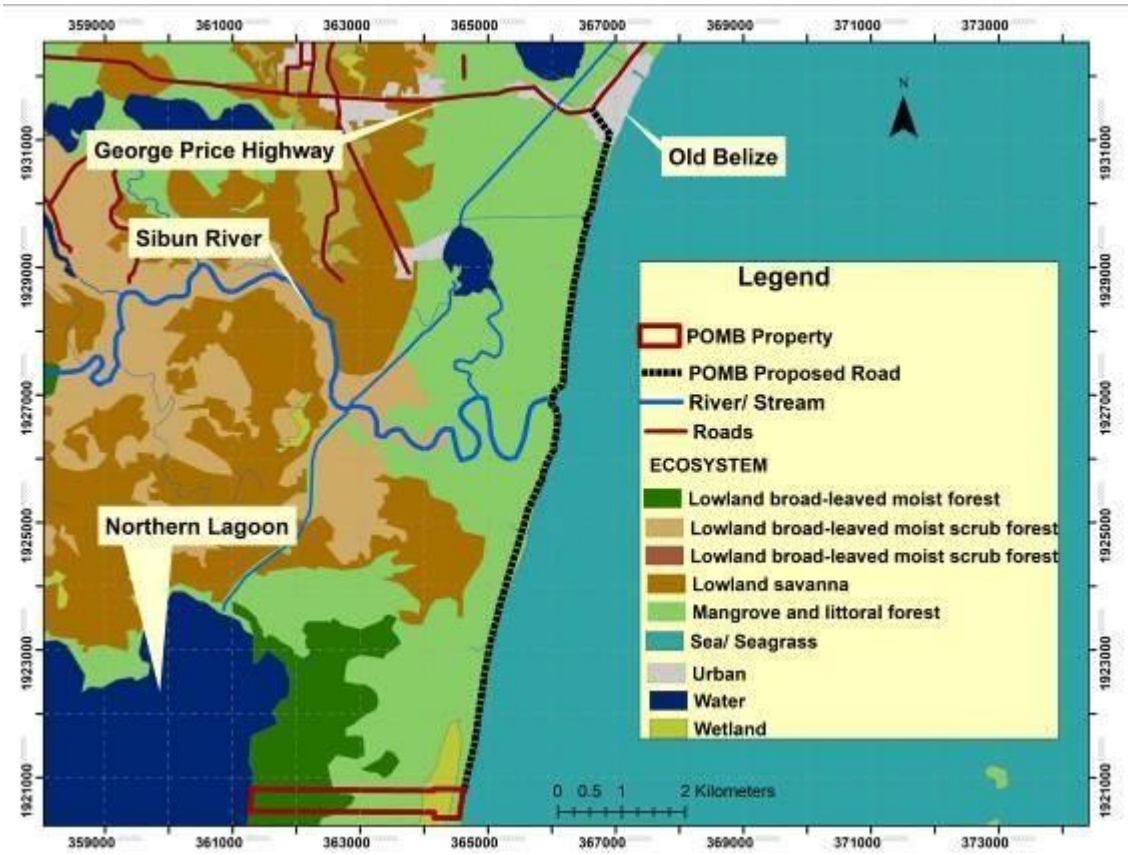

Figure 4-4: Major ecosystems found within and around the Port of Magical Belize project.

Table 4-1: Area covered by major ecosystems within the Port of Magical Belize project boundaries.

Ecosystem	Area (acres / hectares)	% property cover
Lowland broad-leaved moist forest	115 / 47	45.6
Mangrove and littoral forest	104 / 42	41.3
Wetland	33 / 13	13.1

4.1.1.4 Lowland Broad-leaved Moist Forest

The Lowland broad-leave moist forest is located on the west portion of the project site bordering the east coast of the Northern Lagoon. This ecosystem is characterized by occurring at elevations less than 100m on nutrient poor, acidic soils of moderately well drained conditions with average rainfall of less than 2,500mm per year, canopy height of around 12m and fire occurrence is occasional within the habitat. Characteristic plant species as shown in **Figure 4-5** include: *Calophyllum brasiliense* (Santa maria), *Gliricidia sepium* (Madre cacao), *Acosmium panamense* (Billy web), *Miconia spp*., *Terminalia amazonia* (Nargusta), *Vochysia hondurensis* (Yemeri), *Virola koschnyi* (Llora sangre), *Bucida buceras* (Bullet Tree), *Byrsonima crassifolia* (Craboo), *Chrysobalanus icaco* (Coco plum), *Chrysophyllum mexicanum* (Wild caimito), *Metopium brownei* (Black Poison Wood), *Coccoloba sp*., *Psychotria poeppigiana* (Hot lips), *Simarouba glauca* (Gombolimbo), *Scleria bracteata* (Cutting grass), *Pinus caribaea* (Caribbean pine) and *Guettarda combsii* (Glossywood).

Figure 4-5: Vegetative characteristics of lowland broad-leaved moist forest surveyed. Clockwise: dense understory of polewood, low and open canopy, dominance of understory by cutting grass and disperse trees with greater than 10cm diameter at breast height.

4.1.1.5 Mangroves and Littoral Forest

The mangrove and littoral forests located within the property and along road proposed route can be characterized into Mixed, Coastal Fringe and Basin mangrove communities (**Figure 4-6**).

Mixed mangrove community is located away from the coastline, occurs at sea level and is not permanently inundated. All three mangrove species occur: *Avicennia germinans* (Black mangrove), *Laguncularia racemosa* (White mangrove), and *Rhizophora mangle* (Red mangrove). Other frequent species include *Conocarpus erectus* (Bottonwood), *Acoelorraphe wrightii* (Palmetto palms), *Acrostichum aureum* (Coastal swamp fern), *Crescentia cujete* (Calabash), and *Rhabdadenia biflora*.

Figure 4-6: Mixed mangrove forest.

Coastal fringe mangroves develop in conditions of permanent inundation occurring on narrow fringes along beaches and river mouths. It is dominated by Red, Black and white mangrove (**Figure 4-7**).

Figure 4-7: Fringe mangrove community along coast (left) and small pockets along the Northern Lagoon coastline (right).

Basin Mangrove forests occur in mostly waterlogged area, along coastal lagoon and in land-locked coastal depressions (**Figure 4-8**). Species composition and structure is highly variable depending on frequency and depth of inundation, nutrient exchange and water salinity.

Figure 4-8: Basin mangrove community dominated by Red, Black, and White mangroves.

4.1.1.6 Wetland

This ecosystem is better characterized as Tropical lowland tall herbaceous swamp, which is inundated mainly during rainy season, but water level is shallow (**Figure 4-9**). Fires are not a major factor driving plant community composition and structure. It is a graminoid ecosystem and noticeable shrub component with *Bucida buceras* (Bullet tree), *Crescentia cujete* (Calabash), and *Acoelorrhaphe wrightii* (Palmetto palm).

Figure 4-9: Wetlands-Tall herbaceous swamps. Clockwise: Grass dominate community, grass dominated community with palmetto palms, tall herbaceous swamp as patches within lowland broad-leave moist forest, and herbaceous swamp with high soil salinity preventing establishment of grasses.

4.1.2 Results: Flora

4.1.2.1 Mangrove forest and associations

Fourteen tree species were identified, of which Red, White, and Black Mangrove, along with Black Poisonwood were recorded both within the project boundaries and proposed road site. Within the project boundaries, Calabash and white mangroves registered highest mean dbh, while Palmetto palms and *Erythroxylum guatemalense* (Pigeon berry) had smallest mean dbh (**Figure 4-10**). On the proposed road site Gombolimbo, followed Black and White Mangrove had greater mean dbh, while Cacho de vaca and *Thrinax radiata* (Swamp sabal) registered smaller dbh. Coastal vegetation had an overall mean canopy height of 6.25m. Both on the project site and proposed road site, White, Black and Red Mangroves recorded greatest mean heights, while the Pigeon berry and palms were the smallest within the project site and road site respectively (**Figure 4-11**).

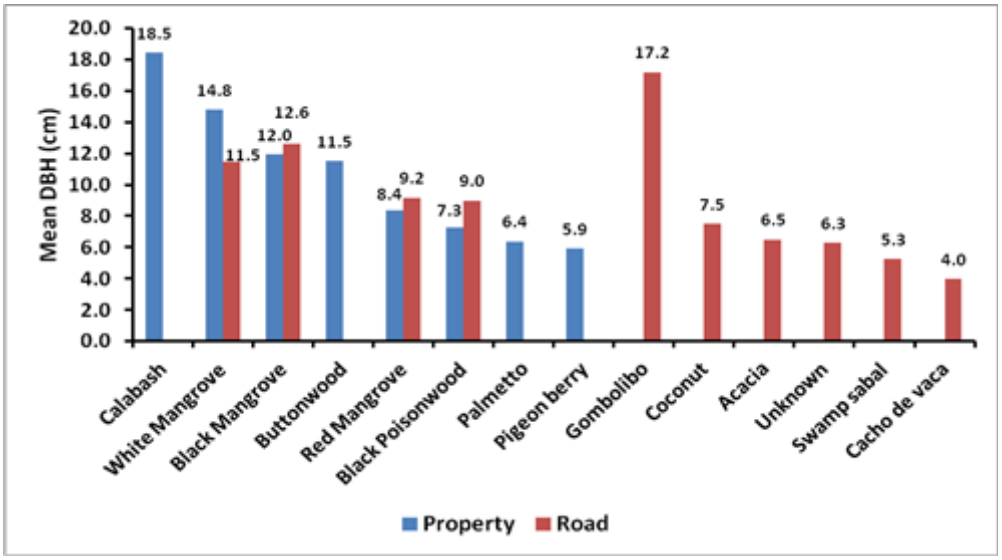

Figure 4-10: Mean diameter at breast height for all trees by species recorded at Port of Magical Belize project site.

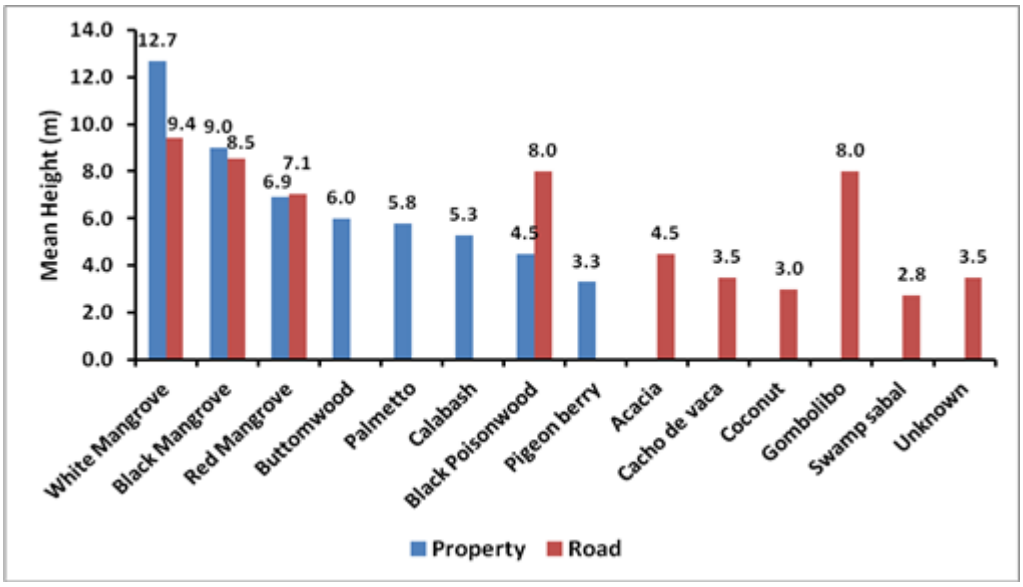

Figure 4-11: Mean height (m) for all trees by species recorded at Port of Magical Belize project site.

Estimates of tree stem densities show that Red Mangrove, Black Mangrove and Buttonwood were most common within the project boundaries, while Black and White Mangrove were common along propose road site (**Figure 4-12**). A similar pattern was observed for tree basal area (Figure 4-13).

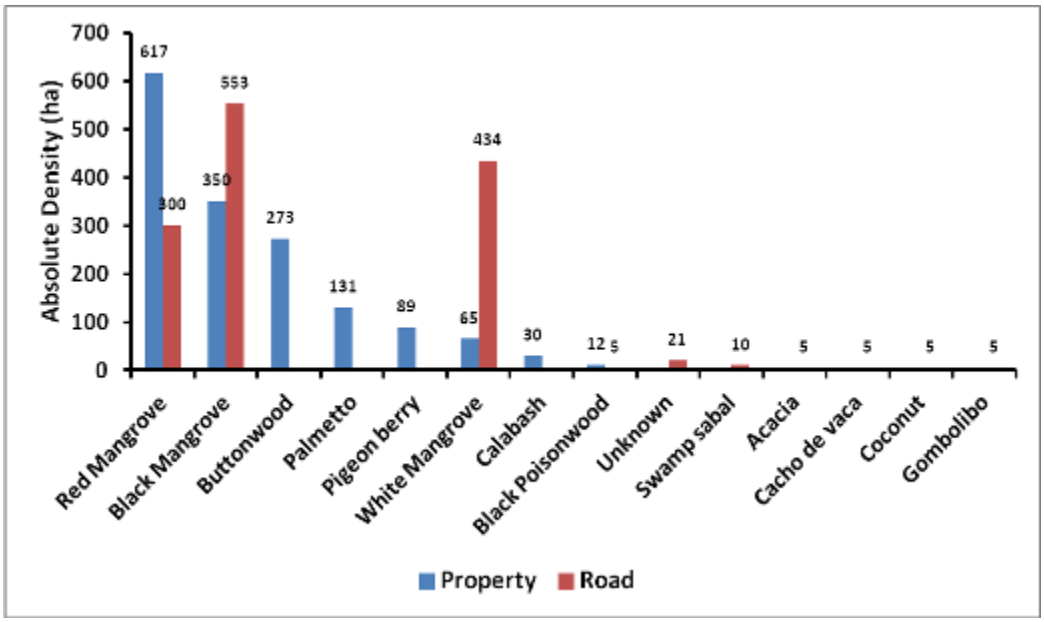

Figure 4-12: Absolute stem density for all trees by species recorded at Port of Magical Belize project site.

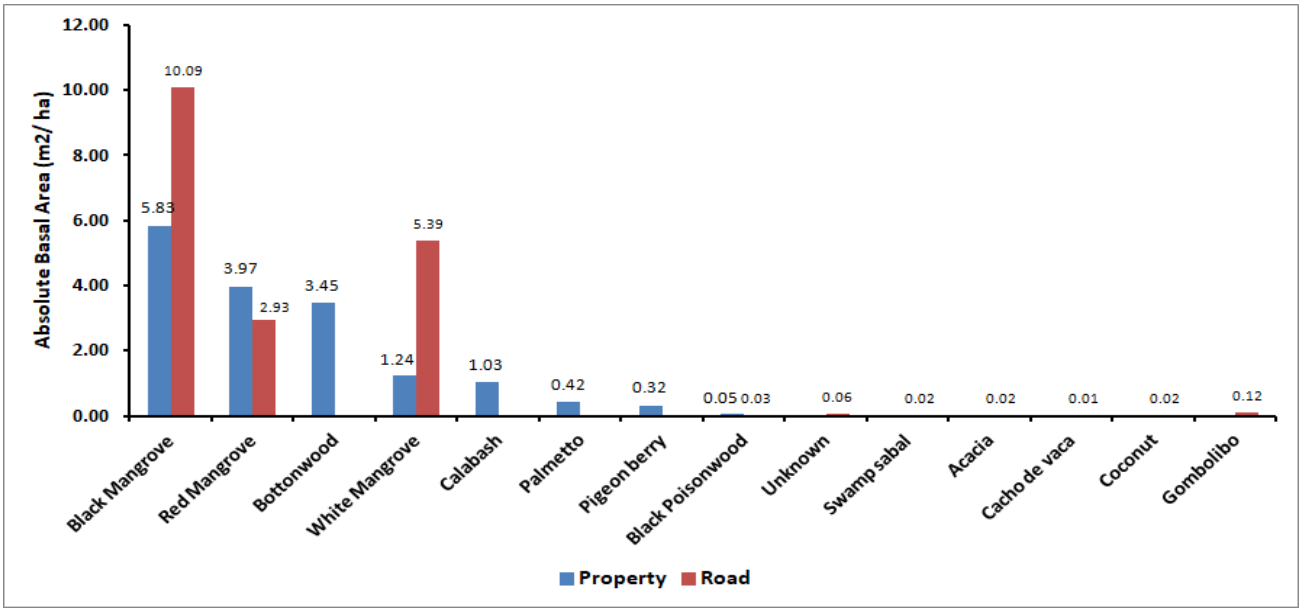

Figure 4-13: Absolute basal area for all trees by species recorded at Port of Magical Belize project site.

Figure 4-14: Dominant tree species recorded on the coastal habitats. Clockwise: Red, Black, and White Mangrove and the mangrove associate Buttonwood.

4.1.2.2 Broad-leaved Forest and associations

Seventeen tree species were recorded within the surveyed transects with 15.0cm mean dbh and the mean canopy height of 7.2m. *Quercus oleoides* (oak), *Manilkara zapota* (sapodilla) and *Vitix gaumeri* (fiddlewood) recorded greatest mean dbh (Figure 4-15). Fiddlewood was the only documented species of interest as it is considered endangered by IUCN. Tallest recorded trees were nargusta, swamp sabal, sapodilla, and Santa Maria, while coco plum and bullet tree were the smallest (**Figure 4-16**).

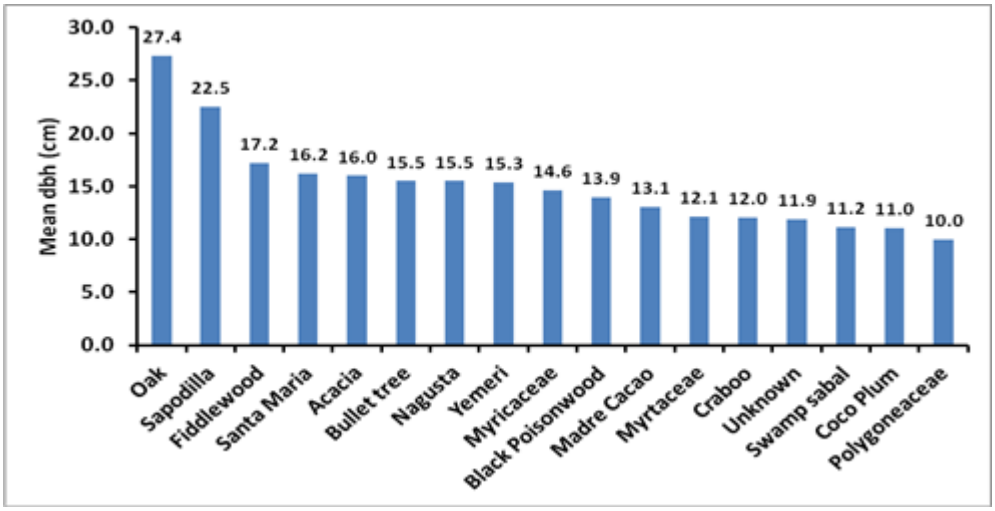

Figure 4-15: Mean dbh (cm) per tree species recorded within the broad-leaved forest at Port of Magical Belize project site.

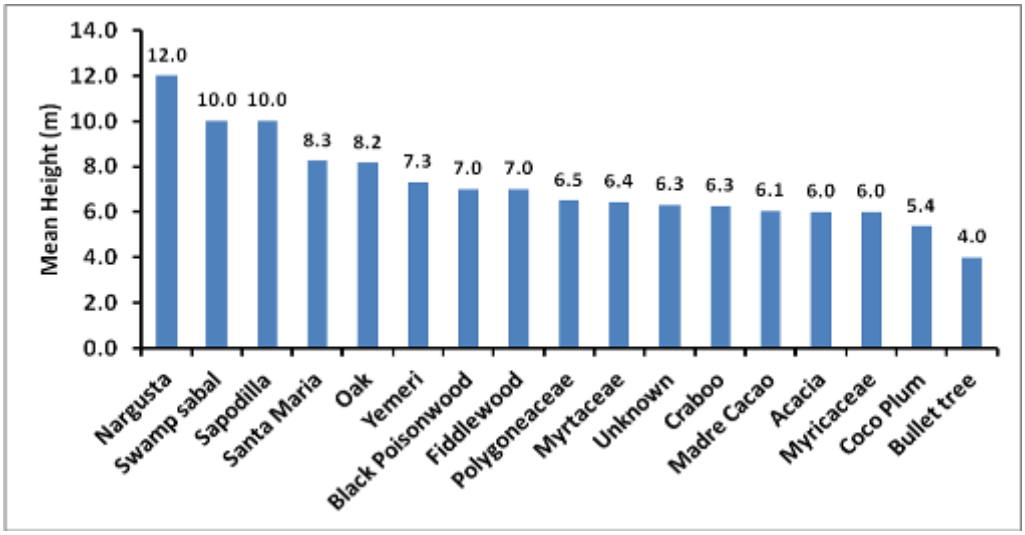

Figure 4-16: Mean height (m) per tree species recorded within the broad-leaved forest at Port of Magical Belize project site.

Oak and yemeri were most common with 98 and 32 individual trees per hectare, respectively while other recorded species were represented by less than 18 individual per hectare (**Figure 4-17**). Tree basal area was dominated by oak occupying 7.30m^2/ha, followed by yemeri (0.64m^2/ha.), while the other species occupied areas of less than 0.3m^2/ha. (**Figure 4-18**).

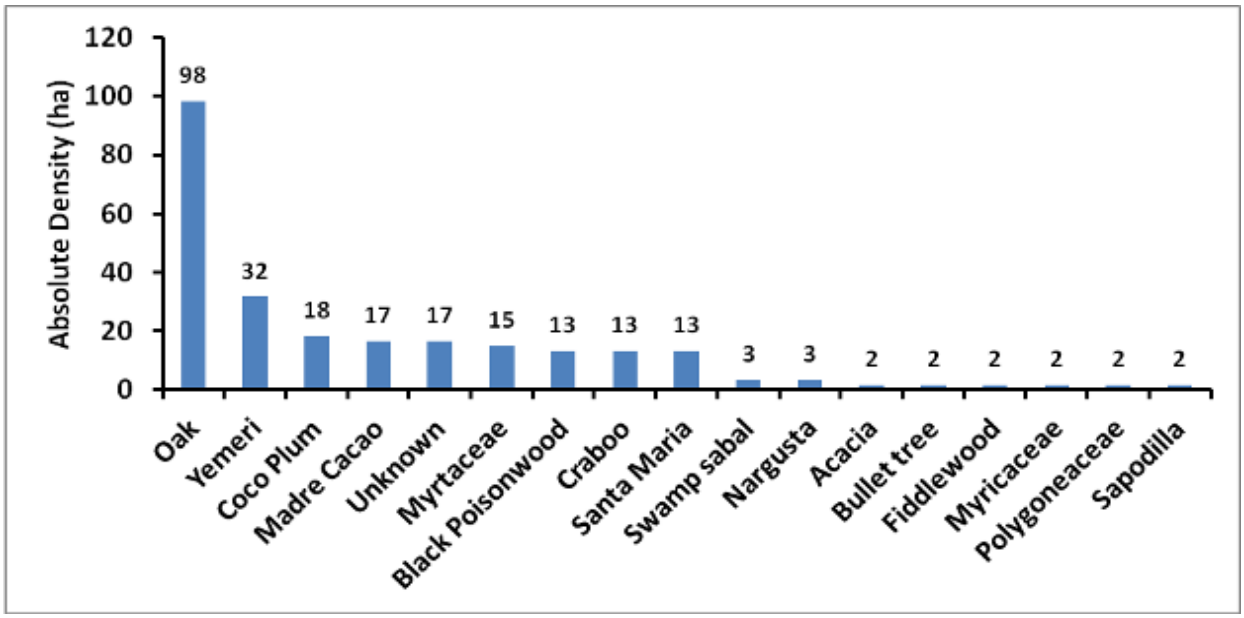

Figure 4-17: Absolute density (stems/ ha) for all trees by species recorded within the broad-leaved forest at Port of Magical Belize project site.

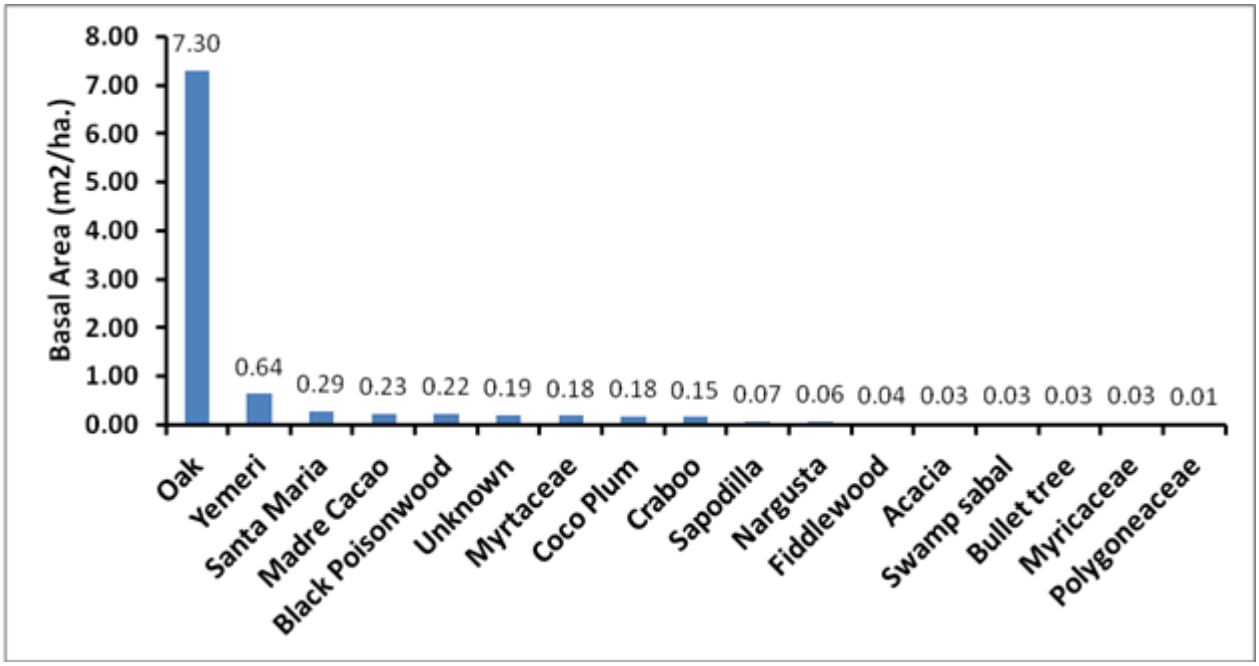

Figure 4-18: Absolute basal area (m2/ ha) for all trees by species recorded within the broad-leaved forest at Port of Magical Belize project site.

4.1.2.3 Discussion

The results clearly support that coastal vegetation with Port of Magical Belize site and proposed road is mangrove and associates dominated vegetation. The three known mangrove species and buttonwood were most abundant and occupied greatest area than all other tree species. Observed mangrove community was variable in terms of composition and structure. Characteristics dependent on soil nutrient and salinity plus frequency and intensity of inundations. Fringe mangrove habitats were characteristic along coastline, followed by basin mangrove habitats that were within a matrix of mixed mangrove forests, that became more broad-leaved as one moved inland. Wetland patches characterized as tall herbaceous swamps were also observed, dominate by grasses and sedges interspersed with tree species adapted to poor soil nutrient and seasonal waterlogged conditions such as Palmetto palms and Calabash trees.

Vegetation on the Northern Lagoon east coast toward the sea was identified by the Belize Ecosystem Map (Meerman and Sabido 2001) as tropical broad-leaved moist forest. The survey results support this classification from a species composition aspect. The characteristic tree species for this ecosystem were common within surveyed transects but results diverge from this classification from a community structure point of view (**Figure 4-18**). Average canopy height was less than 8m (7.2m) and frequently broken leading to an understory dominated by cutting grass (*Scleria bracteata*) and sedges with abundant shrubs of *Miconia spp*. In areas with close canopy understory was dominated by mostly pole wood (tree with less than 4cm in dbh). It was also common to observe small islands of herbaceous swamps interspersed with Palmetto palms. An interesting finding was the dominance of oak trees within the broad-leave forest, explained by the dominance of sandy and acidic soils but can also be an indication that this ecosystem is on a transition from broken ridge pine forest to broad-leave. There were also evidences of wildfires which could help explain the low occurrence of trees with dbh $\geq$10cm, low and broken canopy, and the dominance of the understory by cutting grass and *Miconia spp*.

Figure 4-19: Characteristics of lowland broad-leaved forest encountered within the project site. Clockwise: dominance of polewood, cutting grass dominated broken canopy areas, tall herbaceous swamps patches with the broad-leaved forest matrix, and evidence of fire affecting the ecosystem.

4.1.3 Results - Fauna

4.1.3.1 Mammals

Six mammal species were observed within the study site (**Table 4-2**), of which paca and nine-banded armadillo were the most common. None of the recorded species are of conservation concern but generalist species able to adapt well to habitat disturbances. Recorded species are typical of coastal habitat.

Table 4-2: Mammal species recorded within the project site.

English Name	Scientific Name	Abundance	Method of Recording
Racoon	*Procyon lotor shufeldti*	1	Tracks
Agouti	*Dasyprocta punctata*	2	Direct sighting & Tracks
Paca	*Agouti paca nelsoni*	8	Tracks
Nine-banded Armadillo	*Dasypus novemcinctus mexicanus*	5	Tracks
White-Nose Coati	*Nasua narica*	1	Direct sighting
White-tail Deer	*Odocoileus virginianus truei*	3	Direct sighting & Tracks

4.1.3.2 Reptiles

Three lizards and 4 snake species were recorded (**Table 4-3**), most common was the spiny-tail iguana, followed by the rainbow ameiva.

Table 4-3: List of reptile species recorded within the project site.

English Name	Scientific Name	Abundance
Spiny-tail Iguana	*Ctenosaura similis*	7
Rainbow Ameiva	*Ameiva undulata*	4
Yucatan whiptail	*Cnemidophorus angusticeps*	1
Boa	*Boa constrictor*	1
Speckled Racer	*Drymobius margaritiferus*	1
Mexican vine snake	*Oxybelis aeneus*	1
Green vine snake	*Oxybelis fulgidus*	2

4.1.3.3 Birds

One thousand twenty-two individual birds representing ninety-three species were documented within the project site. The most abundant species was the white ibis with 584 recorded individuals representing 57.1% of the total bird abundance but was not included in the rank-abundance species curve as recorded individuals were all flyovers (meaning not recorded within the 25m radius point counts. The rank-abundance curve (**Figure 4-20**) shows great bird diversity and evenness (which refers to how close in abundance each species in an ecosystem is) indicating no dominance by a single of group of species. The Mangrove vireo, Pale-vented pigeon, and Tropical kingbird where frequently sighted bird species (**Figure 4-21**) while 57% of bird diversity was represented by less than 4 individuals.

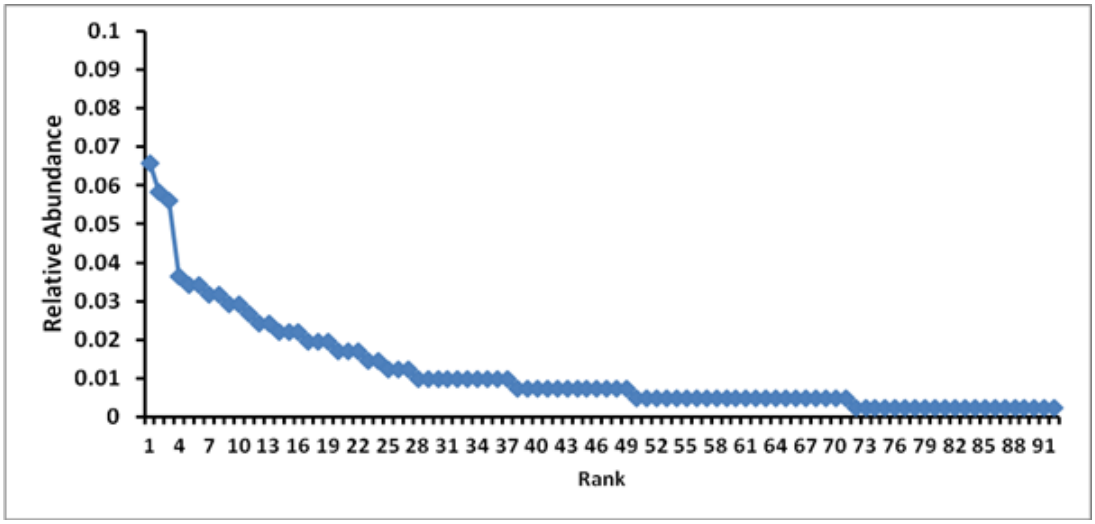

Figure 4-20: Rank-Abundance Curve for bird assemblage recorded within the Port of Magical Belize project site.

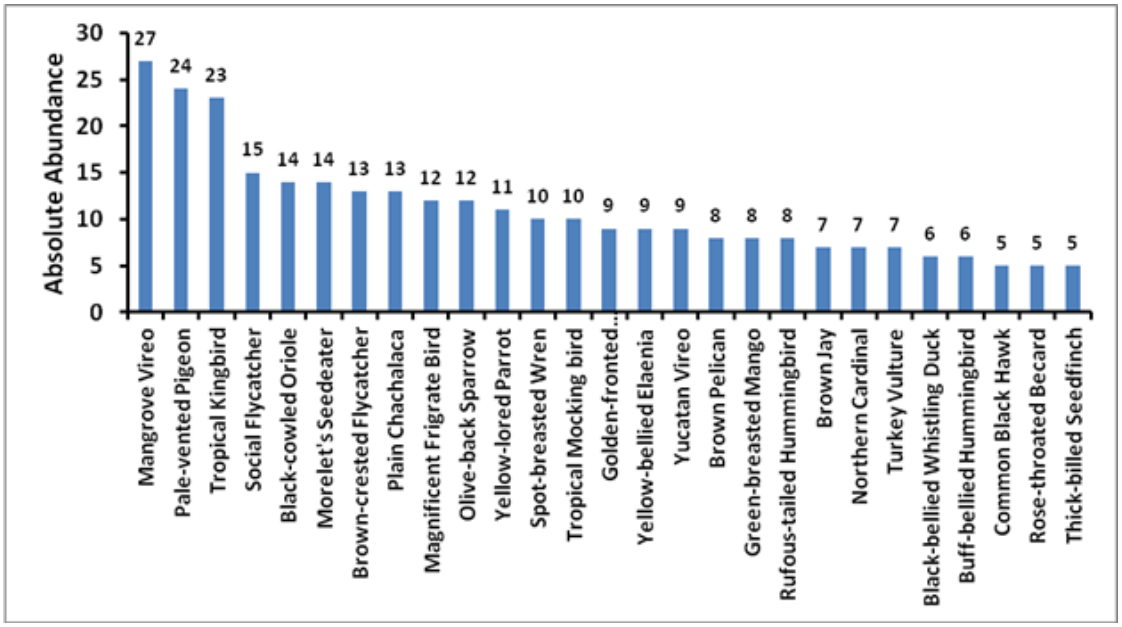

Figure 4-21: Absolute abundance of bird species with greater than 4 recorded individuals at Port of Magical Belize project site.

4.1.3.4 Discussion

The project site harbours a rich diversity of birds, independent of its relatively small size, which is reflected by the high mobility of the species which move into the area from surrounding natural habitats. Observed species evenness is indicative of a stable, well conserved natural system, surrounded by a well conserved landscape. Bird species assemblage was characteristic of coastal and broad-leaved habitats (Figure 4-22). The high abundance of White Ibis was as a result of the species leaving and going to a roosting site located on a small island in the Northern Lagoon; an estimated 1 km south of the project property boundary. For post development, bird monitoring will be required, and the White Ibis can serve as a candidate for monitoring and can be performed as a citizen science effort by facility users. It will be challenging to correlate changes in abundance to project development as changes may be driven by direct changes to the roosting site. The project site serves vital resources for bird communities such as food, nesting ground, and protection from storms. During field surveys five species were recorded nesting, including the Common Black hawk, and many observed foraging.

Figure 4-22: Observed bird nest during field surveys on the project site. Clockwise: Mangrove vireo nest, Tropical kingbird with 3 chicks, Social flycatcher nest, and Golden-fronted woodpecker cavity.

4.2 Marine and Brackish Component

4.2.1 Methodology for Collection of Baseline Data on Aquatic Flora and Fauna

A two-part study was performed to access and collect baseline data on marine ecosystems, habitats, flora and fauna within the project site and zone of influence. The first part involved a desktop study in which a range of resources including remote sensing data, past environmental impact assessment reports, and published reports were used to complement field surveys.

The second part included field surveys in which field data collection was carried out during several field visits made to the project site over the course of 4 months (July to October 2019). As it pertains to the survey for marine aquatic flora and fauna, a total of 9 days of diving was carried out by three divers at any given time. For safety measures, two divers were in the water carrying out surveys while one diver was on standby in case there were any emergencies. In addition to having Padi Dive Master certification, two of the divers that carried out the surveys have scientific diving certification and one is a scientific diver in training. The divers all have extensive experience in marine flora and fauna monitoring protocols as they have either worked for the Environmental Research Institute or for the Natural Resource Management Program of the University of Belize carrying out marine research and monitoring work.

4.2.1.1 Methodology for Assessment of Marine Flora

The aim of the field surveys for marine flora was to access flora associated with the project site and zone of influence. This included the assessment of two types of flora, viz the land-based or supra-tidal and emergent vegetation and the sub-tidal or below the surface of the water type. The land-based type consisted of 'littoral forest' and grass savannah, as well as the inter-tidal mangal forest. The sub-tidal component consisted of sea-grass beds and to a much lesser extent macro-algal stands. The land-based flora is addressed in the land-based/terrestrial assessment found earlier in this chapter.

For the sub-tidal assessment of flora, initially, the intended plan was to use the Seagrass-Watch Monitoring Protocol (McKenzie *et.al.*, 2001). The protocol is from the Sea-Grass Watch: Manual for Mapping and Monitoring Seagrass Resources by Community (Citizen) Volunteers. The protocol is well accepted monitoring protocol for seagrass in Australia, a country with long history of marine biodiversity monitoring. However, the protocol was modified due to the nature of the survey sites. The visibility at each site surveyed ranged from Extremely Poor (0-10cm or 0-0.25 ft) visibility, Poor (10-30cm or 0.25-1 ft) visibility to Fair (30-90cm or 1-3ft) visibility. None of the sites surveyed met criteria for Clear (0.9 - 3.0m or 3-10ft) water conditions. Visibility for effectively conducting aquatic surveys and ensuring diver safety for seagrass monitoring requires a minimum of 3m (10 ft) visibility. As example, seagrass monitoring protocols such as the Seagrass-Watch Monitoring protocol and seagrass Net which is more commonly used in Belize for seagrass monitoring, a visibility of at least 5m (16.4 ft) between transect lines is required. All the sites surveyed did not meet this requirement as the visibility was poor; in most instances even necessitating the use of flash lights to carry out a modified version of the protocol.

Due to the reasons above, the method was modified resulting in only one (50m) transect conducted in each site with exception of the sites with extremely poor visibility where surveys were not possible even-though the divers descended into the water to assess the site. At each site, prior to dives, a sediment sample was taken using an Ekman bottom grab sampler for benthic in-fauna assessment. Divers then descended and accessed the visibility and conditions of the sea-floor. The substrate type was determined and recorded. Once the visibility was established, a 50m transect was reeled out at 210^0 using a compass. Divers then swam along the transect line documenting fish species observed within 2.5m on each side of the transect line. The modified protocol does not permit the calculation of fish indices such as diversity, abundance, biomass etcetera. The sampling sites for assessment of both flora and fauna are presented in **Figure 4-23**.

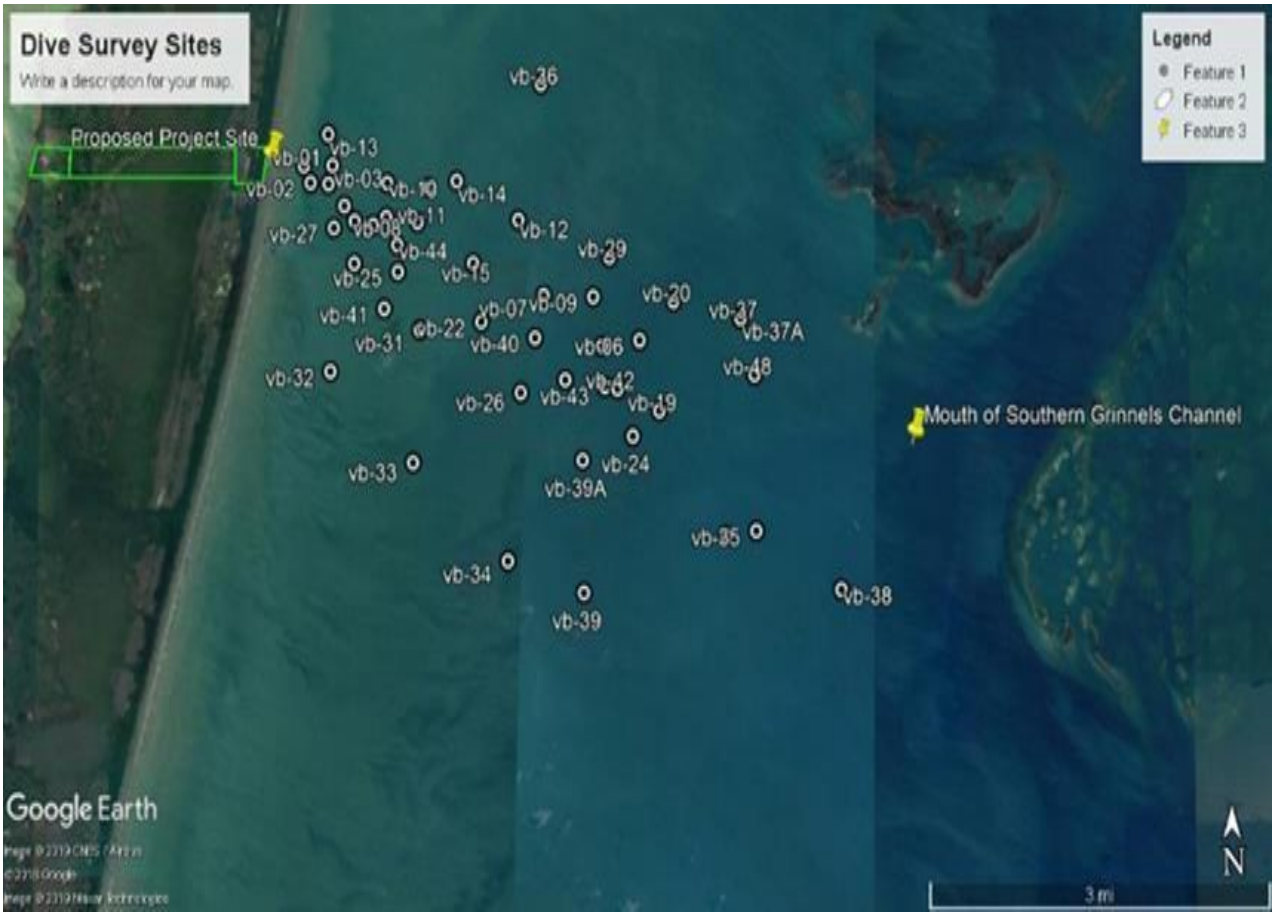

Figure 4-23: Sampling points for flora and fauna assessment for Port of Magical Belize.

4.2.1.2 Methodology for Assessment of Marine Fauna – Fish

Similar to the survey carried out for assessment of flora, the initial plan was to carry out fish species abundance and richness assessments using the MBRS Synoptic Monitoring Program 2003, method II: Rover Diver technique. This method was intended for the deeper areas while for shallower areas, the Belt Transect Count method adapted by the Atlantic and Gulf Rapid Reef Assessment (AGRRA) monitoring program was to be used (Kramer P., *et al.*, 2005).

However, due to poor visibility/turbid water conditions of the area, it was not possible to carry out the intended methodologies. Therefore, the extent of the fish survey included only the recording of the fish species observed within 2.5m on either side of the 50m transect as the divers swam along the transect line.

4.2.1.3 Methodology for Assessment of Brackish and Fresh Water Fauna - Fish

A survey of the fish present in the Sibun river (i.e. section of river within project zone of influence) was carried out using a combination of cast net and hook and line fishing. Fish caught were kept out of water briefly and released immediately once identified and/or picture taken. The area surveyed spawned a distance of approximately 6mi upstream from the mouth of the river. Additional resources (published information and local knowledge by subsistence fishermen) was used as secondary source of information to document fish found in the Sibun river.

The turbid conditions of the Northern lagoon during site visits complicated capturing of fish using cast net and hook and line. A picture of the turbid conditions observed in the lagoon is presented in **Figure 4-24**. Therefore, the information on fish species of the Northern Lagoon come from secondary sources.

Figure 4-24: Drone picture showing Turbid/eutrophic conditions of Northern Lagoon in October 2019.

4.2.1.4 Methodology for Assessment of Marine Fauna – Corals

Again, the initial intention was to use a point intercept method based on the Atlantic and Gulf Rapid Reef Assessment (AGRRA) manual for coral assessment; however, due to poor visibility/turbid water conditions, estimation of coral cover was not possible. Therefore, the

extent of coral assessment only included the documenting (pictures taken) of the species of corals observed along a 50m transect line. Therefore, the basis of the assessment for corals is from bathymetric study carried out for the project which produced maps of seafloor features inclusive of coral reefs within the area.

4.2.1.5 Methodology for Assessment of Marine Mammals, reptiles, Birds and Amphibians

Marine mammals, reptiles and amphibians were assessed by opportunistic sightings during several site visits to the project site. Species that were observed during these field visits were documented. Species composition and abundance of both marine and terrestrial birds were assessed using point counts.

4.2.2 Physical Description of Brackish and Marine Environment

4.2.2.1 Marine Environment

A large-scale overview of the coastal stretch, between Belize City and Colson Point, along which the Port of Magical Belize is to be located is provided in **Figure 4-25**. In front of the beach facing the Caribbean Sea there is an approximately 15.5mi (25km) wide reef that is shallow near the beach and near the offshore reef edge. This reef system is approximately 14mi (22.5km) directly east of the cruise ship docking pier and approximately 11.5mi (18.5km) directly east of the closest point in which dredging activities will be carried out for construction of the access channel (**Figure 4-25**).

The centre part of the reef is up to 18 – 20m deep, see **Figure 4-26**, with localized shallower areas. In the north, aligning directly east of the Port of Magical Belize project site, the reef is crossed by a curved channel known as English Caye Channel, see **Figure 4-26**.

At a distance of at least 5.6mi (9km) offshore of the shore-connected reef there is another reef, the Turneffe Atoll. In between these reefs the Caribbean Sea is over 200m deep, see **Figure 4-25**. Further offshore there is a third reef, the Lighthouse Atoll. These reefs and atolls provide significant shelter against waves from the Caribbean Sea. The Belize barrier reef system and atolls are a considerable distance away from the project site as such they are considered to be outside the project zone of influence.

From Google Earth images it appears that at a macro scale, a major part of the coastline between Belize City and Dangriga is vegetated and only some stretches south of Manatee River consists of narrow strips of beach, see **Figure 4-27**. Pictures of a typical stretch of the beach south of Manatee River is shown in Figure **4-28**.

About 7km north of Port of Magical, the Sibun River discharges into the Caribbean Sea. A close up of the river mouth is provided in **Figure 4-29**. Google Earth images of earlier dates demonstrate that the river mouth is fairly stable. This means that the river discharge is sufficient to keep the river mouth open, acknowledging that the supply of sediment with the littoral drift and the river itself will be limited. Furthermore, Google Earth images illustrate that the coastline 1km at either side of the Port of Magical site has been more or less stable during the last 13 years, see **Figure 4-30**. The figure shows very localized coastline advance and retreat but does not show significant coastline advance or retreat on a large scale. It can also not be excluded that the apparent coastline changes are due to water level differences between the two images.

Depth profile of the project zone of influence on the marine side as seen in the bathymetry map developed for the project site shows that the area between the coastline and the mouth of South Grennel's channel is relatively shallow (**Figure 4-26**). Manual depth soundings and multiple dives carried out over a period of 4 months between July and October 2019 confirmed that the water depth between the project site and the mouth of Southern Grennel's Channel is relatively shallow ranging from < 1m close to the coastline to 15m close to the mouth of South Grennel's channel. Location of dives carried out are shown in **Figure 4-31**. During the field assessments, the water was observed to be turbid every time that field visits were made. This information along with local knowledge of water conditions along the project site indicates that the water adjacent to the project site is turbid throughout extensive periods of the year likely due to a combination of local long-shore currents and strong wave energy conditions of the area.

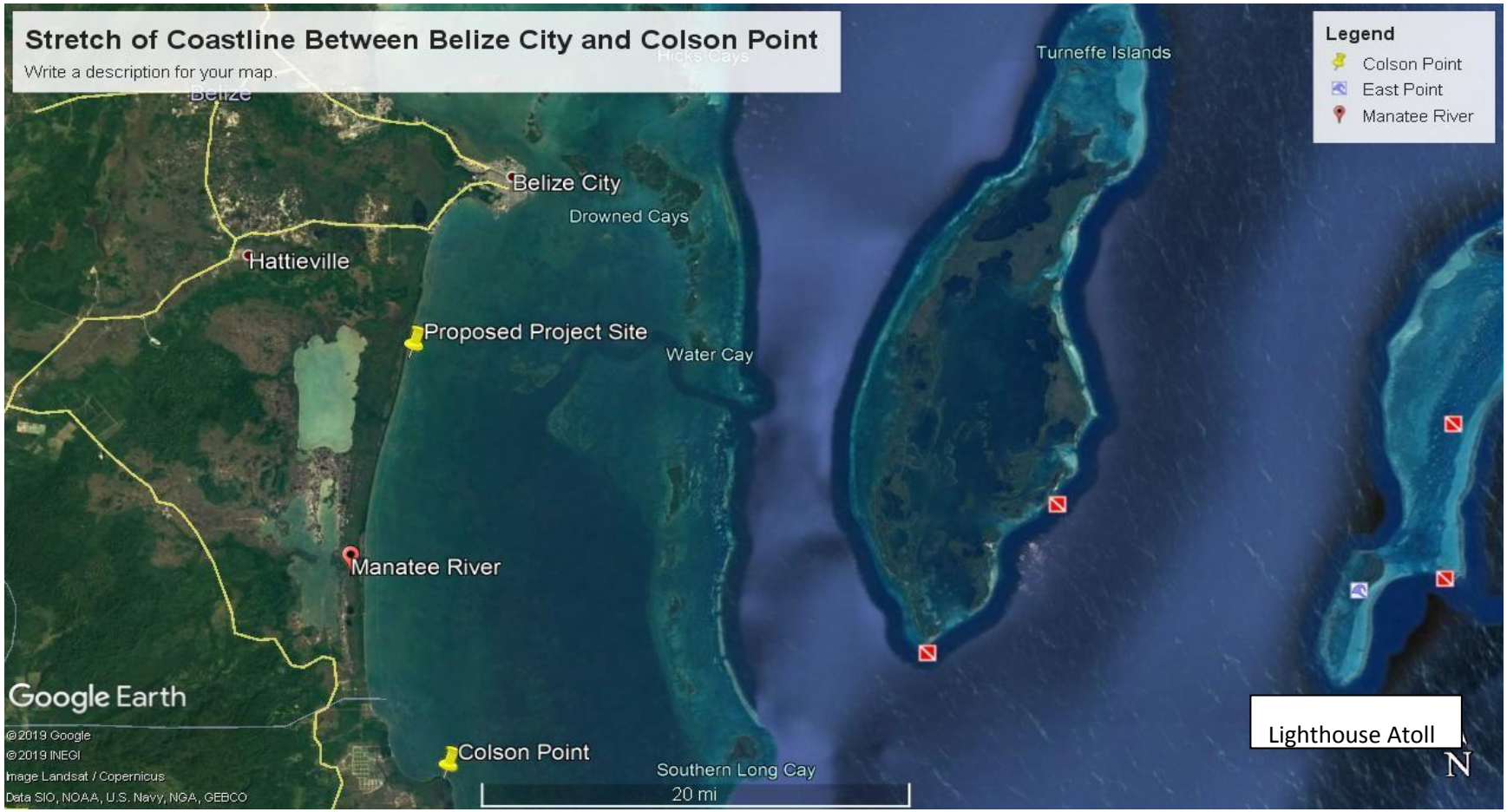

Figure 4-25: Overview of the coastal stretch between Belize City and Dangriga along which the Port of Magical Belize is to be located

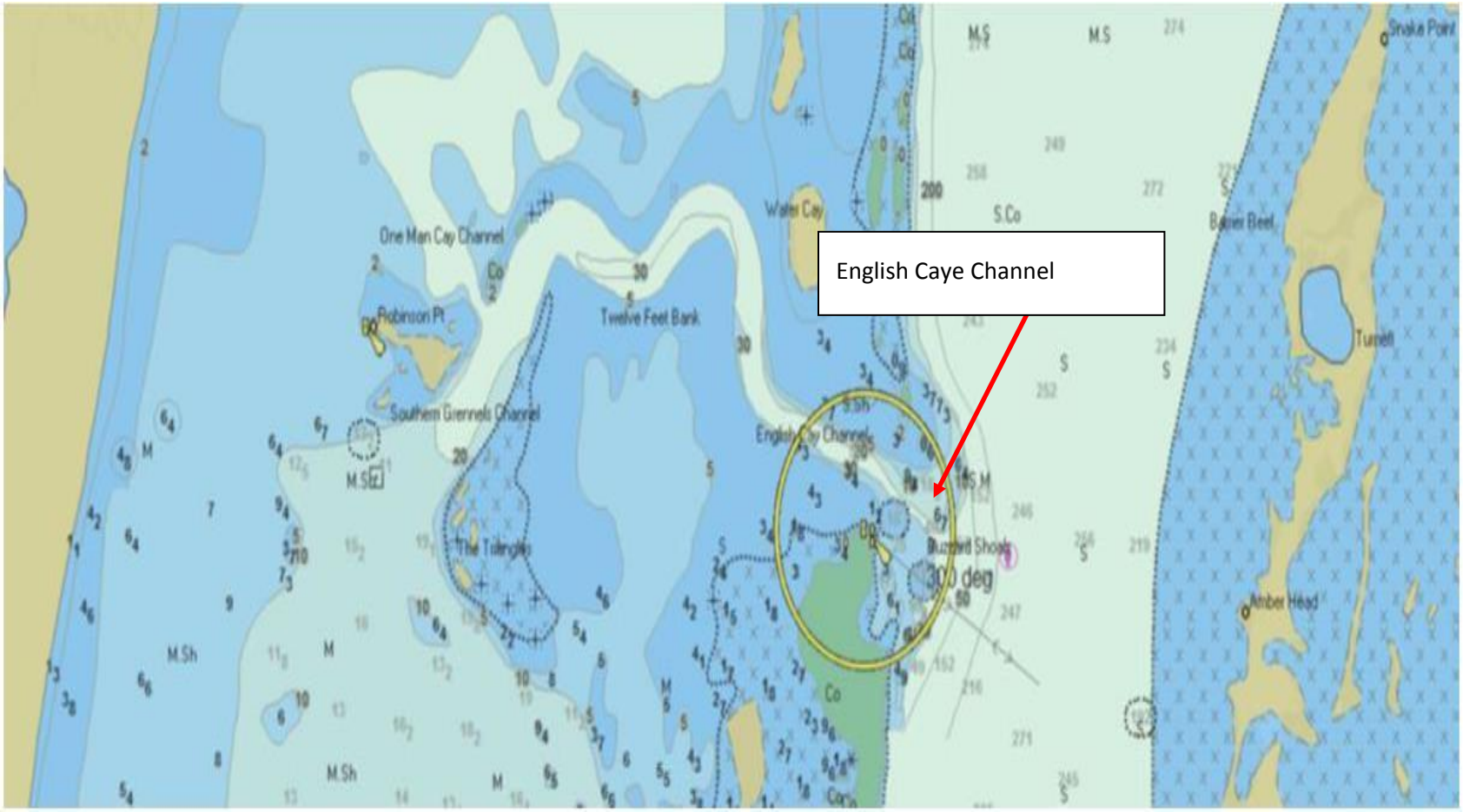

Figure 4-26: Impression of the bathymetry of the norther part of the reef system (Source: Credit: Hydronamic).

Figure 4-27: Belize coastline between Belize City and Dangriga showing that the coastline is mostly vegetated.

Figure 4-28: Impression of the width of the beach south of Manatee River (Source: Hydronamic).

Figure 4-29: Close up of the mouth of the Sibun River.

Figure 4-30: Coastline in March 2006 (yellow) and April 2019 (white) 1 km at either side of Port of Magical Site.

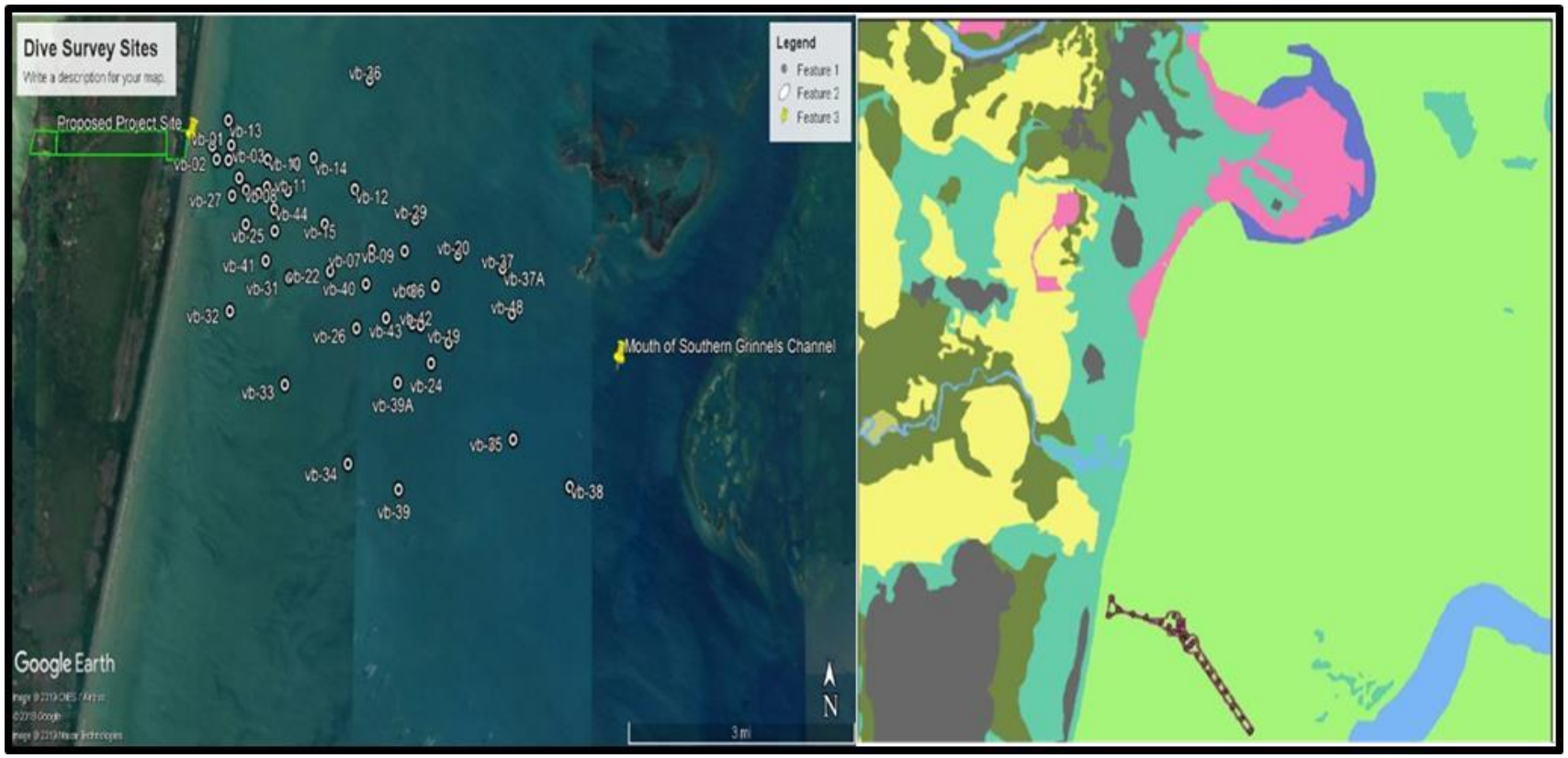

Figure 4-31: Sites of dive surveys for flora and fauna for Port of Magical Belize.

4.2.2.2 General Description of Water Conditions Encountered Along the Coastline

The land mass barriers created by small islands/cayes and the peninsula on which Belize City is located, combined with shallow water depth along the coast and the submerged channel (English Caye -Southern Grennel's Channel) create a complex local current flow pattern along the coastline of Belize and by extension along the coastline of the proposed project site and it's zone of influence. As can be noted in **Figure 4-32**, a hydrodynamic modelling study performed for the proposed port project using the D-Flow FM model, indicates that the prevailing winds along the coastal zone of Belize throughout the year (predominantly southeast and east) creates a longshore current that is driven both towards the north as towards the south during southeast and east trade winds respectively (Boskalis, 2019). Between the submerged channel (Southern Grennel's channel) and the peninsula (Belize city) a current circulation is visible. The strongest flow is observed in the submerged meandering English Caye channel (directed offshore) and along the peninsula of Belize City (directed southward).

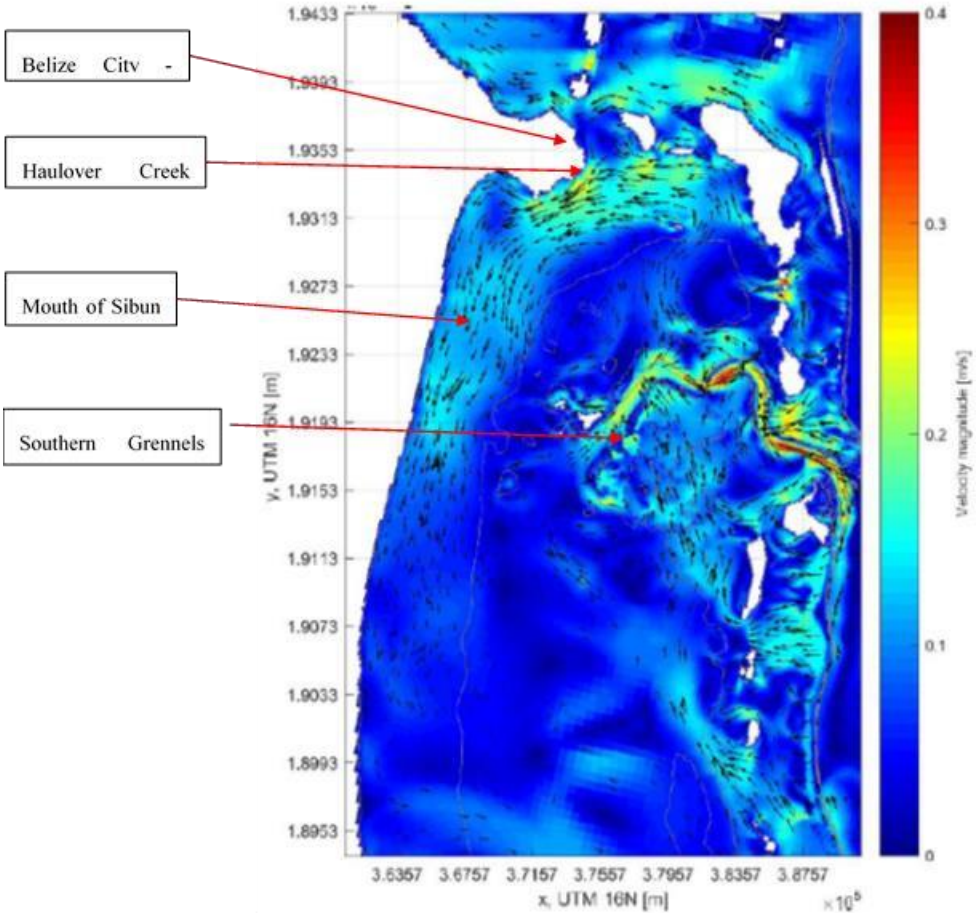

Figure 4-32: Local current flow patterns along the coastline of the project site for easterly predominant winds obtained from a hydrodynamic modelling study performed using the D-Flow FM model (Boskalis, 2019).

Due to this complex local current flow pattern, the effluents inclusive of sediments from the Sibun River as well as from the haulover canal which drains part of the Belize River and Belize City in its entirety, is transported southwards towards the project site during predominantly easterly winds. This constant input of effluents influences the marine aquatic habitat and by extension the fauna and flora found in the coastline along the project site and zone of influence. The hydrodynamic modelling study further concluded that the wind driven current is stronger in shallow parts closer to the shoreline. This may explain the turbid environment observed during surveys carried out over a 4-month period as part of the assessment of marine flora and fauna for the project.

4.2.2.3 Seagrass Beds and Coral Reefs

The closest known seagrass beds to the proposed project site are located within the Robinson Point area (**Figure 4-33**, **Figure 4-34** and **Figure 4-35**). In relation to the project site, the seagrass beds are located near the mouth of Southern Grennel's Channel flanking its southern side. This area containing seagrass is located approximately 12mi south east of the location to the proposed cruise docking area and an estimated 4mi away from the closest proposed dredging activity for construction of the cruise ship access channel. Dive surveys confirmed the absence of seagrass beds in the area assessed. Furthermore, no seagrass fragments were observed in sea floor sediment samples collected with grab samplers (**Figure 4-36**). Depending on final route selected, dredging for the proposed access channel will likely start in proximity (i.e. approximately 0.5mi) away from the seagrass beds.

In regards to coral reef systems close to the project site, **Figure 4-35** shows the closest identified coral reef. This coral reef system was identified based on bathymetry assessment and confirmed by dive surveys. For more in-depth assessment of coral reefs and live corals close to the project site see section on "Marine Fauna – Corals".

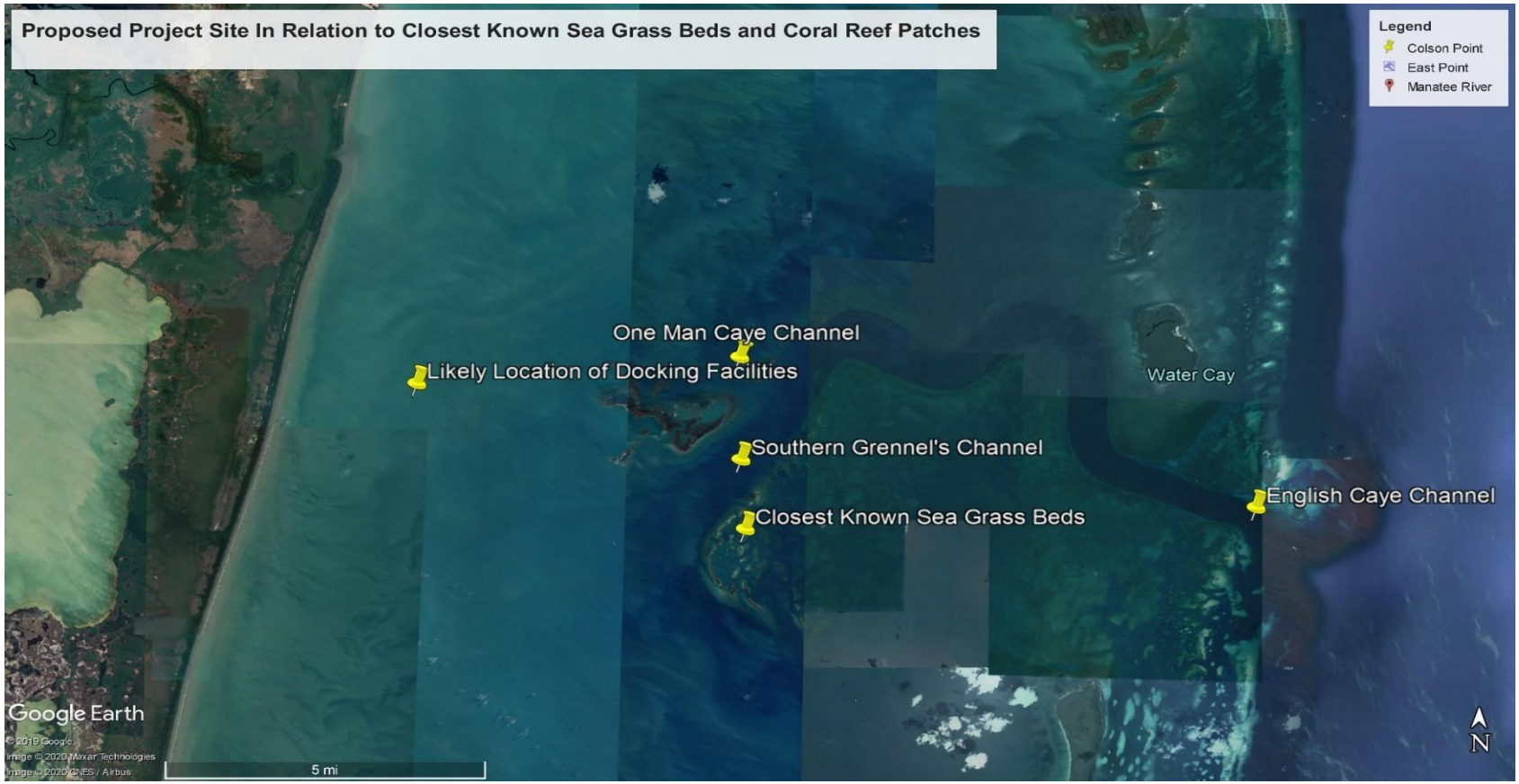

Figure 4-33: Map showing the closest known seagrass beds and patch reefs to the project site.

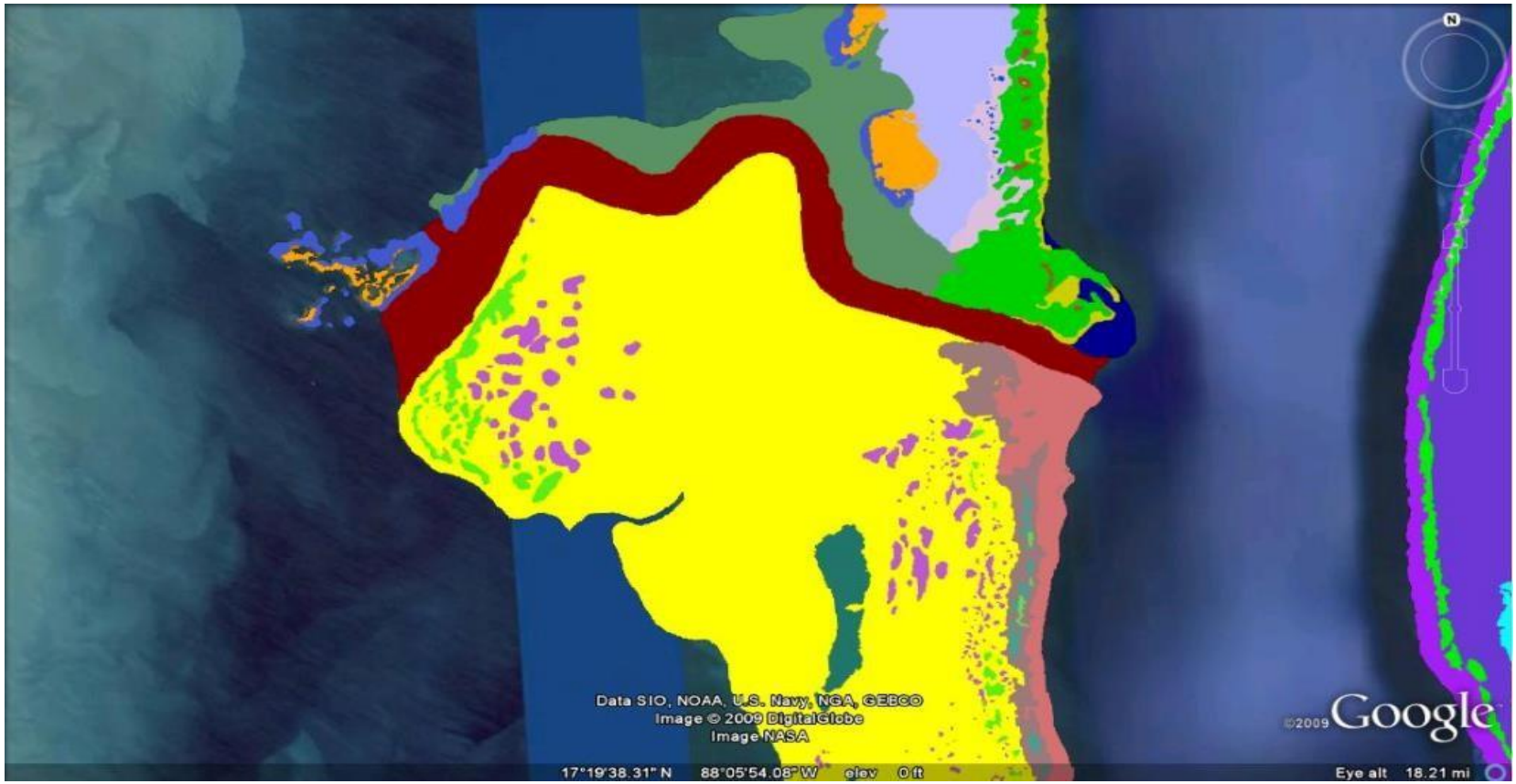

Figure 4-34: Robinson Point Area showing shallow (green patches) and deep reef (purple patches) and the most abundant benthic community, seagrass (yellow). Source: Millennium Reef Mapping Project (2009) map of the Robinson Point Area.

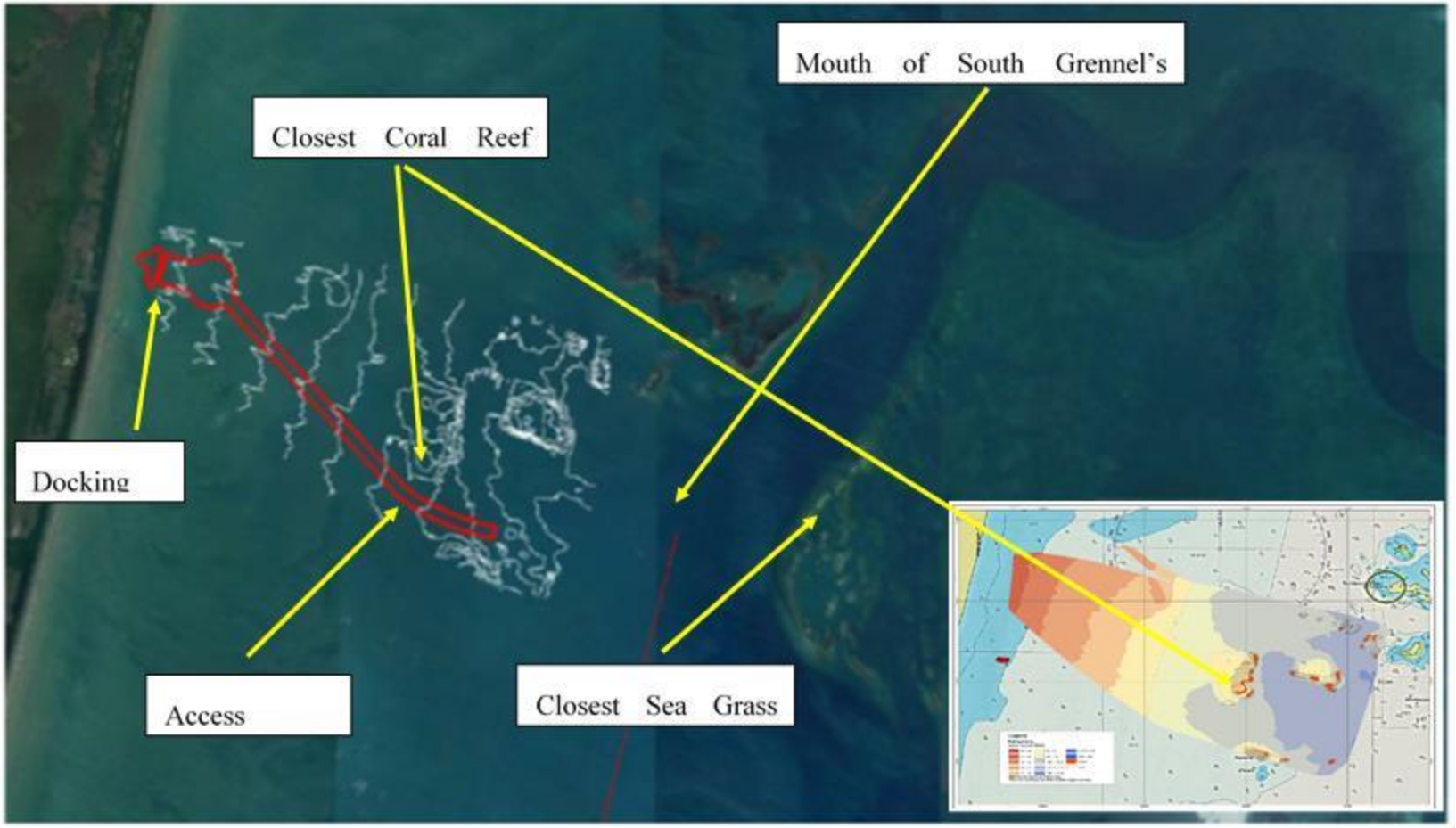

Figure 4-35: Map of the project site showing the closest coral reef patch and seagrass beds in relation to the project site and zone of influence.

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Figure 4-36: Pictures of some sediment samples collected by grab sampler showing sediment characteristics and lack of seagrass material.

4.2.2.4 Marine Flora – Subtidal Marine Flora

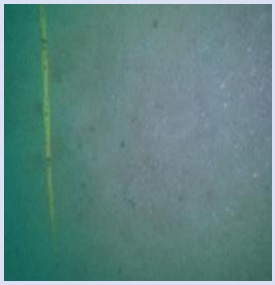
The result of the survey for subtidal marine flora is presented in **Table 4-4**. Seagrass species were not observed in any of the sites surveyed. This may be attributed to a combination of substrate type (i.e. mostly mud/silt) and the high turbidity conditions of water observed during field surveys (**Figure 4-37**). shows representative types of the sea floor substrate present at the sampling sites.

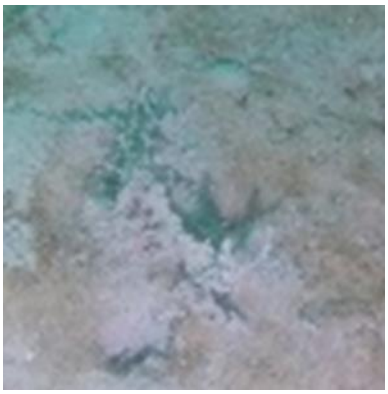
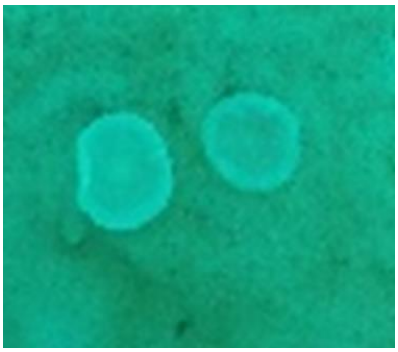
Figure 4-37: Photographs showing typical turbid conditions of waters surrounding project site observed during field visits.

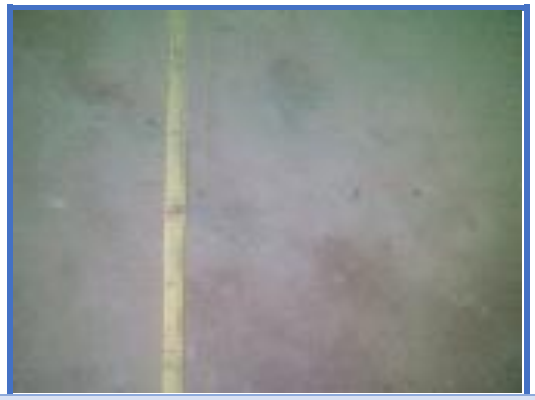
Visibility at the bottom of the sea floor was characterized by survey divers as being Extremely Poor (0-10cm or 0-0.25ft) to Poor (10-30cm or 0.25-1ft) for all sites assessed, with exception of sites VB-06, VB-37, VB-38, and VB-48 which were characterized as having Fair (0.3-0.9m or -1-3ft) visibility. Furthermore, on the surface of the water, the average secchi disk reading of all sites sampled was 1.6m (5.2ft). Seagrass meadows need a more stable substrate and also enough sunlight for photosynthesis in order to strive.

In regard to macro-algae, sparse macro-algae were observed along survey transects at only 4 sites as shown in **Table 4-4.** The conditions of the macro-algae observed is not considered healthy as silt material/sediment was observed smothering the sparse macro algae present.

Table 4-4: Aquatic vegetation observed during dive surveys for Port of Magical Belize.

Site ID	Seagrass Species	Algae Species
VB-38	Image showing the absence of seagrass vegetation in site VB38. 	Macro-Algae
VB-48	Image showing the absence of seagrass vegetation in site VB-48, only sparse algae is present 	Macro-Algae Halimeda sp.
VB-34	Not Surveyed due to extremely poor visibility	Not Surveyed due to extremely poor visibility

VB-37	Image showing the absence of seagrass vegetation in site VB-37 	Macro-Algae  Unknown species of Algae 
VB-06	Image showing the absence of seagrass vegetation in site VB-06, only sparse algae present 	Udotea sp.
VB-09	Not Surveyed due to extremely poor visibility	Not Surveyed due to extremely poor visibility
VB-12	Not Surveyed due to extremely poor visibility	Not Surveyed due to extremely poor visibility

VB- 19	Image showing the absence of aquatic vegetation in site VB-19 	No algae was observed along the survey transect
VB-07	Not Surveyed due to extremely poor visibility	Not Surveyed due to extremely poor visibility
VB-36	Not Surveyed due to extremely poor visibility	Not Surveyed due to extremely poor visibility
VB-39	Image showing the absence of aquatic vegetation in site VB-39 	No algae was observed along the survey transect
VB-26	Not Surveyed due to extremely poor visibility	Not Surveyed due to extremely poor visibility

4.2.2.5 Marine Fauna – Fish

Fish species observed during the dive surveys are presented in. Fish were observed only at site VB-06 and VB-48. These sites are approximately 5 km (3miles) and 6.5km (4 miles) away from the coastline respectively at water depths of 8 and 15m respectively. As can be noted in **Figure 4-31**, these sites are the sites surveyed that are furthest from the coastline and by extension from the project site. Generally, what the divers observed is that the farthest away from the coastline the water becomes clearer and the habitat becomes more suitable for aquatic life.

The lack of fish presence in other sites surveyed and the low number of different fish species observed may not necessarily mean that other fish species are not found in the area and may simply be that it was difficult to see fish under turbid water conditions prevailing during surveys. Extensive search for data available on fish diversity and abundance in areas surrounding the project site is non-existent; however, our assessment indicates that the turbid water which seems to prevail throughout most of the year and the highly sedimented sea floor environment all point to an area of overall low marine aquatic diversity and biomass inclusive of fish. Local knowledge about fish diversity in the area combined with mapping of Belize's coastal zone according to uses further corroborate that this area is not considered a fish rich area and as such is not classified as an area of fisheries usage (**Figure 4-38**).

Table 4-5: List of marine fish observed during marine field surveys of the Port of Magical Belize project site and surrounding areas.

Site ID	Fish Species
VB-38	No fish species was observed along the survey transect
VB-48	• Lionfish (*Pterois volitans*) • Yellowtail Snapper (*Ocyurus chrysurus*) • Bar Jack (*Caranx ruber*) • Four-eye butterfly (*Chaetodon capistratus*) • Sand gobies (*Pomatoschistus minutus*) • Porkfish (*Anisotremus virginicus*) • Princess Parrotfish (*Scarus taeniopterus*)
VB-34	Survey not possible due to extremely poor visibility
VB-37	No fish species observed along the survey transect
VB-06	• Flag-fin mojarra • Sand gobies (Pomatoschistus minutus) • Porkfish (Anisotremus virginicus) • Tomtate (*Haemulon aurolineatum*) • Juvenile snapper • High-hat fish (*Pareques acuminatus*) • Bluewing Searobin (*Prionotus punctatus*)

Site ID	Fish Species
VB-09	Survey not possible due to extremely poor visibility
VB-12	Survey not possible due to extremely poor visibility
VB- 19	No fish species observed along the survey transect
VB-07	Survey not possible due to extremely poor visibility
VB-36	Survey not possible due to extremely poor visibility
VB-39	No fish species observed along the survey line
VB-26	No fish species observed along the survey line

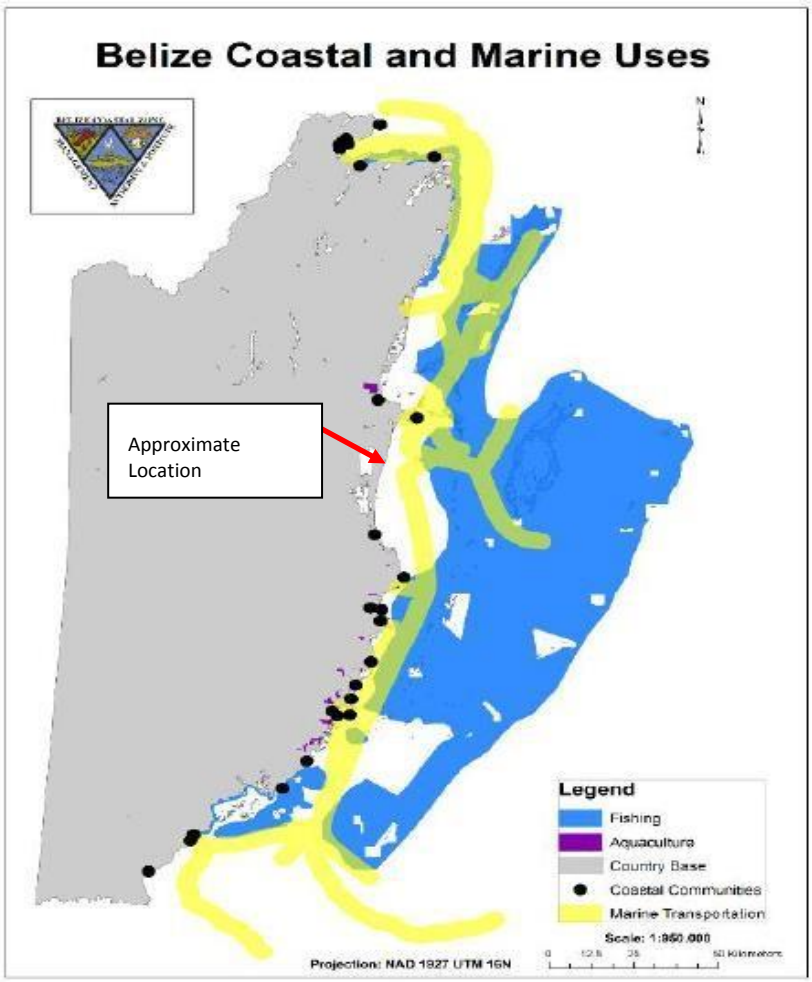


Figure 4-38: Belize coastal and marine zone classifications adopted form Belize Integrated Coastal Zone Management Plan.

4.2.2.6 Brackish and Fresh Water Fauna – Fish and Other Vertebrates

Brackish and fresh water fish species and other vertebrates documented during field surveys are presented in **Table 4-6**. Additionally, a list of fish species documented through secondary sources is presented in **Table** 4-7. This list was put together using data from various sources, inclusive of a study carried out by Wildtracks that was commissioned by the developers of Port of Magical Belize. Additionally, knowledge of fish species found in the area was gathered by interviewing local fishermen that fish the area for subsistence fishing.

Similarly, to fish in the marine environment, the determination of diversity and biomass of fish in the Sibun River and the Northern Lagoon from dive surveys carried out for the project was not possible. Furthermore, secondary data is non-existent.

Table 4-6: List of brackish and fresh water fish and other vertebrates documented from the mouth of the Sibun river during field survey carried out in October 2019.

Site ID	Fish Species
VB-38	• Mutton snapper (*Lutjanus analis*) • Blue crab (*Callinectes sapidus*)

- Horse-eye Jack (*Caranx latus*) Jack

- Grunt (*Haemulon plumierii*)

- Blue catfish (*Ictalurus furcatus*)

- Dog snapper (*Lutjanus jocu*)/ black snapper

- Tubba (*Cichlasoma synspilum*)

Table 4-7: List of fish found in the Sibun River mouth and in the Northern Lagoon as documented through secondary sources.

Common Name	Scientific Name	Location	Source
Barracuda	*Sphyraena barracuda*	Sibun River	Local Fisherman
Common snook	*Centropomus undecimalis*	Sibun River	Local Fishermen
Tarpon	*Megalops atlanticus*	Sibun River	Local Fishermen
Sheepshead	*Archosargus probatocephalus*	Sibun River	Local Fishermen
Lookdown Jack	*Selene vomer*	Subun River	Local Fishermen
Stone Bass	*Polyprion americanus*	Sibun River	Local Fishermen
Bay Snook	*Petenia splendida*	Sibun River	Local Fishermen
Nile Tilapia	*Oreochromis niloticus*	Sibun River	Local Fishermen
Northern Checkmark Cichlid	*Theraps intermedius*	Sibun River	Patrick de Rham (1990)
Belize Anchovy	*Anchoa belizensis*	Sibun River	Fishbase
Mayan Catfish	*Ariopsis assimilis*	Sibun River	Local Fishermen
Redhead Cichlid	*Vieja melanura (Günther, 1862)*	Sibun River	Patrick de Rham (1990)
Panya Gial/Firemouth Cichlid	*Thorichthys meeki*	Sibun River	Patrick de Rham (1990)
Botasi/Chulin	*Rhamdia zongolicensis*	Sibun River	Local Fishermen
Fan Tail Mullet	*Mugil trichodon*		
Crana	*Cichlasoma uropthalmus*	Sibun River	Local Fishermen
Black Snapper/Dog Snapper	*Lutjanus jocu*	Sibun River	Local Fishermen

Common Name	Scientific Name	Location	Source
River Lobster	*Macrobrachium carcinus*	Sibun River	Local Fishermen
Bull Shark	*Carcharhinus leucas*	Sibun River	Local Fishermen
Mayan Cichlid	*Mayaheros urophthalmus*	Sibun River and Northern Lagoon	Local Fishermen and by Greenfield and Thomerson (1997).
Long Guard	*Ablennes hians*	Sibun River	Local Fishermen
Evorthodus Lyricus	*Lrye goby*	Sibun River	Fishbase
Southern Stingray	*Dasyatis americana*	Northern Lagoon	Wildtracks (2005)
Checkered Pufferfish	*Sphoeroides testudines*	Northern Lagoon	Wildtracks (2005)
Ocellated killifish	*Floridichthys polyommus*	Northern Lagoon	Wildtracks (2005)
Triple Fin	*Lobotes surinamensis*	Northern Lagoon	Greenfield and Thomerson (1997)
Redfin Needlefish	*Strongylura notata*	Northern Lagoon	Greenfield and Thomerson (1997)
Central Tetra	*Astyanax aeneus*	Sibun River	Greenfield and Thomerson (1997)
Mayan Tetra	*Hyphessobrycon compressus*	Sibun River	Greenfield and Thomerson (1997)
Pike Killfish	*Belonesox belizanus*	Sibun River	Greenfield and Thomerson (1997)
Shortfin Molly	*Poecilia mexicana*	Sibun River	Greenfield and Thomerson (1997)
Yellowbelly Cichlid	*Cichlasoma salvini*	Sibun River	Greenfield and Thomerson (1997)

4.2.2.7 Marine Benthic Fauna - Corals

The presence of coral species observed along a 50m transect line during dive surveys was documented and recorded **Table 4-8**. Site VB-48 was the only site where multiple coral species were observed. This site was the furthest from the coastline and in close proximity to the mouth of the South Grennel's channel. The only other sites where corals were observed are VB-06 and VB-38. These sites are also close to the mouth of South Grennel's channel.

Dive surveys noted that sediment deposits (silt) is prevalent on corals. Overall, the health of the corals can be categorized as poor as evidenced by sparse coral patches, coral bleaching and numerous dead corals. Additionally, fragments of dead corals were observed in these sites. The observation of fragments of dead corals suggest an area of dynamic water current activity that is likely moving/transporting broken coral fragments into the area and/or breaking corals found withing the surrounding areas.

Collectively, the species of corals observed are not coral reef builders, are considered generalists and are known to be found/strive in harsh environments (e.g. high sediment and strong currents) (

Table 4-9). Furthermore, none of the species documented are critically endangered and/or of major conservation concern due to their generalist status.

Table 4-8: Coral species observed along the 50m transect

Site ID	Coral Species
VB-38	Cup coral
VB-48	*Siderastrea siderea*

	Meandrina jacksoni *Stephanocoenia intercepta*

Millepora alcicornis

Scolymia cubensis

Siderastrea radians

	Montestrea cavernosa Gorgonian (Seawhip)

VB-06	Gorgonian- Seawhip *Alcyanocea sp*
VB-09, VB-12, VB-07, VB-34, VB-36,	Sites were not surveyed due to extremely poor visibility
VB- 19, VB-26, VB-39, VB-37	Sites were surveyed; however, no coral species was observed along the survey transect

Table 4-9: Conservation status and common habitats/environmental conditions tolerated by coral species documented during the coral assessment for Port of Magical Belize.

Species	Habitat that they Occupy	Conservation Status
Cup Coral	Cup corals are non-reef building species that inhabit shaded vertical surface and caverns down to great depths.	Not on the IUCN Red List
Siderastrea siderea	Massive scarlet corals can be found in depths as deep as 70m but they generally occur between 5-15m hence they prefer shallow waters (IUCN, 2016). These corals thrive in reefs but are not equipped to survive in unclean, muddy waters or tidal pools.	IUCN Red List Status: Least Concern (LC).
Meandrina jacksoni	These corals are found at depths ranging from 1-80m, although their preferred depth range is 8-30m (Richardson and Voss, 2005). They are quite common in marine environments and can tolerate high levels of turbidity and sedimentation influx (Aronson et al., 2008).	Not on the IUCN Red List
Stephanocoenia intercepta	This species is common and can be locally abundant. This species is depths of 1-100 m. The crustos form is the more abundant form of the species in shallower habitats, lagoons, and silty environments typically at 5-15 m depths (https://www.reeflex.net/tiere/5863_Stephanocoenia_intersepta.htm).	Not on the IUCN Red List
Millepora alcicornis	This species is the only Caribbean fire coral that commonly can be found deeper than 10m with its depth range of 1-50m (Cairns, 1982), and is relatively uncommon in shallow surge zones (Humann and DeLoach, 2006) and low light intensities. It lives attached to wreckages of ships, dead corals and rocks, on reefs, in colonies and have a tendency to encrust and overgrow other species. Millepora can be found in disturbed habitats and can rapidly recover from bleaching events and siltation.	IUCN Red List Status: Least Concern (LC).
Scolymia cubensis	S. cubensis like to settle on reefs that have steep angles to more easily dispose of sediments that get caught around their oral disks. They get rid of the build-up of sediments by using their mucus strands along with water currents to congregate the sediments to edge of their oral disc.	IUCN Red List Status (Ref. 120744): Least Concern (LC).

Species	Habitat that they Occupy	Conservation Status
Siderastrea radians	Colonies generally inhabit shallow rocky reefs from the low tide line to about 10 meters, though specimens have been found down to 30 meters. It is considered one of the most stress-tolerant coral species in the Caribbean. Colonies are often found in disturbed locations under less than ideal environmental conditions (Lewis 1989, Lirman et al. 2002).	IUCN Red List Status: Least Concern (LC).
Montestrea cavernosa	Montestrea cavernosa abound in shallow waters of poor quality (Aronson et al., 2008). Inhabits normally between 10 and 30 m deep, although it is from 0.5 to 113 m.	Not on the IUCN Red List
Gorgonian-Seawhip	Gorgonians grow attached to a hard surface, such a rock or coral. Different gorgonians are found at different locations. Gorgonians such as the one observed in this assessment typically grow in shallow areas exposed to strong currents and are normally highly flexible and fan-shaped.	Not on the IUCN Red List
Alcyanocea sp. (soft corals)	Unlike stony corals, most soft corals thrive in nutrient-rich waters with less intense light. Almost all use symbiotic photosynthetic zooxanthella as a major energy source. However, most readily eat any free-floating food, such as zooplankton, out of the water column.	Not on the IUCN Red List

Based on bathymetric study carried out for the project, the closest patch reef system to the project site is located on the fringes of the mouth of South Grennel's channel some 19km (12 miles) south east of the proposed cruise ship docking facilities and a couple hundred meters away from the closest proposed dredging activity for the construction of an access channel (**Figure 4-39**). Based on bathymetry mapping, the reef system has patches of living corals (**Figure 4-40**).

Figure 4-39: Location map of bathymetry survey area for Port of Magical Belize

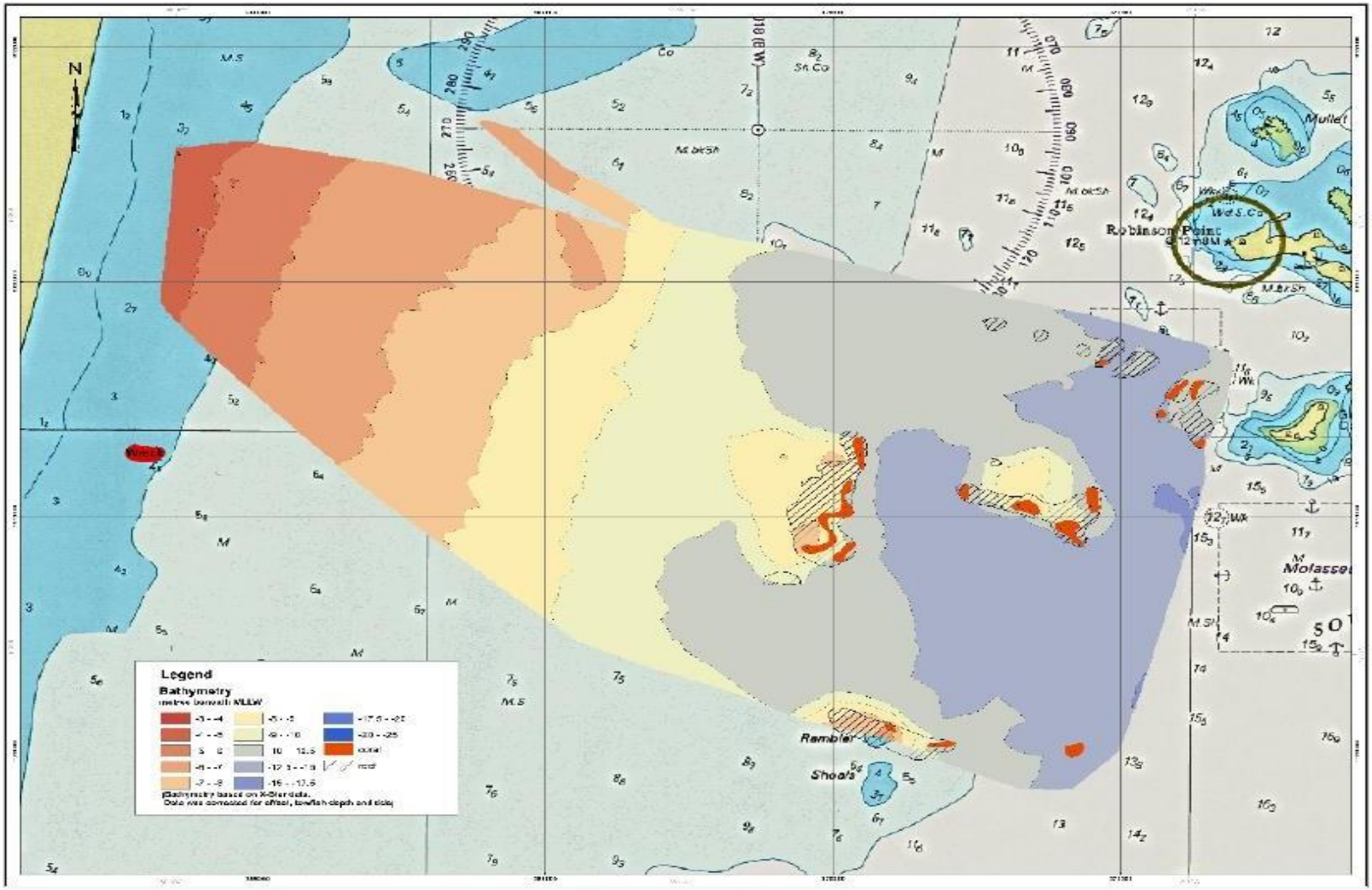


Figure 4-40: Bathymetry map of survey area. The bathymetry map has been produced using the 210kHz single beam data. The shaded areas represent the reefs and the red areas the (living) coral. (Source: Deltares 2019).

4.2.2.8 Marine Benthic Fauna – Others

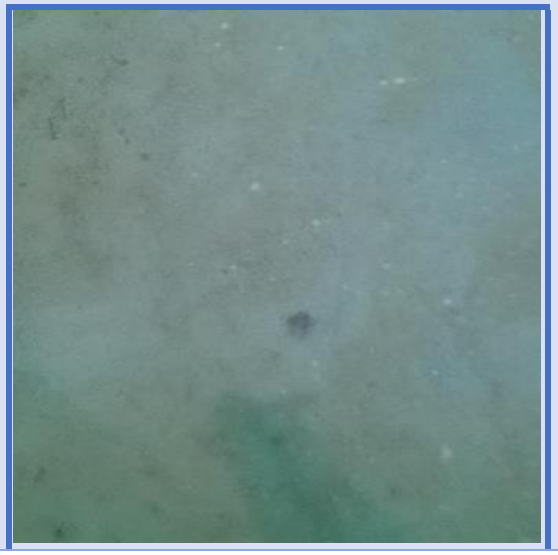
The presence of benthic fauna other than corals was also documented and recorded. **Table 4-10** shows the different species observed along a 50m transect line during dives. Although not included in the table below, the most commonly observed organism was the hermit crab. Hermit crab and/or hermit crab trails were observed at sites VB-06, VB-19, VB-37, VB-38, and VB 39. Conch (*Strombus gigas*) and lobster (*Panulirus argus*) were observed at sites VB-38 and VB-48 respectively. Both species are of commercial importance; however, as shown in the Marine Uses Zone map for Belize (**Figure 4-38**) the sites/general area where these organisms were observed are not considered important fishing grounds.

Table 4-10: List of "other benthic organism" observed during dive surveys for Port of Magical Belize.

Site ID	Other Benthic Organisms
VB-38	Juvenile Queen Conch (*Strombus gigas*) Sponge

VB-48	Sponges Spiny Lobster (*Panulirus argus*)
VB-34	Site not surveyed due to extremely poor visibility
VB-37	Sponges

VB-06	Sponges Three-Rowed Sea-cucumber
VB-09	Site not surveyed due to extremely poor visibility
VB-12	Site not surveyed due to extremely poor visibility
VB- 19	Tube dwelling Sea Anemone Trail of nine-tentacled sea star (*Luidia senegalensis*)

VB-07	Site not surveyed due to extremely poor visibility
VB-36	Site not surveyed due to extremely poor visibility
VB-39	Borrow worm holes 

VB-26	Borrow worm holes

4.2.2.9 Marine Benthic Habitat

Introduction

The following section reports on the benthic fauna survey. The specific objectives of this survey area are: 1. to collect baseline information of benthic fauna in the area. 2. to characterize the structure of the benthic fauna community (abundance, species richness, and diversity) in the areas to be dredged.

Location of sampling stations

A total of eighteen sites were sampled, see **Table 4-11** and **Figure 4-41**. Two sites were at the Sibun River mouth, One site in the Northern Lagoon, in front of the proposed development area. The other sites were in the windward side of the development area, from the shallow depths towards the deeper areas. The sampling coverage includes the proposed project site for Port of Magical Belize and zone of influence. This is inclusive of the proposed dredging area of the cruise ship access channel, docking facilities and reclaimed land connecting docking facilities to the mainland.

Table 4-11: The Geographic coordinators of the Sample Sites.

SITES	Latitude	Longitude	SITES	Latitude	Longitude
SIB01	17.42681	-88.25926	**VB19**	Coordinates were not taken	
SIB02	17.26130	-88.26303	**VB22**	17.34386	-88.24462
LAG01	17.36921	-88.30858	**VB26**	17.34247	-88.23949
VB01	17.36674	-88.26934	**VB34**	17.32564	-88.24162
VB05	17.36064	-88.25984	**VB36**	17.37558	-88.23650

VB07	17.35461	-88.23663	**VB37**	17.35042	-88.20988
VB08	17.36230	-88.25334	**VB38**	17.32197	-88.20614
VB09	17.35324	-88.23022	**VB39**	17.34272	-88.23083
VB12	17.36283	-88.24009	**VB48**	17.34475	-88.20787

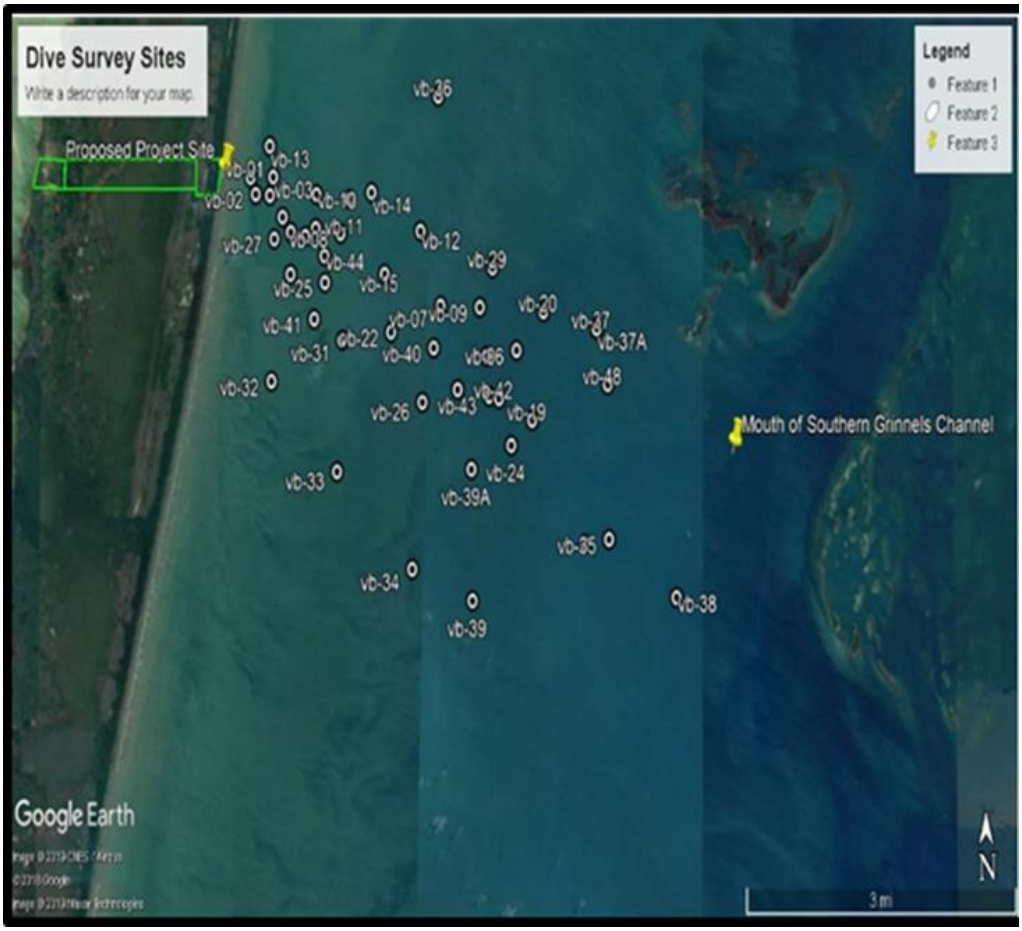


Figure 4-41: Sampling sites for benthic survey for Port of Magical Belize.

Samples were collected using a Standard Ekman Bottom Grab at the following sites: SIB02, LAG02, VB01, VB05, VB0 7, VB08, VB09, VB22, VB26, VB34, VB36, VB37, VB38, VB39. Due to sediment conditions the following sites the PVC Corer was used to obtain one sample per site: SIB01, VB12, Vb19 and VB48.

Results

The collected benthic fauna specimens were a total of eighty-two different species belonging to forty-four Families, twenty-five Orders, twelve Classes, eight Phyla and two Kingdoms. **Table 4-12** shows the families represented in the study area. **Table 4-13** shows the presence of the identified benthic fauna, Family taxon, at the eighteen sample sites. The collected fauna specimen was divided into two groups: dead and living

specimens. The dead specimens were classified into thirty-six Families, twenty Orders, nine Classes and five Phyla. Hence, the dead specimens made 86.6% of the collected and identified species, while 13.4% were living specimens. The dead specimens were juvenile-size broken shells, green algae, coral fragments and seagrass debris. The collected broken shells, mostly juvenile shells were of mollusks; mainly scaphopod, bivalves and gastropods. The broken dead hard corals were Scleractinia corals. The marine plants were green algae, manatee and shoal seagrass. The identified shells were from tusks, cockles, clams, quahogs, tellins, and lucines. Eight species were identified for each family of Veneridae and Cariiidae; while Tellinidae and Fasciolariidae had four species represented.

Table 4-12: Families of benthic fauna represented in benthic samples collected at Port of Magical Project site.

Dentaliidae	*Asterdidae*
Veneridae	*Patellidae*
Cardiidae	*Pectinidae*
Tellinidae	*Bellolividae*
Lucinidae	*Turritellidae*
Arcidae	*Nautilidae*
Conidae	*Haminoeidae*
Potamididae	*Cymothoidae*
Cylichnidae	*Sabellidae*
Calyptraeidae	*Amphinomidae*
Fasciolariidae	*Mellitidae*
Naticidae	*Strombidae*
Donacidae	*Palaemonidae*
Mactridae	*Hydrocharitaceae*
Haminoeidae	*Cymodoceaceae*
Pharidae	*Ophiolepididae*
Balanidae	*Udoteaceae*
Ostreidae	*Dendrophylliidae*
Olividae	*Poritidae*

Plicatulidae	*Meandrinidae*
Pyramidellidae	*Acroporidae*
Terebridae	*Chotonidae*

Table 4-13: List of Families present in benthic samples collected for Port of Magical Belize.

Families/ Sites	SIB01	SIB02	LAG01	VB01	VB05	VB07	VB08	VB09	VB12	Vb19	VB22	VB26	VB34	VB36	VB37	VB38	VB39	VB48
Dentaliidae	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Veneridae				X		X	X	X	X	X		X	X	X	X	X	X	X
Cardiidae	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tellinidae	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Lucinidae				X	X	X	X	X	X		X	X	X	X	X	X	X	
Arcidae				X		X			X	X		X	X	X	X	X	X	X
Conidae									X								X	
Potamididae																	X	
Cylichnidae					X	X					X						X	
Calyptraeidae		X																
Fasciolariidae				X		X	X			X	X					X	X	X
Naticidae			X	X														
Donacidae	X				X	X	X										X	X
Mactridae	X		X	X	X	X	X		X	X	X	X		X			X	
Haminoeidae						X	X					X	X	X	X	X		X
Pharidae			X		X	X	X	X	X		X				X	X	X	
Balanidae				X														

Families/ Sites	SIB01	SIB02	LAG01	VB01	VB05	VB07	VB08	VB09	VB12	Vb19	VB22	VB26	VB34	VB36	VB37	VB38	VB39	VB48
Ostreidae				X														X
Olividae						X	X	X		X	X	X	X	X			X	
Plicatulidae	X				X	X	X		X	X	X	X	X	X				
Pyramidellidae												X						
Terebridae			X												X			
Asterdidae			X						X			X		X				
Patellidae																		X
Pectinidae															X	X		X
Bellolividae			X			X												
Turritellidae					X													
Nautilidae					X													
Haminoeidae						X												
Cymothoidae						X												
Sabellidae			X	X	X	X	X				X	X		X			X	
Amphinomidae						X												
Mellitidae																		X
Strombidae				X											X			X
Palaemonidae													X					

Families/ Sites	SIB01	SIB02	LAG01	VB01	VB05	VB07	VB08	VB09	VB12	Vb19	VB22	VB26	VB34	VB36	VB37	VB38	VB39	VB48
Hydrocharitaceae			X	X		X	X				X	X						
Cymodoceaceae		X			X	X			X									
Ophiolepididae						X	X				X	X				X		
Udoteaceae									X									
Dendrophylliidae									X									X
Poritidae																		X
Meandrinidae																		X
Acroporidae																		X
Chitonidae																		X

The living (at the time of sampling) specimens were classified into nine Families, eight Orders, five Classes and five Phyla. There was a total of eleven species identified in seventeen out of the eighteen sites, with a total of forty-nine individuals. These species belong in the Phyla of Gastropod, Arthropod, Polychaetae, Echinoderm and Nematode. Four species of marine worms were collected, of which the marine worm species were the most abundant. **Figure 4-42** shows the relative abundance of the eleven species in the seventeen selected sites.

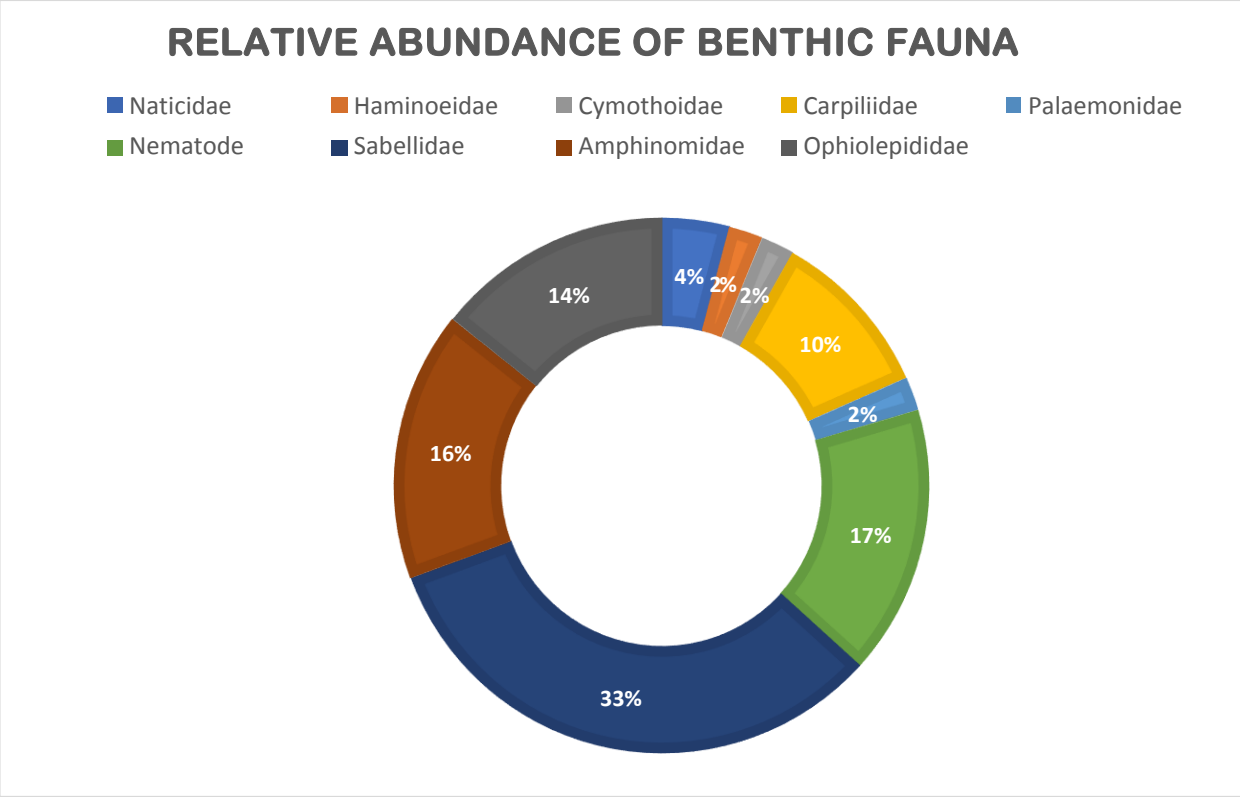


Figure 4-42: Relative Abundance of Families of Benthic Fauna

The species of marine worms were the most abundant with a total of 66% (32 individuals) followed by echinoderms with 14% (7 individuals). The polychaetae worms made up 49% of the collected marine worms, which comprised with feather-duster worms (*Bispira sp.*) and fire worms (*Hermodice sp.*) belonging to the families; Sabellidae (33%) and Amphinomidae (16%), respectfully. The unidentified nematode worm, to the family level, had 17% abundance. The two species of brittle stars (*Ophionereis reticulata* and *Ophiolepis superba*) with 14% belong to the family Ophiolepididae. Juvenile batwing coral crab (*Carpillus corallinus*) had an abundance of 10% belonging to the family Carpiliidae. The relative abundance of the other species, ranging from 2% to 4%, belong to the families of Naticidae, Haminoeidae, Cymothoidae and Palaemonidae.

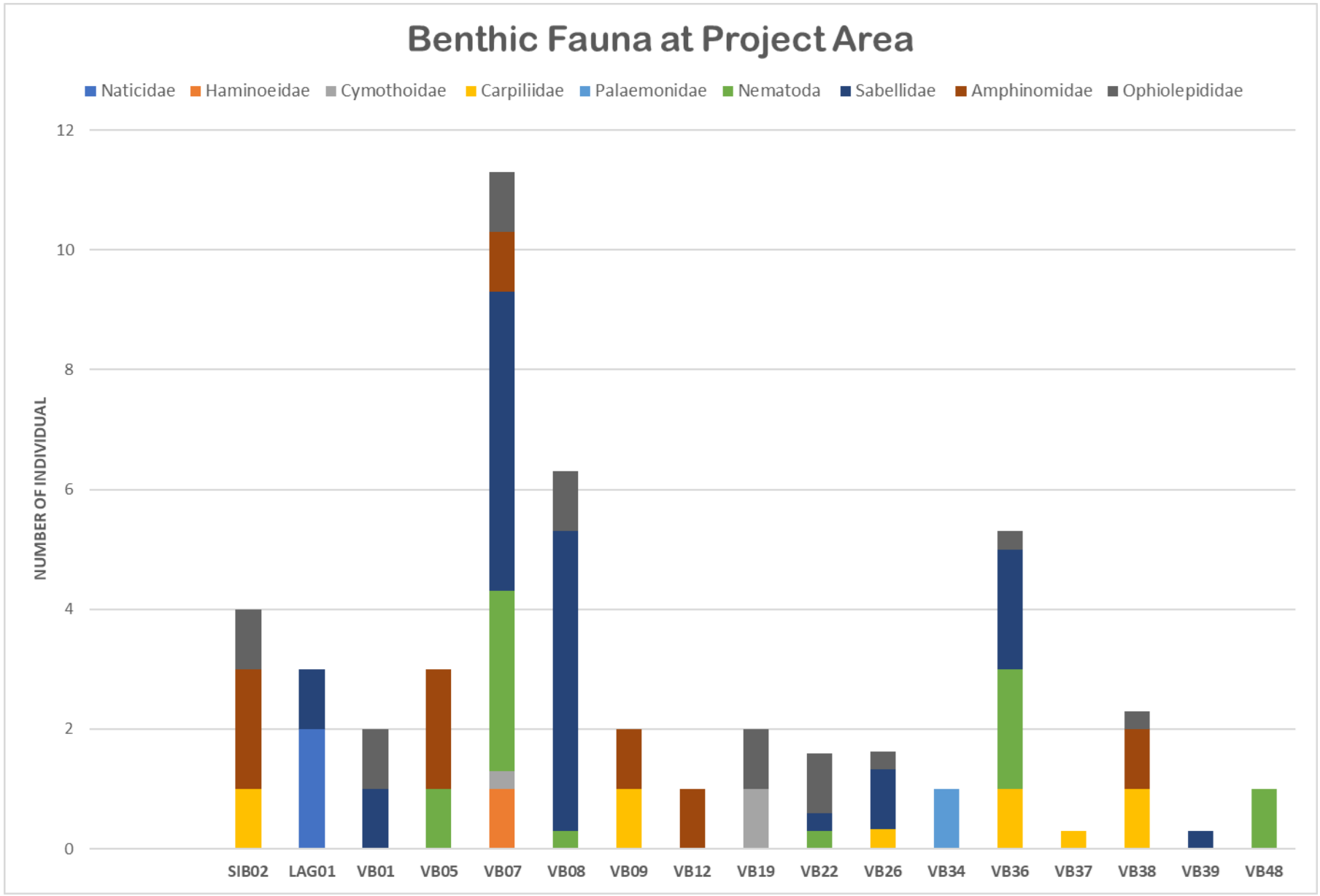


Figure 4-43 Distribution of Benthic Fauna in the selected sites for the Port of Magical Belize Project Area.

Figure 5 shows the distribution of the identified benthic fauna. Sites VB07 and VB 36 had six and four species, respectfully. The following sites had only one species of benthic fauna: VB12, VB37, VB39 and VB48. This observation corresponds with the results of evenness, see **Table 4-14**. The other species present in Site VB39 and VB48 were dead specimens comprised of broken pieces of coral and shells of mollusks. The polychaetae worms (Bispera sp. and Hermodice sp.) were collected at twelve sites of the seventeen sites. Site VB07 and VB08 each had five individuals of the Bispera sp. Site VB07 had species of feather duster worm, fire worm and brittle star (*O. reticulata*). The unidentified nematode worm was collected at six sites, namely: VB05, VB07, VB08, VB22, VB36 and VB48. Where site VB48 had one individual of the unknown nematode. The brittle star species of family Ophiolepididae were collected in nine sites, with an average of one individual at each site. *O. reticulata* were collected in eight sites and *C. coralinus* in six sites. The juvenile *C. corallinus* (family Carpiliidae) was collected at six sites, with an average of one individual at each site. Site VB37 had only one induvial of one species of *C. corallinus.* While VB34 had the only species of ghost shrimp (*P. paludosus*) of the family Palaemonidae. The two species of gastropods that belong to the families of Naticidae and Haminoeidae were collected in site LAG01 and VB07, respectfully. These species are *Natica sp.* and *Haminella solitaria*. Site VB07 and VB19 had the species of isopod (*Anilocra sp.)* from the family Cymothoidae.

According to the Biodiversity Indices shown in **Table 4-13** the eleven species in the seventeen sites of the project area have a very low diversity and evenness. The species richness was low in all the sites, with a range of 1 to 3; except for two sites: Site VB07 and VB36, with six and four, respectfully. Shannon-Wiener (H') Index (Range 1- 4.5) indicates a very low diversity if the value is near or less than 1. Sites SIB02, VB07 and VB36 had diversity ranging from 1.45 to 1.04, the other sites had the diversity index less than 1.00. The Pielou (J') evenness index indicates an even distribution of species in the area if the value is 1.00. The evenness corresponded to the Shannon-Weiner diversity. The highest evenness was site VB07 with 0.61, followed by site VB36 with 0.51 and site SIB02 with 0.43. Five sites had 0 (zero) evenness, namely; VB12, VB34, VB37, VB39 and VB48.

Table 4-14: Biodiversity of Benthic Fauna at the Port of Magical Belize Project Area.

Diversity Indices			
Sites	**Species Richness (S)**	**Shannon's (H')**	**Evenness (J')**
SIB02	2	1.04	0.43
LAG01	3	0.64	0.27
VB01	2	0.69	0.29
VB05	2	0.50	0.21
VB07	6	1.45	0.61

VB08	3	0.62	0.26
VB09	2	0.69	0.29
VB12	1	0.00	0.00
VB19	2	0.69	0.29
VB22	3	0.92	0.38
VB26	3	0.95	0.40
VB34	1	0.00	0.00
VB36	4	1.21	0.51
VB37	1	0.00	0.00
VB38	3	0.99	0.41
VB39	1	0.00	0.00
VB48	1	0.00	0.00

Estimates of Density and Biomass

The total biomass of the eleven species identified in seventeen sites, with a total of forty-nine individuals was 5.53/M^2 and the total density was 8.43 Ind/M^2.

Table 4-15: Classification, Relative Abundance, Composition and Biomass of the Benthic Fauna collected at the sites at the Port of Magical Belize Project Area.

Phylum	Class	Order	Family	Abundance (Ind/sp)	Density (Ind/M^2)	Biomass (g/M^2)
Mollusca	**Gastropoda**	**Littorinimorpha**	**Naticidae**	2	0.36	0.02
		Cephalaspidae	**Haminoeidae**	1	0.18	0.01
Arthropoda	**Malacostraca**	**Isopoda**	**Cymothoidae**	1	0.28	0.10
		Decapoda	**Carpiliidae**	5	0.68	0.24
			Palaemonidae	1	0.18	0.0009
Nematode			**Nematode**	8	1.33	0.98
Annelida	**Polycheata**	**Sabellida**	**Sabellidae**	16	2.84	7.78
		Amphinomida	**Amphinomidae**	8	1.33	0.23

Phylum	Class	Order	Family	Abundance (Ind/sp)	Density (Ind/M^2)	Biomass (g/M^2)
Echinodermata	**Ophiuroidea**	**Amphilepidida**	**Ophiolepididae**	7	1.25	12.32
TOTAL				**49**	**8.43**	**21.67**

The biomass and density for species in the families: Naticidae, Haminoeidae, Cymothoidae and Palaemonidae, corresponds to the abundance (1 – 2 individual) in those families; which were extremely low, biomass – 0.10 to 0.0009 g/$M^{2,}$ density – 0.36 to 0.18 Ind/M^2. The species of Ophiolepididae (Brittle stars) had the highest biomass with 12.32 g/M^2, followed by species in Sabellidae (feather duster worms) with 7.78 g/M^2. The biomass of the Brittle stars was heavier than that of the duster worms. See Table five.

The graph of **Figure 4-44** shows the biomass of benthic fauna was higher from families Ophiolepididae and Sabellidae. This statement was verified with Graph A in Figure Seven and Pie Chart B in Figure Eight, whereby, the density and biomass of *Bispera sp.* and *Ophionereis reticulata* were the highest. These two species made up 93% of the biomass of the benthic fauna in the project area, *Bispera sp.* with 36% and *Ophionereis reticulata* with 57%. Figure Six demonstrate similar distribution of biomass with the species abundance (**Figure 4-43**) and density (Figure Seven, Graph B) at the selected sites.

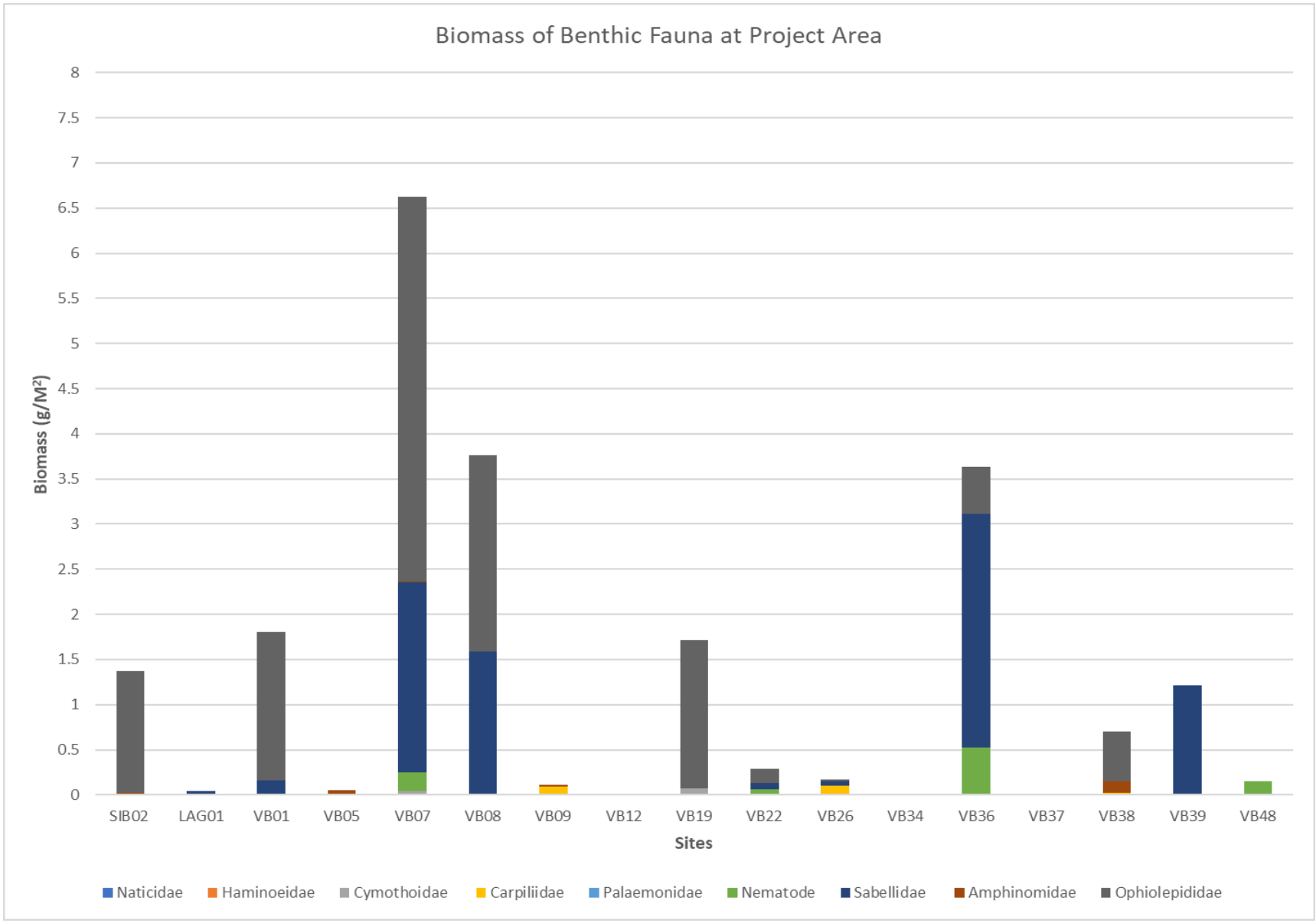
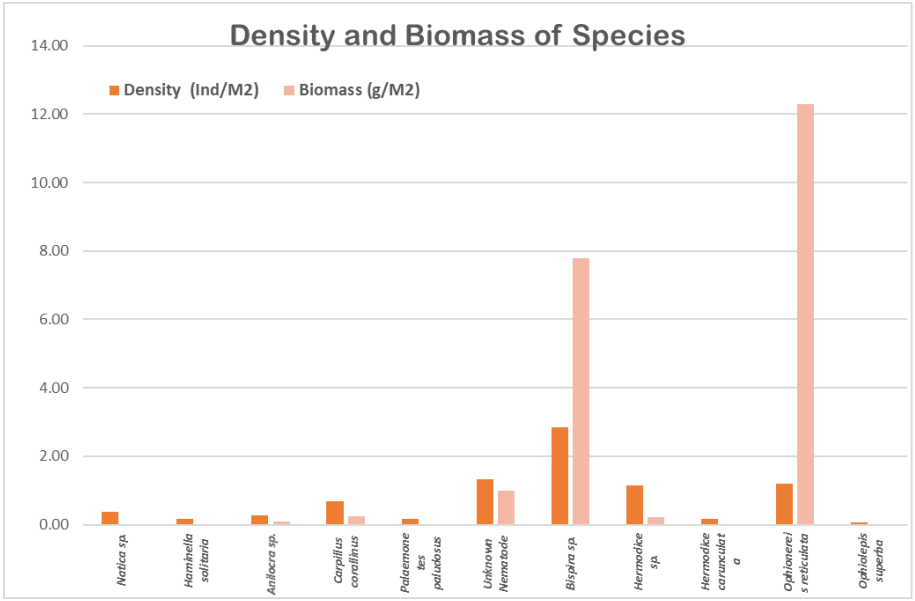


Figure 4-44: Biomass of species at the selected sites at the Port of Magical Belize Project Area.

Graph A



Graph B

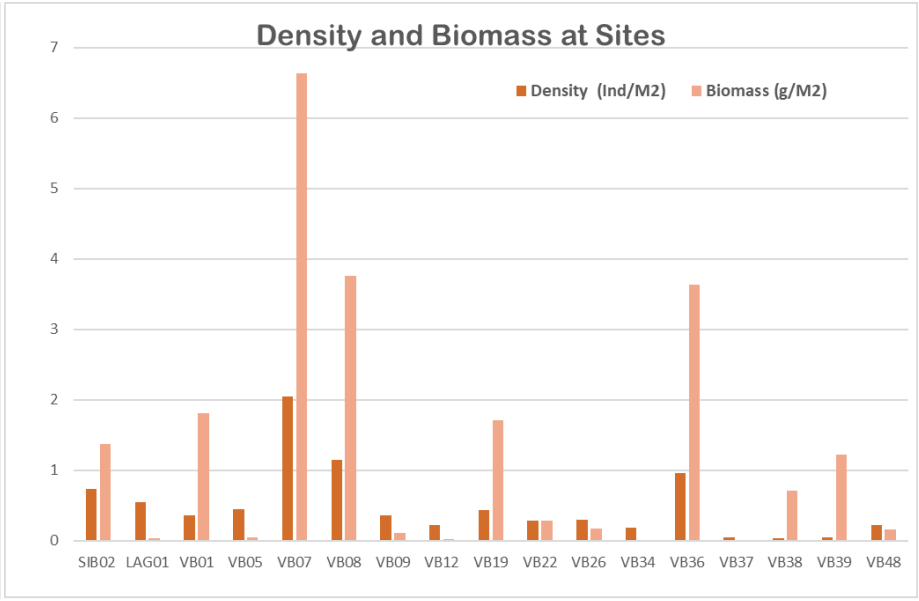
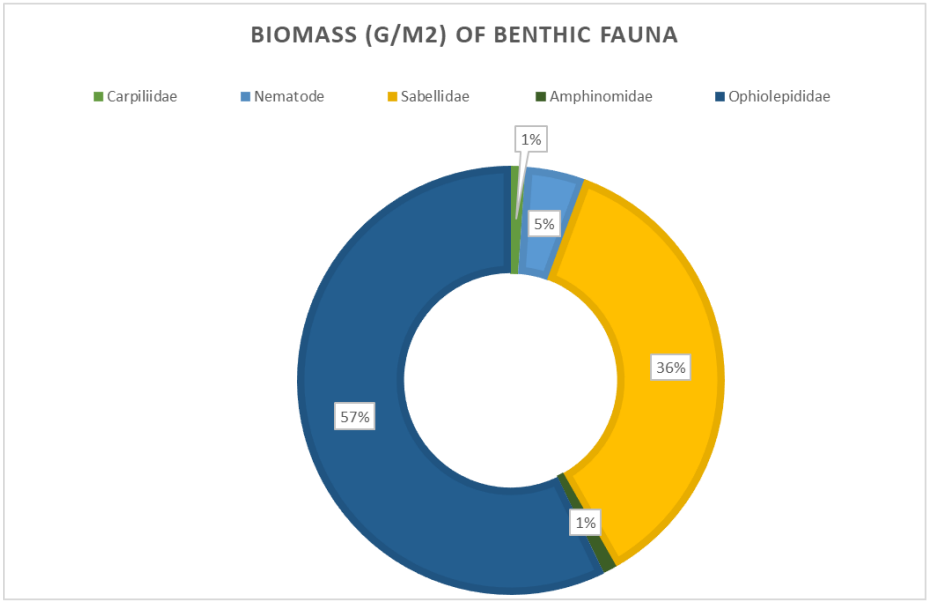


Figure 4-45: Comparison: Density and Biomass of Benthic Fauna at the Port of Magical Belize Project Area

A



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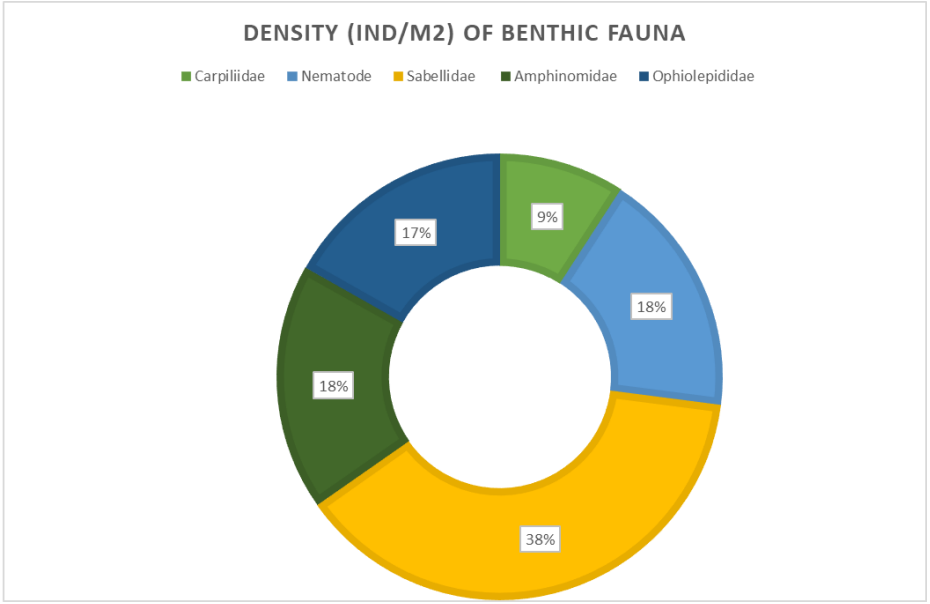


Figure 4-46: Biomass and Density of identified Benthic Fauna species at the Port of Magical Belize Project Area.

Conclusion

Overall, there was an extreme low diversity (1.45 – 0.00) and evenness (0.61 – 0.00) of the benthic fauna collected at the seventeen sites in the project area. The benthic fauna that make up the extreme low diversity, low distribution and abundance in the project area were marine worms (Sabellidae and Amphinomidae), brittle stars (Ophiolepididae), juvenile coral crab (Carpiliidae) and an unknown nematode. The biomass of these benthic fauna was also low with a total of 21.67 g/M^2. The brittle stars had 12.32 g/M^2, the feather duster worm had 7.78 g/M^2, fire worm just had 0.23 g/M^2 and for the juvenile coral crab had 0.24 g/M^2.

13.40% of the identified species were living specimens. Sites VB07 had the highest number of species (6) and highest biomass (6.630g/ M2) with *O. reticulata* having the highest biomass. This site had a diversity index of 1.45 and evenness of 0.61. Site VB36 had four species with the second highest biomass. Sites SIB2, VB08, VB22, VB26 and VB38, all had three species.

Site VB07, VB08 VB36, and VB39 had diversity of broken juvenile-size mollusks shells from Families Dentaliidae, Cardiidae, Veneridae, Tellinidae, Lucinidae, Conidae and Donacidae. Site VB48 had shells and broken corals, sand dollars and chiton. These broken specimens were from families Dendrophylliidae, Poritidae, Meandrinidae, Acroporidae, Pectinidae, Mellitidae and Chotonidae. Sites VB01, VB48 and VB37 had broken shell of Queen Conch (*L. gigas*).This is an indication that predators, such as, sting rays feed or dispose of its prey, gastropods. Shells of species from Family Cardiidae were present in all sites, except sites SIB02; while shells of Ivory Tusk, Family Dentaliidae, were present in all sites except sites SIB02 and LAG01. Shells from species of Family Tellinidae were present in all sites, except in site VB05.

There was no presence of rare or endangered species sampled at the sites of the project area. The identified species of marine worms and brittle stars are filter feeders that are present in areas where there are high levels of sediments (Tonon, et al., 2015) (Simon, 2007). The crab species collected and identified is of significance because it is under legal protection in Belize. The crab and shrimp species are under protection within the fisheries regulations and Marine Protected Areas regulations (Fisheries Belize, 2003). Within the fisheries regulations permits and boat license are required to harvest adult size soft shelled crustaceans (crabs and shrimps).

4.2.4 Marine Species of Conservation Significance

A list of marine species (reptiles and mammals) of conservation concern known to be present in the marine environment considered within the zone of influence of the project site are presented in **Table 4-16**. Although not observed during site visits and during the ecological survey, the American crocodile has been reported anecdotally to be found in the surrounding areas of the project site. Typically, they can be found in coastal lagoons, estuaries, cayes and atolls (CZMAI, 2014). The American crocodile is currently considered “vulnerable” by the IUCN and the Belize Fisheries Department considers it a “threatened species.” The American crocodile is also under CITES protection prohibiting its international trade.

Two marine mammals (Manatee and Bottlenose Dolphin) have been reported from this site. The presence of these mammals in the area were confirmed by visual sightings. Multiple visual sightings of manatees were made during field surveys within a stretch of the Sibun river approximately 1mi upstream from the mouth of the river. The Sibun river is approximately 3.7mi (6km) north of the main infrastructures of the proposed project; however, the construction of a bridge for road access will pass over the river in the vicinity of the mouth of the river. Similarly, multiple bottlenose dolphin sightings were made during field visits in a general area that is located approximately 1mi south east of the proposed location of the cruise ship pier.

Table 4-16: Marine Fauna of conservation significance identified at the Study Site.

Common name	Scientific name	Observed during survey	Reported Anecdotally
American Crocodile	*Crocodylus acutus*		P
Antillean Manatee	*Trichechus manatus*	P	P
Bottlenose Dolphin	*Tursiops truncatus*	P	P

The abundance of both species in the area is unknown; however, it appears that the area where sightings were made are not considered "hotspot" for these animals, rather these animals likely migrate through the area. In the case of the Antillean Manatee, it is well documented that the networks of freshwater rivers are regions of importance, as manatees require freshwater sources for survival (Castelblanco-Martinez et al. 2012). Anecdotal information is that manatees likely migrate from aggregation sites to access freshwater systems such as the Sibun river and the Belize river located north of the project site (Jamal Galvez, personal communication, January 2020). One of the few studies corroborating this shows that manatees migrate daily from Drowned Cayes to the mouth of the Belize river (Galvez et. al., 2013). Daily migratory patterns acquired through tagging and satellite tracking are presented in **Figure 4-47**.

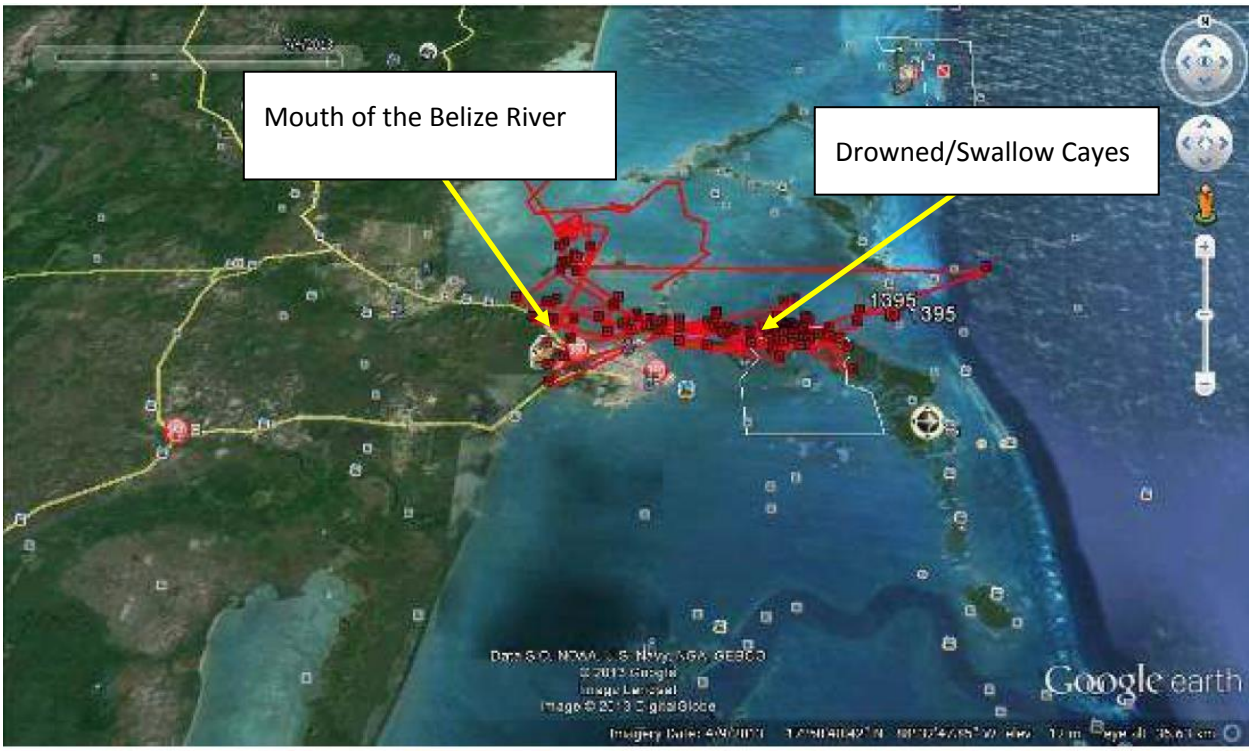


Figure 4-47: Image showing the movements of a tagged manatee with satellite transmitter attached. Source: Jamal Galvez.

There are two important manatee aggregation sites that are of relevance to the project: Southern Lagoon and the Drowned Cayes (Castelblanco-Martinez et al. 2012). The Southern Lagoon and the Drowned Cayes/Swallow Caye Wildlife Sanctuary (manatee reserve) are approximately 10 mi (16km) south and 13.7mi (22km) north east of the project site. Given the distance, these sites are considered outside the zone of influence of the project.

The two marine mammals (Manatee and Bottlenose Dolphin) that are reported from this site enjoy protection status under the National Parks System Act of Belize (CZMAI, 2014). In the case of the West Indian Manatee, the animal is listed as endangered by the U.S. Fish and Wildlife Service and has been listed as vulnerable to extinction by IUCN. The species is also protected under the CITES Regulations where it has been placed on Appendix I of the 'Species List'. Therefore, special consideration should be given to ensure that mitigation measures during the development and operation of the proposed cruise terminal are in place to protect these vulnerable species. Protection of these mammals is not only important to ensure the long - term survival of these species but also presents an ideal tourism attraction for sightings of these animals in the area.

Five species of sea turtle have been documented in the marine environment of Belize (Searle 2013). According to Searle (2013), the more commonly observed sea turtles by divers and snorkelers in Belize are the critically endangered hawksbill turtle (*Eretmochelys imbricata*), the endangered green turtle (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*). These are found throughout

shelf lagoon, along the main Barrier Reef and on the three offshore atolls (Searle 2013). Reports of the critically endangered leatherback turtle (*Dermochelys coriacea*) are rare, and while most reports are observations made at sea between the barrier reef and atolls, there have been three reports of sightings in the Victoria Channel (Searle 2013). There is one confirmed report of the vulnerable olive ridley (*Lepidochelys olivacea*) that was found stranded and entangled in fishing line in northern Belize in 2011 (Searle 2013). While there are no quantitative numbers on abundance of sea turtles in Belize, Searle & Day (2012) report that the Belize Sea Turtle Census for 2011 indicated the most common turtle observed in Belize was the hawksbill (*Eretmochelys imbricate).*

In regards to the presence of any of these endangered sea turtles close to the project site and its zone of influence, there is documented tracking data of migration of green turtles (*Chelonia mydas*), and hawksbill turtles (*Eretmochelys imbricata*) in and out of Robinson Point. Robinson Point encompasses the area at the mouth of the South Grennel's Channel and seagrass beds flanking the southern side of the channel (**Figure 4-48**).

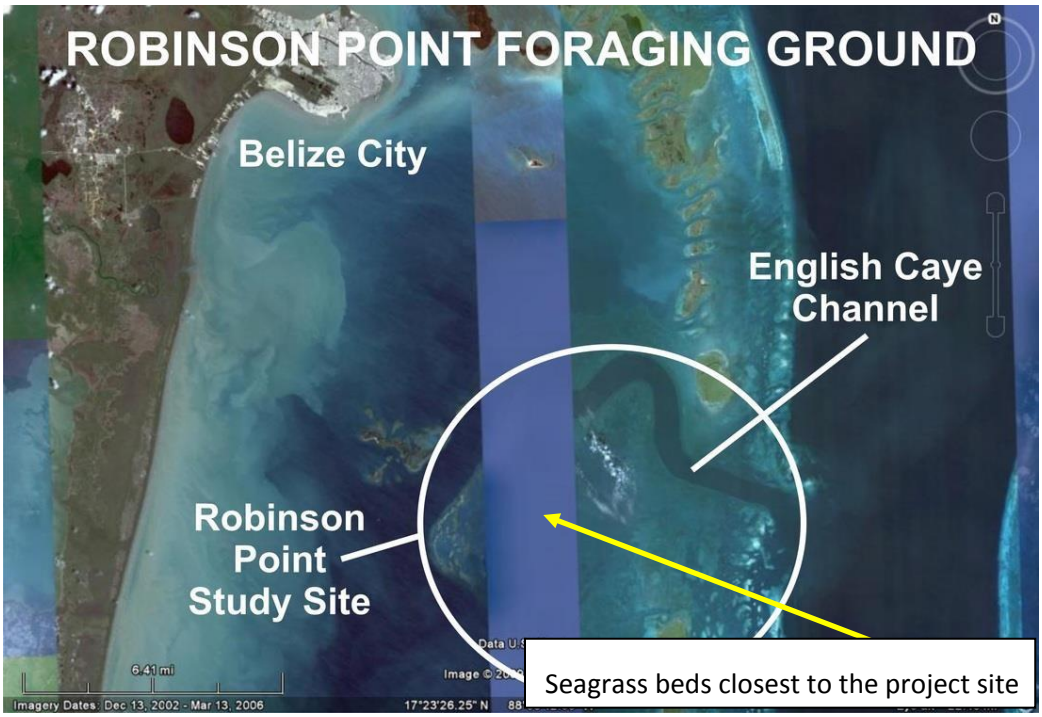


Figure 4-48: Map showing the area known as Robinson Point. Map adopted from Ecomar.

5 Water Resources

5.1 Methodology

Baseline water quality data was determined in-situ as well as by sending surface water samples to be analysed by a certified independent laboratory (El Colegio de la Frontera Sur Laboratory in Chetumal, Mexico). These sites were strategically selected based on proximity to the study site. More specifically, in-situ water quality assessments were conducted using a YSI professional plus multi parameter meter (YSI Inc., Yellow Springs, Ohio, USA) at several sites within and near the Port of Magical Belize project site on June 30th, 2019 from 9:00 am to 4:00 pm. As recommended by the DOE in the TOR, sampling sites were selected to represent the major water bodies (i.e. river, lagoon and sea). The proposed location for the Port of Magical Belize is shown in **Figure** 5-1. In the areas surrounding the proposed port there is currently no sewage system and all the storm water in the area discharges directly into the Northern Lagoon or into the sea. The proposed port is located 16km (10mi) south of Belize City, 5.7km (3.5mi) south of the mouth of the Sibun River and 21km (13miles) north of Gales Point. The sampling sites for the water quality physical and chemical parameters are shown on **Figure** 5-1. The water samples obtained from the sea, each site was two kilometres apart and in front of the property 4 water samples were taken (S5, S6, S7 and S8). Three water samples were obtained randomly for the Sibun River (R1, R2 and R3) and three from the Northern Lagoon (L1, L2 and L3). For the lagoon samples, L1 sample site was right next to the location for the Port of Magical Belize. Water samples were collected using a Niskin water bottle. Samples were taken from at one foot from the sea surface. Once the water sample was obtained, the water was poured into sterilized 250 millilitres bottles.

The physical parameters collected were; temperature, conductivity, salinity, dissolved oxygen, pH, ammonia and Total Dissolved Solids (TDS).

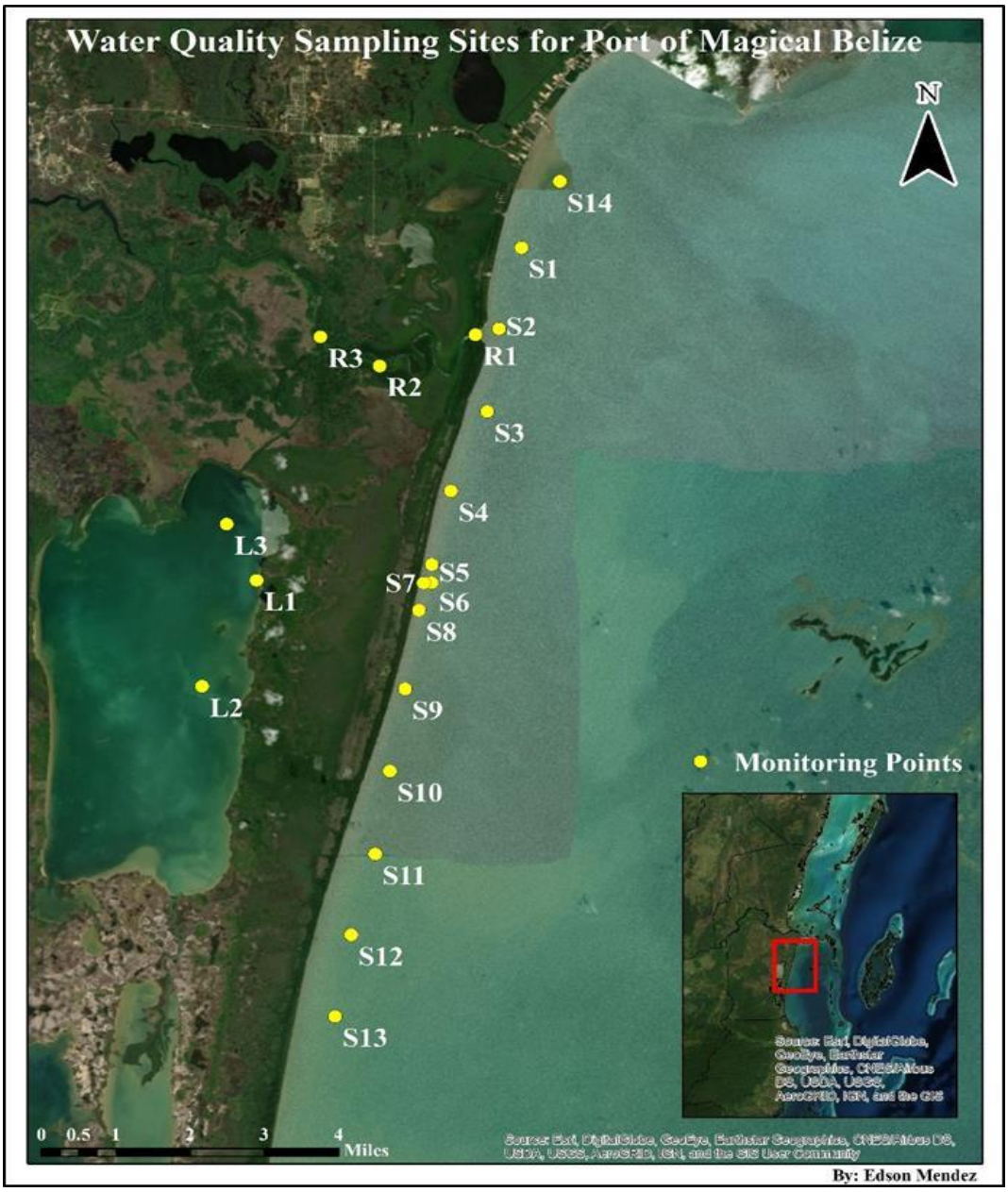


Figure 5-1: Sampling sites for the water quality analysis for Port of Magical Belize.

5.2 Baseline Water Quality

The results of the in-situ and laboratory chemical, and microbial water quality tests are summarised in Table 5-1 and

Table 5-2. Raw data results from the laboratory water analysis are presented in **Annex 6**. The results of the in-situ water quality are presented bellow in **Table** 5-2. **Table 5-1** represents the location, time and depth of the water collected at each site.

Table 5-1: Summary of Water Quality Site location.

Site	Description	LON (X)	LAT (Y)	WATER DEPTH (M)	Time
S14-1	Windward: 12 km North of Property: Old Belize	-88.245136	17.459340	3.00	15:50.15
S1-2	Windward:10 km North of Property	-88.252890	17.445071	3.00	9:02:13
S2-3	Windward: 8 km North of Property	-88.257386	17.427623	3.00	9:12:43
S3-4	Windward: 6 km North of Property	-88.259652	17.409879	3.00	9:24:48
S4-5	Windward: 4 km North of Property	-88.266914	17.392807	3.00	9:36:39
S5 -6	Windward: 413m North of Property	-88.270701	17.376993	1.00	10:06:18
S6-7	Windward: Center of Property	-88.270727	17.373111	1.00	10:14:53
S7-8	Windward: 175m East of Center of Property	-88.272340	17.373043	1.00	10:26:09
S8-9	Windward:710m South of Property	-88.273263	17.367171	1.00	10:53:05
S9-10	Windward: 2 km South of Property	-88.275976	17.350292	3.00	11:00:40
S10-11	Windward:4 km South of Property	-88.278930	17.332627	5.00	11:09:44
S11-12	Windward: 6 km South of Property	-88.281821	17.314835	7.50	11:19:11
S12-13	Windward: 8 km South of Property	-88.286596	17.297476	6.00	11:30:12
S13-14	Windward:10 km South of Property	-88.289731	17.279974	6.00	11:40:44
R1-15	River: Mouth OF Sibun River	-88.262120	17.426369	0.50	12:57:43
R2 -16	River: Change of Vegetation in Sibun River	-88.281668	17.419525	2.00	13:22:35
R3-17	River:	-88.281668	17.419525	2.50	13:29:35
L1-18	Lagoon	-88.306403	17.373407	1.00	14:12:51
L2-19	Lagoon	-88.317374	17.350589	1.00	14:40:36
L3-20	Lagoon	-88.312601	17.385372	2.00	14:56:15

Chemical analyses included: total phosphates (PO_4), Biological Oxygen Demand (BOD), total hardness, TDS, sulphate (SO_4) and Nitrate (NO_4). Microbial analyses included faecal coliforms, enterococcus and *Escherichia coli* (Table 5-3).

Table 5-2: Summary of Water Quality Site location.

Site	Temp (C)	DO (mg/L)	Specific Cond (uS/cm)	Conductivity (uS/cm)	TDS (mg/L)		PSU (PPT)	pH
S14-1	29.90	5.32	56703.00	61996.00	36855.00		37.56	8.09
S1-2	29.30	4.90	27560.00	30115.00	17375.00		17.25	8.14
S2-3	29.50	5.60	27496.00	29882.00	17875.00		16.79	8.13
S3-4	29.20	4.70	56374.00	60905.00	36660.00		37.34	8.09
S4-5	28.80	4.80	56163.00	60214.00	36530.00		37.20	8.06
S5 -6	28.90	5.00	56364.00	60578.00	36660.00		37.34	8.10
S6-7	29.00	5.00	55892.00	60196.00	36335.00		36.99	8.14
S7-8	28.00	5.20	54653.00	57818.00	35555.00		36.09	7.94
S8-9	27.90	5.30	53893.00	56875.00	35035.00		35.53	8.03
S9-10	28.60	5.10	52678.00	56236.00	34223.00		34.63	8.11
S10-11	29.10	4.80	53605.00	59367.00	35815.00		36.40	8.13
S11-12	29.20	4.80	56472.00	61017.00	36693.00		37.42	8.15
S12-13	29.20	4.90	56314.00	60801.00	36628.00		37.30	8.14
S13-14	29.20	4.90	60768.00	65644.00	39488.00		40.69	8.16
R1-15	29.90	4.80	55042.00	60551.00	35458.00		36.32	8.07
R2 -16	29.80	3.10	25411.00	27749.00	16516.50		15.39	7.07
R3-17	31.30	2.90	34188.00	38315.00	22223.50		15.30	7.64
L1-18	27.70	6.10	25131.00	26410.00	16334.50		15.25	8.16
L2-19	27.80	5.60	25822.00	27214.00	16783.00		15.70	8.20
L3-20	27.90	5.80	23357.00	24664.00	15054.00		14.07	8.19

Table 5-3: Summary of Water Quality Results for the Proposed Site.

Site	PO_4 (mg/L)	$N0_3$ (mg/L)	SO_4 (g/L)	TDS (g/L)	BOD (mg/L)	Hardness (g/L)	Total Coliforms CFUs/100mL	*E.coli* CFUs/100mL	Enterococcus CFUs/100mL
S14-1	< LD	0.0196	3.024	40.792	2.7994	6.8404	30.5	9.7	< 1
S1-2	< LD	0.0156	2.688	37.538	3.1994	6.3518	33.6	7.4	5.2
S2-3	< LD	0.0133	2.975	40.094	2.9994	6.5472	34.1	7.4	2.0
S3-4	< LD	0.0123	2.983	40.070	2.5995	6.7427	16.9	6.3	1.0
S4-5	< LD	0.0141	2.967	40.496	3.1994	6.7427	21.1	4.1	1
S5 -6	< LD	0.0131	2.916	38.738	1.9996	6.6450	34.5	7.4	1
S6-7	< LD	0.0176	2.835	37.990	3.1994	6.1564	24.0	3.1	7.4
S7-8	0.0035	0.0151	2.843	37.794	3.7992	6.4495	31.8	1.0	16.1
S8-9	< LD	0.0130	2.983	39.264	3.7992	6.5472	24.0	2.0	< 1
S9-10	< LD	0.0164	2.978	40.356	3.9992	6.5472	27.5	3.0	< 1
S10-11	< LD	0.0152	1.141	40.088	3.5993	6.5472	49.8	1.0	< 1
S11-12	< LD	0.0162	2.287	38.812	2.5995	6.6450	55.6	2.0	7.3
S12-13	< LD	0.0616	2.925	39.238	3.3993	6.5472	45.5	3.0	< 1
S13-14	< LD	0.0146	3.021	39.186	3.5993	6.7427	42.4	1.0	4.1
R1-15	< LD	0.0335	2.431	28.900	3.1994	5.8632	72.9	5.1	5.1
R2 -16	< LD	0.1002	0.418	6.592	1.9996	2.3453	62.6	3.0	45.0
R3-17	< LD	0.1035	0.431	5.358	1.1998	1.2704	53.4	5.1	48.7
L1-18	< LD	0.0766	1.171	15.234	2.3995	2.8339	116.9	2.0	1.0
L2-19	< LD	0.0711	1.296	16.838	2.1996	2.9316	103.6	2.0	1.0
L3-20	0.0088	0.0657	1.185	15.276	2.4662	2.8339	124.2	2.0	< 1
DOE Limits	5 mg/L	3 mg/L	50 mg/L	2,000 mg/L	35 mg/L	350 mg/L (EPA)	200/100 ml	126-100 ml	35-100 ml

<LD – Lower than the detectable range for the methodology.

5.2.1 Water Quality Standards and Water Sample Tests Results

Temperature

Considered one of the most important physical parameters because it directly affects the life processes and distribution of marine life (Nybakken and Bartness, 2005). It can directly or indirectly affect reproductive rates, survival and migration patterns of aquatic organisms. Many water quality parameters will vary depending on the temperature, particularly DO and BOD.

Temperature of all *in situ* readings varied between 27.70 to 29.90°C (

Table 5-2). Temperature can vary depending on readings taken either latitudinal or vertically (Nybakken and Bartness, 2005). It can also vary during seasons or the time of the day that the readings are taken. Temperatures are normally in the higher range in shallow waters; however, the temperatures here were in the mid to higher part of the range even though most of the sites had depths of less than 3m. Four sites (S10-11, S11-12, S12-13 and S13-14) had depth between 5 and 7m. Temperature results show that all sites were within the recorded for tropical regions which are 20-30°C (Nybakken and Bartness, 2005) during a summertime.

Dissolved Oxygen

DO is the amount of oxygen present in a sample of water. The DO is mainly dependent on the rate of photosynthesis and respiration; temperature and depth (Castro and Huber, 2005). DO becomes limiting in aquatic environments when there is rapid decomposition of organic matter by aerobic organisms. In general, marine organisms will thrive between 3-5 mgl/L (Fondriest Environmental, Inc. 2013).

All sites had DO amounts that were well within normal range (3.10 to 5.60 mg/l) only one site (R3-17) recorded a slightly lower DO levels 2.90 mg/L, this amount might have been as a result of decomposition since at the site there was a lot of organic matter floating in the area. Oxygen enters the surface water mainly through the atmosphere or by plant photosynthesis (Fondriest Environmental, Inc. 2013).

Conductivity

Conductivity is a measure of the ability of a water body to transmit electrical current; it is affected by the presence of varied concentrations of dissolved ions in water. Typically, seawater has a conductivity value of about 55000mS/cm and freshwater of 100-2,000mS/cm (Fondriest Environmental, Inc. 2013). Seawater has higher conductivity than freshwater because of the higher concentrations of ions present in it. Values for all samples were above the normal range for both seawater and freshwater (

Table 5-2). Conductivity in seawater is normally affected by several factors like; temperature, and salinity/TDS. No guidelines have been established to regulate specific conductance since high values are found to correlate with total dissolved solids. In freshwater, geological effect is the factor which will have the major impact on conductivity levels (Fondriest Environmental, Inc. 2013). As observed on the results, conductivity levels for the river sites and lagoon were high possible because of clay and high TDS levels present in the area.

pH

When free hydrogen ions are available in water it causes the solution to be acidic; less hydrogen result in an alkaline solution (Nybakken and Bartness, 2005). pH is one of those factors that are critical in many chemical processes e.g. oxidation and weathering. pH levels between the range 7 to 9 (Nybakken and Bartness, 2005) is best suited for aquatic survival. It can also affect the solubility of toxic chemicals and heavy metals in seawater (Fondriest Environmental, Inc. 2013). All the pH values were within the normal range.

Salinity

Salinity can be defined as the total solid material in one kilogram of water after all initially present carbonate has been converted to oxide (Thurman, 1991). Dissolved solid substances include inorganic salts (present as ions, chloride, sodium, sulphate, magnesium, calcium and potassium), organic compounds and dissolved gases (Nybakken and Bartness, 2005). According to Nybakken and Bartness (2005) the salinity in seawater varies between 34 to 37 psu as you move away from the coast. Salinity will be directly affected by evaporation and precipitation rates; as well as freshwater runoff from the mainland.

The salinity with sites (S1-2, S2-3, R2-16, R3-17, L1-18, L2-19 and L3-20) near fresh water the salinity was lower than 17 psu. While the sites in sea water the psu was greater than 35 (S8-9). The sites far from freshwater runoff presented the highest salinities (S13-14 which 40.69 psu).

Orthophosphate (Phosphate (PO_4), mg/L)

Living organisms need nutrients like nitrogen and phosphorous for growth, metabolism and reproduction (Patey et. al, 2008). When excess phosphate is present in the water, algae and weeds will grow rapidly, choking waterway, and using up large qualities of oxygen. The result may be the death of many fish and aquatic organisms. Phosphorus is one of the key elements necessary for growth of plants and animals. Phosphates are required for nucleic acids, phospholipids and adenosine triphosphate production (Patey et. al, 2008). Phosphates (PO_4) are formed from this element. Phosphates exist in three forms: orthophosphate, metaphosphate (or polyphosphate) and organically bound phosphate.

The water quality test result (

Table 5-3) show that phosphate levels were general low in all sites and far below the acceptable limit set by DOE. Concentrations level were lower than the detectable range for the methodology for most of the sites except for site S7-8 and L3-20. The site with the highest concentration was site L3-20 with 0.0088 mg/l and site S1-2 with 0.0035 mg/L.

Nitrate (N, mg/L)

Nitrate is commonly present in surface and groundwater's and is the most highly oxidized form of the nitrogen compounds. This because nitrate is the end product of aerobic decomposition of organic nitrogenous matter. Apart of agricultural practices, nitrates can be present in the natural environment by runoff from septic systems and naturally by decaying organic matter. Water with low pollution will only have little concentrations of nitrates (less than 1 mg/L).

Nitrogen, like phosphorous, is important for plant nutrient, growth, metabolism and reproduction (Patey *et. al,* 2008). Nitrogen is an essential component of amino acid, nucleic acids and other biological molecules of cells (Patey et. al, 2008). Nitrates are a form of nitrogen, which is found in several different forms in terrestrial and marine habitats.

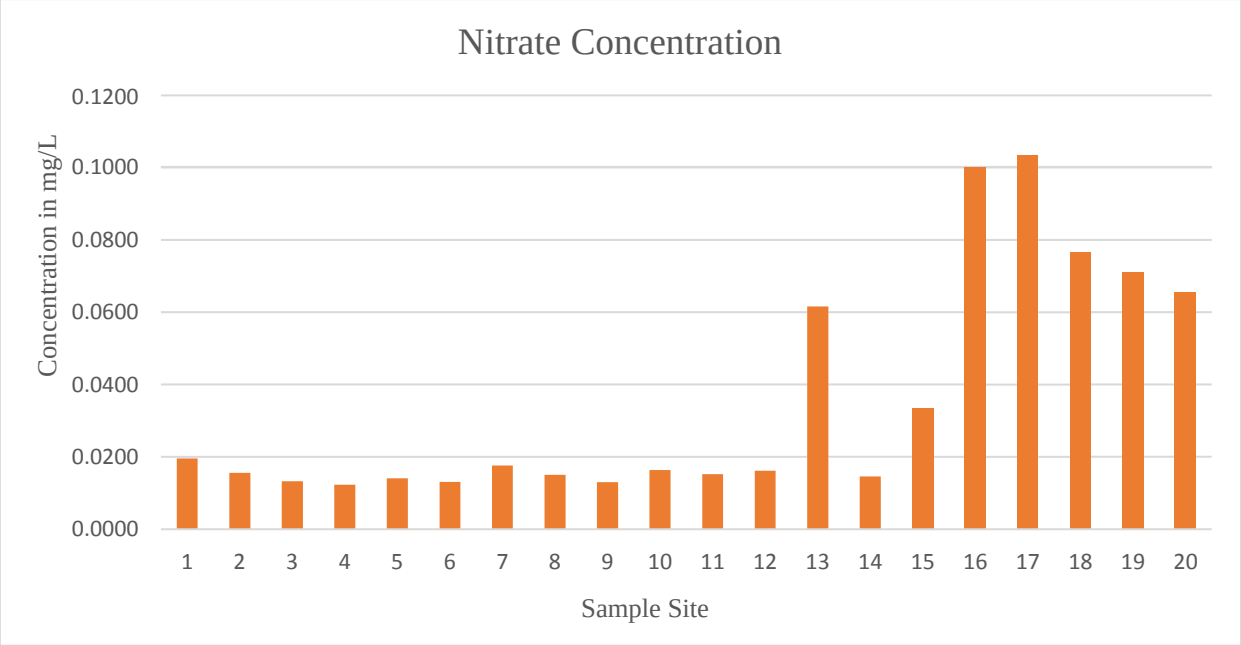


Figure 5-2: Nitrate concentration at the twenty sampling sites in PMB aquatic ecosystems. These forms of nitrogen include; ammonia (NH3), nitrates (NO3), and nitrites (NO2). Nitrates in excess amounts can lead to significant water quality problems. Phosphorus and nitrates in excess can stimulate plant growth, especially algae which latter can lead to eutrophication. The subsequent death and decay of the algae produces secondary effects on the water quality which will affect the oxygen concentration in bodies of water.

The concentrations of nitrate for all sites were less than 0.11 mg/L. The highest concentration was located at site R3-17 with 0.1035 mg/L and the lowest at site S3-4 with 0.0123 mg/L. All sites were within the acceptable range (**Figure 5-2**).

Sulphate (SO_4^{2-})

Sulphate is the second major anion in water just after bicarbonate. Sulphates are salts that are made up from sulfuric acid and be found natural occurring or as a result of anthropogenic factors.

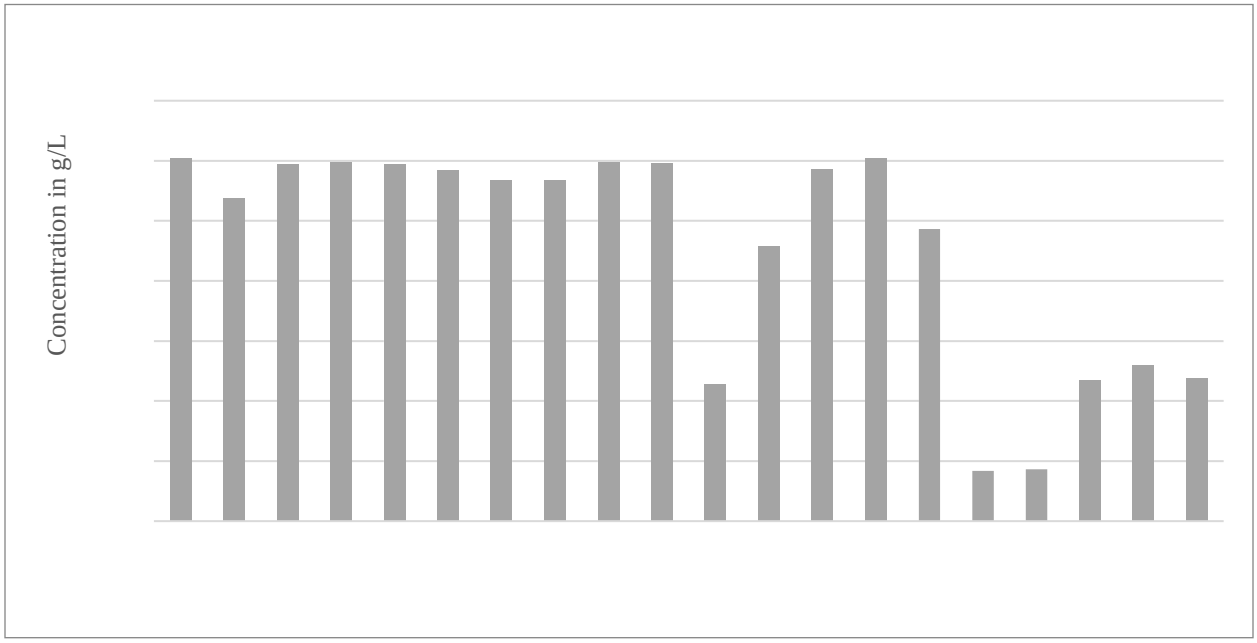


Figure 5-3: Sulphate concentration at the twenty sampling sites in Port of Magical Belize.

In nature, sulphates occur as a result of leaf decomposition, water passing through rock or soil containing gypsum or limestone, volcanoes, decomposition and combustion of organic matter and from sea salt over the oceans. By anthropogenic factors, sulphate is discharged into the aquatic environment in wastes from industries that use sulphates and sulfuric acid, such as mining and smelting operations, craft pulp and paper mills, textile mills and tanneries.

The sulphate ion is reported to cause cathartic action in humans at a concentration above 250mL (DOE, 1995). High sulphate concentration also contributes to poor water taste in the presence of sodium and magnesium.

Table 5-2 is a summary of Water Quality Guidelines for water use dissolved sulphate as mg/L SO_4.

The concentrations of sulphate for all sites was less than 3.1mg/L. The highest concentration was located at site S14-1 with 3.024g/L and the lowest at site R2-16 with 0.418g/L. All sites above the acceptable range (**Figure 5-3**). The high concentrations of sulphate can be explained because of the sedimentation rate present in the area.

Total Dissolved Solids (TDS, g/L)

TDS The Total Dissolved Solids (TDS) refers to the total dissolved organic and inorganic materials present in seawater. TDS are not often considered as principal pollutants in seawater because the salts present would naturally cause the TDS to be more than 35,000mg/l. The Belize Department of the Environment has as limits for drinking water of 2,000mg/L.

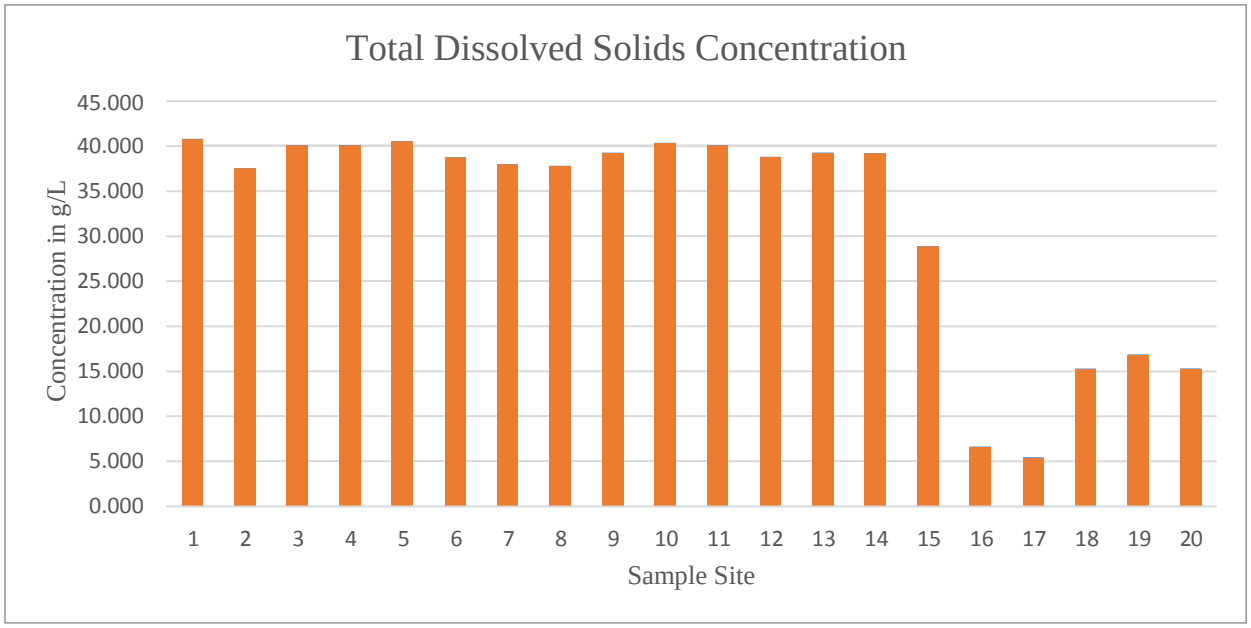


Figure 5-4: Total Dissolved Solids concentration at the twenty sampling sites in Port of the Magical Belize.

The amount of solid materials in suspension may result from natural erosion, runoff, and algal blooms, although some of this material may be the result of anthropogenic activities. The concentration and particle size may cause significant variation of turbidity values. TDS is normally high during the rainy season runoff. High turbidity reduces the photosynthesis of submerged, rooted aquatic vegetation and algae; this reduced plant growth may in turn suppress fish productivity. TDS therefore, can affect aquatic biological communities. Water quality guidelines suggest that discharges resulting from human activities should not alter ambient turbidity levels.

TDS levels for all sites were beyond the acceptable range (**Figure 5-4**). The lowest concentration was found at site R3-17 with 5.4g/L and the highest at site S14-1 with 40.8g/L. The high

concentration of TDS can be attributed to the high sedimentation that is found in the area which is influenced by the Sibun River. The Sibun River drains an area of approximately 970km^2 and a discharge ranging between 5 to 250 m^3 s^{-1}.

Oxygen Demand (BOD, mg/L)

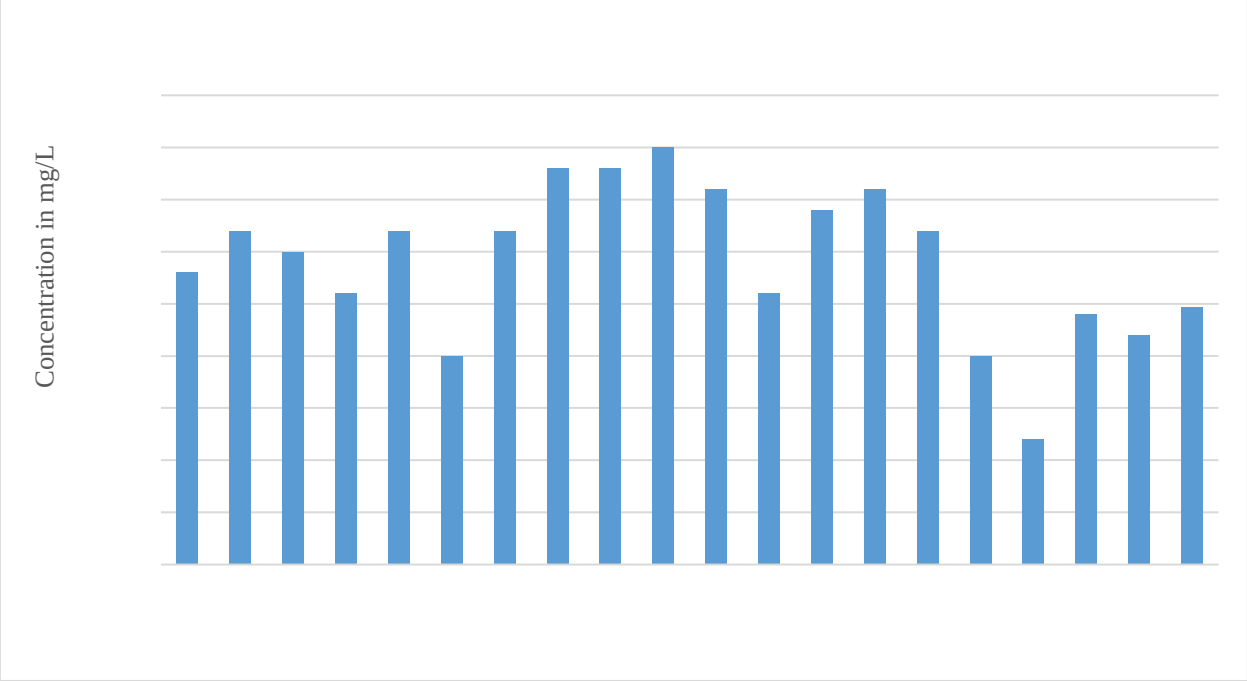


Figure 5-5: Biological Oxygen Demand concentration at the twenty sampling sites in Port of Magical Belize.

Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen required for microorganisms to decomposing organic matter in given water samples at a particular temperature at a specific period of time. BOD also measures the chemical oxidation of inorganic matter or the extraction of oxygen from water via chemical reaction (APHA, 1992). A test is used to measure the amount of oxygen consumed by these organisms during a specified period of time (usually 5 days at 20°C). Variables such as: temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water will affect the rate of oxygen consumption.

Wastewater from sewage treatment plants often contains organic materials that are decomposed by microorganisms, which use oxygen in the process. Presence of this wastewater will therefore significantly increase the BOD. Other anthropogenic sources of oxygen-consuming waste include storm water runoff from farmland or urban streets, feedlots, and failing septic systems; natural sources can include leaves and woody debris and dead plants and animals.

BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly oxygen is being depleted in the stream. This means less oxygen is available for

use by larger forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die.

The BOD ranged between 1 to 4mg/L. Site S9-10 had the highest concentrations with 3.9992 mg/L, while sites R3-17 had the lowest concentrations with 1.1998mg/L. All sites were below the acceptable range (**Figure 5-5**). DOE limits for this parameter does not reflect the normal range found in fresh water and sea water but effluent discharge. In water bodies the normal range is 0-5mg/L.

Hardness

Hardness is a measure of the total dissolved mineral salts in water with focus mainly on calcium, magnesium and other ions. Aquatic organisms, like fish are directly affected by the total hardness of water. These organisms are affected when the total harness is above 350 mg/L. Their growth, transfer of nutrients and waste products through cell membrane, spawning (sperm transfer, egg fertility or hatching) and the proper functioning of vital organs like the kidney can be affected. All sites had concentrations higher than the limits stipulated by EPA. The high concentrations of sulphate can be explained because of the sedimentation rate present in the area.

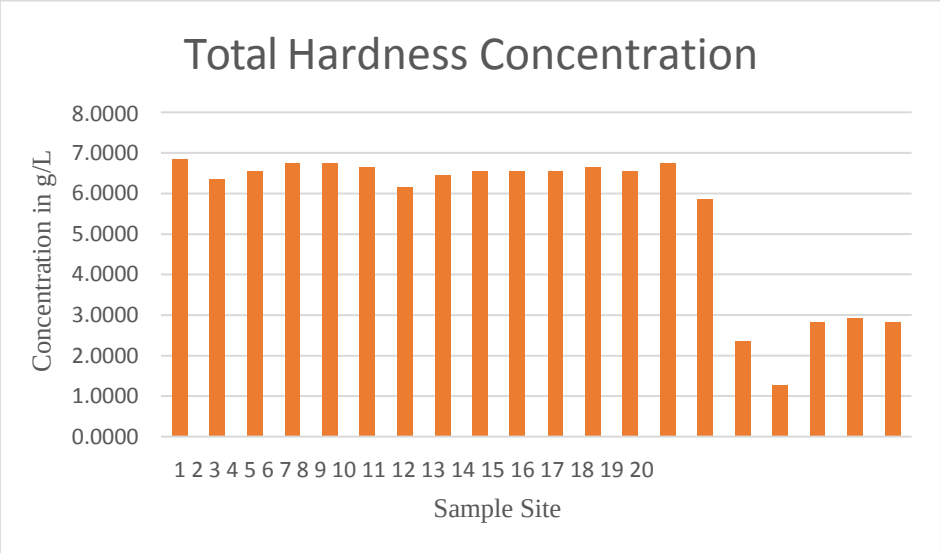


Figure 5-6: Total hardness concentration at the twenty sampling sites in Port of Magical Belize.

Bacteriological Quality

Coliform bacteria are rod shaped, Gram-negative bacteria that are unable to form spores. The term "coliforms" encompasses several genera of bacteria belonging to the family Enterobacteriaceae. Most coliforms are harmless and are naturally found in soil, water, and the digestive system of animals. A subset of this group called faecal coliforms are present in abundance in the faeces and intestinal tracts of humans and other warm-blooded animals. Faecal coliforms can enter water bodies through contamination with human and animal waste.

Most faecal coliforms do not cause disease, i.e. they are not pathogenic, but because of their source, they are usually found alongside microorganisms that are pathogenic such as those responsible for dysentery, gastroenteritis, and hepatitis A. It would be difficult and costly to test for the multitude of possible pathogens associated with faecal matter. It is therefore a common practice to just test for faecal coliforms as indirect evidence of potential contamination from faeces and therefore the potential presence of pathogens associated with faeces. Rapid assessment of total coliform presence is normally done using an assay for bacteria containing the enzyme β-galactosidase. A colour change in a dyed substrate indicates that these bacteria are in the water sample. If many faecal coliforms are found in a water sample (over 200 colonies/100 mL of water), the water sample is deemed to likely be contaminate with faeces.

Enterococci are another set of bacteria that is used as an indicator of possible faecal contamination of a water sample. These bacteria are found in the gastrointestinal tract of a variety of animals including human and other mammals, birds, reptiles and insects. It is often used along with coliform tests when conducting water quality tests for marine waters because it is better able to survive the saline conditions.

Escherichia Coli (E coli, /100 ml)

Presence of one particular specie of the Enterobacteriaceae family, called *Escherichia coli*, is especially associated with faecal contamination because it is one of the few coliforms that does not naturally grow and reproduce in the environment. *E. coli*, depending upon the strain may grow at 37^{o}C or at 44-45^{o}C (PAHO/MASICA/PROAGUA, 1994). It is differentiated from the other coliforms by presence of the enzyme B-glucuronidase. Two routine methods for identification and counts for *E. coli* have been accepted as standards both nationally and internationally: The Most Probable Number and the Membrane Filtration Method. Potable water should have *E. coli* counts of 0 colony/100 mL of water. Nevertheless, 1 colony/100 mL of water is the recommended limit with 5% or fewer of all collected samples exceeding this limit being considered as acceptable.

Both the *E-coli* and Faecal Coliform levels at all sampling sites were below the limit with counts of 0 colony/100 mL of water.

The Enterococci counts in some samples were a little above the DOE recommended limit of 35 CFU/100mL. This may be due to the high sedimentation in the area. Although, used as an indicator for faecal matter, it is known that Enterococci can be found in habitats that are have limited or no contamination human or animal faeces. They can survive and reproduce in places other than the gastrointestinal tract e.g. in soil, sediments, beach sand and various vegetation (Byappanahalli, 2012). They are also able to withstand a range of temperatures (Byappanahalli, 2012). Enterococci have also been shown to thrive in detritus and natural plankton (Mote, 2012).

5.3 Additional Surface Water Baseline Study

Given the importance of properly assessing and establishing water quality baseline data for the project, we went beyond the water testing requirements established in the TOR for the project and

in October 2019, an fieldwork campaign was performed to gather an extensive baseline dataset for the Port of Magical Belize project. The fieldwork campaign was executed by a combined team of Belizean and International experts.

Like previous sampling campaigns, samples were taken from various locations:

- Offshore in the area of the planned development.
- At the mouth of the Sibun river.
- In the northern Lagoon near the area determined for future onshore development.

All samples were taken from a boat. Field measurements were conducted using a YSI professional multi parameter meter. Water samples for chemical analysis were taken with a Niskin water bottle. All surface water samples were taken halfway the water column after establishing the exact water depth at the sample point.

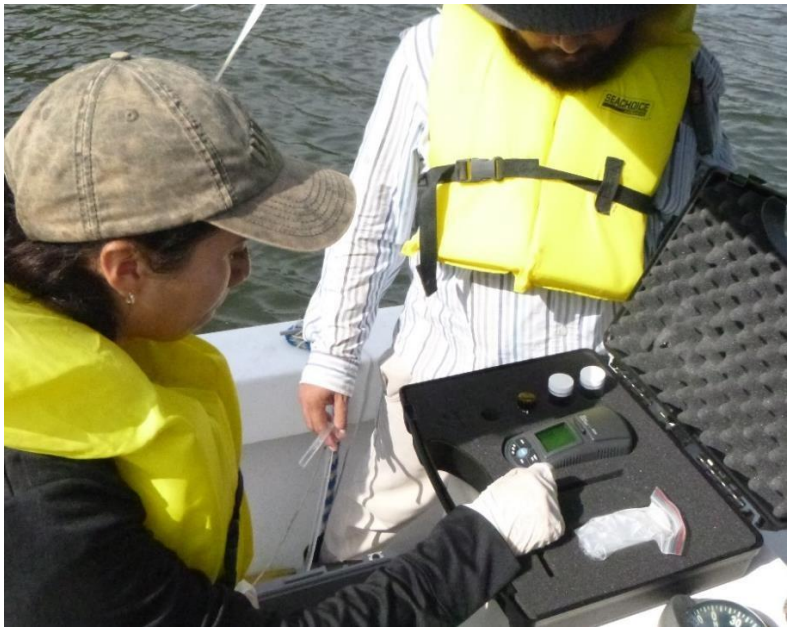
	
Measuring TDS in the field	Preparing the Niskin bottle for sampling

Figure 5-7: Sampling locations of surface water sampling points for Port of Magical Belize

In total, twenty (20) surface water samples were taken of which the physical parameters were measured and recorded in the field. These physical parameters were; Temperature, Conductivity, Salinity, Dissolved Oxygen, pH, Total Dissolved Solids (TDS). The obtained field data is included in the table below (**Table 5-4**).

Table 5-4: Field measurement data surface water sampling.

Sample point	Date	Time	Equipment	Depth	pH	Conductivity	Dissolved Oxygen		Turbidity	Temperature	Salinity	TDS	Visibility
				m		(us/cm)	mg/L	%	(NTU)	(°C)	ppt	mg/l	(m)
SIB 2	7-Oct-19	2:00 PM	YSI	11,6	7,61	47614	5,6	88,4	3,4	30,7	29,0	29328	
SIB 1	8-Oct-19	9:30 AM	YSI	10,6	8,40	18,95	7,8	104,3	3,5	28,1	0,0	12,17	1,0
LAG 2	8-Oct-19	11:28 AM	YSI	0,8	8,71	27084	7,3	103,8	14,3	28,5	16,5	17604	
LAG 1	8-Oct-19	11:50 AM	YSI	1,4	8,79	27849	7,4	106,2	106,2	29,2	17,0	18102	
vb-01	8-Oct-19	2:30 PM	YSI	4,2	8,59	55527	5,9	98,2	3,9	30,0	36,7	36092	
vb-05	8-Oct-19	3:22 PM	YSI	3,0	8,66	55375	6,2	101,4	3,5	30,2	36,6	35994	
vb-03	8-Oct-19	4:25 PM	YSI	5,3	8,66	55454	6,2	101,3	3,7	30,4	36,6	36045	
vb-38	9-okt-19	12:00 PM	YSI	14,5	8,60	56273	6,0	97,0	0,1	30,0	37,2	36577	
vb-48	9-okt-19	2:00 PM	YSI	10,0	8,37	56126	6,1	99,7	0,2	30,1	37,1	36482	
vb-34	9-okt-19	3:55 PM	YSI	10,0		56242	6,1	99,1		30,0	37,2	36557	2,4
vb-37	10-okt-19	9:10 AM	YSI	13,0	7,91	56073	6,0	97,2	2,0	30,0	37,1	36447	2,0
vb-06	10-Oct-19	11:55 AM	YSI	8,5	7,98	55914	6,0	98,0	0,8	30,0	37,0	36344	
vb-09	10-Oct-19	1:59 PM	YSI	10,3	*	55830	6,2	100,2	1,5	30,0	36,9	36289	
vb-12	11-Oct-19	9:05 AM	YSI	7,3	*	60558	6,1	98,6	2,9	29,8	36,7	36072	1,8
vb-19	11-Oct-19	10:23 AM	YSI	12,3	*	61474	5,9	96,3	1,0	30,0	37,2	36502	2,8
vb-07	11-Oct-19	12:20 PM	YSI	9,8	*	60603	6,2	100,8	1,6	29,9	36,6	36016	1,4
vb-08	11-Oct-19	1:45 PM	YSI	7,2	*	60191	6,4	104,2	2,6	30,1	36,2	35667	1,2
vb-36	12-okt-19	9:10 AM	YSI	7,2	*	55319	6,1	98,9	2,3	29,8	36,5	35957	1,6
vb-39	12-okt-19	10:10 AM	YSI	10,8	*	55864	6,1	98,2	1,3	29,9	36,9	36231	1,4
vb-22	12-okt-19	11:12 AM	YSI	10,1	*	55179	6,3	100,8	1,2	29,7	36,4	35867	1,1

*	measurements not carried out due to malfunctioning meter.
	for this sample also chemical analysis were performed

At ten (10) sample points also samples were taken for chemical parameters to be analysed in the laboratory. These locations of these sample points are included in the table below (**Table 5-5**).

Table 5-5: Sampling points for chemical analysis.

Sampling Point	Sample type	Sample date	Easting	Northing
vb-05	surface water sample	8-10-2019	366181	1919888
vb-08	surface water sample	11-10-2019	366635	1920557
vb-09	surface water sample	10-10-2019	366813	1919988
vb-12	surface water sample	11-10-2019	367307	1919966
vb-22	surface water sample	12-10-2019	368315	1918311
vb-34	surface water sample	9-10-2019	368100	1915979
vb-39A	surface water sample	12-10-2019	368090	1920066
vb-48	surface water sample	9-10-2019	371654	1918088
Sib2	surface water sample	7-10-2019	365836	1927132
Lag1	surface water sample	8-10-2019	360950	1920851
note: sampling point vb-39A is indicated in the laboratory certificate under code vb-39.				

Chemical analyses were performed in the environmental laboratory of Eurofins Analytico in The Netherlands. The following chemical analysis were performed on selected samples: phosphate, dry residue, total organic carbon, suite of metals (16), inorganic compounds (12), chlorinated hydrocarbons and pesticides (19).

The analytical results are shown in the tables below (**Table 5-6**).

Table 5-6: Laboratory results in surface water.

Water sample		Lag1	Sib2	Vb-05	Vb-08
Date		8-10-2019	7-10-2019	8-10-2019	11-10-2019
MISCELLANEOUS					
2-Phosfate (as PO4) (ortho-Phosphate)	mg PO4/l	< 0,06	< 0,06	< 0,06	< 0,06
Phosphate (as P2O5)	mg P2O5/l	< 0,12	< 0,12	< 0,12	< 0,12
Dry residue, undissolved components	mg/l	2,5	2,2	4,2	2,9
Total organic carbon (TOC)	mg/l	4,7	3,9	2,3	2,4
METALEN					
Antimony	µg/l	< 5	< 5	< 5	< 5
Arsenic [As]	µg/l	< 3	< 3	< 3	< 3
Barium [Ba]	µg/l	31	13	7,8	7,7
Beryllium [Be]	µg/l	< 10	< 10	< 100	< 100
Cadmium [Cd]	µg/l	< 0,4	< 0,4	< 0,4	< 0,4
Chromium [Cr]	µg/l	< 20	< 20	< 200	< 200
Cobalt [Co]	µg/l	< 1	< 1	< 1	< 1
Copper [Cu]	µg/l	< 30	< 30	< 300	< 300
Mercury [Hg]	µg/l	< 0,04	< 0,04	< 0,04	< 0,04
Lead [Pb]	µg/l	< 3	< 3	< 3	< 3
Molybdenum [Mo]	µg/l	5,8	4,2	12	12
Nickel [Ni]	µg/l	< 2	< 2	< 2	< 2
Selenium [Se]	µg/l	< 5	< 5	< 5	< 5
Tin [Sn]	µg/l	< 5	< 5	< 5	< 5
Vanadium [V]	µg/l	< 2	< 2	< 2	< 2
Zinc [Zn]	µg/l	< 50	< 50	< 500	< 500
ANORGANIC COMPOUNDS					
Nitrate (as NO3)	mg/l	< 0,9	< 0,9	< 0,9	< 0,9
Ammonium	mg/l	0,21	0,31	0,075	0,087
Phosphate (as PO4)	mg PO4/l	< 0,15	< 0,15	< 0,15	< 0,15
Chloride	mg/l	9500	8600	26000	25000
Ammonium (as N)	mg N/l	0,16	0,24	0,058	0,068

Water sample		Lag1	Sib2	Vb-05	Vb-08
Date		8-10-2019	7-10-2019	8-10-2019	11-10-2019
Phosphate (as P)	mg P/l	< 0,02	< 0,02	< 0,02	< 0,02
Sulphate (as SO4)	mg/l	1500	11000	3500	3200
Nitrate (as N)	mg N/l	< 0,4	< 0,4	< 0,4	< 0,4
Phosphorus [P]	mg/l	< 0,05	< 0,05	< 0,05	< 0,05
Nitrite (as N)	mg N/l	< 0,01	< 0,01	< 0,01	< 0,01
Nitrite (as NO2)	mg/l	< 0,03	< 0,03	< 0,03	< 0,03
Nitrogen (N; Kjeldahl method)	mg/l	< 1	< 1	1,1	1
CHLORINATED HYDROCARBONS					
Hexachlorobenzene (HCB)	µg/l	< 0,005	< 0,005	< 0,005	< 0,005
PESTICIDES					
cis-Chlordane	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
trans-Chlordane	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
2,4-DDT (ortho, para-DDT)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
4,4-DDT (para, para-DDT)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
2,4-DDE (ortho, para-DDE)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
4,4-DDE (para, para-DDE)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
2,4-DDD (ortho, para-DDD)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
4,4-DDD (para, para-DDD)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
Aldrin	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
Dieldrin	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
Endrin	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
alpha-Endosulfan	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
alpha-HCH	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
beta-HCH	µg/l	< 0,008	< 0,008	< 0,008	< 0,008
gamma-HCH	µg/l	< 0,009	< 0,009	< 0,009	< 0,009
delta-HCH	µg/l	< 0,008	< 0,008	< 0,008	< 0,008
Heptachlor	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
trans-Heptachloroepoxide	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
cis-Heptachloroepoxide	µg/l	< 0,01	< 0,01	< 0,01	< 0,01

Water sample		Vb-09	Vb-12	Vb-22	Vb-34
Date		10-10-2019	11-10-2019	12-10-2019	9-10-2019
MISCELLANEOUS					
2-Phosfate (as PO4) (ortho-Phosphate)	mg PO4/l	< 0,06	< 0,06	< 0,06	< 0,06
Phosphate (as P2O5)	mg P2O5/l	< 0,12	< 0,12	< 0,12	< 0,12
Dry residue, undissolved components	mg/l	2,1	2,7	< 2	< 2
Total organic carbon (TOC)	mg/l	2,1	2,1	2,3	2,2
METALEN					
Antimony	µg/l	< 5	< 5	< 5	< 5
Arsenic [As]	µg/l	< 3	< 3	< 3	< 3
Barium [Ba]	µg/l	7,6	7,8	7,9	7,6
Beryllium [Be]	µg/l	< 100	< 100	< 100	< 100
Cadmium [Cd]	µg/l	< 0,4	< 0,4	< 0,4	< 0,4
Chromium [Cr]	µg/l	< 200	< 200	< 200	< 200
Cobalt [Co]	µg/l	< 1	< 1	< 1	< 1
Copper [Cu]	µg/l	< 300	< 300	< 300	< 300
Mercury [Hg]	µg/l	< 0,04	< 0,04	< 0,04	< 0,04
Lead [Pb]	µg/l	< 3	< 3	< 3	< 3
Molybdenum [Mo]	µg/l	12	12	12	12
Nickel [Ni]	µg/l	< 2	< 2	< 2	< 2
Selenium [Se]	µg/l	< 5	< 5	< 5	< 5
Tin [Sn]	µg/l	< 5	< 5	< 5	< 5
Vanadium [V]	µg/l	< 2	< 2	< 2	< 2
Zinc [Zn]	µg/l	< 500	< 500	< 500	< 500
ANORGANIC COMPOUNDS					
Nitrate (as NO3)	mg/l	< 0,9	< 0,9	< 0,9	< 0,9
Ammonium	mg/l	< 0,065	0,47	< 0,065	< 0,065
Phosphate (as PO4)	mg PO4/l	< 0,15	< 0,15	< 0,15	< 0,15
Chloride	mg/l	14000	22000	12000	12000
Ammonium (as N)	mg N/l	< 0,05	0,36	< 0,05	< 0,05
Phosphate (as P)	mg P/l	< 0,02	< 0,02	< 0,02	< 0,02
Sulphate (as SO4)	mg/l	1600	2900	1500	1500
Nitrate (as N)	mg N/l	< 0,4	< 0,4	< 0,4	< 0,4
Phosphorus [P]	mg/l	< 0,05	< 0,05	< 0,05	< 0,05
Nitrite (as N)	mg N/l	< 0,01	< 0,01	< 0,01	< 0,01
Nitrite (as NO2)	mg/l	< 0,03	< 0,03	< 0,03	< 0,03

Water sample		Vb-09	Vb-12	Vb-22	Vb-34
Date		10-10-2019	11-10-2019	12-10-2019	9-10-2019
Nitrogen (N; Kjeldahl method)	mg/l	< 1	< 1	2	1
CHLORINATED HYDROCARBONS					
Hexachlorobenzene (HCB)	µg/l	< 0,005	< 0,005	< 0,005	< 0,005
PESTICIDES					
cis-Chlordane	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
trans-Chlordane	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
2,4-DDT (ortho, para-DDT)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
4,4-DDT (para, para-DDT)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
2,4-DDE (ortho, para-DDE)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
4,4-DDE (para, para-DDE)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
2,4-DDD (ortho, para-DDD)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
4,4-DDD (para, para-DDD)	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
Aldrin	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
Dieldrin	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
Endrin	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
alpha-Endosulfan	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
alpha-HCH	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
beta-HCH	µg/l	< 0,008	< 0,008	< 0,008	< 0,008
gamma-HCH	µg/l	< 0,009	< 0,009	< 0,009	< 0,009
delta-HCH	µg/l	< 0,008	< 0,008	< 0,008	< 0,008
Heptachlor	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
trans-Heptachloroepoxide	µg/l	< 0,01	< 0,01	< 0,01	< 0,01
cis-Heptachloroepoxide	µg/l	< 0,01	< 0,01	< 0,01	< 0,01

Water sample		Vb-39	Vb-48
Date		12-10-2019	9-10-2019
MISCELLANEOUS			
2-Phosfate (as PO4) (ortho-Phosphate)	mg PO4/l	< 0,06	< 0,06
Phosphate (as P2O5)	mg P2O5/l	< 0,12	< 0,12
Dry residue, undissolved components	mg/l	2,1	< 2
Total organic carbon (TOC)	mg/l	2,4	< 2
METALEN			
Antimony	µg/l	< 5	< 5

Water sample		Vb-39	Vb-48
Date		12-10-2019	9-10-2019
Arsenic [As]	µg/l	< 3	< 3
Barium [Ba]	µg/l	8,6	7
Beryllium [Be]	µg/l	< 100	< 100
Cadmium [Cd]	µg/l	< 0,4	< 0,4
Chromium [Cr]	µg/l	< 200	< 200
Cobalt [Co]	µg/l	< 1	< 1
Copper [Cu]	µg/l	< 300	< 300
Mercury [Hg]	µg/l	< 0,04	< 0,04
Lead [Pb]	µg/l	< 3	< 3
Molybdenum [Mo]	µg/l	12	12
Nickel [Ni]	µg/l	< 2	< 2
Selenium [Se]	µg/l	< 5	< 5
Tin [Sn]	µg/l	< 5	< 5
Vanadium [V]	µg/l	< 2	< 2
Zinc [Zn]	µg/l	< 500	< 500
ANORGANIC COMPOUNDS			
Nitrate (as NO3)	mg/l	< 0,9	< 0,9
Ammonium	mg/l	< 0,065	< 0,065
Phosphate (as PO4)	mg PO4/l	< 0,15	< 0,15
Chloride	mg/l	15000	24000
Ammonium (as N)	mg N/l	< 0,05	< 0,05
Phosphate (as P)	mg P/l	< 0,02	< 0,02
Sulphate (as SO4)	mg/l	1800	3200
Nitrate (as N)	mg N/l	< 0,4	< 0,4
Phosphorus [P]	mg/l	< 0,05	< 0,05
Nitrite (as N)	mg N/l	< 0,01	< 0,01
Nitrite (as NO2)	mg/l	< 0,03	< 0,03
Nitrogen (N; Kjeldahl method)	mg/l	< 1	1,1
CHLORINATED HYDROCARBONS			
Hexachlorobenzene (HCB)	µg/l	< 0,005	< 0,005
PESTICIDES			
cis-Chlordane	µg/l	< 0,01	< 0,01
trans-Chlordane	µg/l	< 0,01	< 0,01
2,4-DDT (ortho, para-DDT)	µg/l	< 0,01	< 0,01
4,4-DDT (para, para-DDT)	µg/l	< 0,01	< 0,01

Water sample		Vb-39	Vb-48
Date		12-10-2019	9-10-2019
2,4-DDE (ortho, para-DDE)	µg/l	< 0,01	< 0,01
4,4-DDE (para, para-DDE)	µg/l	< 0,01	< 0,01
2,4-DDD (ortho, para-DDD)	µg/l	< 0,01	< 0,01
4,4-DDD (para, para-DDD)	µg/l	< 0,01	< 0,01
Aldrin	µg/l	< 0,01	< 0,01
Dieldrin	µg/l	< 0,01	< 0,01
Endrin	µg/l	< 0,01	< 0,01
alpha-Endosulfan	µg/l	< 0,01	< 0,01
alpha-HCH	µg/l	< 0,01	< 0,01
beta-HCH	µg/l	< 0,008	< 0,008
gamma-HCH	µg/l	< 0,009	< 0,009
delta-HCH	µg/l	< 0,008	< 0,008
Heptachlor	µg/l	< 0,01	< 0,01
trans-Heptachloroepoxide	µg/l	< 0,01	< 0,01
cis-Heptachloroepoxide	µg/l	< 0,01	< 0,01

Based on the collected results it can be concluded that no pesticides, chlorinated hydrocarbons, or significant metal concentrations were observed in any of the surface water. Inorganic parameters mostly show consistent levels, except for sulphate, which shows slightly fluctuating sulphate levels. The variety in sulphate concentrations at sea is most likely the result of the outflow of the Sibun river, which has significantly higher (factor 3-4) sulphate concentrations than any of the samples at sea or in the lagoon. The sulphate concentrations at the project side are subject to variation as sea currents in southern direction result in spreading and dilution of Sibun river water.

It appears, based on sulphate and chloride concentrations that the Sibun has limited influence on the water quality of the Northern Lagoon.

5.4 Water Resources, Demand and Use

5.4.1 Occupancy

The occupancy for the Port of Magical Belize project was calculated based on the number of people on the different sizes of cruise ships arriving at the port, crew members and the people employed at the different facilities. **Table 5-7** below, describes the maximum daily number of people that could possibly be accommodated at the facilities at any given time within the premises of the facilities at full development and operation. 37,000 persons represents 100% occupancy, this figure includes passengers, crew from ships and staff working at the port. To calculate the water requirements, the assumption is based on the information provided by BTB where 85% of cruise passengers disembark during the 2018 cruise ship season. This would give an estimated figure of

31,450 persons on the facilities. It has been estimated, from the 31,450 persons, 65% (20,443) will be transient visitors while the remain 22% (6,919) will stay on the facilities to enjoy the amenities like restaurants, shops and bars.

Table 5-7: Projected daily occupancy of the Port.

Type	Persons/Unit	Passengers	Crew	Subtotal
Large ship	2	6,700	2,300	18,000
Medium ship	2	4,500	1,700	12,400
Small ship	2	2,500	800	6,600
Staff (BZE)	500			500
Total Estimated Occupancy				**37,500**

5.4.2 Water Supply Resources

Availability of fresh water is important for essential services to visitors and for port operations. The developer intends to connect to Belize Water Services Limited (BWSL) to get constant supply of potable water to meet is daily water demand. Below is a list of potential potable water sources that the contractor has available to meet its water demand if there is an additional demand:

Available freshwater sources for domestic use include the following:

- BWSL potable water supply system from Belize City
- Rainfall harvest
- Groundwater (Wells)
- River/lagoon water

5.4.2.1 Reverse Osmosis Filtration

An alternative system that can be used if demand is required is the use of a reverse osmosis system connected to an on-site well and water harvesting. The size and depth of the wells will be determined when proper geotechnical information becomes available. Reverse osmosis is a technology that has been around since the 70's. There are several types of reverse osmosis systems but the preferred is the five step reverse osmosis systems because of the addition of valuable minerals in the last step. In the first step, a pre-filter is used to remove the solid materials like silt, rust, and dirt from the water. This first stage prevents the other RO filters from becoming clogged with larger debris. In steps two and three, the carbon filters and reverse osmosis membrane remove chlorine and elements that may affect the colour of the water are also removed. Step four will remove heavy metals like lead, mercury, fluorine and chromium. In step five re-mineralization

occurs where the addition of essential minerals is added to the water making the water more beneficial for human health. The treated potable water will be stored in tanks or cisterns with capacity to hold two million gallons of water. Amount of needed to a day supply at 100% capacity.

5.4.3 Water Demand

The estimation of water demand during maximal occupancy for the Port of Magical Belize is based on other similar projects carried out in Belize. It has been estimated that guests will normally use about 106 gallons of water per day (Halcrow, 2012) (used for bathing, Laundry and kitchen) while staying at the port. Transient visitors will use approximately 15 gal/day. While Staff on the other hand, will use approximately 25 gal/day. So, at maximum capacity, the site will require is 2,283,243 gal/day. The developer will need to invest in infrastructure to hook up to BWSL (**Table** 5-8).

Table 5-8: Projected Daily water consumption for the Port.

Persons	**Maximum Occupancy**	**Water Demand**	
		Unit	Total (gallons per day.
Permanent Visitors	20,443	106 gal/day	2,166,958
Transient Visitors	6,919	15 gal/day	103,785
Staff (BZE)	500	25 gal/day	12,500
Total demand and consumption			**2,283,243**

6 Waste Management

6.1 Introduction

The increase in tourist traffic and the development of the tourism industry in the country naturally leads to an increase in the amount of waste produced at tourist destinations. If not properly managed, this may have a negative impact on the environment, which is likely to in turn have a negative impact on the industry itself. The importance of implementing sustainable waste management practices is becoming increasingly apparent at many tourist destinations for these reasons. The major objective of any waste management plan is to mitigate the potential negative environmental and health impacts associated with generation, treatment and ultimate disposal of wastes. An effective plan supports economic development and improves quality of life.

6.2 Method

Domestic waste projections are calculated based on published data such as the Stantec Report and similar studies in conjunction with the Western Corridor Study for the Solid Waste Management Authority. These reports are used in lieu of viable data in relation to the study area. Despite limitations in accuracy when predicting exactly how much waste will be produced by each visitor or on-site worker of the Port of Magical Belize Facilities, the report is expected to produce effective estimates of quantities.

6.3 Solid Waste

There are varied terminologies used in describing and categorizing solid waste partly based on the management tools used to handle it. Solid waste can be described as the unwanted or useless solid materials generated by residential and commercial establishments and is often called trash, garbage or refuse. It may be categorized according to its origin (domestic, industrial, commercial, construction or institutional); according to its contents (organic material, glass, metal, plastic paper etc); or according to its hazard potential (toxic, non-toxic, flammable, radioactive, infectious etc) (UNEP, 2003).

Domestic solid wastes can negatively affect the environment as a result of their particular chemical properties, non-biodegradability, contaminating factor and ability to promote proliferation of pests which can act as disease vectors (EPA, 2017). Biodegradable waste is of special concern because it produces leachate, which can be highly polluting to the area, and offensive gasses, which are not only unpleasant but may be hazardous to human health (UNEP, 2003). Non-biodegradable waste has the potential to litter the premises and mar the aesthetics of the area. In addition, depending on composition, some of these wastes also have the potential to be toxic or hazardous to the environment. When removing waste from a site, transportation must also be done properly taking into consideration cost. Solid waste transported via road has the potential to contribute to the problem of flying debris which may impact a larger area.

Currently, according to the EPA, the main environmental concerns related to the generation and management of solid waste include the attraction of pests and vermin to the site and the potential increase in incidences of infectious diseases spread by these vermin; contamination of ground water from leachate; and issues associated with littering (EPA, 2017). Another potential concern involves the unwanted attraction of certain wildlife to the site (e.g. raccoons, crocodiles, egrets, crackles, vultures, mice, etc.). This can negatively impact the wildlife as well as the site. For example, in coastal areas, sea birds can be attracted to an area by the smell or presence of readily available food scraps. To avoid having these birds constantly visit and linger at the site, food waste saved for composting must be properly stored until use. The actual composting of organic material must also be done in a manner where neither pests nor wildlife have access to it.

Management of solid waste reduces or eliminates adverse impacts on the environment and human health and supports economic development and improved quality of life (Woodside et al, 1997).

6.3.1 Port of Magical Belize Solid Waste Sources

The proposed Port of Magical Belize development is intended to house a cruise ship terminal and a tourist village with associated facilities. The proposed project will attract mainly cruise ship tourists, both temporary and full-time workers, boaters and a small administrative team. The port is naturally expected to produce a variety of solid wastes during both the construction and operational phases of the project. This includes domestic waste generated by the cruise ship visitors and on-site workers. Commercial waste will be generated from the business units that will be at the project sites. These include bars, restaurants, gift shops, and shopping marts. It is anticipated that the domestic waste will be less than the commercial. Field and construction wastes will be generated during initial construction phase and thereafter by later contracted work such as building modification, repairs or expansion. Given the magnitude of the project and as is the reporting norm, the solid waste generated by the project will be calculated in metric tons per week since the cruise ships are expected to make calls to port on a weekly basis. This measurement is suitable for gross estimates for use in sizing disposal facilities and resource recovery operations but may not be appropriate for the design of collection systems.

6.3.1.1 Construction Phase Solid Waste

During the construction phase the amount and characterization of the solid waste produced will be primarily in the form of masonry works and by-products accounting for almost 80 percent of all waste, with 20 percent of the waste being domestic waste produced by the construction crew (ESCAP, 1992). Waste from infrastructure development is often subcategorized into “construction” and “field” waste.

6.3.1.2 Construction Waste

“Construction waste” means any substance, matter or thing which is generated as a result of construction work and abandoned, whether or not it has been processed or stockpiled before being

abandoned (Corbit, 1998). In essence, it is a mixture of surplus materials arising from site clearance, excavation, construction, demolition and road works.

The general assumption in the building construction industry is that 5 – 10% of all building materials will eventually be discarded as waste during construction activities (Corbit, 1998). Given the dimension of the project, during the construction of Port of Magical Belize, the amount of solid waste generated during the construction phase will be significant. It will also be diverse in terms of source and composition. The construction waste stream will be associated with the construction of the roads, walkways, piers, berthing facilities, drains and buildings. Construction waste will include construction rubble (concrete and wood material), plastics and paper (primarily from cement waste bags and packaging), scrap metal, small quantities of glass casing materials, piping and wires. Over 90% of construction waste are inert and are known as public fill (Corbit, 1998) including material debris, rubble, earth and concrete which is suitable for land reclamation and site formation. All public fill waste produced at the Port of Magical Belize Development site, including plasterboard, mortar, and tiles will be collected and used as landfill on the site.

Besides the usual scraps and discards common to construction sites, wrappings and packing are a significant addition. This is usually associated with primary building materials, equipment, fixtures and commercial furnishings. These will be collected, sorted and compacted for transport to the BSWMA transfer station at mile 3 on the George Price Highway prior to its final disposal at BSWMA Regional Sanitary Landfill.

6.3.1.3 Field Waste

Field waste is mostly produced during site preparation and topographical contouring such as soil excavation and land clearing for the construction of building foundations, drains and recreational activities. Field waste from the project is expected to consist of general debris such as plant material (trees, shrubs, grasses, etc.) and soil material (sand, rocks, humus, etc.) from clearing vegetation and the digging of trenches. However, it must be mentioned that it is the intention of the developer to retain as much of the native vegetation as possible. Given the nature of the on-site vegetation (mainly Coastal Pine Ridge Savannah), it is expected that the vegetation cleared from the property will have little commercial value. Some may be recycled by deployment into the construction effort as formworks, otherwise they will be collected and chipped to be used as a mix for the composter or as a lawn beautifier. Soil waste material produced by these activities will be recycled and used as fill in the various stages of construction.

6.3.1.4 Domestic Waste

Given the estimated crew size for construction (close to 500 on-site workers), food wastes during the construction period may be substantial. For this reason, the senior management will purchase a composter unit (Earth Tub/Dome) for use during the construction phase to process these types of organic wastes along with the wood chips derived from the field wastes and construction wood.

6.3.1.5 Operational Phase Solid Waste

The facilities of Port of Magical Belize Development will become operational once the pathways, cruise ships berthing facilities and the establishments of the tourism village (i.e. bars and restaurants, gift shops, shopping marts and associated facilities) have been completed. In the operational phase, it is projected that most (70 – 80%) of the solid waste generated will be classified as domestic waste since very little maintenance and construction waste will be generated during this phase. It is important to remember that the range of domestic waste can run the full gamut of waste categories and therefore the term "domestic" refers more to origin than to a specific waste category. For this reason, it is practical to do some sorting of domestic waste as part of its proper management.

The average daily amount of waste produced in the tourism village is expected to be moderate given the size of the development and the fact that much of the food produced for the visitors will be pre-prepared at offsite establishments in Belize City. The various establishments in the port will add to the amount through their daily production of food, waste paper etc.

The management of Port of Magical Belize will play a key role in the collection, handling and disposal of its waste. The project will therefore develop and implement a waste management plan to address this important issue. The plan will entail the separation of solid waste into those that can be treated on site from those that will have to be transported to the waste transfer stations. It is anticipated that waste minimization strategies will also form a part of the plan and will address issues relating to the "green purchasing" of materials, implementation of a green policy and 3 R's as well as the composting of its organic waste.

Domestic waste management for the project will focus on the separation of the waste into three general categories: biodegradable, non-biodegradable and hazardous wastes. This separation is slowly becoming a common practice in Belize because of our regional sanitary landfill and waste transfer stations. The different types of domestic waste will be stored in separate, properly labelled containers indicating which grouping it is classified in. This practice may also be done at the community level by having separate, labelled disposal bins and encouraging conscientious individuals to use them.

6.3.2 Port of Magical Belize Solid Waste Production Volume Estimates

As previously mentioned, domestic waste projections are calculated based on the published data from a combination of studies including the Stantec Report and the Western Corridor Study for the Belize Solid Waste Management Authority (BSWaMA).

It is assumed that the rate of goods and services consumption and the rate of waste production by the onshore cruise ship visitors staying at port will be equivalent to that of any international tourist; while that of on-site workers will be closer to the Belizean average. Studies show that the average cruise ship passenger generates approximately 1kg of non-hazardous waste solid waste per day (CELB, 2003) not including an average of 2 recyclable bottles and 2 can per day. However, it is

not unusual for tourists to act uncharacteristically, producing more waste than they generally would. The average international tourist in Europe generates at minimum of 1 kg of solid waste per day (IFEN, 1999) while, according to the US EPA, UNEP/Infoterra, tourists from developed countries tend to produce a bit more, up to 2 kg/person/day (kg/p/d). Other studies show varied quantities. Using this data as baseline information, it is estimated that the average cruise tourist will produce about 1.5 kg/p/d. This does not take into consideration the fact that the cruise ship visitor will likely only spend approximately 6-8 hours in the cruise terminal to make use of terminal's facilities, consuming perhaps one meal per stay and doing some purchases.

In 2018, there was over a million tourists who visited Belize via cruise ships. Belize dis-embarkment rate is "higher than the rates in other Caribbean destinations" (BTB, 2018). Several factors appear to contribute to this. Under Belize's 2000 Cruise Ship Policy, cruise lines must shut down all activities onboard the vessels—casinos, restaurants, and entertainment—while in Belize. According to the BTB, this policy "results in more people coming off the ships and spending money in Belize." In addition, Belize offers a wider diversity of tours than most, if not all, Caribbean destinations (BTB, 2018).

According to the BTB, in 2018, approximately 85% of all cruise passengers chose to disembark. Of this group, 65% of these individuals purchased tours while onboard and about 18% purchased tours onshore through operators in the Village or independent guides outside the Village. This means that approximately 17 % of disembarked passengers remained in the Tourism Village and surrounding areas. For this project a higher percentage (22%) will be extrapolated given the fact that the facilities at Port of Magical Belize will be more attractive to visitors and given the location of the port being outside of the city (thus more tourists will tend to stay on the facilities).

Average solid waste production values in Belize show some variations dependent on location. In 1999, in its regional evaluation, BSWaMA estimated an average of 1.32 kg/capita/day in inland urban areas, quantities varied a bit e.g. Dangriga was 0.95, Belmopan was 1.18, and Belize City was 1.54 kg/capita/day. In its more recent 2016 Western Corridor Study, BSWaMA estimated an average of 1.03 kg/capita/day (BSWaMA Publications). For San Pedro residents, BSWaMA studies showed a higher average of 2.18 kg p/d. However, the rate in production varied widely in the San Pedro study as the average office worker was producing only 1.09 kg/p/d while eating/drinking establishments were producing a whopping 6.77 kg/p/d. The average generation rate has been estimated at 1.3 kgs/p/d for workers in the ports establishments including, administrative staff, staff as well as transient tourists and employees of commercial areas.

Using the per capita approximations for the cruise tourists and the local workers, the estimated number of tourists visiting via the different cruise ships, and the maximum number of workers that will be at the port at any given time (500 persons), one arrives at the figures for domestic waste production during the operational phase shown in Table 6-1.

Table 6-1: Showing the projected maximum total domestic waste production at Port of Magical Belize per week during its operational phase.

Cruise ship type	Tourists per ship type @ 100 % occupancy	Disembarked tourists (85%)	Individuals staying on Facilities (22% of disembarked)	Estimated Solid waste produced per day (Kg/p/d)	Solid wastes Per day (metric tons)	Calls to port per week	Estimated Solid waste produced per week (metric tons)
Large	6700	5695	1253	1.5	1.880	4	7.52
Medium	4500	3825	842	1.5	1.263	4	5.05
Small	2500	2125	468	1.5	.702	4	2.81
On site workers	-	-	500	1.3	.650	7	4.55
					TOTAL		***19.93***

As seen in the table, it can then be estimated that the total ***maximum*** amount of waste that would be produced by the daily operation would be ~20 metric tonnes per week (or an average of 4.50 metric tonnes per day). It is important to note that these calculations are based on raw solid waste production not subject to any waste minimization strategies that Port of Magical Belize will implement as part of its solid waste management plan to further reduce the daily production of wastes.

At project completion and at maximum operational capacity (high season for cruise tourism and having 6 cruise ships – 2 per category – calling to port in one day) approximately 5,626 persons could be on site, that will include 5126 projected cruise visitors and 500 on-site workers. Nevertheless, although maximum occupancy may be difficult to achieve at any given time, it is recommended that solid waste management needs to be put in place for maximum occupancy at the projected site. As is law, cruise ships are forbidden to dispose at any port in Belize of any solid waste produced in the vessel, so no solid waste, or significant quantities thereof, are expected at the port from these vessels (BTB, 2003).

6.3.3 Solid Waste Categorization

An essential component in the management of solid waste is that proper procedures be devised to sort and categorize the waste. The categorization of solid waste hinges on defining a system of waste classes to ensure that the waste is treated properly. According to literary sources, the most common type of solid waste produced within tourist destinations during operational phase can be

divided based on three criteria: hazardous, biodegradable and non-biodegradable, and combustible and non-combustible waste (UNEP, 2003).

6.3.3.1 Non-Hazardous Waste

It is expected that during the operational phase of the Port of Magical Belize, a wide variety of non-hazardous solid wastes will be produced. The projection of the precise composition is not possible since this is a data poor study area (SIB, 2004). Nevertheless, there are typical wastes associated with various activities that can be itemized as shown below.

Restaurants/Bars:

- empty cans, bottles, tins and glass.
- food, used cooking oil.
- small non-refillable product containers (sugar, salt, pepper, flour and cream).
- paper serviettes, drinking straws, coasters, toothpicks and cocktail napkins.
- used aprons, kitchen towels and napkins.

Shopping marts and malls

- paper.
- packing materials, cardboard boxes, plastic wrappings.

Open Spaces and Grounds

- plant trimmings.
- empty pesticide containers and fertilizer packs and fertilizer products (which are often hazardous).

Administrative and Office Functions

- paper and envelopes.
- pamphlets and brochures which are often quickly discarded by tourists.

6.3.3.2 Hazardous Waste

Hazardous waste contains harmful chemicals and produces harmful by-products when burned or placed in a landfill site. Common hazardous wastes at tourism facilities include paints, cleaners, oils, batteries and pesticides, discarded electronic equipment; all of which can have a severe impact on the environment if left untreated (UNEP, 2003). Hazardous waste requires special treatment procedures before disposal and is not appropriate for ordinary on-site treatment, placement in open landfill sites or burnt in an uncontrolled manner (not incinerated). The Port of Magical Belize Development proponent does not expect to use any toxic substances beyond the normal products

used within any tourist establishment. Notwithstanding this, in the event that circumstances dictate that hazardous wastes are produced, it should be remembered that they are outright dangerous to human health and should only be handled with specialized equipment and carefully disposed by personnel from BSWMA.

6.3.3.3 Biodegradable Waste

Biodegradable waste contains organic substances which can be broken down over time, treated and recycled into useful by-products such as biogas, bio fertilizer and compost while non-biodegradable waste (e.g., chemicals, rubber and plastics) do not. Biodegradation time depends on the type and nature of the substance and can range from a few weeks to many years. When biodegradable wastes are processed using composting technology the decomposition process can be accelerated tremendously, while in a covered landfill site, decomposition time can be significantly extended (EPA, 2017).

6.3.3.4 Non-biodegradable Waste

Non-biodegradable wastes are those materials not readily broken down by natural processes such as textiles, aluminium foil, foam, plastics, rubber etc. The options for the disposal of these types of waste are more limited than for domestic waste. Essentially the only way of responsibly disposing of this waste is disposal at BSWMA Regional Sanitary Landfill at mile 22 on the George Price Highway, although some types can also be incinerated or recycled.

6.3.4 Proposed Solid Waste Management Plan

The Integrated Solid Waste Management Plan proposed for Port of Magical Belize could be divided into two main phases: a) Management during Construction Phase and b) Management during Operational Phase. The costliest element of solid waste management is the collection of the waste. Seventy-five to eighty percent of the solid waste budget is spent on collection costs (Corbit, 2000). Reducing these costs by the project can best be accomplished by understanding refuse service processes and equipment. Collection is the part of solid waste management involving the reception of waste along designated areas of the development. The process begins where the waste or garbage is placed for pickup and ends when the collection truck leaves the area and transports the waste to its final destination. For waste that is treated at the site, disposal methods must also be considered. An additional and important component of this plan is implementation of systematic practices to minimize waste production.

6.3.4.1 Collection

Solid waste collection is one of the most visible services that will be provided to the Port of Magical Belize project. This task will be carried out on a daily basis according to the collection routes and service levels. This collection mechanism will require an effective administration that is detailed in the following sections:

a) Service Arrangements – There are 2 possible options in terms of service arrangements that can be contemplated for the proposed project. The **option A** is that the collection can be undertaken internally by a special department that will be fully responsible of management and final disposal of the solid wastes generated. **Option B**, the preferred option, is that the project will be responsible for the management of its own waste, but will enter into contractual arrangements with Belize Waste Control to ensure regular collection services from the project site and with BSWMA for the eventual final disposal of the non-recoverable wastes.

b) Service Level – the level of service will be set by the frequency of routine collection which conforms to the daily collection of wastes and their ultimate disposal. Therefore, the frequency of service will be adjusted based on the total wastes produced per day, which will in turn be determined by the number of calls to port by the cruise ships [hence the number of cruise visitors] on any given day.

c) Collection Containers – The project will make use of two types of collecting containers for [small] manual and [large] mechanized collection. Storage containers will be regulated to match the characteristics of the collection mechanism. The development will use suitable storage containers which are easy to handle and to keep clean. The containers would be designed to trap odours, to limit the spread of pathogens and to keep out as much as possible feral animals and vectors. Option B will include besides the aforementioned, large mechanized containers to be provided through service agreements by Belize Waste Control.

d) Central Collection Centre (Internal Waste Transfer Site) – The project contemplates the construction of an internal waste transfer site where all the day's waste will be collected, classified and separated until a suitable or sizeable load of non- recoverable wastes can be prepared for transport to the BSWMA Regional Sanitary Landfill. The need for this site is for environmental and economic purposes since daily disposal of non- recoverable wastes can be costly and would not allow enough time for the post collection waste reduction mechanisms to be set in place. The internal transfer site will be enclosed in a chain linked fence and located near the wastewater treatment plant. The site will be in the utility zone which is one of the highest areas of the projected site and will be approximately 200 metres from the nearest structure and will be westward (downwind of prevailing winds) of the port facilities. This will be done as a mitigation measure to reduce exposure to waste gases to visitors and staff and in the unlikely event of flooding in the area due to extremely heavy rains caused by storms such as hurricanes. The area will have easy access to facilitate the transportation of compostable wastes to the composters and the final disposal site. The mechanized metal containers will for the temporary storage of non-recoverable wastes before crushing and compaction by Belize Waste Control compactors. Materials that are reusable will be neatly stored under a shed on one corner of the utility zone and properly labelled.

6.3.4.2 Storage

This portion of the Control compactor trucks to their transfer station at mile 3 on the George Price Highway or to the Regional Sanitary Landfill at mile 24. The project plans contracting out this service of final disposal to the BSWMA.

6.3.4.3 Disposal

Due to the location of the development, the options for solid waste disposal are limited to two options: Option A, on site disposal of all solid wastes, and Option B, treatment of recoverable wastes on site and disposal of non-recoverable waste at the BSWMA Regional Sanitary Landfill.

Option A, onsite disposal of all solid wastes would involve the disposal of all the solid wastes generated by the development site through the implementation of 4 main methods.

i) Composting – In this method the domestic waste is placed into a commercial composter (Earth Tub) acquired by the developer for this purpose. In a process that promotes natural decomposition, the biodegradable waste is gradually broken down to inert materials that would be utilized on the site as a valuable fertilizer to be used for landscaping purposes. The Composter will be used and maintained by specially trained workers of the development. A properly run composter can have an accelerated decomposition process and can achieve a high level of efficiency. The compost heap must be properly treated to prevent the proliferation of disease-causing microbes and must be protected from disease carrying vectors and feral animals. If properly managed, this type of composter is environmentally friendly since it depends mostly on a natural process and allows the recycling of nutrients. In some developed countries, composting is used to recycle up to 90% of all biodegradable wastes (EPA, 2017). With proper attention to detail and commitment, such percentages could be easily accomplished on the development, especially since our climate is more conducive to composting.

ii) Burying – In many rural locations in Belize, domestic waste is buried in pits as the preferred method of disposal. Apart from open air burning, this is perhaps the cheapest and most rapid way to deal with domestic waste - however it is not always environmentally friendly. Burying garbage in locations with porous soils (as is the case in the project site) may cause leachate to easily percolate into the ground water and contaminate it and eventually drain into coastal waters and affect coastal ecosystems. Other undesirable side effects are the production of unpleasant odours and the encouragement of feral animals such as raccoons and crocodiles into the site.

iii) Burning – Burning or incineration in open-air piles is one of the main methods for solid waste disposal at many construction sites. A more advanced and preferred variation on this theme is to use a specially designed incinerator. The incinerator offers the most rapid system to dispose of domestic waste permanently and with the least threat to the public health. Incinerators operate at very high temperatures (around 1,200 ^{0}C) at which point they rapidly break down materials into their constituent chemicals, which in the case of organic domestic waste is mostly H2O and CO2 (UNEP, 2003). In the process they consume a considerable amount of fuel and pollute the

environment with smoke if proper safeguards are not installed. Incinerators failing to achieve the desired temperature, experience incomplete combustion and release toxic gases into the environment including dioxins and PCB's. Incinerators for the site would be expensive to purchase and would require substantial investments in maintenance and operation. However, the projected volume of wastes is relatively high, such that, it may warrant an unnecessary huge investment in incinerators and fuel. Other much less costly options are available that are of an acceptable standard.

iv) Sanitary Landfill – Are specially designed excavations with an adequate barrier lining for the disposal of waste. As the name implies they are designed to prevent seepage into the ground water and to reduce other environmental impacts such as being a visual eyesore, affecting adversely wildlife or to reduce the production of unpleasant odours. The construction of a sanitary landfill nearby that conforms to the standards set by DOE would involve the careful selection of a site, clearing of more native vegetation (thus disrupting the ecological balance of another area) and investing a prohibitive sum of resources.

Option B includes the treatment of recoverable wastes on site and disposal of non-recoverable waste at the BSWMA Regional Sanitary Landfill. The final disposal option for solid waste forms part of a more integrated solid waste management plan that incorporates measures to reduce, reuse, and recycle the domestic solid waste from the day-to-day operations of the facility.

From the aforementioned options burying and burning are immediately eliminated due to serious environmental concerns that are contrary to Port of Magical Belize objective to envision itself as a modern, model, "green" cruise terminal facility in the region. The developers of Port of Magical Belize have subscribed to the new mantra of the solid waste management hierarchy of reduction, reuse, and recycle with the purpose of minimizing as much as possible the disposal of non-recoverable wastes. This option will involve waste reduction strategies and recoverable wastes will be treated (reused and recycled) within the project. The non-recoverable wastes will be finally disposed at BSWMA Regional Sanitary Landfill at mile 24 of the George Price Highway since the analysis identified that it would be environmentally, ecologically and financially beneficial to use an already existing site. This site is the only sanitary landfill in the country that complies with standards set by the Department of the Environment (DOE), thus ensuring an environmentally friendly disposal of solid wastes (BSWMA publication). Construction of a local site for the disposal of the solid wastes that meet the standards of DOE would reduce the aesthetic value of the project and the entire area and would involve considerable costs that may prove prohibitive for the developers.

6.3.4.4 Waste Reduction

Developers of Port of Magical Belize will work with all staff and stakeholders to create a hierarchy of waste management where reducing the amounts of waste generated should be a priority. Such

a reduction in waste production will be taken into consideration during the construction phase and will continue throughout the operational phase.

6.3.4.5 Reduce/Reuse

From inception, the project will be adopting a "Green Purchasing" policy where the developers will commit to purchase, wherever possible, products for the project that are environmentally "friendly." During the Construction phase, this will involve purchasing products that are long lasting; that do not release persistent toxic substances into the environment; and that conserve energy and resources during production, use and disposal. Construction materials will be chosen, not only based on costs during construction but will also be based on the associated expenses involved in waste treatment and disposal. Goods for the facility will be purchased in bulk obviating the need for many small packages. During the operational phase, food and beverage establishments are expected to contribute significantly to the solid waste output, therefore there will also be measures in place to reduce these wastes. These will include establishing rigid purchasing guidelines to ensure that the following are obtained for the facilities as much as is practical:

i) durable equipment which can be maintained and repaired easily.

ii) refillable containers for such items as sugar, salt, pepper, flour, syrup and cream (instead of single wrapped units)

iii) washable cups, dishes and utensils (instead of plastic/paper cups, utensils and plates)

iv) reusable drinking straws (instead of disposable straws).

v) hand dryers (instead of paper towels).

vi) soft drinks in reusable containers or dispensers (instead of disposable plastic containers).

Additionally, visitors to these establishments will be offered the option to order half-portions of food at reduced prices to reduce food wastage and food scraps. At the shopping marts and malls, the use of single use plastic bags will be banned and only bio-degradable/compostable paper bags will be used where necessary.

At the administrative and office level green purchasing and a culture of waste reduction will also be adopted. Refillable pens and toner cartridges will be obtained, and staff will be trained to use e-mails and bulletin boards for memos instead of circulating copies to all staff and double-sided photocopying will be the norm. Purchasing "green" products makes good business sense since it can save money, addresses the problems of persistent toxic substances in the environment, conserves natural resources, reduces the quantity of solid waste generation and saves energy and resources in dealing with waste (UNEP, 2003).

Once materials are bought, they should be reused as many times as possible. Reusing items by repairing, selling at a much-reduced price or donating these to charity and community groups reduces waste. Reuse is preferable to recycling since the item does not need to be reprocessed, thus

conserving energy (UNEP, 2003). For example, wooden pallets used to move construction supplies and the scraps of PVC pipes used for electrical fixtures will be reused in the landscaping phase. During the operational phase, dispensing systems for soap will be installed in all food and beverage facilities. Single use purified water and soft drink bottles are two of the main contributors to plastic pollution (EPA, 2017), hence water bottle refilling stations will be installed (Elkay LZS8WSLP Enhanced EZH2O Bottle Filling Station) to minimize the quantity of single use water bottles. Stained linens produced by these establishments will be reused for aprons and kitchen towels or used as cleaning rags. Old furniture and equipment to be discarded by the facilities in the port after years of service will be donated to educational institutions or charities, thus reducing the volume of solid wastes to be disposed.

6.3.4.6 Recycle

Recycling turns materials that would otherwise become waste into valuable resources with environmental, financial and social benefits (UNEP, 2003). It diverts waste from landfills, saves energy and water and creates less air and water pollution.

Some of the items that the visitors and staff dispose of will be recyclable items such as plastic, glass, aluminium and food scraps. However, in order to effectively recycle wastes, their segregation is essential. For example, if glass bottles or plastics are mixed with food, it is difficult to recycle the material without health risks and if toxic chemicals are mixed with food waste, composting is impossible. In order to facilitate the recycling of wastes, the placing of colour coded and clearly labelled waste bins for biodegradable and non-biodegradable (for glass, aluminium and plastic) wastes will be installed throughout the project site and its establishments. Bins for hazardous wastes (e.g. used cooking and motor oil, antifreeze, paint, empty pesticide containers, used batteries, etc.) will be placed in key locations of the port and in the workshops of grounds keeping and maintenance staff. Staff will be trained, and visitors will be sensitized about the importance and advantages of waste separation. Once the wastes reach the internal transfer/storage area of the project, the wastes will be sorted (trash auditing), packed and temporarily stored by category.

Fortunately, now in Belize there are established business operations that will take paper/cardboard, plastic and metal waste for recycling. So, once there is a substantial quantity of plastics, aluminium, paper and glass, sorted and packed, these will be transported to Authorized Recycling Depots (ARD's) in the city. It is the intention of the developers to reach an agreement with a local recycling company, e.g. "Resource, Recovery and Recycling Ltd" to receive technical assistance in this venture and to process these recyclable items.

Much of the waste generated from the food and beverage establishments in the port will be biodegradable and can be composted rather than sent to a landfill. Once the compostable wastes have been separated at the internal transfer station they will placed into commercial composters (Earth Tub/Earth Dome) acquired by the developer for this purpose. These will be mixed with

grass trimmings, hedge trimmings, wood chippings and other landscaping refuse derived from gardening activities. In these composters' bacteria help convert the biodegradable matter into carbon dioxide, water, minerals and humus. Composting, on average, reduce the bulk of the waste material by 40 to 50% (EPA, 2017). The composters will be set next to the internal waste transfer station, away from public areas, and once the compost is produced it will be allowed to cure in an especially designed curing area. Once cured, the compost will be used as bio fertilizer for landscaping purposes, thus reducing the need of purchasing and using artificial fertilizers which tend to be costly and are potentially harmful to the environment. Additionally, since plants grown using compost are less prone to pest attack and disease (UNEP, 2003) this method of landscaping will also reduce the use of highly polluting pesticides (and their containers) in the project site. Composting will also enhance the environmental profile of Port of Magical Belize. The developers are expecting to recycle close to 90% of all biodegradable wastes - as is done in many developed countries in Europe and in the USA (EPA, 2017).

6.3.4.7 Education

A fundamental component of integrated solid waste management is education - the training of staff and the sensitization of visitors on the importance of proper solid waste management. A successful solid waste management program involves all stakeholders and is just as important as the actual implementation of the waste reduction strategies and the acquisition of state-of-the-art solid waste management technology. Stakeholders in the tourism industry need to understand that the only economically viable, long-term approach to avoiding environmentally harmful waste is to prevent its production in the first place (UNEP, 2003). This will require altering the traditional way business is conducted at cruise terminals and eliminating problems at the source rather than dealing with them in the future.

Port of Magical Belize will take the training of staff as a priority and will undertake a massive sensitization campaign of cruise ship visitors. Attractive brochures and flyers clearly explaining the role of cruise ship visitors in the waste management program of the project will be produced by the developers and distributed to all cruise ships calling to port. Panels and other technologies promoting a waste free culture and sensitizing cruise ship visitors and locals to the solid waste reduction efforts underway will be installed at key points of the port. For example, the water bottle re-filling stations will include countertop graphics which will inform visitors how many bottles are being kept out of the landfill by simply refilling re-usable bottles. Once staff and visitors are aware of what is expected from them and of the benefits of contributing to a more environmentally friendly enterprise, the aim of reducing the impacts of solid wastes will most likely be achieved. Additionally, requirements for cruise line companies to adopt and comply with MARPOL guidelines pertaining to solid waste disposal regulations will be enforced at port while ensuring that portside waste reception facilities and waste management strategies are adequate to accommodate the waste generated by passengers while onshore. Perhaps the provision of fee-based

waste disposal services (i.e., services not covered by dockage fees) would assist in ensuring proper waste disposal.

Effective integrated solid waste management can reduce waste production and disposal, for example, in the US the disposal of waste to landfills decreased from 94% of the amount generated in 1960, when waste management practices were rudimentary to under 53% of the amount generated in 2015 when comprehensive management practices were gaining more acceptance (EPA, 2017).

6.4 Liquid waste

Liquid waste management is an important component of any development, especially one of this nature. Liquid waste generated by any facility can become a threat if not managed properly. In our coastal waters liquid waste management is even more important. Currently, liquid waste management is not being done in countries like Belize and Port of Magical Belize will try to capitalize on the management, treatment and reuse of wastewater.

6.4.1 Wastewater Characterization and Classification

Operational phase

Establishment of a cruise tourism port with associated infrastructure requires supportive services. One of the services and support for these ports is waste management. The cruise tourism industry is one which deals with a large number of people at any given time. In Belize, the industry has been on a steady growth. In 2018, the BTB data showed 1.2+ million cruise visitors arrivals (BTB, 2018). This is from approximately 360 port calls for this period from 7 cruise lines (BTB, 2018).

Table 6-2: Above cruise tourism passenger arrivals 2012 - 2018 (source: BTB, 2018)

	2012	2013	2014	2015	2016	2017	2018	% Change
JANUARY	86,128	102,871	109,251	127,376	102,337	127,061	131,509	3.5
FEBRUARY	70,711	78,766	97,740	95,067	98,623	120,996	118,799	-1.8
MARCH	81,315	82,416	115,227	133,482	135,283	117,578	132,122	12.4
APRIL	57,158	62,643	104,188	91,325	90,657	97,422	91,253	-6.3
MAY	42,215	33,988	46,842	43,847	61,977	61,152	82,084	34.2
JUNE	30,798	24,432	53,789	50,790	65,399	47,007	73,917	57.2
JULY	35,224	32,874	67,986	54,471	51,968	44,392	82,282	85.4
AUGUST	27,894	36,309	52,037	50,656	39,189	52,534	91,313	73.8
SEPTEMBER	23,877	25,056	47,625	45,265	54,569	57,718	66,889	15.9
OCTOBER	33,388	42,181	57,913	40,985	56,697	76,403	75,465	-1.2
NOVEMBER	69,674	63,583	74,247	81,113	106,144	100,797	112,283	11.4
DECEMBER	82,352	92,231	141,286	143,598	142,551	111,171	150,221	35.1
	640,734	677,350	968,131	957,975	1,005,394	1,014,231	1,208,137	19.1

In terms of liquid wastes, this represents the generation of different types of liquid wastes. The liquid wastes that are generated include onsite and off-site. In 2018, the statistics show that Belize

received 1.2 + million tourists' arrivals from cruise ships alone (**Table 6-2**). This means that the existing ports and receiving destinations had to accommodate the wastes generated from these 1.2+ million arrivals.

The cruise ships itself generates several liquid waste types, some of which are considered hazardous such as ballast water, bilge water and brine. The passengers and crew on the ships also generate black and grey water which are treated via treatment systems on-board. Similarly, the other types of liquid wastes are self-contained in the ship and the volumes would be dependent on the class of the ship.

For the purposes of this assessment however, the team will not be assessing these wastes generated on board as Belize does not accept international wastes despite being a signatory to the MARPOL Protocol. Belize like most small islands in the Caribbean lacks the infrastructure to provide these services.

The only wastes considered for this assessment are those that will be associated with the facilities at Port of Magical Belize. These facilities referred to in the introductory chapter was used to calculate the total liquid waste that will require treatment and final disposal. The wastes generated off-site at other destination facilities are not considered.

The occupancy for the entire project is expected to peak at 20,000 people on its highest day. Estimating sewage waste can take several forms. On board a cruise ship, the estimations per person is between 0.04 and 0.45m^3 or 118 gallons per person and considers the number of people on board, the types of toilets and the length of the voyage (CE Delft, 2017). While this estimation is based on the volumes of wastewater to be generated on board the vessel it provides guidance for the estimation of volume at the project site. Using a conservative value of 75 gallons of waste per person per or (0.28m^3) the estimated volume of wastewater is 1.5 million gallons per day at the highest peak.

Port of Magical Belize will address the wastes generated at its onsite facilities through the development of a proper wastewater management plan. This plan will be developed to ensure that the wastes expected to be generated from the proposed port could be addressed adequately. There will be several types of liquid waste that will be generated; these include grey water, black water and water resulting from the dewatering site from the dredging activities however this chapter will focus on the grey water and black water. The wastes from the dredging will be covered entirely in a separate chapter.

The estimation of waste loads can take several approaches. The typical constituents of wastes generated from these types of projects are below (Table 6-4), this is important because it will allow for the evaluation of the options for treatment further in this chapter.

Table 6-3: Constituents of typical wastes generated from cruise ship ports (Source: Davis, 1998).

Constituent	Weak	Medium	Strong
	(all mg/l, except for settleable solids)		
Alkalinity (as CaC03)	50	100	200
BOD	100	200	300
COD	250	500	1000
Total Suspended Solids (TSS)	100	200	350
Settleable Solids	5	10	20
Total Dissolved Solids (TDS)	200	500	1000
Total Kjeldahl Nitrogen (TkN)	20	40	80
Total Organic Carbon (TOC)	75	150	300
Total Phosphorus	5	10	20

Construction Phase

During the construction phase, liquid waste will be generated by the work force at the project site; this will include water from lavatories and kitchen areas etc. At its peak the workforce is estimated to be 500 persons on site. There is a correlation between water used at a facility and waste generated, however these ratios have not been documented for construction sites. Considering that the installation of worker camps is not envisioned, the workforce is expected to generate about 50 gallons of wastewater per day, the constituents during this phase is expected to be at the lower end. Therefore, the estimated waste water production on site is 25,000 gallons per day.

6.4.2 Alternative Options for Liquid Waste

Wastewater treatment is the process of removing contaminants from effluent to such an extent that it renders the water safe to put back into the receiving environment or reuse for other non-potable purposes.

Wastewater treatment technologies have advanced into a sophisticated science of mechanical, chemical and biological engineering (Loosdrecht, Nielsen, Lopez-Vasquez, & Brdjanovic, 2016). Today, many systems exist for general applications, specific applications and custom applications. It is important therefore to evaluate different systems with the capacity to treat the various wastewater streams, knowing in advance, the characteristics of wastewater that will be generated on site. The preferred wastewater treatment option will be required to treat effluent to a level in line with the Environmental Protection Effluent (Limitations) (Amendment) Regulations, 2009.

For a project of this type, a system must be chosen with the right capacity and functionality. While capacity is easily determined, the functionality is more complex because it will have to take into consideration variability in daily, weekly and monthly use. Functionally also relates to continuous verses batch loads, peak daily, weekly and monthly load, low and high seasons, etc. To put it

another way, the system will have to accommodate variable use that flocculates with daily, weekly, monthly and yearly occupancy.

There currently exist in the market, numerous wastewater treatment systems such as the Activated Sludge Model, Membrane Bioreactor, Trickling-bed Reactor, Anaerobic Digester Types, just to name a few. Each has similarities and few differences but in terms of application, one must be careful to choose the right system for the right application. In this case, the right application means a system that can accommodate domestic effluent (sewage) functioning in batch or consignment. This means that that volume of wastewater that will flow into the system will not be constant or continuous. The system will have to be able to accommodate low and peak loading and fluctuations consistent with the volume of visitors and staff at the Port. In such cases conventional logic suggest the use of an Automatic Batch Wastewater Treatment System.

This section will explore three options for consideration and will present the preferred option. The three options are as follows:

1. Sabre Sequencing Batch Reactor (SBR) Wastewater Treatment System
2. Biologically Engineered Single Sludge Treatment System
3. Wastewater Treatment Biofilters

6.4.2.1 Sabre Sequencing Batch Reactor (SBR) Wastewater Treatment System:

The SBR system was invented by a team of engineers who have been designing wastewater treatment systems for almost 40 years. It is one of the most versatile systems and has proven to be highly effective at low cost.

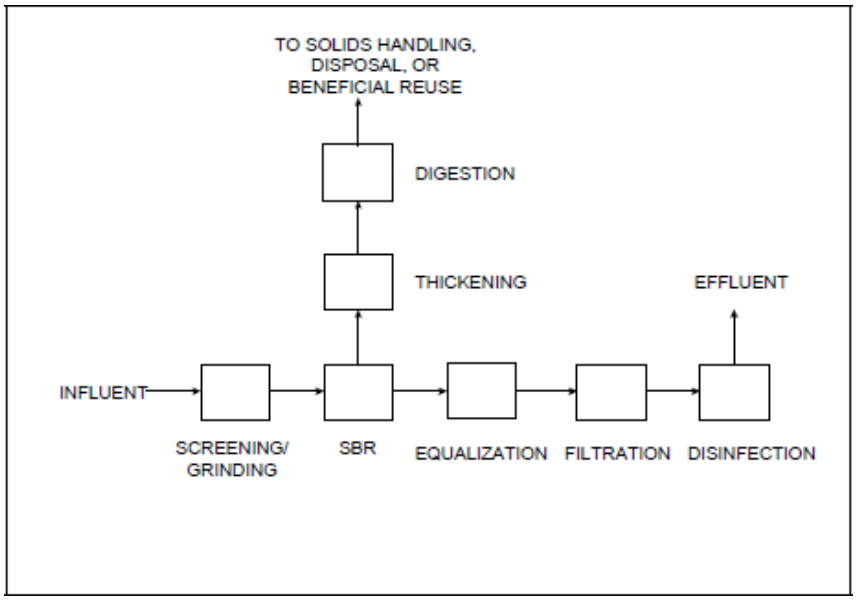


Figure 6-1: Working scheme of a Sabre Sequence Batch Reactor (SBR).

A typical system using SBR technology commence with influent being screened or grinded. The stage is optional, but it is important because it helps remove grit (large solids) that can otherwise create complications in other down-flow processes. From the screening the influent goes into a partially filled sequence batch reactor (*a reactor is a place where chemical processes occur in a control manner)* containing biomass which has been acclimated to the wastewater constituent during preceding cycles. Once the reactor is full, it behaves like a conventional activated sludge system but without the continuous flow, hence the name "batch" reactor. The effluent is aerated and mixed in the SBR giving enough time for good microbe to biologically break down or clean the wastewater. The aeration and mixing is discontinued after the biological reactions are completed, the biomass settles to the bottom of the chamber and the treated supernatant is sent to the equalization chamber. While a portion of the biomass is digested by microbes it is important to leave enough in the system to treat the other sequence (load) of effluent. Therefore, the mass ratio of influent substrate to biomass must be determined during the early use of the system and thereafter it must remain constant. In the equalization chamber the pH is controlled to near 7 and then the filtration chamber further clarifies the effluent before it is disinfected and discharged. After the batch reactor the flow to the other chambers can be constant and controlled.

	Municipal	Industrial
Food to Mass (F:M)	0.15 - 0.4/day	0.15 - 0.6/day
Treatment Cycle Duration	4.0 hours	4.0 - 24 hours
Typically Low Water Level Mixed Liquor Suspended Solids	2,000-2,500 mg/L	2,000 - 4,000 mg/L
Hydraulic Retention Time	6 - 14 hours	varies

Source: AquaSBR Design Manual, 1995.

Flow	Reactors			Blowers	
(MGD)	No.	Size (feet)	Volume (MG)	No.	Size (HP)
0.012	1	18 x 12	0.021	1	15
0.10	2	24 x 24	0.069	3	7.5
1.2	2	80 x 80	0.908	3	125
1.0	2	58 x 58	0.479	3	40
1.4	2	69 x 69	0.678	3	60
1.46	2	78 x 78	0.910	4	40
2.0	2	82 x 82	0.958	3	75
4.25	4	104 x 80	1.556	5	200
5.2	4	87 x 87	1.359	5	125

Note: These case studies and sizing estimates were provided by Aqua-Aerobic Systems, Inc. and are site specific to individual treatment systems.

Figure 6-2: Sabre Sequence Batch Reactor design information.

SBR systems are normally used for facilities that generate 5MGD of wastewater or less. One main advantage of the system to this specific project is that it has the lowest footprint of any other conventional systems. Other advantages include the ability to modify cycles with the system for nutrient removal, the system is extremely flexible and versatile. The most convincing advantage is that the system is the highly effective at the lowest cost.

6.4.2.2 Biologically Engineered Single Sludge Treatment System:

The Biologically Engineered Single Sludge Treatment (BESST) System shown in **Figure 6-3** is a commercial patented process that provides high quality treatment to wastewater using the single

sludge treatment method for BOD_5, nutrient removal and clarification (Purestream Incorporated, 2019).

The BESST system was engineered by Purestream Incorporated, a company formed in 1971 to deliver wastewater treatment options for household, commercial and industrial purposes. The system utilized a modified activated sludge system, called the single sludge activated system. Purestream claims that the process is one of the most advance systems that are contained in one single vessel. The system therefore can accommodate any capacity because single vessels can be added to treat greater volumes of wastewater.

Figure 6-3: Picture of a Biologically Engineered Single Sludge Treatment (BESST) System.

The system operates in stages commencing at the Pre-Anoxic zone where influent mixes with returned sludge from the sludge blanket clarifier to promote denitrification. Mixers stir the wastewater in the anoxic zone to create homogeneity. Thereafter, the mixture enters the aerobic zone, where small bubbles add oxygen to reduce BOD and foster nitrification. After the aerobic bacteria have consumed the organic load, the treated wastewater enters a clarifier where solids are removed. After solids are removed, all that remains is treated effluent. The solids are pumped back into the anoxic zone to act as activated sludge for the incoming wastewater. In addition to the clarifier, the system has a weir with scum baffle and skimmer to help reduce TSS. From there the effluent can pass through ozone or ultraviolet system to sanitize the wastewater of bacteria before it goes in the environment.

6.4.2.3 Wastewater Treatment Biofilters:

Biofiltration is the process of breaking down contaminants in wastewater using medium filters through sand or carbon. According to (Chaudhary, Vigneswaran, No, Shim, & Moon, 2003), "any type of filter with attached biomass on the filter-media can be defined as a bio-filter. This system

therefore is broad in its design and application. The working schematics of a typical biofilter system is shown in Figure 6-3.

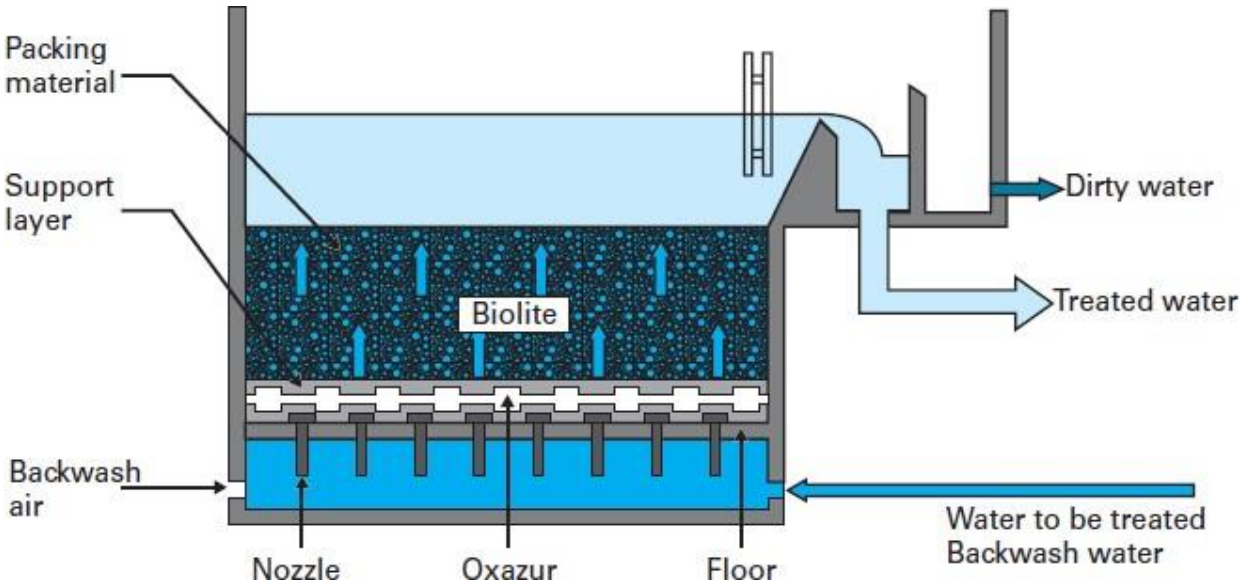


Figure 6-4: Working schematics of a typical biofilter (Source: https://www.suezwaterhandbook.com/processes-and-technologies/biological-processes/attached-growth-processes/biological-filters).

The schematic diagram above shows a typical bio-filter wastewater treatment system. The effluent enters the system at the bottom and air pushes (pump) the effluent via nozzles through a biofilm, where the effluent is treated, and clean water reaches the top and flows into a tank ready for discharge. The biofilm is made of expanding clay with a density higher that 1.2 and has roughness. The material provides a substrate for bacteria to grow to form a biofilm. The nutrients from the wastewater is consumed by the biofilm with is being aerated with help of air coming from the nozzle.

For treatment of a large volume of effluent, several series of this one system can be installed.

6.4.2.4 Preferred Option

After carefully evaluating several alternatives for treatment of wastewater for the Port of Magic Belize project, including the other two systems described above, the chosen system is the Sabre Sequencing Batch Reactor (SBR) Wastewater Treatment System. The system was chosen for its efficiency and effectiveness in treating wastewater, versatility, operational convenience (no noise, no odour, buried out of site, small footprint), reduce cost of operation and maintenance and its automation. The system is perfect for this project from all angles.

It is highly possible that the system will be installed by the company that created it, “Earthtek Environmental, LLC, Wastewater Treatment Solutions” from Batesville Indiana, USA. The

company has the technical expertise to install the system, provide engineer documentation, operator training, service assistance, long term technical support and performance guarantee.

One additional reason for choosing the system is that the final discharged water will be of such a healthy quality that it will be stored and used for irrigation and firefighting purposes. This way water use is maximized which promotes water conservation. The system's greatest benefit is that it will allow Port of Magic Belize to protect the natural surroundings, which the project so heavily depend on.

6.4.3 Wastewater Treatment System Maintenance Plan

Due to the lack of primary and secondary clarifiers the SBR system is low in maintenance. Also, because of the simplicity of the system, meaning almost all the treatment occurs in the reactor, it is fairly easy to maintain.

Maintenance will include biweekly inspections of controls, automatic valves and switches. Because these are the main parts of the system that can fail, biweekly inspections are recommended.

7 Air and Noise Management

7.1 Introduction

A comprehensive Environmental Assessment for a project such as this requires that air quality and noise emissions are considered in the overall scope of the EIA process. While the project will not be located near any residential or human populated areas, it is still important that the potential adverse impacts of these aspects of the project are considered and where impacts are identified, measures are put in place to mitigate them.

7.1.1 Air Emissions from Port

Clean air is considered to be a basic requirement of human health and well-being. However, air pollution continues to pose a significant threat to health worldwide.

The characterization of the effects of cruise ship emissions on local air quality is not well studied. A study was conducted to investigate community level concentrations of fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) associated with cruise ships in James Bay, Victoria, British Columbia, Canada. Data obtained showed concentrations of $PM_{2.5}$ and nitrogen oxide (NO) were elevated on weekends with ships present and winds from the direction of the terminal to the monitoring station. SO_2 displayed the greatest impact from the presence of cruise ships in the area (Poplawski, 2011).

The World Health Organization (WHO) Air Quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide, 2006, consolidated scientific studies for four major air contaminants; Particulate Matter (PM), O_3, NO_2, and SO_2 and sets limits (standards) for the four contaminants base on human health effects. The limit set by WHO for PM is $PM_{2.5}$: 10µg/m^3 annual mean and 25µg/m^3 24-hour mean. The limit for PM_{10} is 20µg/m^3 annual mean and 50µg/m^3 24-hour mean. The limit for O_3 is 100µg/m^3 8-hour mean. NO_2 is set at 40µg/m^3 annual mean and 200µg/m^3 1-hour mean and lastly SO_2 is set at 20µg/m^3 24-hour mean and 500µg/m^3 10-minute mean.

Air emissions are regulated under the Pollution Regulations of 1995, amended in 2009, of the Subsidiary Laws of Belize. This legislation prevents the emission and deposition of a contaminant from domestic, commercial, agricultural, recreational, industrial or any other source, without the issuance of a permit with conditions to do so by the Department of the Environment. The law also contains emission standards from various sources using different types of fuels. Emissions in the form of particulate matter, sulphur dioxide, nitrogen oxides, and water pollutants.

Historic air quality data for Belize is not easy to obtain mostly because hardly any air quality monitoring has been undertaken in country. The Department of the Environment reports that air quality data exist for several facilities in Belize such as the Belize Natural Energy Limited (BNE), Harvest Caye, Santander, and recently the Belize Sugar Industry. The DOE itself implemented an air quality monitoring programme in Belize City in 2016 and expects to implement another such

monitoring programme in Orange Walk District. Parameters that were monitored include NO_x, SO_x, and Ground Level Ozone (**Figure 7-1**).

In 2018, the DOE obtained the services of a consultant to analyse the air quality data from BNE, Harvest Caye and Belize City. The report generated at the three data sets from BNE, Harvest Caye and Belize City indicates that the overall air quality within these areas was good. The report stated that all parameters were within the WHO standards. Belize City is very close to the project site therefore the data set is applicable.

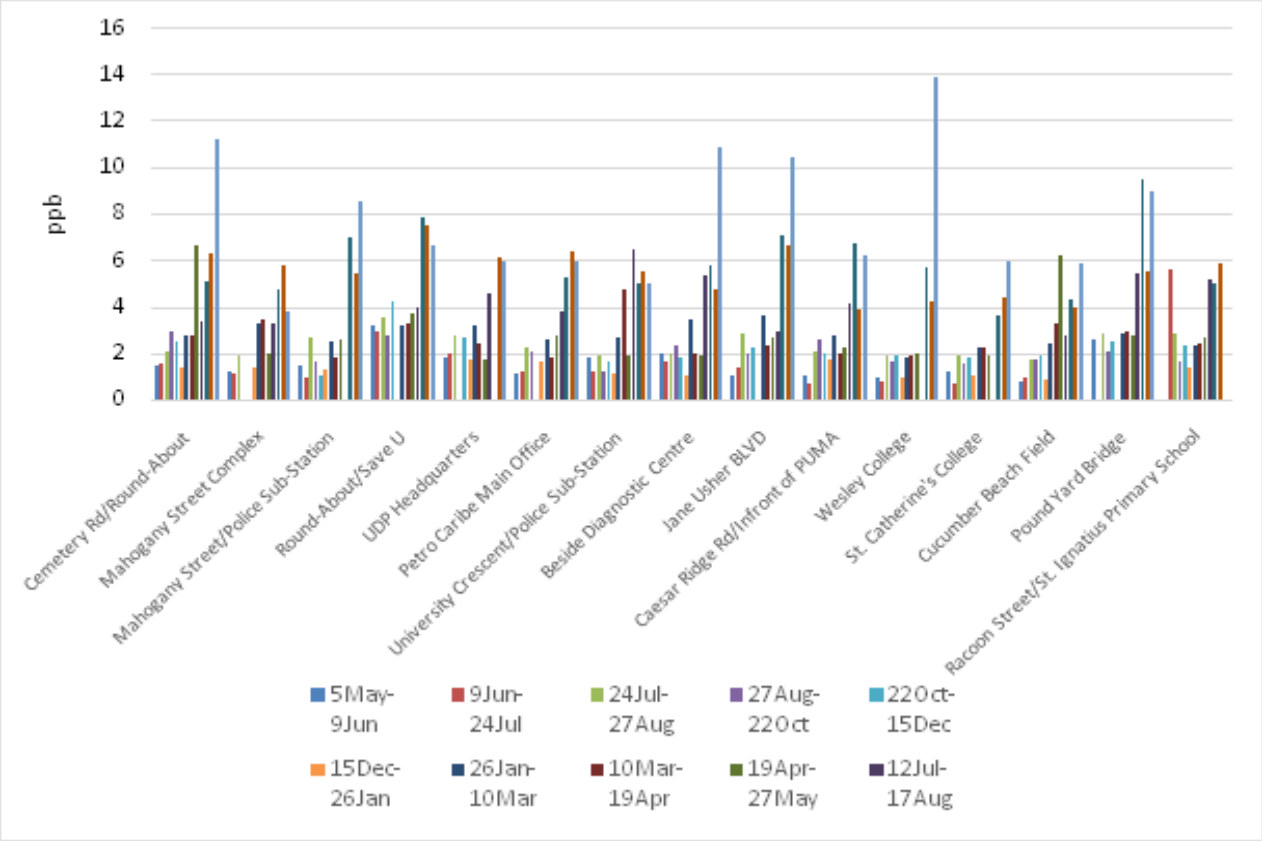


Figure 7-1: Temporal trends in SO_2 concentrations in Belize City.

Figure 7-1 above plots the temporal trends in average concentrations at each station, confirming the trend of increasing concentrations of SO_2 between the beginning and end of the monitoring campaign. SO_2 was measured at virtually all sampling stations and during all sampling periods in Belize City. Concentrations showed a high degree of uniformity. There was a trend of increasing concentrations during the monitoring campaign.

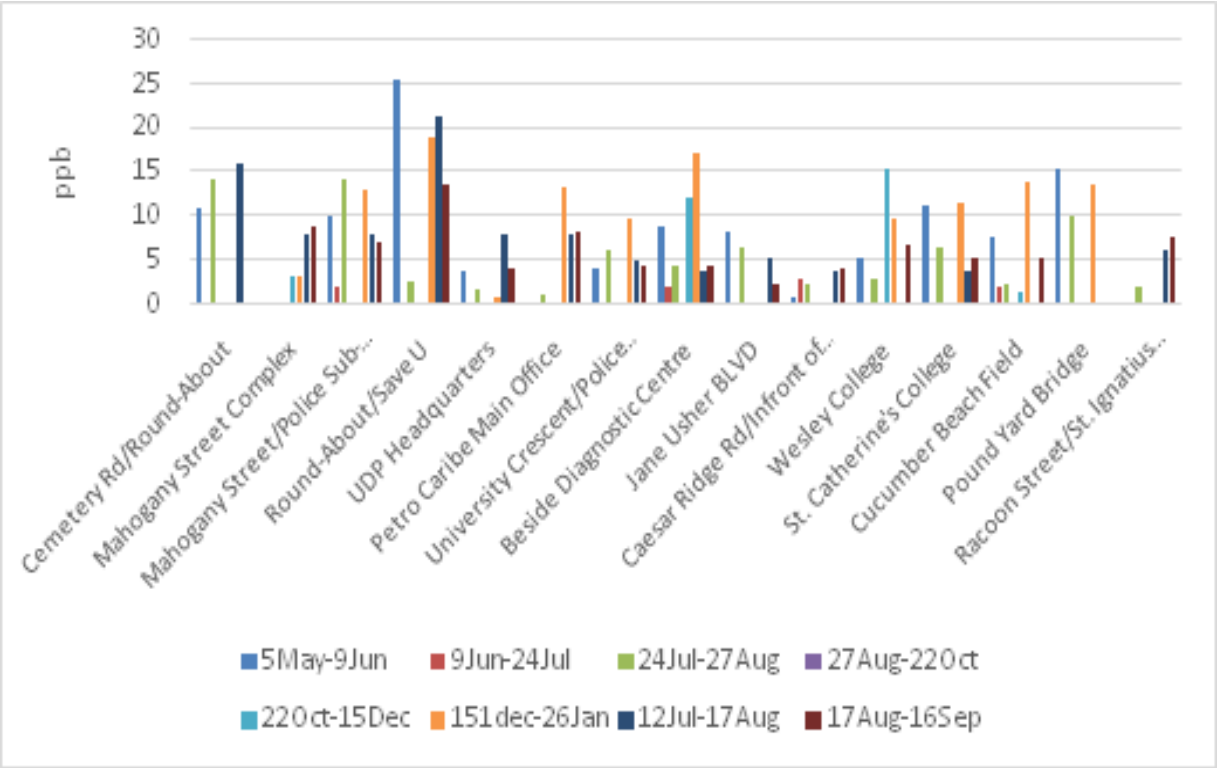


Figure 7-2: Temporal trends in NO2 average concentrations in Belize City.

NO_2 was measured in many stations in Belize City. Concentrations exhibited spatial and temporal variability. Levels were generally higher at the SaveU Roundabout, Pound Yard Bridge and Cemetery Road Roundabout, and Mahogany Street Police Substation stations while they were generally lower at the Caesar Ridge station. NO_2 is emitted mainly by vehicles so spatial differences likely reflect different traffic patterns. As seen in **Figure 7-2**, the data did not indicate any temporal trends (increasing or decreasing concentrations).

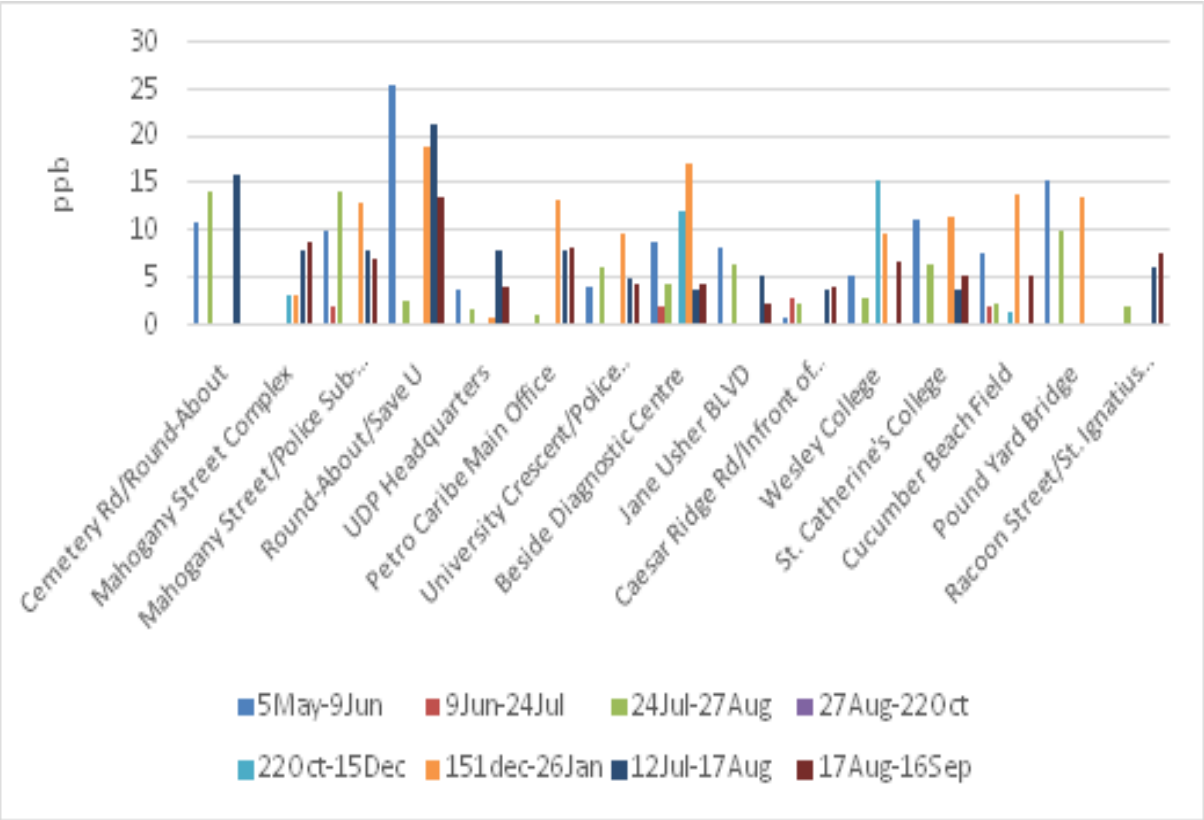


Figure 7-3: Temporal trends of O3 concentrations in Belize City.

Photochemical oxidants are formed when sunlight falls on a mixture of chemicals in the air. Ozone (O_3) is one of the main photochemical oxidants. Other chemicals such as formaldehyde are also found and, like ozone, have adverse health effects. Environment agencies measure the level of ozone because it indicates the total amount of photochemical oxidants in the air. Cities that have abundant sunshine over periods of time, together with moderate winds and high temperatures, are most likely to experience high levels of photochemical oxidants. O_3 was measured in virtually all stations and during all sampling periods in Belize City. The data indicated a high degree of uniformity spatially and temporally. The high degree of uniformity is likely due to mixing by air.

Section 1 of this EIA report describes the various components of the project and shows visually, the layout of all the components, including ancillaries. Generally, the project entails the construction of new cruise terminal with pier, Magical Belize Welcome Centre and other tourist amenities etc.

During the site preparation phase, it is expected that many heavy-duty machineries will be in use. Most of this machinery will use diesel fuel as their primary source of fuel and diesel fuel is known to emit more contaminants that gasoline or butane for example. During the site preparation phase most of the air emissions will be from the use of diesel engines (pickup trucks, bulldozers, barges, dump trucks, backhoes, excavators, dredge, etc.).

7.1.2 Types of Emissions Expected

7.1.2.1 Construction Phase

The type of emissions expected from the Port during the construction phase will be mostly from combustion of bunker, diesel and gasoline. The sources of emission will be from the large dredge, diesel from light and heavy-duty machinery and other light cars, motorcycle, etc. Emissions from all these sources are normally exhaust gas which contains NO_x, SO_x, and Carbon Monoxide, Ground Level Ozone and Particulate Matter.

The Pollution Regulations mentioned above contains standard levels for these parameters and the company must ensure that their equipment is well maintained and good working conditions for the standards to be met.

Since open burning of solid and hazardous waste is strictly prohibited other emissions such as dioxins and furans will not be generated.

At the construction site, temporary offices will be on site with air conditioning units. If not properly handled, these air conditioners could be a source of the emission of ozone depleting substances. It will be expected that only qualified and licensed air condition and refrigeration technicians can handle these units.

Due to the size of this project, it is also expected that gasses such as methane, hydrogen sulphide, and carbon dioxide will be generated at the sewage waste treatment system, however, the amount will be negligible.

The burning of butane gas may also emit some gasses during cooking, but these are expected to be very minimal at best.

7.1.2.2 Operational Phase

During the operation phase, the emission from machinery will decrease but another source of emission will be introduced, which are from the various classes of cruise ships which will make calls to and dock at the Port (**Figure 7-4**).

	Shipping emissions in ports (mln tonnes)
CO_2	18.3
NO_x	0.4
SO_x	0.2
PM_{10}	0.03
$PM_{2.5}$	0.03
CO	0.03
CH_4	0.002

Source: Author's calculations and elaborations, based on data from Lloyds Marine Intelligence Unit

Figure 7-4: Typical shipping emissions from ports.

There is not much data on emissions of ships at port, but some studies have been done. The most significant studies are presented in section above. The table above (**Table 7-1**) shows the different air contaminants and the volumes they contribute globally in millions of tones. Today, ships, especially cruise ships are designed to be more environmentally friendly and are a relatively clean transport mode. This is true if it is looked at from a perspective of emissions per tone-kilometre (Merk, 2014). CO_2 emissions are reported to be 2 to 3%, SO_x around 5 to 10% and NO_x 17 to 31% of global emissions (Merk, 2014). It is important therefore that an approved air quality monitoring plan be prepared and implemented for the areas surround this project to ensure that emission levels are recorded, and corrective actions are put in place when and where needed.

Table 7-1: Overview of studies on global shipping emissions.

	Estimation (mln tonnes)	Year	Share of total emissions	Source
CO_2	949	2012	2.7%	IMO 2014
	1050	2007	3.3%	IMO 2009
	944	2007	-	Psaraftis & Kontovas 2009
	695	2006	-	Paxian et al. 2010
	813	2001	3%	Eyring et al. 2005
	912	2001	3%	Corbett & Koehler 2003
	501	2000	2%	Endresen et al. 2003
	419	1996	1.5%	IMO 2000
SO_x	10	2012	-	IMO 2014
	15	2007	-	IMO 2009
	14	2005	10%	ICCT 2007
	12	2001	9%	Eyring et al. 2005
	13	2001	9%	Corbett & Koehler 2003
	6.8	2000	5%	Endresen et al. 2003
	16.5	2005	-	Cofala et al. 2007
NO_x	17	2012	-	IMO 2014
	25	2007	-	IMO 2009
	22	2005	27%	ICCT 2007
	24.3		-	Cofala et al. 2007
	21.4	2001	29%	Eyring et al. 2005
	22.6	2001	31%	Corbett & Koehler 2003
	12	2000	17%	Endresen et al. 2003
PM_{10}	1.3	2012	-	IMO 2014
	1.8	2007	-	IMO 2009
	1.9		-	Cofala et al. 2007
	1.7	2001	-	Eyring et al. 2005
	1.6	2001	-	Corbett & Koehler 2003
	0.9	2000	-	Endresen et al. 2003

7.1.3 Climatic Conditions and its Effect on Air Contaminants

The weather has an important effect on air pollution levels. Generally, windy weather causes pollution to be dispersed whereas still weather allows pollution to build up. Coastal locations and

open areas often experience more windy weather and are therefore likely to experience better air quality. The wind direction also affects air pollution. Pollutants can be transported via air masses from local to global levels. For example, if the wind is blowing towards an urban area from an industrial area then pollution levels are likely to be higher in the town or city than if the air is blowing from another direction of for example, open farmland. Sunshine can also affect pollution levels. On hot, summer days, pollution from vehicles can react in the presence of sunlight to form ozone. The pollution that causes ozone to be formed is usually generated from vehicles in cities and towns but because this pollution can be transported by winds, high levels of ozone may be found in the rural countryside. The pressure of the air also affects whether pollution levels build up. During high pressure systems, the air is usually still which allows pollution levels to build up but during low pressure systems the weather is often wet and windy, causing pollutants to be dispersed or washed out of the atmosphere by rain.

7.2 Noise Pollution

It is well known that port areas contain several noise sources in various sectors with different characteristics from each other, such as ships and other operations, industrial and shipyards as well auxiliary services. Such activities strongly impact the environment of the surrounding area including local population, port workers and tourists as well as both terrestrial and marine ecosystems (Corrado Schenone, 2014).

To reduce the impact of noise pollution Port of Magical Belize will implement a multidisciplinary approach, which encompasses technological, regulatory and administrative solutions. Noise is defined as any unwanted or inappropriate sound; noise pollution interferes with normal activities and disrupts a person's quality of life. Since noise pollution is generally treated as an environmental health related matter, the Department of Environment (DOE) is charged with administering the noise pollution regulations.

According to the Noise Abatement Regulations, Part XI, Chapter 328, Revised Edition 2003 of the Subsidiary Laws of Belize, "a person who on any premises uses or causes or allows to be use any equipment in such a way as to cause or allow it to emit unreasonable noise from those premises commits an offence".

The standard levels for noise are based on emission from five structures types along with duration in time and day and night time.

- Structure A: Any building used as a hospital, convalescent home, old age home, or school.
- Structure B: Any residential building.
- Structure C: Any building in an area that is used for residential and one or more of the following purposes: commerce, small scale production, entertainment.
- Structure D: Any residential apartment in an area that is used for the purposes of industry, commerce, or small-scale production.

- Structure E: Any building used for the purpose of industry, commerce, or small-scale production in an area used for the purposes of industry, commerce or small-scale production.

Once noise sensitive receptors are identified, it is recommended that noise monitoring is undertaken using equipment capable of logging data continuously at each location for up to 48 hours covering both daytime and night-time reference periods. Monitors should be positioned at approximately 1.5m above ground level and in free-field conditions were possible.

Table 7-2: Noise sources and their effects (Source: modified from http://www.wenet.net/~hpb/dblevels.html] on 2/2000. SOURCES: Temple University Department of Civil/Environmental Engineering (www.temple.edu/departments/CETP/environ10.html), and Federal Agency Review of Selected Airport Noise Analysis Issues, Federal Interagency Committee on Noise (August 1992). Source of the information is attributed to Outdoor Noise and the Metropolitan Environment, M.C. Branch et al., Department of City Planning, City of Los Angeles, 1970)

Noise Source	Decibel Level	Comment
Jet take-off (at 25 meters)	150	Eardrum rupture
Aircraft carrier deck	140	
Military jet aircraft take-off from aircraft carrier with afterburner at 15m or 50 ft (130 dB).	130	
Thunderclap, chain saw. Oxygen torch (121 dB).	120	Painful. 32 times as loud as 70 dB.
Steel mill, auto horn at 1 meter. Turbo-fan aircraft at take-off power at 60m or 200 ft (118 dB). Riveting machine (110 dB); live rock music (108 - 114 dB).	110	Average human pain threshold. 16 times as loud as 70 dB.
Jet take-off (at 305 meters), use of outboard motor, power lawn mower, motorcycle, farm tractor, jackhammer, garbage truck. Boeing 707 or DC-8 aircraft at one nautical mile (6080 ft) before landing (106 dB); jet flyover at 300m (1000 feet) (103 dB); Bell J-2A helicopter at 100 ft (100 dB).	100	8 times as loud as 70 dB. Serious damage possible in 8 hr exposure
Boeing 737 or DC-9 aircraft at one nautical mile (6080 ft) before landing (97 dB); power mower (96 dB); motorcycle at 25 ft (90 dB). Newspaper press (97 dB).	90	4 times as loud as 70 dB. Likely damage 8 hr exp
Garbage disposal, dishwasher, average factory, freight train (at 15 meters). Car wash at 6m or 20 ft (89 dB); propeller plane flyover at 300m or 1000 ft (88 dB); diesel truck 40 mph at 4.5m or 50 ft (84 dB); diesel train at 45 mph at 30m or 100 ft (83 dB). Food blender (88 dB); milling machine (85 dB); garbage disposal (80 dB).	80	2 times as loud as 70 dB. Possible damage in 8 h exposure.

Noise Source	Decibel Level	Comment
Passenger car at 65 mph at 7.6m or 25 ft (77 dB); freeway at 15m or 50 ft from pavement edge 10 a.m. (76 dB). Living room music (76 dB); radio or TV-audio, vacuum cleaner (70 dB).	70	Arbitrary base of comparison. Upper 70s are annoyingly loud to some people.
Conversation in restaurant, office, background music, Air conditioning unit at 30m or 100 ft	60	Half as loud as 70 dB. Fairly quiet
Quiet suburb, conversation at home. Large electrical transformers at 30m or 100 ft	50	One-fourth as loud as 70 dB.
Library, bird calls (44 dB); lowest limit of urban ambient sound	40	One-eighth as loud as 70 dB.
Quiet rural area	30	One-sixteenth as loud as 70 dB. Very Quiet
Whisper, rustling leaves	20	
Breathing	10	Barely audible

Table 7-3: OSHA's "Table G-16" Showing Permissible Noise Exposures. Source: OSHA.

Table 3
OSHA's "Table G-16" Showing Permissible Noise Exposures

Duration per day (hours)	Sound level, dB(A) slow response
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

8 Energy Generation

The energy demands are estimated based on average consumption of model/similar buildings to calculate the energy requirements for the project unless otherwise referenced.

Energy generation is an important component in any project in order to prove viable power supply. The following sections describe the generic energy requirements for the project.

The Port of Magical Belize Project comprises of several infrastructures including: a welcome centre and other tourist facilities.

8.1 Operational Phase

Electricity requirements of this project is expected to be mainly for domestic and semi-commercial purposes.

Table 8-1 gives a breakdown of the project as unit equivalents. Typical model buildings were used to calculate the energy requirements for the project unless otherwise referenced. The project will require approximately 364MWh daily.

Table 8-1: Energy requirements of the project.

Ref	Function	Qty	Daily Unit Rate kVA	Utility Factor	Total Daily KVA	Total Yearly kVA
Hotel	Twin	270	14	0.7	2,646	965,790
	Suites	30	14	0.7	294	107,310
	Casino	1	200	0.9	180	65,700
	Other Facilities*	4	27.0	0.9	97	35,478
Other tourist amenities	Estimation only	-	2,039	0.86	2,115	772,079
Public Lighting		100	30	0.9	180	65,700
				Sub Total	**18.20 MWh**	**6,644 MWh**
Cruise Terminal	Cruise Ship On Shore Power (optional)	4	96000 (GERMAN-GALKIN, 2019)	0.9	345,600	126,144,000
				Grand Total	**364 MWh**	**132,789 MWh**

8.2 Construction Phase

It is estimated that there will be a demand of about 200 kWh/day - 400 kWh/day during construction of the project. All the electrical energy demand for the construction phase will be obtained from gas- or diesel-powered generators.

8.3 Electricity Source and Supply

The Port of Magical Belize Limited intends to run electricity from the main line located on the George Price Highway at the neighbourhood of Old Belize through an all- weather road connecting to the project site. The overhead lines will be built along the coastline road. On the project site, much of the power lines will be laid underground where there are no boardwalks. This will increase the aesthetic appeal of the project site as well as reduce the risk of fallen power lines in the event of a storm. It is anticipated that the power from BEL will first be directed to the project's Utility Zone where it will be distributed to the rest of the development. All the electrical work and oversight will be conducted by BEL personnel who will certify the proposed activity.

The project will also include backup generators to supply electricity whenever needed to supply the entire facilities except for the Cruise Ships. A dedicated solar farm can be built to supply energy.

8.3.1 Diesel Generators

The Diesel generators will be enclosed and installed in the utilities area of the proposed project plan. These will not be visible to the guest and will be in a far enough secluded area that noise from the complex will not be a factor. Two generators will be installed with a capacity of 2MW each for operation when the national grid is down for maintenance or fault. A typical generator used in port facilities is shown in **Figure 8-1**.

Figure 8-1: CAT 2 MW Diesel Generator.

8.3.2 Solar Energy

Solar power has the greatest potential for utilization in this project. Recently the technology has achieved economic maturity and grid parity in many regions resulting in worldwide deployment to offset fossil fuel burning generators and to reduce carbon footprint. Photovoltaic (PV) is now relatively inexpensive and can provide power at a density of roughly 12 watts per square foot.

A 40MW Solar installation would be required for the sole purpose of providing electricity to the Cruise Ships when docked at the marina. Shore power can help to reduce the environmental impact of cruise ships. Shore power comprises an installation on shore and an installation aboard a ship, enabling the ship to be connected to the grid while it is in port. It is relatively costly to establish an onshore facility, and not all ships can receive shore power. The ships typically have an energy consumption of 7-11MW while they are in port. Unfortunately, the alternative energy source is not practical as it is estimated it would require approximately 160 acres (65 hectares) of land for the establishment of such a plant.

8.4 Evaluation of Energy Alternatives

Figure 8-2 below shows a comparison of alternate energy sources for Port of Magical Belize.

Figure 8-2: Comparison of alternate energy sources for Port of Magical Belize.

Criteria	Wind Power	Solar Power	Generators
Installation Cost	High	High	Low to Medium
Operation Cost	Low	Low	High
Reliability	Dependent on wind speed	Dependent on available radiant energy	Very reliable
Environmental Pollution	Low	Low	Medium
Capacity	Requires large blades to power facility	Requires Battery storage for night time	Able to work continuously

8.5 Fuel Requirements

The proposed development will require fuel in order to undertake the different operational activities. This requirement is primarily for the backup generators that will be used in emergency cases as well as the fuelling of marina vessels. The fuel demand for the anticipated project is difficult to calculate because of the generator operational hours during emergencies and hurricanes, domestic usage (butane) and number of marine vessels to service. Therefore, the project will be required to store an adequate volume of fuel for these typical scenarios.

8.5.1 Fuel Storage and Transportation

Fuel for the diesel generators will be bought from local distributor and only importer of fuels in Belize. This fuel will be transported to the project site via the coastal road. Fuel will be stored on project site next to the utility area and backup generators in two 15,000 gallons Above Storage Tanks (ASTs) contained in a re-enforce concrete containment wall (**Figure 8-3**). The Containment wall will be constructed to hold 110% of the combined volume of the AST. In addition to the Diesel Storage tanks, the facility will have one gasoline 10,000 gallons Above Storage Tank (AST) that will receive the same health, safety and hazard protocols.

The Project will also have fuelling stations on the dock and marina to cater to both diesel and gasoline powered vessels. The fuel for the fuelling station will be supplied from the AST via fiberglass piping laid underground and laid beneath the pier for safety reasons. The fuelling station will be managed by a trained and qualified service attendant.

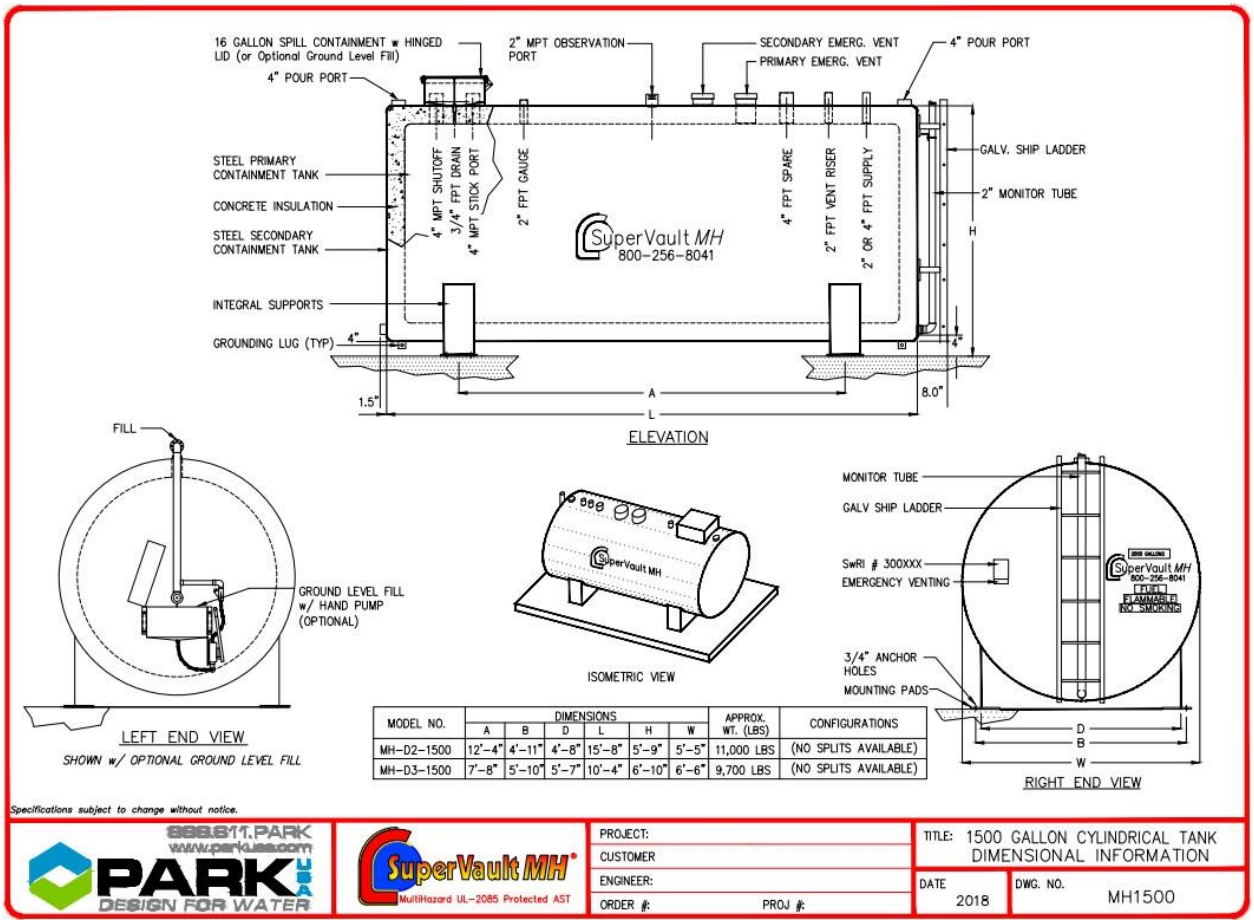


Figure 8-3: Above Storage Tank 1500 Gallons.

The developers will develop a Fuel Handling, Spill and Fire Contingency Plan to address prevention, containment, and cleaning of fuel/oil spills and leaks as well as fire prevention and firefighting capabilities.

8.5.2 Cooking Fuel

Fuel such as butane and propane used for cooking and refrigeration, if necessary, will be stored using the recommended guidelines. Each facility such as the villas and restaurant will store these fuels at adequate locations with the proper containment measures. The transportation of butane and propane will be the responsibility of the developer, who will follow the recommended guidelines for the transportation of hazardous materials. The supplier will be responsible for the refilling and/or replacement of any faulty or corroded container. Installation of the tanks will be done by trained maintenance personnel.

9 Transportation and cruise ship management

9.1 Layout of the proposed road(s)/walkways to be established for the proposed development.

Port of Magic Belize is strategically located within proximity and access to sites and activities that are popular with current cruise ship passengers. These sites and activities include, San Pedro Town, Caye Caulker Island, and other local islands (Caye), Belize City Airport, and archaeological sites such as Al Tun Ha, just to name a few.

Figure 9-1: Proximity and Access to Port of Magic Belize.

Currently, the main access to the project site is by water either through the sea leaving from Belize City or through the Sibun River. However, once completed, the main access to the project site will be through an all- weather two-lane road connecting the project site to the George Price highway at a point near Old Belize (Cucumber Beach). The road will be built parallel to the coastline as shown in **Figure 9-2**.

Figure 9-2: Navigational Lanes and Coastline Access Road

Port of Magical Belize will be accessible via a road that will connect the project property to the George Price Highways. The proposed road will be 10.2m wide, two traffic lanes pave surface with an approximately 9km in length. Each traffic lane of 3.6m wide and on each side 1.5m wide shoulders. This will require at minimum a stripe of 20m wide to be cleared. With this assumption the road construction will clear approximately 44.5 acres (18ha). Accessibility will also require the construction of a bridge over the Sibun River.

9.2 Preferred option for the provision of suitable roads/walkways

The section above mentioned that a 6 km (6 mile) two-paved lane road will be constructed along with a bridge over the Sibun River. This is the preferred option for accessibility to the development. Construction methods will follow locally used methods and procedures for road construction. The steps will include, (i) clearing, grubbing and excavation, (ii) embankment, (iii) sub-grade, (iv) pavement layers, (v) bituminous layers and mixes, (vi) reinforcement as required.

Clearing, grubbing and excavation is one of the major works involved in road construction. It involves the removal of topsoil, along with any vegetation, before scraping and grading the area to the finished formation level. The soil below the formation level is known as the sub-grade and it is important that the strength of the sub-grade is tested for moving on. The required thickness of the pavement is determined by the sub-grade strength, so it is recommended to make the sub-grade as strong as possible. Once the sub-grade has been prepared and drainage or buried utilities are

installed, the paving construction begins. Paving can be either flexible or rigid. There are pros and cons to each type, with one being selected over the other depending on the specific needs of a project, in this case rigid. Rigid pavements tend to have lower maintenance costs, a longer design life and higher flexural strength.

The proposed road alignment will connect the Port of Magical Belize to the George Price Highway (former Western Highway) near Mile 5 as shown in **Figure 9-3**. The alignment shall be situated parallel to the coastline following former tracks in the area; this option has been evaluated as most feasible. Other options would have involved having to traverse greater quantities of mangrove forests and swamps, and would potentially have greater impact on the inland ecology. In addition, it was evaluated that the most economic beneficial option was to connect the access roadway as close as possible to Belize City.

The roadway geometry is anticipated to be elevated an average height of 1.5m to provide for suitable base stability and drainage as shown in **Figure 9-4**. An estimated 235,200m^3 of fill materials would be required at minimum to construct the roadway in accordance with the parameters indicated. Detail design will typically involve developing the requirements for roadway materials suitable for base, sub-base and wear coarse. Typical options for the sourcing of this fill material are either from along the hills in the Coastal Road area or from Mile 21 Rockville Quarry. Sand fill materials are typically procured in the central Belize District areas between Hattieville and Rural Belize District. The harder materials for the wear course would best be sourced from the quarries in the Hellgates area (Caves Branch River) or the Churchyard area (Sibun River).

Figure 9-3: Proposed Access Road Alignment to Port of Magical Belize.

Generally, a minimum separation of about 2ft (0.6m) is required between the bottom of the roadway base and the seasonal high groundwater table levels along the roadway. Drainage infrastructure should provide for suitable positive flow to move runoff away from the roadway base. As such it may be feasible to establish the bottom of swales a minimum of 1ft (0.3m) above the seasonal high groundwater table levels. The overall movement of runoff is anticipated to involve moving all runoff to the west of the roadway embankment through the use of interconnecting culverts (east to west across the roadway embankment) and swales for ultimate release of runoff into the swamps.

ROADWAY FILL QUANTITY SHEET

NOTE: Design is for a typical two-lane roadway in Belize

Estimated Average Fill Height	=	**1.5 m**
Carriageway Width	=	**7 m**
Estimated Top Embankment Width	=	**11 m**
Estimated Shoulders, Sidewalk, and Drains	=	**7 m**
Est. Total Req. ROW	=	**20 m**
Est. Avg Cross Section	=	**21 m^2**
Est. Roadway Length	=	**11,200 m**
Est. Fill Volumes	=	**235,200 m^3**

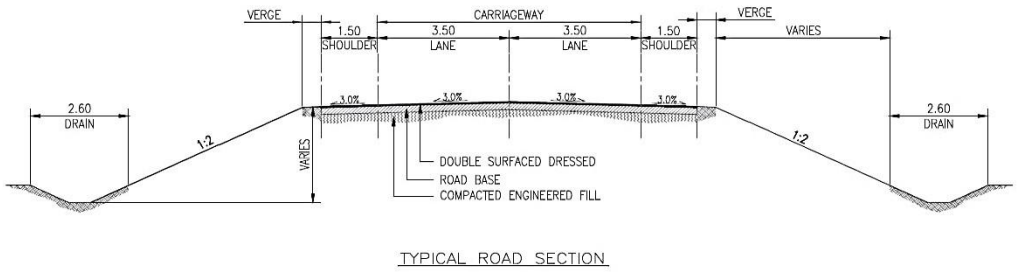


Figure 9-4: Typical Roadway Cross-Section and Fill Quantity Estimates

Further design considerations should also include for erosion mitigation from potential storm surges that can occur along the coastline. Further studies are required during the detailed roadway design.

10 Social Factors

10.1 Introduction

Belize is counted among the 83% of all countries in which tourism is one of the top five exports. It is also part of the 38% of the world's nations in which tourism is the main foreign exchange earner. A study conducted by The Belize Tourism Board (BTB) indicated that one out of every four jobs was related to tourism. Therefore, it comes as no surprise that this industry features prominently in Government of Belize's (GOB) effort to eradicate poverty.

Belize's Horizon 2030 Strategy puts forth the economic goal of a sustainable and profitable tourism sector. Several strategies are identified to attain this goal inclusive of a vibrant business sector and support for responsible and socially inclusive tourism as an alternative.

The National Sustainable Tourism Master Plan 2012-2030 (NSTMP) endorsed by the GOB in 2012 affirms these strategic priorities and sets out ambitious sector targets necessary for Belize's economy to grow by 5% per annum in the medium term.

10.2 Cruise Tourism in Belize

According to a 2018 report on the Economic Contribution of Cruise Tourism to the Destination Economies Volume II prepared by BREA for Florida–Caribbean Cruise Association and Caribbean Destination the amount of tourist that visited Belize for 2017/2018 were 877,279 yielding $68.3 million US dollars. This created 2,530 jobs and $27.7 million in wages for the same year 2017/2018.

According to the same report, with respect to passenger satisfaction the following are the responses:

- Cruise passengers were satisfied with their overall visit to Belize (7.9) and in terms of the visit "meeting expectations" (7.3).
- "Guided Tours" (or Shore Excursions) received a 'very satisfied' mean score of 8.6. Additionally, the high ratings in "knowledge of guide" (9.2)," professionalism of guide (9.1) and "value of tours" (8.3) indicates visitors to Belize were very satisfied with their onshore excursions.
- Passenger interactions with residents and store employees were very positive as the mean scores for "friendliness of residents" (8.5) and "courtesy of employees" (8.4) were among the highest of all ratings.
- Passengers were also very satisfied with the "initial shore side welcome" (8.2) and the "taxis and local transportation" (8.4).

- Belize scored lowest in the likelihood passengers to say they are "likely to return for a land-based visit (5.3), and their "likelihood of recommending to a friend" (5.8), however, both were rated as 'somewhat likely'.

The Caribbean Tourism Organization's latest statistics (August 16, 2019) for Cruise Tourism reported that for the first six month of the year January to June 2019, 697,767 tourist visited Belize, and this represent 10.8% more than 2018 which stood at 629,684.

Cruise Tourism Policy for Belize highlights two main objectives are: to increase the number of cruise ship calls and passenger arrivals in a sustainable manner and to explore other ports and suitable anchoring sites on the coast of Belize with a view to making additional cruise ship calls to other areas of the country. Precisely because of this, the intention of Port of Magical Belize proposes to establish a State-of-the-Art cruise terminal that will berth larger ships than those currently docking in Belize thereby facilitating the increase of the number of tourists that can visit Belize.

10.3 Social Impact Assessment Objective and Methodology

The purpose of this social assessment was to inform stakeholders about the proposed project and to gather and record relevant information of stakeholder's views and opinions on potential positive and negative socio-economic impacts associated with the project. The information will be used to identify mitigation measures for the impacts identified and will be included in the EIA for the project.

10.3.1 Questionnaire Development

A desktop review of previous Social Impact Assessments of similar projects was done with the objective of acquiring information on the range of questions needed for the study and the methodology used in the acquisition of information. After a thorough analysis of previous sample reports was done, a comprehensive questionnaire relevant to this development was developed.

10.3.2 Target Population

This assessment outlines and summarizes the key analytical opinions of varied group of stakeholders. It identifies main points about community stakeholder's attitudes towards the proposed development.

Stakeholders from various capacities were invited to participate in this survey. The main targets were farmers, Village Councillors, High School and Six Form Student as well as Government and Non-Governmental organizations and departments. The participatory approach process included:

- Preparation of the baseline survey form questionnaire.
- Review of the questionnaire form and preparation of final form.
- Field visit interview with key stakeholders as mentioned above.

- Meeting with stakeholders and.
- Report Preparation.

This evaluation incorporated the participatory approach methodology and gave interviewees the opportunity to express free and openly their views and opinion on what they thought of the proposed development and how it will contribute to the overall development of Belize. A total of 45 minutes was taken with each interviewee in order for them to have a clear understanding of the proposed development and to answer the questions in the questionnaire. The filled in questionnaires are provided in **Annex 17**. Below is the result of the assessment carried out.

10.4 Background Information on Impacted Communities

10.4.1 Belize City

The Belize District is the fourth largest District of the Country of Belize with an extension of 1,663 sq. ml. or 4,310km² and a population of 95,292 inhabitants according to the 2010 Belize Census Report. Of this total, 46,872 are males and 48,419 females.

Belize City is known as the old capital and is located at the mouth of the Belize River on the coast of the Caribbean Sea and is the principal commercial and financial centre of the country of Belize. Belize City spreads out to Mile 8 on the George Price Highway and Mile 13 on the Philip Goldson Highway or by Haulover Bridge.

Belize City is divided into two areas: North side, bounded by the Haulover Creek and ending to the east of Fort George, and Southside, extending to the outskirts of the City and the Port of Belize area and includes downtown. Politically it is divided into ten constituencies.

According to the 2010 Belize Population and Housing Census, the City of Belize counts with a population of 57,169 inhabitants with 27,655 being males and 29,514 being females. Today Belize City it is the home of multi-ethnic people such as Creole, Mestizos, Garifuna, Lebanese, Chinese, East Indians and European. The City is managed by a City Council comprised of ten (10) members whose responsibility is the management of the affairs of the municipality for the creation of development. They are elected every three years.

Cruise Tourism is a contributor to the economy of Belize city. The Fort Street Tourism Village (FSTV) located on North Front Street receives major arrivals of tourist from several cruise ships that anchors outside the port and are tended by local citizens. Belize City is the home of a multi-ethnic group which consist of Creole, Mestizos, Chinese, East Indian and other ethnic groups. The official language is English but Creole, Spanish, and other languages are spoken.

Belize City have the most secondary and tertiary educational institutions in the nation bosting institutions such as St. Johns College and the University of Belize. The City counts with three major hospital: 1. Karl Heusner Memorial Hospital (KHMH); Belize Medical Associate, and the Universal Health Services. KHMH serve as the National Referral Hospital for the country.

10.4.2 Gales Point Manatee

Gales Point Manatee is a village located south east of Belize City. It is approximately 81km (53mi) from Belize City by road through the George Price Highway. In relation to nearby communities it is located 37km (23mi) east of the village of La Democracia. Gales Point Manatee is a peninsula in the Belize District almost surrounded by water from the Southern Lagoon.

The 2010 Population and Housing Census indicates that the village of Gales Point is comprised of 72 households and a population of 296 people of which 152 are males and 144 are females mainly of Creole descent.

According to the villagers, the name Gales Point Manatee came from a group of slaves who resisted enslavement, fled and settled this area in the 17th century. Among this group of slaves was the leader whose surname was Gales. These slaves settled at the furthest point of the peninsula where the presence of manatees was common leading to the name Gales Point Manatee. According to the villagers, the village is not prone to flooding.

Gales Point Manatee count with a Primary School Building and an enrolment of 70 students of which 35 are males and 35 females. The school is staffed with 7 teachers who are responsible in imparting classes. Presently, there are 32 students from the village who are attending high school in Dangriga Town.

In addition to the school building the village counts with a potable water system, electricity, a Methodist Church and a community Health Centre which is used monthly by health workers from the Southern Regional Hospital located in Dangriga Town. Health services are provided once a month for both children and adults and the most common diseases identified are fever and common cold, but a lot of bush medicines are used by the villagers to treat common ailments. Villagers said that medical attention for more serious diseases is obtained at the Southern Regional Hospital located in Dangriga Town.

Based on information provided by the villagers, men are dedicated to subsistence farming cultivating mainly cassava, corn and plantain for home consumption. Some men do fishing and others work at the Citrus Plantation during the harvest season which starts during the month of November and end in May. Gales Point is considered a poor community with lack of jobs and employment opportunities. Although, jobs are hard to come by, crime is low. Typically, the houses in the village are made out of cement block or lumber with zinc roofing and cement floor.

The village is managed by an elected Village Council comprised of 7 representatives whose responsibility is to work for the development of the village. The village contains a 36 km^2 (14 sq. miles) of wildlife reserve known as the Gales Point Wildlife Sanctuary whose present President is Mr. Kevin Andrewin.

10.4.3 La Democracia

The village of La Democracia is located approximately 30 mi south of Belize City and sits at the junction of the George Price Highway and the Coastal Road. According to the 2010 Belize Population and Housing Census, the village is comprised of 109 households with a population of 353 of which 191 are males and 162 females mainly of Creole descent. The official language of the village is English but Creole as well as Spanish are spoken by some inhabitants.

Residents travel either to Belize City or Belmopan seeking employment. There are few families that do agriculture, planting corn, plantain and fruit trees for home consumption. Those who are employed work in the construction industry or at public offices while others work in the citrus industry on a temporary basis. Despite the high unemployment rate crime is very low and the village is considered a safe village.

The village vice chairlady indicated that La Democracia counts with a Community Health Worker who provides basic health services for minor illness; however, for more serious conditions, medical attention are seek either from Belize City or Belmopan.

La Democracia counts with a Primary School, a Potable Water System, Electricity and a Church building.

The village affairs are managed by an elected village council comprised of seven persons whose responsibility is to work towards the development of the village. They are elected every three years.

10.4.4 Gracie Rock/Rockville

Gracie Rock/Rockville is located close to Mile 21 George Price Highway. Gracie Rock is approximately 1mi off the road and lies on the bank of the Sibun River while Rock Ville is on the main highway. The population of this twin villages is 255 persons of whom 142 are males and 113 females. The village has 69 household of mostly creole descent.

With the exception of electricity, the village of Gracie Rock provides no other services than a school, health centre and a potable water system. According to information provided by locals, primary school children attend school in the village of Hattieville which is located approximately 3mi east of the village while high school students attend school in Belize City. With respect to water consumption, most families purchase bottled water or use rainwater stored in water tanks. River water is used for washing and bathing.

Availability of employment in the village is limited. Villagers seek temporary employment in Belize City or at a Quarry that is located between Rock Ville and Gracie Rock. Farming of ground food, corn and plantain for home consumption is practiced. Despite the high unemployment rate, the village is considered safe and peaceful.

The village does not count with a health centre and villagers seek medical attention in Belize City. Major illnesses reported were fever and common cold. The affair of the community is managed by an elected village council whose responsibility is to work for the development of the village. The name Gracie Rock came as a result of a woman by the name of Grace living in the village and in front of her house was a big rock and so they named the village Gracie Rock.

10.4.5 Freetown Sibun

Freetown Sibun is a very small community located 16mi south of Belize City or 4mi east of the Village of Hattieville. The village lies on the bank of the Sibun River and counts with 20 households and a population of 80 inhabitants mainly of Creole and Spanish descent. The village has its own village council who is responsible for managing internal affairs of the village.

According to resident Mrs. Mariam Conorquie, Freetown Sibun is an old village older than Hattieville which was establish during slavery days. A group of slaves escaped and established themselves down the Sibun River. Being free from their slave master they name the village Freetown Sibun.

The village has electricity but no school, potable water system, nor health centre. Due to its small population there are 5 primary school children that attend primary school at the village of Hattieville. Secondary education is sought in Belize City at different high schools. According to residents, consumption of water is directly from the river and drinking water from rainwater catch collected on water tanks.

Employment opportunity in the village is limited and residents commonly work in Belize City or are self-employed on their farm producing corn, plantain and ground food for consumption while livestock is reared for the local market. Crime in the area is very low. Health Centre is nonexistence and medical attention are obtained in Belize City or when the mobile clinic visits the village. According to community members, the most common illnesses of the residents are flu and common fever.

10.4.6 Survey Results

A total of 10 days was taken to conduct this survey of stakeholders from the villages of Gales Point Manatee, La Democracia, Gracie Rock/Rock Ville, Freetown Sibun, and from the City of Belmopan and Belize. Stakeholders were from diverse occupation/representing a diverse group of institutions. This included kitchen assistant, six form students, house wives, school warden, farmers, fishermen, caretaker, tour guides, tour operators, security personnel, boat captain, City Council personnel, Fishery Department personnel, Coastal Zone Management Authority personnel, and village council members. The social interview data (3 pages for each of the 45 interviewees) are provided in **Annex 17**.

Community awareness of this proposed development was inquired through this survey. A total of 26.7% of the respondents knew about Portico and their plans for developing Port of Magical Belize

Some of the respondent said they knew that the company was planning to build a bridge, hotel and terminal. 73.3% of those interviewed had no knowledge of the proposed development; therefore, the interviewer shared information about the project with them prior to the interview.

Participants were asked to provide their general opinion about the proposed development. As shown in **Figure 10-1**, more than half of the population surveyed is of the opinion that the proposed development will be beneficial to members of their community. A total of 78.51% of the interviewees indicated that the development will create job opportunities for the residents. They stated that the proposed development will bring more tourists to the country thus creating more revenue. Based on the responses, 12.16% of the respondents indicated that they are concerned about the impacts that the project might cause to the mangroves and marine life when dredging the channel. 4.4% of the respondents believed that the project will cause saturation of the local tourist market.

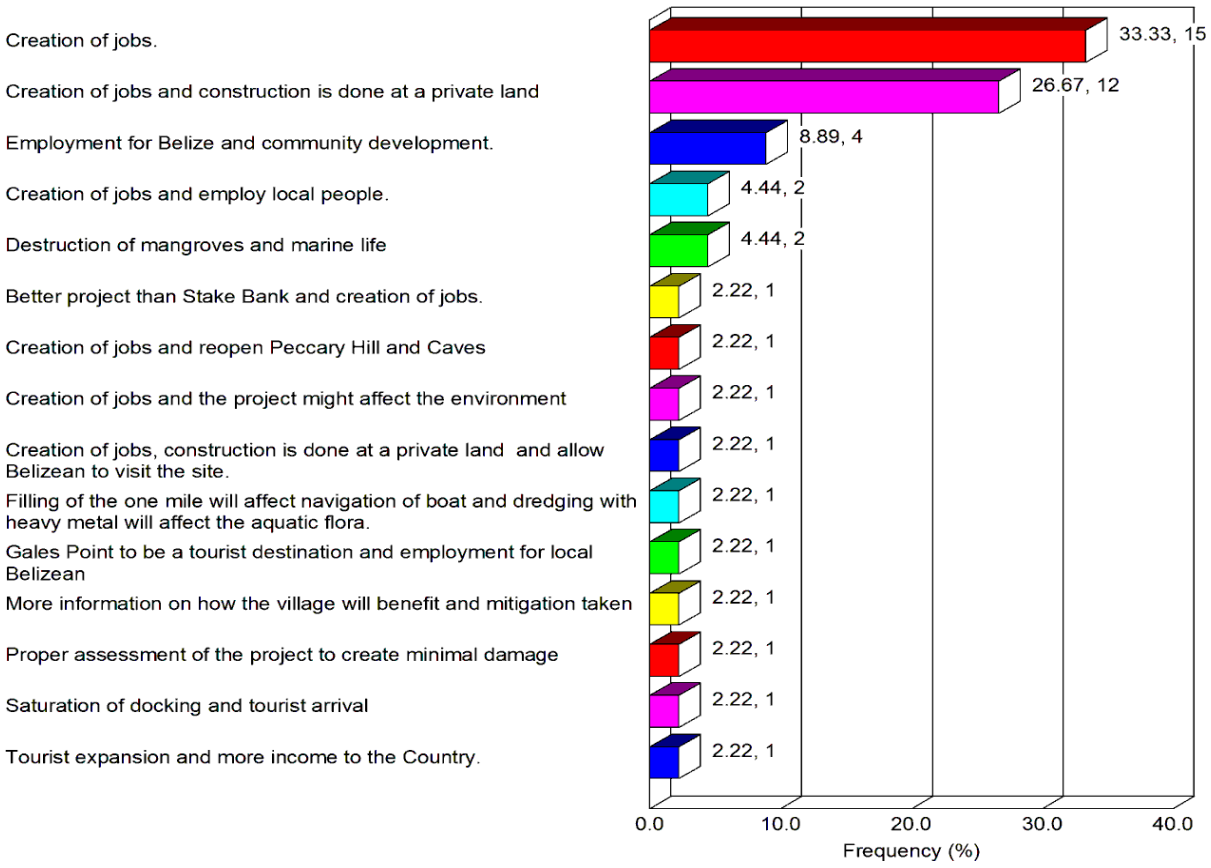


Figure 10-1: Chart showing participant's opinion about the proposed development.

Participants were questioned if they believe that the proposed development will benefit local businesses such as hotels, bus companies, arts and craft shop, restaurants, local food vendors or the country of Belize as a whole. In **Figure 10-2**, most of the participants (97.62%) believed that business will benefit from this project and will create new jobs and opportunities for small

businesses in the communities. Some of the responses indicated that the project will contribute to economic growth in the community, and the reopening of Peccary Hill as a tourist destination. They also believe that tour buses will stop by the community to allow tourist to purchase arts and craft. A few pointed out that additional information is required on how the community will benefit from the project.

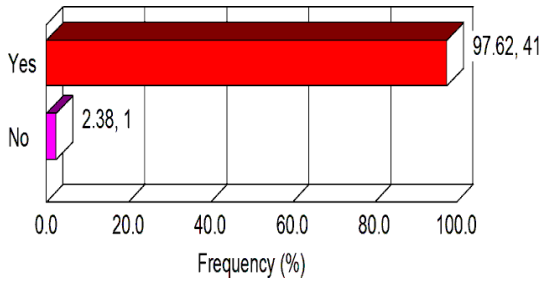


Figure 10-2: Chart showing response on whether the proposed development will benefit businesses in the community or the country as a whole.

The participants were questioned if the project will affect the community negatively or positively on various aspects. The majority of those interviewed responded that they believed that the development will bring about new jobs which is urgently needed in the communities. Also, they believed that the road would be paved; Peccary Hill open creating additional jobs and making the community of Gracie Rock and Gales Point a tourist destination. On the other hand, a few of the respondents stated that that the project could have a negative impact on the surrounding communities.

The respondents were asked if they had any knowledge of commercial fishing done in the area where the project will be situated. All said that no commercial fishing was done at the site. In addition, they mentioned that fishing at a small-scale level is carried out at the Southern lagoon and the Sibun river.

All participants were asked if tour guides will be affected or if they will they benefit from the project. A 100% of the responses indicated that the tour guides would benefit the most, but the risk would be if Belize doesn't have enough tour guides to support the arrival of a larger amount of tourist. They also indicated that Belizean should be first and that no foreign operators should be employed or given licensed to work.

Participants were asked if the project could impact negatively on human health, aquatic animal health, aquatic plant health, business for locals and noise pollution. In **Figure 10-3**, the result showed that the majority, 81.3%, of the responses believed that the aquatic life would be the least affected. A total of 43.8% of the responses suggested that the aquatic plant would not be destroyed. A 31.3% of the response indicated that noise pollution would not contribute. While 12.5% believe that human health would not be affected. Also 6.3% believed that the project would create business

for locals. Apart from the activities mentioned above, participants pointed that the developer needs to comply with the laws of Belize and use the available landfill for proper garbage disposal.

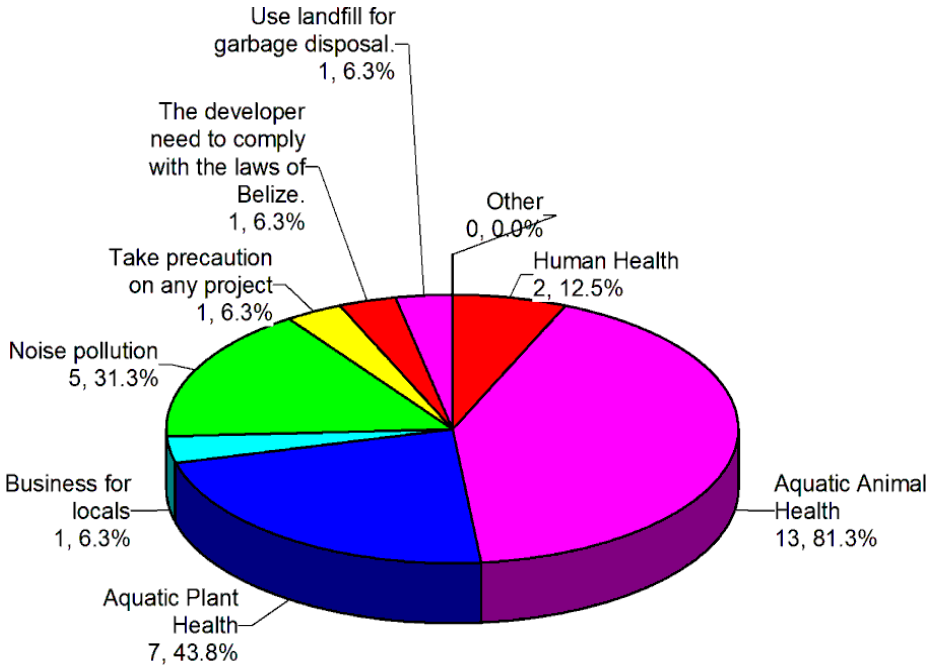


Figure 10-3: Chart showing response on whether the activities associated with the proposed project will affect negatively.

All participants were asked whether they thought dredging will create damage/impact to the marine environment. **Figure 10-4** indicated that 42.24% of the respondents agreed that the development would impact the marine and aquatic organisms. A 42.07% of the interviewees agreed that the area is considered a "dead zone". They stressed that the developer should abide by the laws of Belize, avoid oil spilling, avoid destruction of mangroves, dredge when there is low tide, follow international acceptable standard when dredging and use high technology that would avoid any impact to the marine environment and aquatic life. The graph also shows that 6.66% of the participants believe that in the event of any negative impact to the sea and people of the community, the project should compensate the affected parties for any damages done.

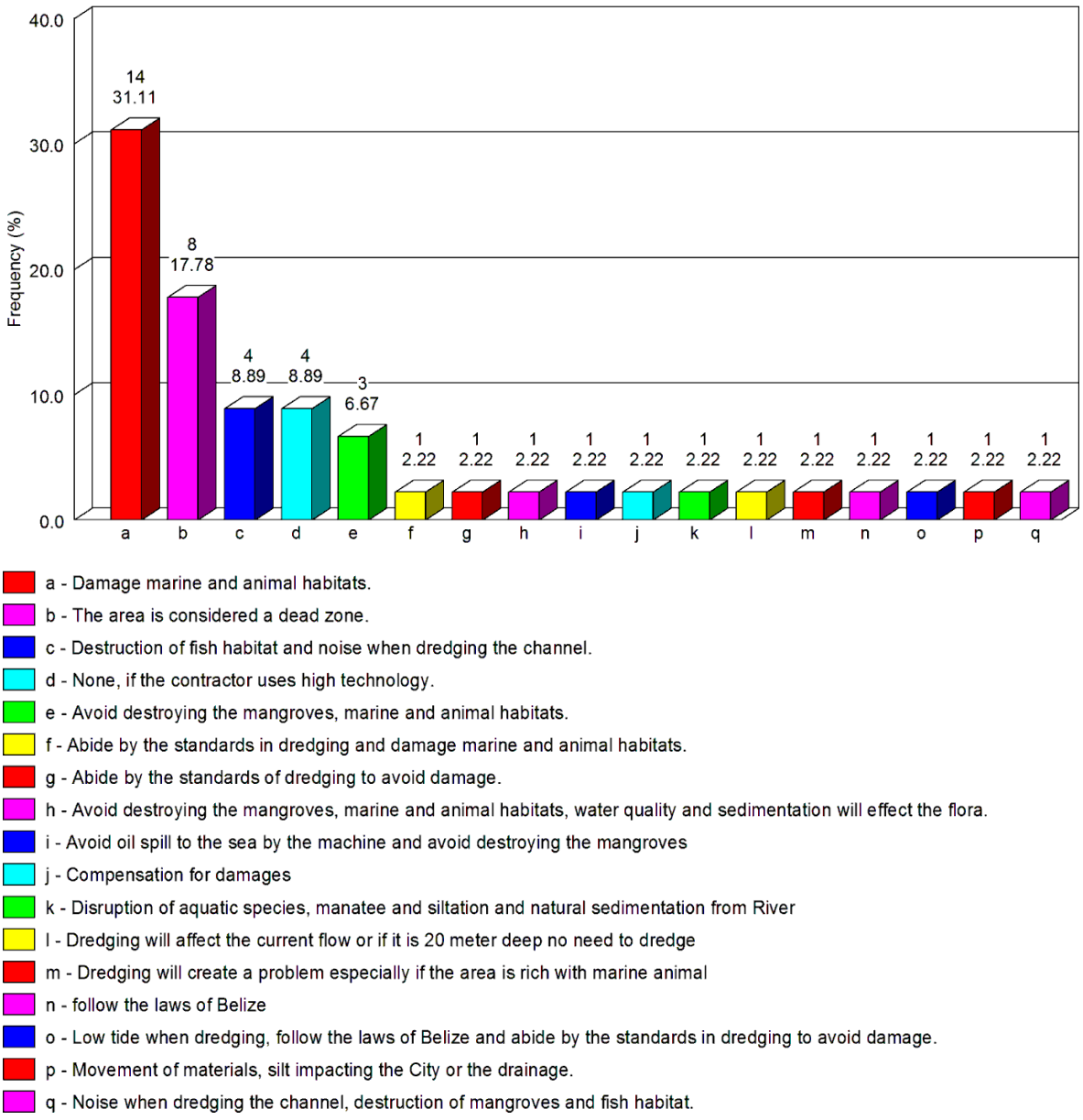


Figure 10-4: Chart showing response on whether dredging would create any damage/impact on the sea for the passage of cruise ship.

The survey also questioned participants if they are aware of the presence of endangered species or commercially valuable species both terrestrial and aquatic that would negatively be affected by the development. 66.7% believed that there are no endangered or commercially valuable species in the area. Responses indicated that the developer needs to be careful not to harm manatee and sea

turtle and avoid destroying the forest as it is the habitat of the jaguar and tapir. A small number of respondents indicated that the only endangered species found in the area that they are aware of is the manatees and hicatees.

Participants were asked if they believe that the construction of the road that would lead to the George Price Highway would cause any negative effect to flora and fauna. 91.7% of the responses indicated that the destruction of the mangroves would not be affected. A total of 75% believed that the habitat of birds and reptiles would be the least affected. While 50% believed that the species (flora and fauna) will not be affected by the construction of the road. The respondents indicated that there is no protected area in the area.

In addition, participants were asked if they foresee any major problem that would be caused by the development; a small amount indicated that the mangroves would be destroyed when building the road and advised that precaution should be taken when dredging in order not to disturb manatee and turtle habitat. They also indicated that the area where the development will be situated is considered a dead zone but suggested that the developer should consider opening a passage for sea current to flow when filling the 1.4km (0.9mile) of sea. They voiced that the project would create jobs for Belizean, increase income and increase tourism in the country.

The participants were asked what they would like the developer to consider in order to minimize potential impact from the activities associated with the project. The majority suggested that the developer should have a secure plan, use specified standard, follow the laws of Belize, and avoid destruction of the mangrove when constructing the road. Also. they suggested considering Peccary Hill located south east of Gracie Rock as a tourist destination as well as the Northern Lagoon they further indicated that creating a passage for wild life animal is important and that the filling of the 1mi of seas should have passage of water for sedimentation to flow. One of the participants said that the developer should complete the project and not to leave it halfway.

The survey also questioned participants if they believed that the project would provide opportunities for Belize in the areas of job creation, poverty alleviation, expert earnings and tourist expansion. In **Figure 10-5**, it was agreed based on the responses that the proposed development will provide positive opportunities for Belizean. Responses indicated that the development will certainly create employment opportunities for locals. By creating employment, such developments can also alleviate poverty, reduce crime and have a direct influence on the Belizean economy. Expert earning is also an opportunity garnered by these projects. The vast majority of respondents stated that the lives of the locals and the economy of the country as well would significantly be improved by this project.

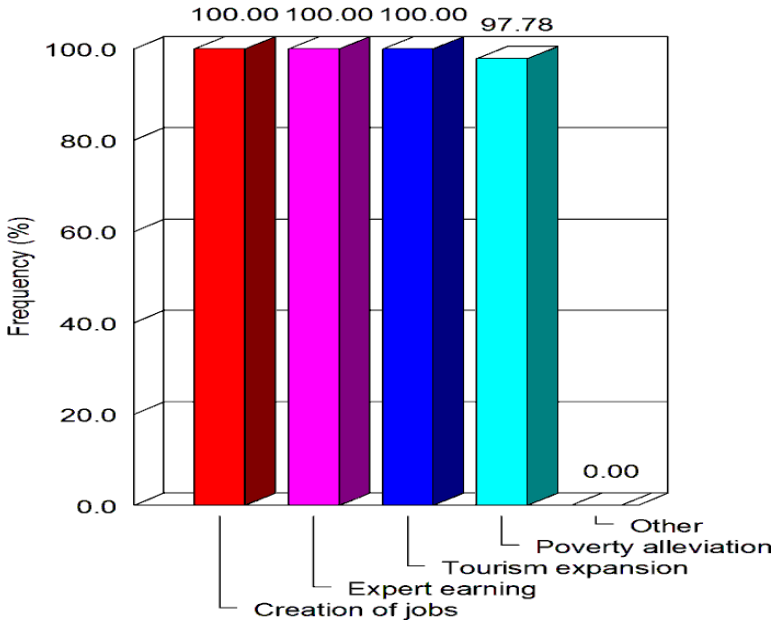


Figure 10-5: Chart showing response on whether the proposed development will provide opportunities for Belize.

Figure 10-6 shows that most of the respondents agree that the project will provide employment and business opportunities for Belizeans. However, they recommend that the developer avoid errors done in the past whereby big companies such as Chukka has been contracted and now, they manipulate all tourist business related activities. They further recommend that a push should be made to help Peccary Hill become a tourist destination. Other recommendations are that the developers should seek guidance from the Ministry of Tourism and have affordable rates for Belizean tourists. The participants also recommended that the developers should have a detail plan to mitigate any impacts from the project and that the company should have proper waste disposal and management system in place. Participants suggested that the company should obey the laws of Belize, use acceptable standards and use appropriate measures to address any risk that might be encountered during construction and operation of the project.

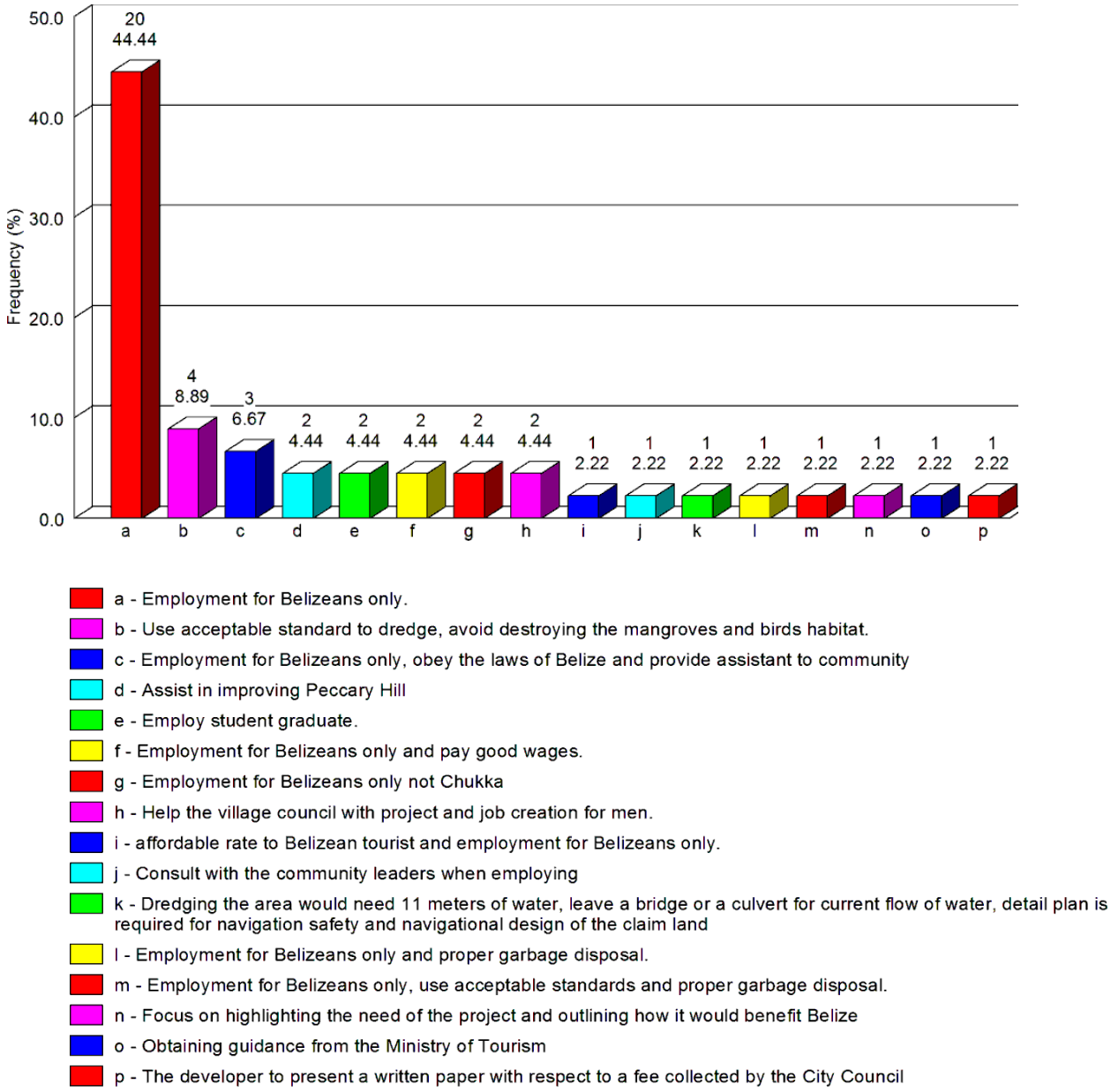


Figure 10-6: Chart showing response on recommendations that the developer should undertake in order to address or minimize any potential impact.

The final comments of the participants on the proposed development reveal that the targeted audience believes that the company should hire Belizean community workers and should offer them good wages. A significant percentage of the responses suggest that the proposed development is a positive development for the country as it will create jobs opportunities for the locals and will

help alleviate poverty. This project will be a big boost for the local economy and thus can reduce crime in the immediate area. The respondents also believe that the developer should collaborate in community development projects.

In addition to those surveyed individually, a meeting was held with a group of independent Tour Operators and Tour Guides . The focus group consisted of Elvin Torres Jr. (ATV Tour Guide), Oscar Guerra (Tour Guide), Evan Willians (Tour Guide) Damine Myles (Tour Operator), David Almendarez (Tour Operator), Jhony Rosado (Tour Operator), Keith Vailez (Tour Guide), Jeremaiz (ARV Tour Guide), Ricardo P. (Tour Guide), Kelvin Ramnarace (Tour Guide). Below are listed the recommendations from the meeting:

- The rules should be the same for all tour operators and tour guides.
- The selected site is ideal for this project but might create sedimentation and turbidity problems.
- The reduced traffic time will result in an increase in the amount of time that tourists can spend in Belize which is good for us and will result in more income for local Belizeans.
- If the project is successful opportunities should be provided to the local people for them to benefit.
- The hope is that new cruise port caters for all Belizeans and not only benefit the cruise owners and few privileged people.
- The new terminal will eliminate all problems of traffic congestion in Belize city as is currently the situation.
- This development needs to have a good waste disposal management system.
- It is good that this consultation was done for us to know what is going on and how we can contribute to its success. We want to ensure that we are taken into consideration early on to ensure that independent tour guides and the general public benefit from the project.
- We recommend that the project provides business opportunities to everyone.
- Our aim is to see tourism expand so that Belize benefit from it. Do not marginalized us.
- A lot of us are local to the area and know the area well where the project is going to be sited. Some of us have fished and hunted these areas. Although the area is not known as a commercial fisheries area, we feel it is important to protect the manatees and the mangroves since it serves as barrier during hurricane.
- This project can fix the problems that FSTV has now with traffic congestion and little opportunities for locals to benefit.
- We recommend this project since its location is ideal and we are promised that it will benefit Belizeans.
- We feel competition is good.
- The expansion of our tourist industry means more money for the country.
- Belize is long time waiting for a State-Of-Art Cruise Terminal.

Multiple attempts were made to consult with Ms. Janelle Chanona (Vice President) of OCEANA. This included a letter submitted to her on August 22, 2019 requesting time to meet with her. A second letter was emailed to her on December 11, 2019 but no response was received. A letter was also sent to Belize Audubon Society (BAS), Belize Hotel Association (BHA), Belize Tourism Industry Association (BTIA) and to Belize Tourism Board (BTB) on August 22, 2019 requesting time to meet with them but up to January 11, 2010 the only response received was from BHA saying that the letter will be passed on to the Board for input and from BAS saying that they were busy. A subsequent email was sent to BAS in which an appointment was requested for a meeting; however, no further response was received.

10.5 Potential Human Health and Safety Impacts of the Project to the Neighbouring Communities

Question number 7 of the questionnaire asked interviewees of whether they thought that any activities associated with the project will negatively affect the health and safety of members of their community. The majority of people interviewed from the four communities closest to the project site indicated that due to the distance of the project site to their community, they felt that the project would not negatively impact human health and safety in their communities. However, there were some persons who indicated that people that will work in construction of the various project infrastructure may be exposed to typical construction related risk and thus there is a need for the developer to ensure the safety of the labourers/worker onsite. It was the opinion of some interviewees that all workers should have basic first aid training and that all workers should wear safety gear at all times while working. It was pointed that the contractor should have on hand relevant telecommunication system radio/cell phone and a boat in the event of any emergency.

10.6 Description of the Potential Social and Economic Benefits of Establishing the Project

The social assessment captured that a good portion of stakeholders interviewed view this project as a high impact project for the country of Belize. Many interviewed are aware that tourism is the top foreign exchange earner in the country and believe that this project will further create meaningful economic contribution to the nation. They said that if the project becomes a reality, it will create income benefits to the nation not only in foreign exchange earning but in the creation of temporary employment during construction and permanent employment opportunities for Belizeans during its operation phase thus reducing unemployment, crime and related ailments of lack of job opportunities. Some community members interviewed spoke with an open heart saying that the lack of job opportunities in their communities is contributing to social degradation as it is simply difficult to put food on the table, educate their kids, ensure the good health of their family and pay for utilities.

Many interviewees particularly those from La Democracia and Gales Point Manatee shared excitement when they heard about the project as they felt that any new tourist port will increase the number of tourists coming to Belize. They see this s an opportunity for economic development

of their communities especially once the coastal road is completed as this they feel will result in an increase in tourism and/or tourism related activities in their respective villages.

10.7 Conclusion

Final comments and conclusions from the social survey indicates that overall interviewees agreed that this development is a good project since it will provide job opportunities for the Belizean people and will help alleviate poverty by boosting the tourism industry, earn foreign exchange and will put Belize at the forefront as one of the best tourism destinations in the region. However, there are also concerns about the potential negative consequences of the proposed development. Concerns centre on the increased chances for damage and killing of manatees from increased boat traffic, from the destruction of habitat for aquatic wildlife due to activities such as mangrove removal, and effluent releases.

Independent tour operators interviewed expressed their appreciation for being consulted but cautioned and urged that the developer avoid errors done in the past whereby big companies such as Chukka has been contracted and now they manipulate all tourist business related activities.

Finally, the perspective of the project developer is that the proposed first state of the art Cruise Terminal has advantage over the current status in that it will:

- Avoid the narrow and congested streets of Belize City resulting in shorter, safer and more direct navigation route between port facilities and tourist destinations.
- Eliminate tendering.
- Provide scenic views of Northern Lagoon and Peccary Hills National Park.
- Reduced tour times by an average of 2 hours when compared to existing tour times.
- Result in increase in cruise tourist arrivals thus contribution to an overall increase of head tax.
- This New Port is in the unique position to accommodate the growing demand and expansion of the Cruise Industry and to secure the maximum benefit to stakeholders and the people of Belize.
- Create job opportunity thus improving the standard of living of Belizean and crime reduction.

11 Disaster Prevention and Emergency Management

11.1 Overview

Belize lies in the hurricane belt and is vulnerable to the hazards associated with land falling hurricanes namely: torrential rainfall, hurricane force winds, storm surges and floods. Flash floods and riverine floods are also common and are often generated by tropical or frontal convection that are unrelated to tropical cyclones. Droughts and related heat waves will become more intense under impending climate change. Other regional geophysical hazards that may affect the country but are rare include seismic activity and tsunamis. Possible manmade hazards are those associated with fires, chemical spills, oil spills and explosions.

Emergency Management is the discipline dealing with and avoiding and mitigating risks. It is a discipline that involves preparing, supporting, and rebuilding when natural or manmade disasters occur. The actions to avoid or ameliorate the impacts depend in part on the evaluation of the risk and the measures taken to address and prevent the perceived risks.

11.2 12.2 Hazards, Vulnerability, Exposure and Risks

The IPCC Fifth Assessment Report (AR5) on climate risk concept considers: hazards, exposure and vulnerable to assess the risk factor or levels for people and assets, such as the Cruise Terminal development.

Risks

The risk is the potential for consequences where something of value is at stake and where the outcome is uncertain. Risk results from the interaction of vulnerability, exposure, and hazard. The focus is on climate-related risks (i.e. risks related to extreme events as well as slow onset trends).

Hazards

Usually refers to climate-related physical events or trends or their physical impacts. It may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. Example: rise of temperatures or of sea level (climate-related trend); hurricanes (climate-related event), floods (impacts).

Exposure

The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected. The most important criteria for the exposure = **presence** / relevance.

Examples are the presence of tourism infra-structure or sensitive ecosystems.

Vulnerability

The disposition to be adversely affected.

The two elements of vulnerability are: sensitivity and capacity. That is, sensitivity to harm and lack of capacity to cope and adapt.

Capacity: **the ability of societies and communities to prepare for and respond** to current and future climate impacts:

- Capacity to cope (immediate/medium term response to hazard).
- Capacity to adapt (knowledge, techniques, technologies, institutions and economy): ability of the system to take advantage of opportunities, or to respond to consequences.

An example, having an effective early warning system or not for flood or hurricane emergencies.

Adaptation

Adaptation is the process of adjustment to actual or expected climate and its effects.'

Adaptation seeks to:

- moderate or avoid harm or
- exploit beneficial opportunities

Generally, adaptation measures can reduce the risk by focusing on one of its components: exposure or vulnerability.

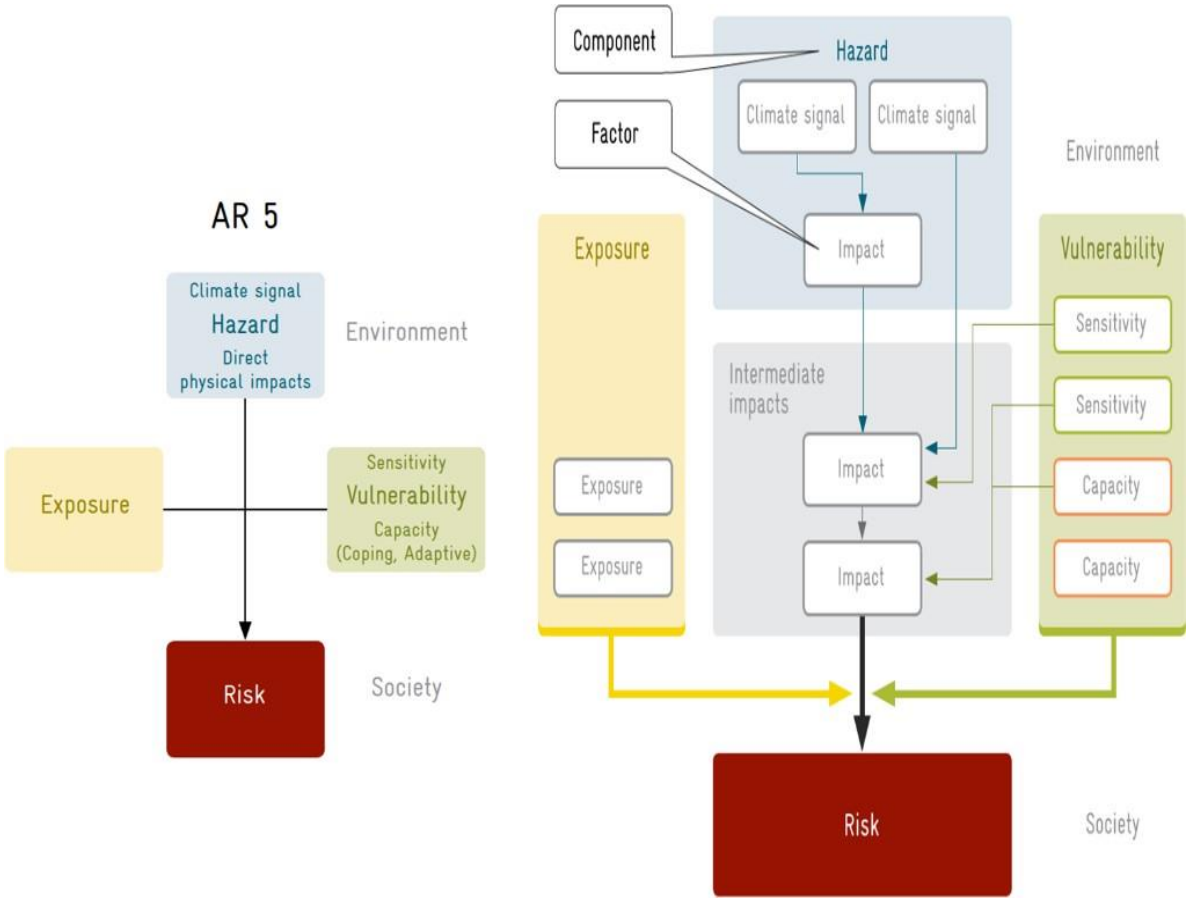


Figure 11-1: IPCC AR5 impact chain concept to evaluate climate risks.

The risks are evaluated after analysing each hazard, the exposure of the assets, their vulnerability, and putting a weight to each, respectively.

Following this approach, we have:

$$\text{Risk} = (\text{Hazard} * W_H) + (\text{Vulnerability} * W_V) + (\text{Exposure} * W_E)/ W_H + W_V + W_E$$

11.3 Hazards and Risk Index

From another perspective, risk assemment takes into consideration the likelihood or probability of the hazards occuring and the consequences or impacts. As before, the likelihood or probability of a hazard impacting an asset is related to its exposure, while the consequences or impacts are related to its vulnerability or capacity to cope (immediate reponse or to adapt in a longer period of time). The outcome of the risks may range from very low or insignificant, moderate (minor), High (significant), very high (major risks) to extreme (or severe). Extreme or severe risk category would probability be prohibitively too costly to mitigate and could jeopaerdize project implementation.

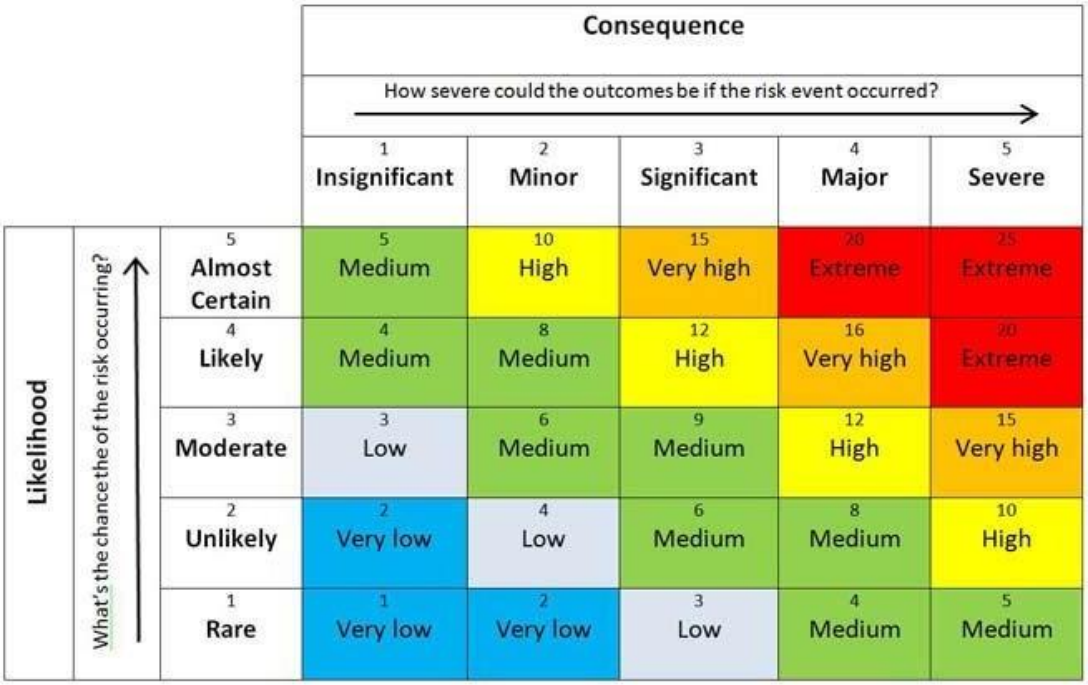


Figure 11-2: Risk assessment matrix.

Based on these definitions, it can be seen that *risk analysis* may be carried out in an objective manner, while *risk assessment* is much more subjective and should include public policymakers.

Risk Management is the process of implementation of actions required to quantify, mitigate and control risk. *Risk Management* is closely related to the concept of safeguards according to the NEMO (2010).

In Disaster Risk Management (DRM) several criteria can be used to determine levels of vulnerability. These may include but are not restricted to: population density and annual growth rates, Human Development Indicators set against long-term urban growth rates, and real adjusted GDP per inhabitant set against illiteracy percentages, or set against child mortality rates. From these indicators, population density and growth rates provide an initial baseline assessment of a country's vulnerability, on the basis that countries with higher population densities are more vulnerable. Another major vulnerability criterion is poverty, which is useful in characterizing the sectors of a society that are most vulnerable to disasters. Housing and infrastructure in disaster-prone area increases a country's vulnerability.

Meteorological and Hydrological Risks and Hazards. Impacts and Mitigation

The main hydrometeorological hazards range from: tropical cyclones and hurricanes, and related hazards (torrentail rains, flash floods and inundations, destructive winds, storm surge and tornadoes), droughts, and heatwaves. Extended droughts and bushfires are also hazards in the

natural environment related to climate variability and climate change that may impact some of the Belize Education Sector Reform project (BESR) Phase II sites.

Geophysical hazards

May include earthquakes and landslides/mudslides, road embankment slippage in hilly terrain, and tsunamis.

Man-made Technological Hazards

Man-made hazards that can directly or idirectly impact the components of the BESR include:

- Chemical Fires.
- Release of toxic fumes.
- Oil Spills.
- Explosion.
- Road traffic accidents.
- Urban fires.
- Air Traffic Accidents.
- Medical Emergency on Project Site or Schools.

The risks of these man-made hazards increase along principal highways and urban and industrial zones. Hazardous substances and material enter Belize from the western and northern borders, and the ports, then transported through communities via the George Price, Philip Goldson, Hummingbird and Southern Highways to their final destination within Belize or elsewhere.

Evaluating the Risk Index Associate with Natural and Tecnological Hazards

The Risk Assessment matrix illustrated in Figure 1o.1 will be used to evaluate the Risk Index for the major hazards identified and reviewed, then prioritized in order of significant.

Impacts

Impacts, either negative or positive, caused by natural or man-made hazards on communities or infrastructure are evaluated through *risk analysis* and *risk assessment* that determine the consequences and importance of the impacts and hence the intensity of the hazards.

Mitigation

Mitigation is the measures necessary to reduce the negative impacts of the hazards

In this connection, the Environmental Management Plan for the project addresses the risks and vulnerability of the project sites.

The prioritized hazards are listed in **Table 11-1**. As can be observed, tropical cyclones and hurricanes and their related hazards, including destructive hurricane-forced winds, torrential rainfall, floods and tornadoes, tops the list. Second was floods (inundations) and flash floods; followed closely by urban/wildfires and heatwaves.

Table 11-1: Prioritized Hazards that can impact the proposed Cruise Terminal construction and operational phase.

Priority	Hazard	Risk Index	Remarks
1	**Tropical Cyclones & Hurricane**	**25** ***Extreme***	- Hurricanes and associated hazards are at the top of the list of extreme hydro-meteorological phenomena to impact the Port of Belize Cruise Terminal project sites. All contingency measures should be implemented during construction and operational phases to build resilience.
2	**Coastal Floods and Flash Floods**	**16** ***Extreme***	- Measures to reduce loss of life and property should be implemented locally in the zone of influence for annual flood events. Access road or street infrastructure to project sites should meet ASSHTO standards for safety and resilience, while infrastructure designs should meet building standard for extreme, hazardous conditions.
3	**Urban and Wildfires**	**15** ***Very High***	- Urban fires are common in Belize City. Large urban fires near the project site or within the Cruise Terminal facility could result in loss of life, property and suspension of operations. - Landfalling hurricanes crossing or impacting the vicinity, destroys buildings and forested areas along their path inland. Authorities and private landowners should clear all fallen trees and debris, to reduce fuel load in subsequent fire season.
4	**Heat Waves**	**12** ***High***	- Heat waves are a major health issue during oppressive and extended dry season/drought conditions as a result of Global Warming. FD/NEMO/Public Health/Administration should have a trained team of first responders to deal with heat wave stress and heat related illnesses. Administration should have a Plan to address heat stress and other medical emergencies in the workplace. Health insurance should be encouraged for staff and employee.
5	**Coastal protection slippage and collapse**	**12** ***High***	- More likely to occur where structure is impacted by wave actions and structural stress because of external forces (docking and weight). -Critical sites along the sea wall should be identified and stabilized. - Shoreline or beach should be maintained and stabilized against erosion due to wave actions and sea level rise.
6	**Explosion (Construction**	**12**	- Rare, but can happen especially during construction phase. Cruise Terminal Administration should have a

Priority	Hazard	Risk Index	Remarks
	&Cruise Terminal Operational Phase)	***High***	SOP to deal with accidental explosions during construction and operation. Liaise with DOE/NEMO/DEMO/Coast Guard/BDF Response Team
7	**Medical Emergency**	**12 High**	- Very likely among visitors and staff/employees. - Cruise Terminal Administration must have a Medical Response Plan. - Contractors must have a Plan to address a medical emergency at work site
8	**Oil Spills**	**9** ***Medium***	- Have SOP to deal with accidental oil spills. Liaise with DOE/NEMO/CEMO/Coast Guard
9	**Earthquakes & Tsunamis**	**9** ***Medium***	- Rare but likely event. NEMO has an Emergency Plan for Seismic Emergencies and Tsunamis. - Get staff and employee familiar with these Plans. - Public education necessary in communities in the zone of influence - Should be done regularly, not after the impact.

11.4 Impacts and Mitigation

An over-arching mitigation measure to reduce the impacts for assets in the proposed development is to transfer risks for extreme hydro-meteorological events through comprehensive insurance schemes or portfolios. A second mitigation measure for the Project is to incorporate risk reduction measures in all infrastructure development and operational plans of the Development, to reduce the impacts of climate change and extreme weather phenomena, and technological hazards. A tested and effective Emergency Plan should be streamlined into the daily operations of the establishment.

Table 11-2: Summary of Natural and Technological Hazards, Impacts and Mitigation in connection with the proposed Cruise Terminal Development project.

Natural Hazards	Impacts		Mitigation Measures		Responsible Entity/Agency	Timing	Equivalent Cost incur
	Construction	**Operation**	**Construction**	**Operation**			
Tropical cyclones & Hurricanes	- Disrupt & delay the works - May damage material, undermine buildings and pier - Loss of life or property	- Disrupts Cruise Terminal operations, - Results in the loss of revenue - Loss of life & property/assets - Administration incur a cost if not insured - Destabilize slope of dredged channel and turning bay. - Increase sediment build-up in navigation channel and turning bay	- Contractor must have a hurricane emergency plan - Have insurance - Safeguard life & property to reduce loss - Construct Cruise Terminal infrastructure to withstand major hurricane events and meet International safety standards for Cruise Terminal construction.	- Cruise Terminal Administration should have a tested Hurricane emergency Plan - Update Plan annually and rehearse from time to time - Have insurance - Safeguard property to reduce losses - New staff and employee must be trained on emergency response - Visitors safety is a priority and are evacuated from danger zone in the Alert phase	- Contractor - Cruise Terminal Administration/Emergency Coordinator - Liaise with NEMO/CEMO/Coats Guard on issues connected with DRR	- Period during the construction phase - During Cruise Terminal operational phase., especially during the high season.	- Contractor insurance portfolio - Disaster Mitigation costs should be budgeted annually into Cruise Terminal budget (should include costs of equipment and training)

Coastal floods & Flashfloods.	- Disrupt transport - May flood project site - Undermine construction activity & infrastructure - Loss of material - Loss of life	- Disrupt access to Cruise Terminal for a short time - Disrupt transportation - Suspension of operations - May cause flooding of Cruise Terminal arrival area - Damage to the property, loss of life	- Have a Flood Emergency Plan - Have a contingency plan to safeguard material, property & life - Have insurance - Build Cruise Terminal infrastructure and access to be resilient to floods	- Have a Flood Emergency Plan - Update Flood Plan Annually - Have a contingency plan to safeguard life and property in flood emergency - Sensitize staff and employee on flood hazard	- Contractor - Cruise Terminal Administration - Liaise with NEMO/CEMO/Coast Guard on issues connected with DRR	- Period during the construction phase - During the regular operational phase and high season	- Contractor insurance portfolio - Flood Mitigation costs should be budgeted
Storm Surge	- May impact the construction site - May disrupt or delay works - Damage material, loss of life and property	- Disrupt operations - May impact or undermine infrastructure on site and off site (in the City and access roads) - Cruise Terminal may incur financial	- Design Cruise Terminal must meet standards for Cat V hurricane and storm surge. (e.g. ASSHTO Standards for public infra structure) - Have a hurricane plan. - Liaise with NEMO/CEMO/Coast Guard	- Administration must have a tested Hurricane Plan and Contingency Plan for imminent Storm Surge and coastal floods - Get insurance - Sensitize staff and employee on storm surge risks for Belize City.	- Contractors - Cruise Terminal Administrations and the MOE - Cruise Terminal Administration should liaise with NEMO/CEMO/Coast Guard/BDF	- Construction period - Operational phase and high season	- Contractor insurance, Contract Security fund. - Insurance of all Cruise terminal assets, including infrastructure and berthing/ disembarkations facilities etc. - Cost will be incorporated in coastal flooding

		loss if not insured - Loss of life and property					the emergency budget line.
Tsunamis	- May impact construction sites near the coast - May disrupt or delay works - Damage material, loss of life and property -	- Loss of property and life	- Familiarize workers with NEMO Tsunami Emergency Plan - Contractor should have insurance	- Familiarize staff with NEMO Tsunami Emergency Plan - Safeguard life and property - School administration should have insurance	- Contractors - Liaise with NEMO/DEMO	- Period during construction phase	- Contractor insurance portfolio - Flood Mitigation costs should be budgeted
Urban &Bushfires	- May impact construction site - May affect human health and safety	- May disrupt operations - May result in loss of assets - May result in smoke inhalation and human health impacts	- Have firefighting equipment - Have a clearly defined fire escape route posted at strategic location in Cruise Terminal lounge and administrative building	- Install fire extinguishers in strategic location in buildings and landing area. - Liaise with Fire Department and get suitable staff members trained in the use of fire extinguishers, and fires response procedures. - Regularly check and maintain fire extinguishers and other equipment	- Contractor - Cruise Terminal Administration - Liaise with Forest Department, Fire Department, NEMO/CEMO	- Construction phase - During regular operational phase and the high season. -	- Contractor insurance portfolio - Fire insurance

Earthquakes	- May impact construction sites. - May undermine or impact Cruise Terminal infrastructure	- May disrupt operations - May very likely damage main infrastructure - May damage access road infrastructure - May directly or indirectly impact communication and other utilities - May start a disastrous fire	- Have contingency Plan for seismic event - Familiarize workers on Earthquake Emergency Plan. - Update Plan if deemed necessary during the construction phase.	- Familiarize staff and employees on NEMO's Earthquake Emergency Plan - Conduct Earthquake simulation (at least once each year with staff and employee - Liaise with NEMO/CEMO/Belize Red Cross/Coast Guard	- Contractor is the responsible to safeguard life and property for seismic events during construction - Cruise Terminal Administration responsible for safety during seismic events during working hours - Administration liaise with NEMO/CEMO/Red Cross/Coast Guard	- Construction phase - During regular operational phase of Cruise Terminal -	- Contractor insurance - Cruise Terminal assets insured
Technological Hazards	**Impacts**		**Mitigation Measures**		**Responsible Entity/Agency**	**Timing**	**Equivalent Cost incur**
	Construction	**Operations**	**Construction**	**Operation**			

Chemical Fires	- Can impact Project Site during construction	- Can impact Cruise Terminal during regular or high season operational phase	- Contractor has a Contingency Plan to address chemical fires, toxic fume release, oil spills, and explosion	- Cruise Terminal administration develops a Contingency Plan to address chemical fires, toxic fume release, oil spills, and explosion	- Contractor - Cruise Terminal administration - Liaise with DOE/NEMO/DEMO/Coast Guard/BDF	- Construction phase - Regular and High Season periods	- Cost contingent with extent of chemical fires and damages - Cruise Terminal authorities should have insurance - Contractor should be protected by insurance and/or contract security
Toxic fumes release	- Can impact Cruise Terminal site and nearby areas during construction	- Can impact Cruise Terminal operational site and adjacency zone	- Contractor has a Contingency Plan to address chemical fires, toxic fume release, oil spills, and explosion	- Cruise Terminal authorities develop a Contingency Plan to address chemical fires, toxic fume release, oil spills, and explosion	- Contractor - Cruise Terminal administration - Liaise with DOE/NEMO/DEMO/BDF/Coast Guard	- Construction phase - Regular and High Season periods	- Cost contingent with extent of toxic fumes accident and damages - Cruise terminal authorities should have insurance - Contractor should be protected by insurance and/or contract security
Oil Spills	- Can impact Project Site during construction	- Can impact Cruise Terminal during regular & high season operational periods - May disrupt road traffic	- Contractor has a Contingency Plan to address chemical fires, toxic fume release, oil spills, and explosion	- Cruise Terminal authorities develop a Contingency Plan to address chemical fires, toxic fume release, oil spills, and explosion	- Contractor - Cruise Terminal administration - Liaise with DOE/NEMO/DEMO/Coast Guard and BDF	- Construction phase - Regular and High Season periods	- Cost contingent with the extent of oil spill and damages - Cruise terminal authorities should have insurance - Contractor should be protected by

		for an extended period					insurance and/or contract security
Explosion	- Can impact Project Site during construction	- Can impact the project site during operational periods	- Contractor has a Contingency Plan to address chemical fires, toxic fume release, oil spills, and explosion	- Authorities of the Cruise Terminal develops a Contingency Plan to address chemical fires, toxic fume release, oil spills, and explosion	- Contractor - Cruise Terminal administration - Liaise with DOE/NEMO/DEMO/BDF/Coast Guard	- Construction phase - Regular and high season operational period	- Cost contingent with size or power of the explosion and damages - Cruise Terminal authorities should have insurance - Contractor should be protected by insurance and/or contract security
Road Traffic Accidents accidents at Cruise Terminal zone of influence	- Can disrupt access road /highway/ Street traffic	- Can disrupt access road to the port - May result in loss of life and property	- Contractor must be prepared to assist during road traffic accident near project site during construction phase. - All precautions must be taken to avoid traffic accidents/other accidents inside Cruise Terminal zone	- Cruise Terminal authorities liaise with Belize Red Cross and BERT Ambulance and nearby Polyclinic/KHMH	- Contractor - Cruise Terminal administration - Liaise with DOE/NEMO/CEMO/Belize City Council Traffic Department.	- Construction phase - Regular and high season operational periods	- Cost for damages may be prescribed by court - Cruise Terminal authorities should have insurance - Contractor should be protected by insurance and/or contract security
Urban Fire	- Can disrupt construction and delay works	- Can reach Cruise Terminal property and result in the loss of material	- Contractor and crew may be asked to assist in putting out the fire	- Cruise Terminal authorities liaise with Belize City Fire Service - Training for staff and selected employees on fire emergency response	- Contractor, Fire Department - Cruise Terminal Administration, Fire Service, CEMO, Police	- Construction phase - Regular and High Season operational phase.	- Cost contingent with the extent of urban fires and damages - Cruise Terminal authorities should have insurance

		assets and life.					- Contractor should be protected by insurance and/or contract security
Medical Emergency	- Is very likely at the project site during construction	- Very likely among staff/employees & visitors	- Have trained First Aider with each work gang. - Have a Medical Emergency Plan to respond if medical emergency turns critical. - Liaise with BERT ambulance, Astrom Helicopters and KHMH/Polyclinics	- Cruise Terminal administration has a tested and updated Medical Emergency Plan for the workplace. - Have at least two First Aider on Staff. - Liaise with Belize Red Cross, HECOPAB, and ambulance service in Belize City.	- Contractor - Cruise Terminal administration liaise with NEMO/DEMO/Red Cross& KHMH	- Construction phase - Regular and High Season operational phase of project	- Contractor should have insurance and/or Contract security funds. - Cost to Cruise Terminal administration dependent on the nature of medical emergency.

11.5 Natural Hazards

11.5.1 Tropical Cyclones and Hurricanes

The most prominent natural hazard that affects Belize City and by extension the project, is landfalling tropical cyclones and hurricanes, and their associated hazards, including destructive hurricane- force winds, torrential rainfall, floods, storm surges and tornadoes.

The Belize City area has experienced several hurricanes over the past 100 years (**Table 11-3**). During this timeframe four hurricanes made a direct hit on the area: The impacts of at least one of these storms (namely Hurricane Hattie) was catastrophic. The area has a relatively high risk to landfalling hurricanes, with predicted storm surges of over 6m. for a Category V hurricane.

Table 11-3: Hurricanes affecting the Belize City and related storm surge at landfall (Source: R. Frutos, 2019).

Name	Year	Category on Landfall	Landfall Distance mls	Location	Estimated Surge m (ft)
No Name	1921	–	0	Direct hit	3.66 (12.0)
No Name	1931	–	0	Belize City & Orange Walk Town	3.05 (10.0)
No Name	1934	–	0	Direct hit	2.59 (8.5)
No Name	1934	–	< 50	Moved along the coast	2.44 (8.0)
Hurricane Janet	1955	5	> 50	Corozal Town	2.44 (8.0)
Hattie	1961	5	0	Direct hit	3.17(12.14)
Fifi	1974	2	>50	South of Placencia	12.0 (3.7)
Greta	1978	2	< 50	Dangriga Town	1.8-2.1(6-7)
Hurricane Keith	2000	2	< 40	Caye Caulker, Caye Chapel and San Pedro	1.20 (3.94)
Hurricane Iris	2001	4	< 50	Placencia	4.6 (15.1)
Hurricane Richard	2010	1	< 40	Gales Point	0.91-1.52(3-5)
Hurricane Earl	2016	1	< 40	Northern Lagoon	1.83 (6.0)

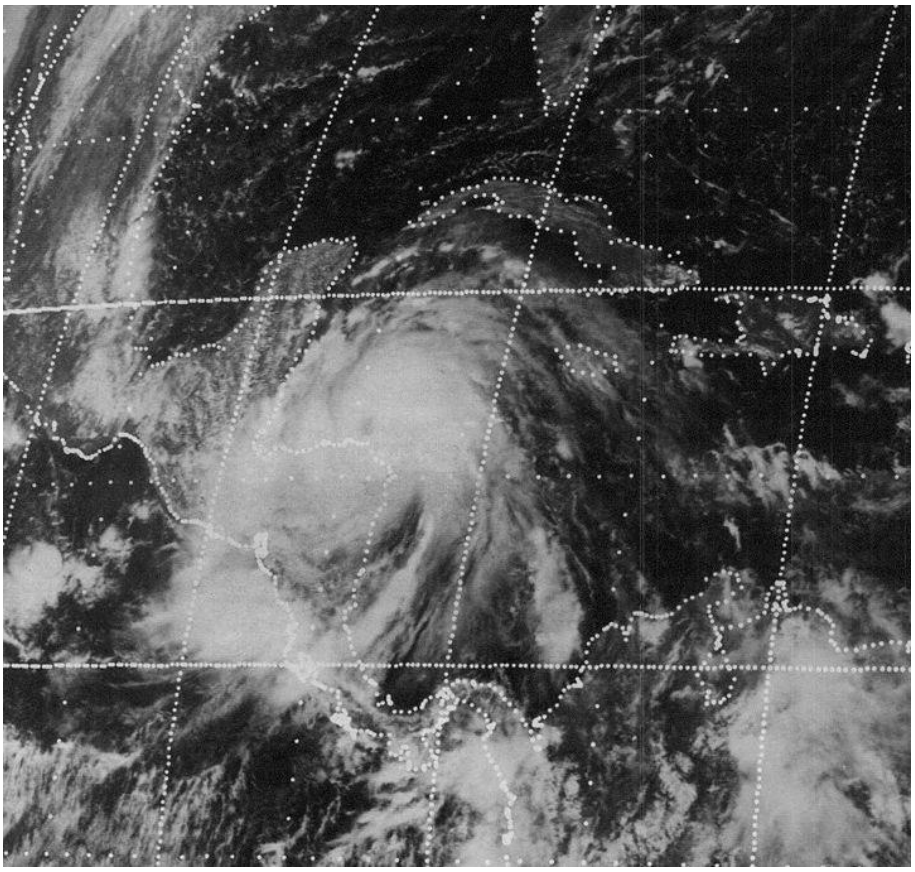


Figure 11-3: Hurricane Fifi at peak intensity just north of Honduras on September 18, 1974 (Source: Belize Met Service, 1974)

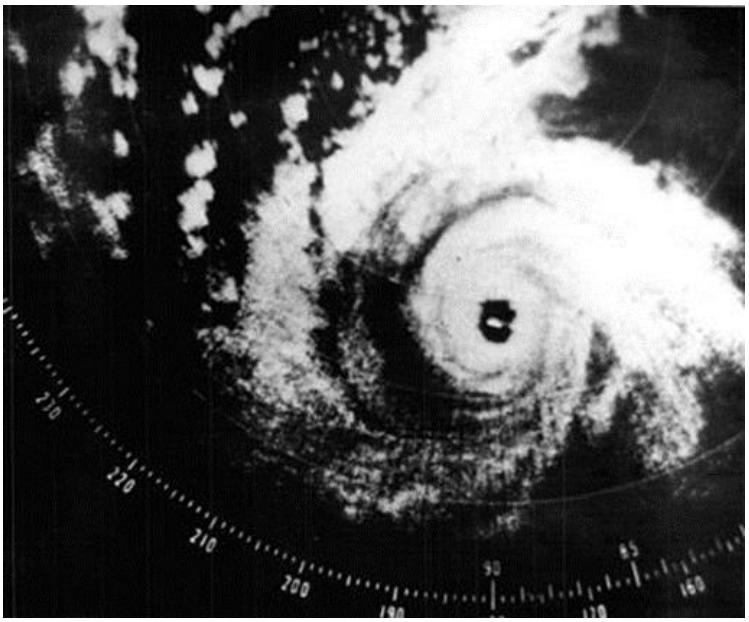


Figure 11-4: Radar image of Hurricane Fifi nearing landfall in Belize (Source: Belize Met Service, 1974).

11.5.2 Climate Change-Related Increases in Storm Intensity and Frequency

In a study conducted by Knutson et al (2010) on climate change and tropical cyclones, it was concluded that the global frequency of tropical cyclones will either decrease or remain essentially unchanged while mean intensity (measured by maximum wind speed) increases by 2 to 11%, and tropical rainfall rates increase by about 20% within 100 km of the cyclone by year 2100. However, the models were not well-resolved for basin-specific areas and confidence in the projections were low (IPCC 2013).

The IPCC Fifth Assessment concludes that there is low confidence in region specific projections of storminess and associated storm surge for the early 21st century due to uncertainties in projections of cyclone frequency and tracks. Projections for the late 21st century have more confidence (more likely than not) that tropical cyclone intensity will increase in the Western North Pacific and North Atlantic (IPCC 2013). Changes in storm intensity related to climate change have not been included in the storm surge analysis due to the low confidence in the regional projections.

11.5.3 Climate Change Projections and Impacts

The impacts of Climate Change are already being experienced across the productive sectors of Belize, affecting the livelihood of much of the population (GOB-NCCO, 2015). As a small, insignificant contributor to global greenhouse gas emissions, Belize has limited capacity to contribute to mitigation of global climate change. However, the country is committed to play its part in support of the UNFCCC target to limit the increase of global average temperature to 1.5 °C compared to pre-industrial levels. In this respect, Belize's Nationally Determine Contribution (NDC) is guided by its commitment to strategically transition to low carbon development, while strengthening its resilience to the effects of Climate Change.

The future climate for Belize will likely be characterized by increasing temperatures and declining levels of precipitation possibly arising due to a shift in the rainy season and extended dry season. One study projected a median temperature increase of 2.0°C (3.6°F) for the Caribbean region and 3.2°C (5.7°F) for the Central American region, and they project a median decrease in annual precipitation of 12% for the Caribbean region and 9% for the Central American region (UNDP, 2009). Average annual temperatures are expected to increase 3.5°C (6.4°F) over the 90-year period, while average rainfall is expected to decrease by 100 mm (IPCC, 2007).

The coastal lowlands in northern Belize are vulnerable to sea-level rise (McSweeney, *et al.* 2012). The climate models project sea-level rise in the region by the 2090s, relative to 1980-1999 sea-level as follow: 0.18 to 0.43 m under SRES B1; 0.21 to 0.53 m under SRES A1B; 0.23 to 0.56 m under SRES A2 (McSweeney, *et al.* 2012). The damages to infrastructure resulting from sea level rise, coupled with increased frequency of intense tropical cyclones, and the economic effects on the tourism sector, the largest contributor to GDP, could negatively impact the sustainable development of Belize (UNDP, 2009).

The impacts on the coastal zone of Belize are: increased seas level rise and tidal influence on flood conditions; increased ambient temperatures; stronger hurricane making landfall along the coast of Yucatan and Belize, provoking destructive storm surges and coastal flooding; and extensive coastal erosion (e.g. the on-going Monkey River village situation). Effective adaptation measure will have to be carried out to mitigate these impacts.

Summary Climate Change Model Projections for Belize

Figure 11-5 is a summary of the regional climate change model projections for Belize

Figure 11-5: Regional Climate Model Projections for Belize.

11.6 Storm Surge and Winds

Storm surge is an additional short-term increase in coastal water level resulting from atmospheric disturbances (pressure and wind) associated with the passage of extreme wind events such as tropical storms and hurricanes (Golder % Associates, 2017). Storm surge is highly variable with each storm (**Figure 11-6**) and is dependent on storm intensity, size, angle of approach, storm speed, and coastal bathymetry. Depending on the storm event, flooding from storm surge in the project area may be combined with pluvial and riverine flooding from intense rainfall in the City and upland and rain in the upland watershed, thus increasing the flood severity. **Figure 11-6** is a map of the TAOS Storm Surge Model result for a Category V hurricane making landfall near Belize City. As can be observed, the model run project a 6 – 7m storm surge just north of the Belize city area for a westward land falling Cat V hurricane around or just south of the project site at the Port. Such an event has a 50 to 100-year Return Period.

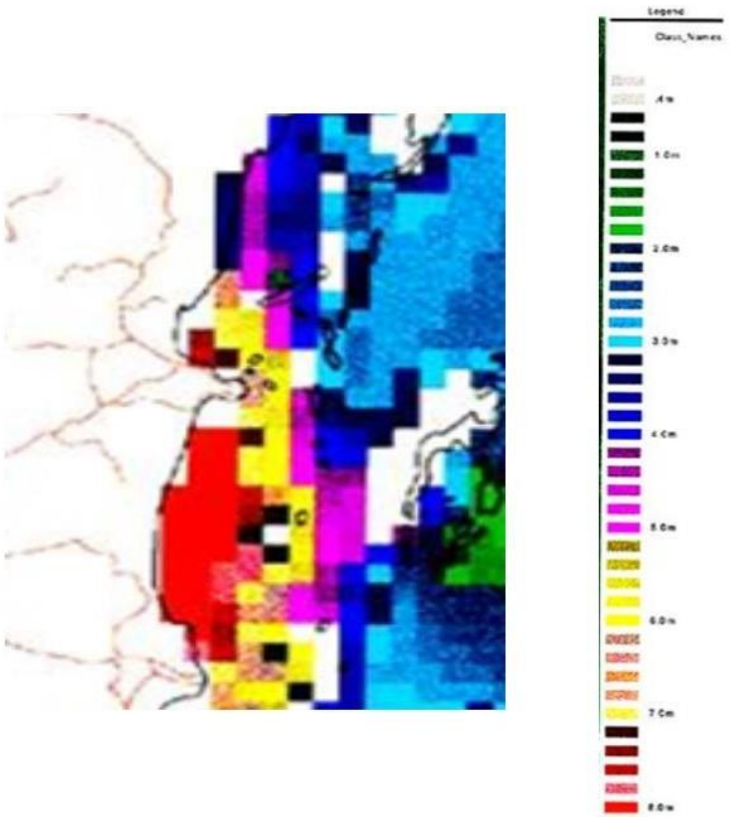


Figure 11-6: TAOS Storm surge projection for the Belize City area (Source: OAS, 1995).

Golder & Associates (2017) conducted a review of available storm surge and storm-related data (wind, pressure, storm track) for coastal Belize and the Yucatan Peninsula. The Atlas of Probable Storm Effects (OAS 1999) produced as part of the Caribbean Disaster Mitigation Project (CDMP) provides estimates of return intervals for maximum winds, maximum wave heights, and maximum storm surges for the entire Caribbean Sea including Belize. However, it was noted that the maps provided in the Atlas of Probable Storm Effects (OAS 1999) are coarse in resolution (1km grid) and are not designed to be used in cases where site-specific information is required. Also, the data used for creating the maps were old and several years of hurricane data were missing. It was concluded therefore that the results for Belize were not realistic.

A national level assessment was completed for Belize (OAS 1995) using the same dataset and produced storm surge and wind hazard maps for each of the five Saffir Simpson hurricane categories (summary of the categories is also provided below and see result for a Cat V in **Table** 11-4). The predicted wind speeds and storm surges near Belize City are substantially higher, but realistic than the basin-wide study results and are summarized in **Table** 11-4 for Category 3 to 5 storms.

Table 11-4: TAOS Storm Surge Model Results for Belize (Source: OAS, 1995, Golder & Associates 2017).

Storm Category	Predicted Wind Speed	Storm Surge
Category III	180 - 198km/hr 112 – 123mph	3 – 4m (wind 198km/hr, 95kPa, westward bound at 19km/hr)
Category IV	217 - 233km/hr 135 – 145mph	5 – 5.5m (wind 233km/hr, 92.8kPa, westward bound at 19km/hr)
Category V	233 - 252km/hr 145 – 157mph	5.5 – 6.5m (wind 252km/hr, 910kPa, westward bound at 19 km/hr)

A report by Climate and Development Knowledge Network (2014 in Golder & Associates, 2017) suggested a storm surge of 6.1m predicted for Belize City for a Category 5 hurricane.

Table 11-5 is a summary result of return periods for different ranges of storm related winds as evaluated by Golder 7 Associates (2017) from hurricane track dataset for Belize.

Table 11-5: Extreme wind speed return intervals based on identified hurricanes and tropical storms affecting Belize (Period: 1931 -2016).

Return Period (Years)	Wind Speed mph (km/hr)	95% Confidence Interval mph (km/hr)
2*	55 (89)	N/A
5	77(124)	58 - 95 (94 – 153)
10	108 (174)	83 - 134(133 – 216)
25	144 (231)	108 - 178 (175 – 287)
50	167 (268)	125 - 208 (202 – 335)
100	188 (303)	140 - 235 (226 – 379)

The 2-year return period is based on the wind speed distribution for Miami, Fl. (Yeo et al, 2012) due to the lack of data for Belize City and the poor fir in the curve at lower return periods.

11.6.1 Floods

Belize City and surrounding low-lying coastal mangrove wetlands are prone to coastal flooding associated with intense rainfall events and storm surge. Increasing sea level rise resulting from Global Warming will only exacerbate coastal floods. The map in **Figure 11-7** shows the areas of Belize City that are prone to floods, which include the Cruise Terminal site.

Figure 11-7: Map of flood prone areas in Belize City (Source: Cherrington and Courtney, 2017)

Historic intense rainfall events and urban flooding have disrupted commercial operations and damaged property, resulting in loss of revenue and cost repairs or replacement.

Coastal flooding in the Belize city area is classified as high. This means that the area is vulnerable to damaging wave action and pluvial flooding. The return period for pluvial flooding is once every 2 years and for surge flooding once every 10 years (De Nul et al, 2018). Project planning decisions, project design and construction methods must consider the level coastal flood hazard. In accordance with the IPCC (2013), there is high confidence that extremes in sea level will increase with mean sea level rise, yet there is low confidence in region-specific projections in storm surge. Hence, projects in low-lying coastal areas such as deltas, should be designed to be robust to projected increase in global sea level.

11.6.2 Earthquakes and Tsunamis

A tsunami is a series of long-wavelength, long-period ocean waves that may take hours to come on shore. The first wave my not be the highest or most energetic. Tsunamis, also known as seismic sea waves, are generated by earthquakes, less commonly by submarine landslides, infrequently by submarine volcanic eruptions and very rarely by large meteorite impacts in the ocean, although latter was more frequent in Earth's geologic past. **Figure 11-8** is a map of the Caribbean historic tsunami events in the region.

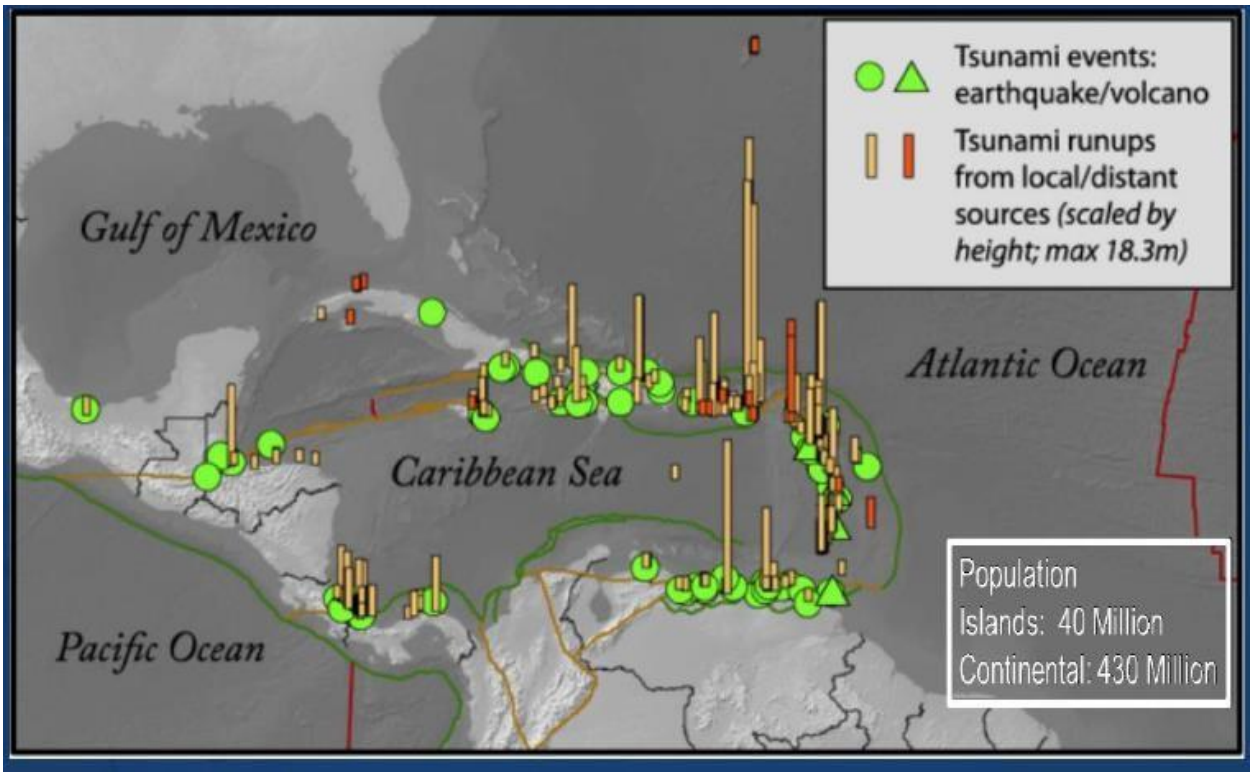


Figure 11-8: Tsunami Events and Earthquakes in the Caribbean Region (Source: von Hillebrandt-Andre, Christa, 2013)

Tsunamis are different from other hazards because of their fast onset and unpredictable character and may give coastal communities little time to prepare. In the absence of a Tsunami Warning System, coastal communities may be caught off guard. The potential for many lives to be lost is at stake if exercises or simulations never take place or infrequent. Recent tsunami events have given rise to need to improve national disaster risk reduction policies and plans. Understanding tsunami hazards is the foundation for motivations to conduct exercises, and for understanding why conducting Exercises is important.

The country of Belize lies adjacent to the Caribbean fault, which runs through the Caribbean and under the Sarstoon River and is thought to be the source of the 7.0 magnitude Haiti and the January 2018 earthquake in Honduras, whose epicentre was 225km (140 miles) from Belize City (Humes, 2018). Figure 12.7 is a map showing the epicentre of the January 9th, 2018, Earthquake of magnitude 7.6 near Roatan, Honduras, that triggered a Tsunami Warning for coastal territories of the north-western Caribbean, including Belize.

The Port area of Belize City is classified as a zone with medium to low tsunami hazard according to current available information. This means that there is a 2% chance of a potentially damaging tsunami occurring in the next 50 years (De Nul et al, 2018). Based on this conclusion, the impact of tsunami may be considered in different phases of the project for any activities located near the coast. Hence, project planning decisions, project design, and methods of construction should take account of the level of tsunami hazard.

Climate Change impact: Coastal areas at risk of tsunamis can see the risk increasing as global sea level rise, near the main fault lines (e.g. in the western Caribbean). The IPCC (2013) global

sea level rise projections depend on a variety of factors and estimates for 2100 range from 20 cm to near 1 meter. However, regional changes in sea level are difficult to predict. Projection for Belize coastal zone are provided in another section of this Report. Projects in low-lying coastal areas such as deltas and coral islands such as Caye Caulker, should be designed to withstand the forces associated with future seismic events and tsunamis.

Figure 11-9: Tsunami warning mobilizes Belize Emergency Response Authorities (Jan. 9 2018)

11.7 Management Plan: Hurricane Emergency

11.7.1 Hurricane Plan for the Project

Hurricane Warning System

The "official alert" system for hurricane entails coordination between the management of the project and the Belize Meteorological Service. The project Management will also supplement their information on the threat of hurricanes from the Internet.

Hurricane Watch

During the "Hurricane Watch" Phase, which means that a hurricane may threaten within 36 hours, the project and Tours Ltd Management will initiate activities to take action if the Belize Weather Bureau issues a warning. The management will be kept informed by radio and television of the progress of the storm.

Hurricane Warning

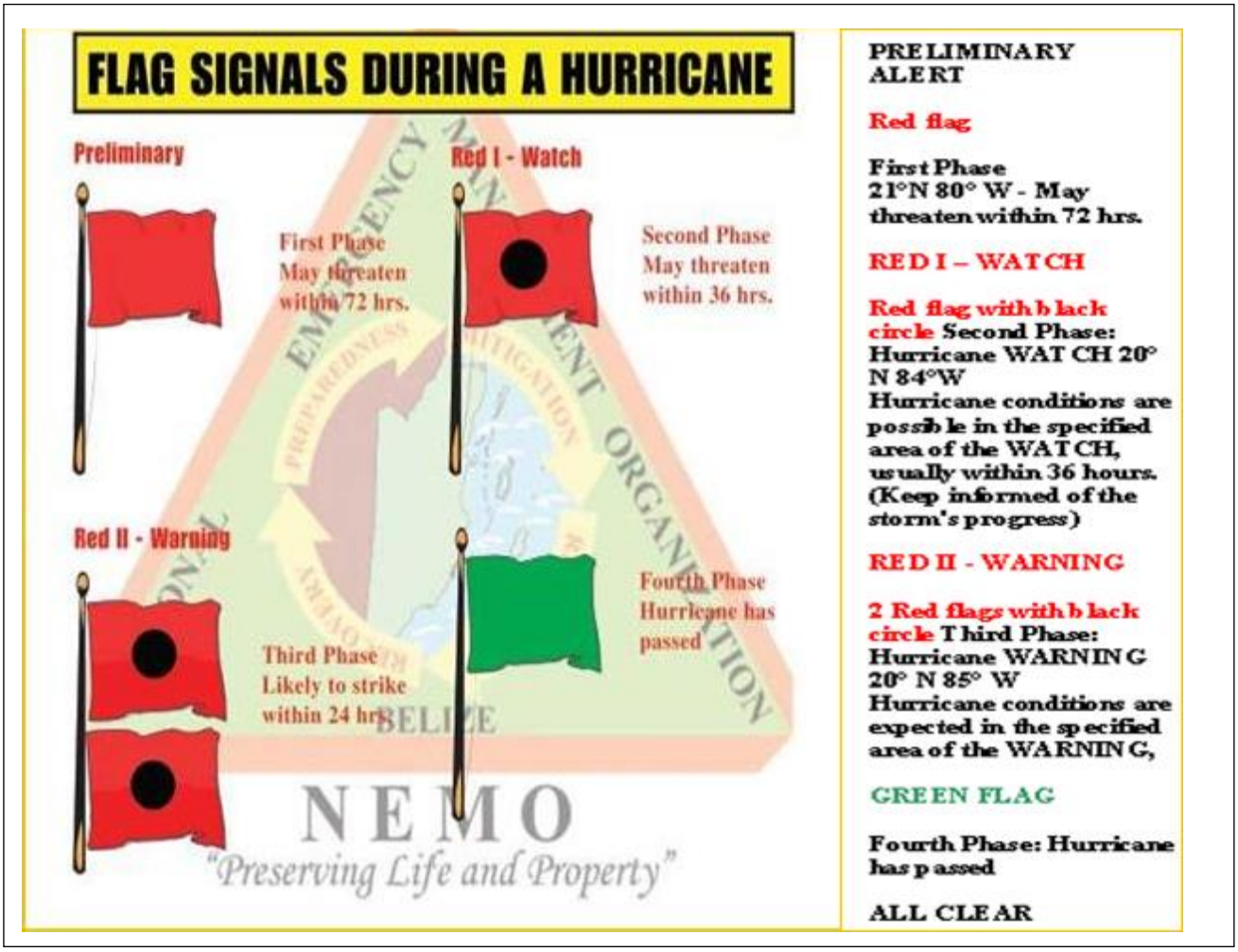
During the "Hurricane Warning" Phase, which means that a hurricane may threaten within 24 hours, all procedures will be put in place to evacuate the project.

The advisories that are to be issued by the National Emergency Management Organization (NEMO) are as follows:

- THE PRELIMINARY PHASE
- SECOND PHASE RED 1

- THIRD PHASE RED 2
- FOURTH PHASE **GREEN**

Figure 11-10 shows the Hurricane Emergency Flag Signals for the country of Belize.



11.8 Figure 11-10: The Hurricane Emergency Flag Signals for Belize (NEMO Hurricane Plan, 2018)Earthquake and Tsunami Response

The National Meteorological Service is the National Tsunami Warning Focal Point. The NMS though NEMO, will issue a Tsunami Warning upon receipt of such a warning from the Pacific Tsunami Warning Center. Upon receiving confirmation from the Met Department and NEMO, the National Fire Service will '***sound***' the Tsunami Warning as follows:

- Four 15-second blasts of a fire engine siren broken up by 5-second pauses, following which;
- there is a three-minute break and the warning begin again; and
- continues with the same sequence until an all clear has been given.

NEMO has reached an agreement with the telephone companies BTL and SMART to issue text messages to subscribers at the time a Tsunami Warning is issued.

The project authorities should therefore develop a SOP to respond to the Tsunami Warning for Belize City, and respond accordingly. Because of the very limited response time, the establishment should always remain in a state of alert and have a safe location to transfer and safeguard important documents and sensitive assets such as computer disk drives and safe deposit boxes.

Figure 11-11: Tsunami Readiness Guidelines ((Source: UNESCO IOC, 2019).

MITIGATION
Mit-1. Have designated and mapped tsunami hazard zones
Mit-2. Have a public display of tsunami information
PREPAREDNESS
Prep-1. Produce easily understood tsunami evacuation maps as determined to be appropriate by local authorities in collaboration with communities
Prep-2. Develop and distribute outreach and public education materials
Prep-3. Hold at least three outreach or educational activities annually
Prep-4: Conduct an annual tsunami community exercise
RESPONSE
Resp–1. Address tsunami hazards in the community's emergency operations plan (EOP)
Resp–2. Commit to supporting the emergency operations center (EOC) during a tsunami incident if an EOC is opened and activated
Resp–3. Have redundant and reliable means for a 24-hour warning point (and EOC if activated) to receive official tsunami threats
Resp–4. Have redundant and reliable means for 24-hour warning point and/or EOC to disseminate official tsunam alerts to the public

11.9 Fire Prevention and Response

The fire prevention and response plan will focus on the possibility of a fire and any fire outbreak, whether large or small, that might occur. It is therefore important to consider its likelihood and, the project proprietors will develop a response plan aimed at addressing the awareness and the mechanism necessary for its response.

The purpose of this policy plan is to include appropriate response mechanism that will protect life first and foremost. The general aspects of these environmental policies are to ensure a safe and professional transition between the different stages of fire response procedures.

11.10 Oil Spills and Toxic Fumes

The Spill Contingency and Response plan provides an organizational structure and procedures for preparing and responding to oil spills, leaks, toxic fumes and explosions. This plan is to be used by the Cruise Terminal development in response to petroleum product spills and/or leaks.

Each spill is different, and it is not practical to develop a spill response procedure, which will encompass every situation. It is better to understand the goals of the response plan in order to

tackle every spill situation. Such understanding coupled with training will enable those involved in the response effort to determine the best response procedures for given circumstances.

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PART C- POTENTIAL AND CUMULATIVE IMPACTS

12 Potential and cumulative impacts

12.1 Introduction

This section deals with the combined impacts of the project only, as cumulative impacts, as a result of the combination of other projects (past, present and in the foreseeable future) are not possible to determine. Currently, there is no knowledge (past, present and in the foreseeable future) of any other development in proximity to the proposed location for the Port of Magical Belize.

12.2 Impact Assessment Methodology

This section describes the overall approach used for the assessment of impacts and the identification of mitigation options (the latter are detailed in Part D). In general, the assessment of impacts and development of mitigation measures has proceeded through an iterative process considering four key elements:

1. Prediction of potential impacts and their magnitude (i.e., the consequences of the activities on the natural and social environment).
2. Evaluation of the importance (or significance) of potential impacts taking the sensitivity of the environmental resources or human receptors into account.
3. Development of mitigation measures to avoid, reduce or manage the potential impacts or enhancement measures to increase positive impacts.
4. Assessment of residual significant impacts after the application of mitigation and enhancement measures.

Where significant residual impacts remain, further options for mitigation may be considered and impacts re-assessed until they are as low as reasonably practicable for the Project.

12.2.1.1 Defining Impacts

Impacts are identified either as a result of an interaction between a project hazard and a sensitivity or an issue raised by stakeholders. The interactions between a project hazard and a sensitivity, are assessed in an entirely objective manner, using the methodology described in the following sections. Once identified, all imparts are listed in an Impacts Table. All issues forcefully raised by the local community are, almost by definition, important since they have caused the community sufficient concern to bring the issue forward for discussion. Thus, all community issues, along with previously identified ones, appear in the Impacts Table which formalizes and describes each impact.

A vital starting point in the impact assessment exercise is the bringing together of data concerning ‘hazards’ and ‘sensitivities’ to estimate the nature, likelihood and significance of the potential impacts. All potential interaction between a hazard and a sensitivity were

identified and assessed, and professional judgement, combined with detailed knowledge of the project hazards and the real conditions of the sensitivity, is used to determine whether it could lead to an impact or not. As a working method for the interaction identification process an interaction matrix has been used providing a structured way to list all hazards and sensitivities and their relevant combination as an impact, making sure that no major issues are missed.

There are several ways defining and quantifying impacts. The definitions adopted for this EIA are described in **Table 12-1** below.

Table 12-1: Types of environmental impacts.

1. Nature of Impact:

An impact is essentially any change to a resource or receptor brought about by the presence of a project component or by the execution of a project related activity.

- Negative – an impact that is considered to represent an adverse change from the baseline or to introduce a new undesirable factor.
- Positive – an impact that is considered to represent an improvement to the baseline or to introduce a new desirable factor.

2. Type of Impact:

- Direct (or primary) – impacts that result from the direct interaction between a planned project activity and the receiving environment (e.g., between stack emissions and the ambient air quality).
- Secondary – impacts that result from the primary interaction between the Project and its environment as a result of subsequent interactions within the environment.
- Indirect – impacts that result from other activities that are encouraged to happen as a consequence of the Project.

3. Temporal Scale of Impact:

- Temporary - impacts are predicted to be of short duration, reversible and intermittent/occasional in nature. The receptor will return to a previous state when the impact ceases or after a period of recovery.
- Short-term - impacts that are predicted to last only for a limited period (i.e., during construction) but will cease on completion of the activity, or as a result of mitigation measures and natural recovery (e.g., non-local construction workforce-local community interactions).
- Mid-term - impacts that are predicted to last longer than limited period (i.e., during construction) but will not be long term (i.e. less 20 years).
- Long-term - Impacts that will continue for the life of the project but cease when the project stops operating (i.e. more than 20 years). These will include impacts that may be intermittent or repeated rather than continuous if they occur over an extended time period.
- Permanent - impacts that occur during the development of the Project and cause a permanent change in the affected receptor or resource that endures substantially beyond the Project's lifetime.
- Continuous – impacts that occur continuously or frequently during the life of the phase of the Project.

12.2.2 Assessment of Significance

There is no statutory definition of 'significance' and its determination is therefore necessarily partially subjective. For the purposes of this EIA, the following definition of significance has been adopted:

"An impact is significant if, in isolation or in combination with other impacts, it should, in the judgment of the EIA team, be taken into account in the decision-making process, including the identification of mitigation measures (by the Project) and consenting conditions (from regulators and stakeholders)."

Criteria for assessing the significance of impacts stem from the following key elements:

- Status of **compliance** with relevant Belizean legislation, policies and plans and any relevant Belizean or industry policies, standards or guidelines.
- The **magnitude** (including nature, scale and duration) of the change to the natural or socio-economic environment (e.g. an increase in noise, an increase in employment opportunities), expressed, wherever practicable, in quantitative terms. The magnitude of all impacts is viewed from the perspective of those affected by considering the likely perceived importance as understood through stakeholder engagement.
- The nature and **sensitivity** of the impact receptor (physical, biological, or human). Where the receptor is physical, the assessment considers the quality, sensitivity to change and importance of the receptor. For a human receptor, the sensitivity of the household, community or wider societal group is considered along with their ability to adapt to and manage the effects of the impact.
- The **likelihood** (probability) that the identified impact will occur. This is estimated based upon experience or evidence that such an outcome has previously occurred.

For this assessment, significance has been defined based on five levels described in **Table 12-2.**

Table 12-2: Categories of Significance.

Positive impacts provide resources or receptors, most often people, with positive benefits. It is noted that concepts of equity need to be considered in assessing the overall positive nature of some impacts such as economic benefits, or opportunities for employment.
Negligible impacts (or Insignificant impacts) are where a resource or receptor (including people) will not be affected in any way by a particular activity or the predicted effect is deemed to be 'negligible' or 'imperceptible' or is indistinguishable from natural background variations.
An impact of **minor significance** ('Minor impact') is one where an effect will be experienced, but the impact magnitude is sufficiently small (with or without mitigation) and well within accepted standards, and/or the receptor is of low sensitivity/value.
An impact of **moderate significance** ('Moderate impact') is one within accepted limits and standards. Moderate impacts may cover a broad range, from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. Clearly to design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is ALARP (as-low-as-reasonably-possible). This does not necessarily mean that 'Moderate' impacts have to be reduced to 'Minor' impacts, but that moderate impacts are being managed effectively and efficiently.
An impact of **major significance** ('Major impact') is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An aim of EIA is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long-term or extend over a large area. However, for some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (ie ALARP has been applied). It is then the function of regulators and stakeholders to weigh such negative factors against the positive ones in coming to a decision on the project.

For environmental impacts the significance criteria used in this EIA is shown in **Table 12-3**.

Table 12-3: Overall Significance Criteria for Environmental Impacts.

Receptor sensitivity (or resource value)	**Impact magnitude**		
	Medium	High	Medium
Low	Minor	Minor	Medium
Medium	Minor	Medium	Major
High	Medium	Major	Major

12.2.3 Magnitude of Impact

The impact assessment describes what will happen by predicting the magnitude of impacts and quantifying these to the extent practical. The term 'magnitude' covers all the dimensions of the predicted impact to the natural and social environment including:

- the nature of the change (what resource or receptor is affected and how).
- the spatial extent of the area impacted, or proportion of the population or community affected.
- its temporal extent (i.e., duration, frequency, reversibility).
- where relevant (accidental or unplanned events), the probability of the impact occurring.

For biophysical impacts, the definitions for the spatial and temporal dimension of the magnitude of impacts used in this assessment are provided in **Table 12-1**.

For social impacts, the magnitude considers the perspective of those affected by taking into account the likely perceived importance of the impact, the ability of people to manage and adapt to change and the extent to which a human receptor gains or loses access to, or control over, socio-economic resources resulting in a positive or negative effect on their well-being (a concept combining an individual's health, prosperity, their quality of life, and their satisfaction).

12.2.4 Sensitivity of Resources and Receptors

Sensitivities are defined as aspects of the natural or social environment which support and sustain people and nature. Once affected, their disruption could lead to a disturbance of the stability or the integrity of that environment.

For ecological impacts, sensitivity can be assigned as low, medium or high based on the conservation importance of habitats and species. For habitats, these are based on naturalness, extent, rarity, fragility, diversity and importance as a community resource.

For socio-economic impacts, the degree of sensitivity of a receptor is defined as 'a stakeholder's (or groups of stakeholders') resilience or capacity to cope with sudden changes or economic shocks'. The sensitivity of a resource is based on its quality and value/importance, for example, by its local, regional, national or international designation, its importance to the local or wider community, or its economic value.

12.2.5 Likelihood

Terms used to define likelihood of occurrence of an impact are explained in Error! Reference s ource not found..

Table 12-4: Explanation of Terms Used for Likelihood of Occurrence.

An impact with a		
High probability	Refers to a very likely impact	Refers to very frequent impacts
Medium probability	Refers to a likely impact	Refers to occasional impacts
Low probability	Refers to a very unlikely impact	Refers to rare impacts
	As far as one-time events (e.g. air emissions) or slowly developing effects are concerned (e.g. impacts on local life style)	**As far as possibly recurring impacts are concerned, such as accident or unplanned events (e.g. traffic accident, fire)**

12.3 Impact Assessment Description

12.3.1 Water quality

12.3.1.1 Construction Phase

During the construction phase, potential impacts arising from the development can be sub-classified into three main categories; construction runoff, general construction activities and sewage from the construction labour force. Below, each of the category's impacts will be discussed.

Construction Runoff

Under this category the major potential surface water pollutants would be suspended solids and contaminants. These potential sources of contaminants would likely pollute water bodies through drainage systems and runoff. These two sources would include the following:

- Runoff and erosion from exposed soil surfaces, existing drains, spoil heaps, and stockpiles.
- Releasing of grouting and cement material with rain wash.
- Soil excavation taking place during the construction period may create a sediment rich runoff that may enter the drainage system, eventually being released into the hydrological environment.
- Wash water from dust suppression sprays.

General Construction Activities

Water pollution from onsite construction activities can potentially be derived from the following activities:

- Uncontrolled discharge of debris and rubbish, hazardous materials and wastes, including cleaning products, cement, batteries, wood preservatives, waste electrical and electronic materials.
- Dredging induced turbidity, explained in **Annex 15**. It is estimated that the silt particles will settle within 100 m from the dredger. Clay particles will spread 400 to 800 m. The increased turbidity is a temporal impact that is controlled by adaptive dredging management.
- Spillage of liquid stored on-site, such as; fuels, chemicals, oils, hydraulic fluids, diesel, solvents and lubricants from maintenance of construction equipment, vehicles and storage tanks.

Sewage from Construction Workforce

Domestic sewage would be generated from the employees during the construction period. During this phase, the work force is estimated for 500 persons. Sewage effluents may arise from sanitary facilities from the following activities:

- Contamination of water bodies by leakage from drains, release of sewage from broken septics or broken pipelines during connection phase.
- Contamination of water bodies from soapy water used for washing and bathing may create nutrient rich runoff which can lead to eutrophication.

Table 12-5 lists the threats, potential sources of threat and the potential environmental impacts associated to these threats.

Table 12-5: Threat and potential impacts on water quality

Threat	Potential source of threat	Potential environmental impact
Turbidity	• Water runoff • Dredging • Disturbance of sediments due to construction activities • Erosion from construction activities and cutting of vegetation • Storm water runoff	• Reduction in light effect on photosynthetic rates • Clogging of gills of fishes and invertebrates • Increase in water temperatures through absorption of solar radiation • Reduction in visibility affecting predator-prey relationship
Contamination	• Dredging • Storm water runoff • Erosion • Clearing of vegetation • Disturbance of sediments through construction • Antifouling paints • Sewage discharge including spills, Garbage	• Toxic impacts on fauna Contamination of food chain • Human health impacts

	• Hazardous material • Return water from reclamations Catchment inflows • Oil spill	
Nutrient input	• Dredging • Storm water runoff • Clearing of vegetation • Disturbance of sediments through construction • Catchment inflows	• Eutrophication • Algal/ Phytoplankton/ dinoflagellate blooms - potentially toxic to both animals and humans

12.3.1.2 Operation Phase

Potential surface water pollutants during operation would mainly be suspended solids in the form of dust. These potential sources of contaminants would likely pollute water bodies through drainage systems and runoff.

12.3.2 Impact on Sibun River and Northern and Southern Lagoon

No impacts are foreseen on the Sibun River nor on the Southern Lagoon as the development is not within close distance from these locations. The Northern Lagoon might be influenced by the project for instance due to run-off water from the dredge spoil disposal site. This and other potential impacts are described under the relevant headings.

12.3.3 Impact on hydrological characteristics

No significant impacts are foreseen on the hydrological characteristics during construction and operations.

12.3.4 Impact on bathymetric characteristics

12.3.4.1 Construction Phase

The direct impacts are related with dredging the access channel (570 acres or 230ha) to a certain depth and the reclamation of the peninsula (235 acres or 95ha).

12.3.4.2 Operation Phase

Once constructed, during the operational phase the reclamation and access channel have a primary impact on the local hydrodynamic regime (waves and currents). As a secondary effect, changes in hydrodynamics may impact the bathymetric characteristics.

The impact of the access channel on currents is limited to a reduction of the cross-currents and the associated sediment transport capacity that may cause channel siltation which is anticipated by maintenance dredging.

The impact of the reclamation is a blockage of the longshore sediment transport, if there is sediment to be transported at all. The typical impact of such blockage is coastline advance at the ‘upstream’ side and coastline erosion at the ‘downstream’ side. Due to the benign wave climate and the apparent limited availability of sediment, the impact of the Port of Magical on the coastline position is estimated to be limited. This is described in a study carried out for the project and presented in **Annex 13**.

12.3.5 Impact on terrestrial and marine ecosystems

Terrestrial Ecology, flora and fauna

12.3.5.1 Construction

The road connecting the project property to the George Price Highways is anticipated to traverse a 20 m wide cleared right-of-way and shall consist a two-lane paved surface with an estimated 11.2 km in length. Each traffic lane of 3.5 m wide and on each side 2m wide shoulders. With this assumption the road construction will clear a minimum 224,000 square meters (55.4 acres or 22.4 ha) of mangrove forest. The building of terrestrial amenities and related infrastructure will lead to clearance of an estimated 15 acres (6ha) of natural habitat.

The terrestrial impact matrix for the project is presented in **Table 12-6**.

Table 12-6: Impact matrix for terrestrial habitats within the project site.

Project Component	Process	Aspect	Impact
Road	Road construction	Removal of vegetation	Direct loss of vegetation and
			Loss of wildlife habitat and food resources
		Soil removal and filling	Soil compaction and altering of soil micro and macro-fauna
			Soil erosion
		Moving machinery and equipment noise	Disturbance of wildlife
		Light pollution	Nocturnal animal disorientation (bats, birds, insects)
	Stock piling material	Clearing of vegetation	Loss of natural vegetation and wildlife food and shelter resources
Drainage and culvert works	Drains and culverts	Removal and/ or disturbance of soil	Disturbance and removal of soil fauna
			Sedimentation
Constructed Road	Operational phase	Increase vehicular traffic and speed	Vehicle-wildlife collisions
		Soil erosion	Sedimentation of coastal waters

Project Component	Process	Aspect	Impact
Building Complex	Preparation of building sites	Removal of vegetation	Loss and disturbance of natural vegetation.
			Wildlife habitat loss
		Soil removal and filling	Soil compaction and altering of soil micro and macro-fauna
			Soil erosion
		Moving machinery and equipment noise	Disturbance of wildlife
		Light pollution	Nocturnal animal disorientation (bats, birds, insects)
Building Complex	Operations	Noise pollution	Disturbance of wildlife
		Light pollution	Nocturnal animal disorientation (bats, birds, insects)

12.3.5.2 Operation

The main impacts on ecology are related to disturbance caused by increased traffic and the visitors, leading to light and noise pollution.

Marine ecology

Two marine mammals (Manatee and Bottlenose Dolphin) have been reported from this site. The presence of these mammals in the area were confirmed by visual sightings. Five species of sea turtle have been documented in the marine environment of Belize. According to the more commonly observed sea turtles by divers and snorkelers in Belize are the critically endangered hawksbill turtle (*Eretmochelys imbricata*), the endangered green turtle (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*).

In regards to the presence of any of these endangered sea turtles close to the project site and its zone of influence, the only existing documented tracking data of migration of green turtles (*Chelonia mydas*), and hawksbill turtles (*Eretmochelys imbricata*) in and out of Robinson Point. Robinson Point encompasses the area at the mouth of the South Grennel's Channel and seagrass beds flanking the southern side of the channel.

12.3.5.3 Construction

The potential impact on marine environment could include:

- Physical disturbance of seabed during construction works in the areas of the dredged channel. Areas affected will be relatively small and seabed recovery is expected quickly following cessation of installation activities, given the likely tolerance and recoverability of the communities present.
- Increased suspended sediments: The construction activities may cause an increase of suspended sediment concentrations in the water column. Such concentrations have the potential to affect benthos through blockage of filter feeders and/or smothering marine species.
- Smothering: Sediment disturbance from construction activities, could have an adverse and indirect impact on the marine species through increased turbidity or as a result of smothering from deposition.
- Re-mobilisation of contaminated sediments: Sediment disturbance could lead to the mobilisation of contaminants that could be harmful to the marine species.
- Underwater noise and vibration: It is likely that there is habituation to noise created by the existing shipping which occurs in the area.

12.3.5.4 Operation

The potential impact on marine environment could include:

- Underwater noise and vibration: Noise and vibration generated by includes vessel movement and increased risk of collision. It is likely that there is habituation to noise created by the existing shipping which occurs in the area.
- Physical disturbance seabed during maintenance works in the areas of the dredged channel.
- Pollution: The operation activities release contaminates into the water column.

12.3.6 Impact on socio-economic environment

12.3.6.1 Construction and Operation Phase

The social survey and visitor's statistics show that annual arrivals of both overnight and cruise visitors to Belize is on the rise. The Port development will boost annual cruise ship arrivals once it becomes operational. Hence, the economic returns in foreign exchange will stimulate the local and national economy and Belize's GDP. An added benefit to this economic venture will be the small and medium-size entrepreneurship spinoff for local communities and the economic sub-sectors such as agriculture, fisheries, food services sector, and several others.

The perceived positive socio-economic impacts from the perspective of those interviewed during the public consultation moments and baseline studies were as follows:

- Increased employment and job creation and the possibility for local residents to enter or expand their business, such as restaurants, hardware supplies, handicraft markets, souvenir shops and fashion centres, and curio shops within the development itself.
- Establish appropriate balance between tourism, the natural environment and fishing.
- Availability of new markets in the area for farm products and fishery commodities.
- General increase in business activity and revenue generation during the construction

and post-construction phase of the development.

- Increases in the customer base of water service provider (i.e. BWS).
- Increases in the customer base of electricity service provider (i.e. BEL).

Those interviewed also saw indirect benefits resulting from existing tourism operations that would cater to retirees in the areas of sports fishing, manatee watching and sea-based freight haulage services.

The perceived negative social impacts articulated by those interviewed are as follows:

- Damage to the habitats, particularly mangrove and to a certain extend patch reefs and sea-grass beds (i.e. those located near mouth of South Grennel's channel) that would result in decline in productivity and biodiversity which can potentially negatively impact the livelihoods of subsistence fishers and tour guides.
- Increased boat traffic and transport movements by road.
- Substantial in-migration of workers for the development who will necessarily need to reside in nearby communities (e.g. Free Town Sibun) leading to a strain on existing public infrastructure and social services.
- Increase in crime in the general area of project zone, putting more strain on an already pressured Police Department.
- Competition for labour with other sectors.
- Discriminating or by-passing locals in relation to skilled labour and senior management jobs.

The other potential negative impact on local and regional tourism sector perceived by residents in the area is competition with Belizeans should the retirees become investors. One of the direct effects of such competition is the possible increase in the price of land.

An overview of the socio-economic impacts have been chronicled in **Table 12-7** from **Table 12-13** below.

Table 12-7: Social Impacts for Port of Magical Belize.

Issue	Activity	Social Impacts
Land Use	Location and size of development.	Macro-scale of development may exacerbate or over-burden social infrastructure and services during both construction and operational phase. Also potential for over-development in terms of high or excessive site coverage of buildings and other standing infrastructure.
Activities during Construction Phase	Transportation of construction supplies and equipment during all phases of development.	Potential for collisions at sea resulting in loss of life and property…Also potential for road-based accidents with consequent injury and death, apart from spillage of equipment and supplies.
	Operation of construction machinery.	Potential threat to human health and safety from operating machinery on-sit. This is magnified with inappropriate usage as well as when equipment and machinery is handled by untrained and inexperienced operators.
Marine and Terrestrial Traffic	Increase in boat traffic between in the project zone and the transportation of operational supplies and equipment, as well as guests and workers.	Potential of adding to volume of pre-existing traffic, as well as contributing to congestion and collision at sea accidents…Has negative implications in terms of injury and loss of life for humans.
		Increased in volume of unregulated traffic likely to lead to increase in risk of collision and consequent injury and death to manatees, sea turtles and other marine life his has direct negative implications in terms of livelihood issues for tour guides and charter boat operators.

Table 12-8: Social Impacts for Port of Magical Belize.

Issue	Activity	Social Impact
Worker Population during post-construction phase	Increased in population of project area (Belize District) as a result of workers employed by the facility migrating to the area.	Increasing demand for housing which would include rental of accommodations followed in some instances by building and purchasing of homes.
		Increase in theft, robbery and violent crimes with consequent need for increase in police and security presence.
	Increased pressure on existing educational and health services.	Increase in malaria, parasites, water borne diseases and sexually communicable diseases with consequent need for expansion in public health and private health care services.
		Increase in school age population for both primary school and high schools with consequent increase in demand for class rooms and educators.
	Increase in population during post-construction phase of development.	Over-crowding of project area resulting in loss of habitat and native fauna. Also, potential to outstrip absorptive capacity and resource potentials in terms of potable water and waste disposal issues. Also potential of interrupting or impeding access of traditional users to nearshore seas and beach areas.

Table 12-9: Social Impacts for Port of Magical Belize.

Issue	Activity	Social Impacts
		Potential for conflict between two (2) different peoples with different, cultures, values, languages and economic status.
Equal opportunity for employment	Employment of skilled labour from other parts of Belize, as well as importation of labour	Importation of labour in upper management positions where skills required are available in-country.
		Exacerbating illegal migration of citizens from neighbouring by preferentially hiring them over native Belizeans because of the ability to pay them lower wages thus adding to the unemployment problem nationally.
		Recruitment of skilled labour from other parts of Belize bypassing local citizens from the project area. The Belize labour laws are to be observed at all times, especially as they relate to the number of working hours per day and per week, minimum wage, sick days entitlement, unionization and the observance of public and bank holidays.
		Abusing of the Labour Laws in terms of the number of working hours per day and per week, minimum wage, sick days entitlement, unionization and the observance of public and bank holidays.
Utility Services	Exceeding or burdening capacity of electrical services and potable water.	National Electricity Grid in project area has finite capacity. Adding Port of Magical Belize Cruise Terminal facilities on to system has no risk of exceeding capacity of systems

Competition	Involvement of residents or otherwise associated with proposed Cruise Terminal to be in competition with local citizens in regards to a range of business opportunities	Citizens resident or otherwise associated with the Cruise Terminal starting up businesses in real estate, boat taxi services, freight haulage etc., in competition with local citizens

12.3.7 Climate impact

12.3.7.1 Construction Phase

Climate Change is among others due to carbon dioxide ($C0_2$). The construction phase of the Project will have no significant effect on the climate as this phase is limited in time.

12.3.7.2 Operation Phase

The impact on climate during the operation phase will mainly be due to the combustion engines of the cruise vessels and vehicles for transport of visitors which cause a long-term source of CO2. These project activities, equipment, and infrastructure can increase community exposure to risks and impacts due to climate change. Also, extreme climatic effects as land falling hurricanes, torrential rainfall, storm surges and floods may impact the cruise terminal infrastructure and the project site.

12.3.8 Solid Waste

12.3.8.1 Construction Phase

Solid wastes will include sludge, food wastes, paper, batteries, glass, plastic, used parts, consumable items such as filters, packing materials, and other materials. The impacts associated with solid waste for the project are presented in **Table 12-10**.

Table 12-10: Solid Wastes Impacts for Port of Magical Belize.

Activity	Potential Impact
Solid waste produced during Construction Phase	• Field and construction wastes produced by land clearing may cause accelerated sedimentation of coastal waters and eutrophication. • Domestic wastes produced by construction workers negatively affecting coastal waters and wildlife. • Contamination of ground and coastal waters by chemicals used during construction

12.3.8.2 Operation Phase

The impacts associated with solid waste for the operation phase of the project are presented in **Table 12-11**.

Table 12-11: Solid Wastes Impacts for Port of Magical Belize.

Activity	Potential Impact
Solid wastes produced during operational Phase.	• Offensive odours produced by organic wastes originating from food and beverage establishments. • Leachate produced by organic wastes from project contaminating ground and coastal waters. • Attraction of feral animals and vectors by organic wastes originating from food and beverage establishments • Contamination of ground and coastal waters by hazardous chemicals used during operation • Non recoverable wastes polluting marine and terrestrial habitats

Activity	Potential Impact
	• Old furniture and appliances serving as breeding grounds for vectors. • Migration of solid waste from storage sites and polluting terrestrial and water resources (wetlands & coastal waters). • Inadequate landside facilities to deal with solid waste generated during peak times and increased tourist traffic.

12.3.9 Noise

12.3.9.1 Construction

Noise generation during construction will result from the following activities:

1. Pre-construction activities - Land clearing for road construction and for siting of project amenities will require the use of heavy machinery (e.g. bulldozers) to remove vegetation. These machines are known to create significant noise levels (i.e. bulldozer produces up to109 dB(A) during operation).
2. Construction of road – Transportation of material and building of road will also require the use of heavy machinery (e.g. dump trucks, bulldozers, graders etc.).
3. Dredging – Operation of dredging equipment (e.g. backhoe dredger, cutter suction dredger, etc.) is required for dredging an access channel and will lead to noise pollution; above ground and underwater.
4. Construction of jetties – The driving of piles for the construction of jetties will lead to noise pollution; above ground and underwater.
5. Port amenities general construction activities will include construction of the framework (installation of beams and columns), floor decks, facade (exterior walls and cladding), and roof construction. These activities will require the use of a number of power tools and equipment. Interior construction and finishing of the building will include the construction of interior walls, installation of lighting fixtures, and interior finishes (flooring, painting, etc.), as well as mechanical and electrical work. It is expected that much of the construction work would be carried out within a 12-month's period.
6. Use of generators – It can be expected that the construction activities would be supported by diesel generators to provide electricity required by the various power tools, pumps and other equipment that would be used.

A primary or direct impact associated with noise pollution is the disturbance to marine and terrestrial wildlife, especially during breeding season. A secondary or indirect impact associated with noise pollution is displacement of wildlife having cascading effects on herbivory and prey/predator relationships in and around project site. The general construction phase of the project is expected to last 3 years. However, noise will be produced only intermittently, depending on the activity. During this period, the noise level both in the marine and terrestrial environment in the area can be expected to be significantly elevated

compared to baseline noise. Although the project site is not close to sensitive wildlife habitats, noise impacts on marine wildlife are of greater concern to organisms such as manatees, sea turtles and dolphins that may migrate close to the project site. Impacts to wildlife are not well understood; however, noise may affect wildlife in various ways or forms and as such needs to be mitigated. As example, noise levels above 180 dB re 1 µPa presented for two hours or less affect behaviour of several fish species (Shannon, *et al*; 2016).

Furthermore, noise might impact human beings. As the project site is away from residential sites the impact will be limited to workers on site. Health and safety impacts to humans associated with noise pollution concern increased risk of the effect of long-term exposure to noise from generating facilities, particularly hearing loss.

12.3.9.2 Operation

Noise generation during operation will result from the following activities:

1. Cruise line and sea vessel movement/transportation
2. Operation of port facilities (i.e. noise associated with huge numbers of people in one general location)
3. Vehicular movement to and from port facilities
4. Use of (backup) generator

The impacts to humans and wildlife from noise during operation phase of the project are of less concern because the magnitude of the noise from activities such as transportation are considered less than those emitted by for example heavy machinery and power tools used during construction. Similarly, the noise levels from vessel navigation are considered far less impactful than those produce for example from pile driving or drilling during construction of jetties.

In regard to noise impacts to humans, the impacts are limited to on-site staff and tourists; given that the closest community is approximately some 19km (12 miles) away from the project site at its closest point.

12.3.10 Geology, Soils/Sediment and Topography

12.3.10.1 Construction

Based on the field survey and geological study, soil impacts associated with the proposed cruise terminal project are as follows:

- The project will entail dredging to remove sediment from the sea floor for the creation of access channels to the project area. Turbidity and sedimentation are anticipated with both backhoe dredger and cutter suction dredger. Less turbidity is anticipated with the suction dredger. The turbidity and sedimentation are expected to create disturbances to benthic habitat.
- Land filling on the main land side of the properly will see some clearing and loss of vegetation. This impact will holds true for the road way as well, which traverses through mangrove vegetatio.

- Introducing saline material from sea on land will temporarilly lead to higher salinity of soil and groundwater.

12.3.10.2 Operation

During the operation phase impacts from maintenance dredging will be the main impact related to soils and sediment.

12.4 Impact Characteristics Tables

Table 12-12 and **Table 12-13** present the characteristics of the impacts.

Table 12-12: Impact Characteristic Matrix - Construction Phase.

Topic Area	Activity	Primary or Direct Impact	Secondary or Indirect Impact	Dir. Impact	TS & Rev	Geo. Scope		
						L	R	N
Marine Water Quality	Dredging, Land Reclamation and Construction Activities.	Physical extraction of seafloor with attendant sedimentation and turbidity influences. Even though observations showed that the general area is not ecologically sensitive the project will lead to disruption of benthic habitats. During construction ecosystems such as patch reef systems and seagrass beds could be impacted by dredging activities and navigational activities. However, these ecosystems are limited in extent and in considered in bad condition.	Effects from sedimentation and turbidity influences in the form of blanketing of sedentary and slow-moving benthic invertebrates as well as impairment of photosynthesis and secondary production in sea-grass areas located on the fringes of the mouth of South Grennel's channel.	-	MT, R	√		
		Land-based deposition of dredged spoils leading to salinization of water and soils. Impact on mangroves and Northern Lagoon, if spoils deposited nearby. Suffocation of root systems and high salinities results in wilting and death	Negative implications for herbivores, as well as woodland birds due to loss of habitat.	-	ST, R	√		

Topic Area	Activity	Primary or Direct Impact	Secondary or Indirect Impact	Dir. Impact	TS & Rev	Geo. Scope L	R	N
		of mangroves and littoral forest vegetation.						
	Land clearing	Exposure of sensitive soils to aerial and sea-based shoreline/coastal erosion	Loss and change of vegetation, with negative implications for native fauna, such as iguanas, land crabs, lizards and woodland birds. Loss of erosion and effluent movement buffer capacity leading to contamination of water with contaminants from terrestrial sources.	-	ST, R	√		
	Excavation for construction along and near shore for terminal structures	Release of hydrogen sulphide and other chemicals associated with deep sediments within mangrove environments.	Change in water chemistry leading to physiological effects of aquatic flora.	_	ST, R	√		
Hydrology and Bathymetry	Dredging of access channel	Change local current flow dynamics and local wave action.	Change in transport of sediments and coastal erosion.	-	P, NR		√	

Topic Area	Activity	Primary or Direct Impact	Secondary or Indirect Impact	Dir. Impact	TS & Rev	Geo. Scope L	R	N
	Land reclamation and building of port docking facilities and supporting infrastructure	Physical blockage of longshore currents changing the dynamics of sediment transportation along the coast.	Accumulation of sand/sediment on the windward side and coastal erosion on the leeward side of the reclaimed land.	-	P, NR		√	
Nearshore Ecosystems - Ecology and nature conservation	Pier and cruise terminal construction	Contamination of soil and underground water from land-based spillages of oils and petrol and diesel from fuel pumps, generators, land-based Vehicles, repair workshop(s)	Direct toxic effects to soil microbes with consequent negative consequences of soil fertility, including denuding areas of vegetation with attendant erosion from wind and water.	-	ST, R	√		
	Solid wastes accumulation	Attraction of feral animals and household pests in the form of crocodiles, raccoons, rats, snakes, vagrant birds, etc.	Interaction of non-native species with native coastal fauna in form of prey/predator relationships, as well as parasite/host relationships and disease introduction situations, and competition/displacement scenarios.	-	*LT, R*	√		
		Alteration of species diversity indices driven by induced and incidental introduction of non-native flora and fauna.	Disruption of ecological balance and gene frequency in the coast with threat of altering course of evolution of native fauna.	-	*LT, R*	√		

Topic Area	Activity	Primary or Direct Impact	Secondary or Indirect Impact	Dir. Impact	TS & Rev	Geo. Scope L	R	N
		Leaching of toxic, pH altering and oxidative substances from discards.	Direct mortality and morbidity to land-based fauna such as iguanas, geckos, blue land crabs crows and vultures, and marine organisms	-	*ST, IR*	√		
	Solid waste mis-management on construction sites (Cruise Terminal centre, pier infrastructure, bridge and access road)	Interaction of land-based and aquatic fauna with plastics, glass, tin-cans, rubber, etc.	Ingestion of plastic bags by juvenile sea turtles mistaken for prey items such as jelly fishes. Entrapment of sharks and fish by six pack ring, beer containers etc.	-	*LT, R*	√		
		Leaching of toxic, pH altering and oxidative substances from discards.	Direct mortality and morbidity to land-based fauna such as iguanas, geckos, blue land crabs, crows, vultures, etc.	-	*LT, IR*	√		
	Land clearing and construction of road and driving path.	Loss of vegetation and natural resource services arising due to need for development of infrastructure and amenities.	Loss of habitat for species living in nearshore ecosystems Loss of vegetation resulting in acceleration of runoff rate with beach erosion and attendant sedimentation and turbidity influences of nearshore waters. Active clearing and incidental loss of mangroves and native fruit trees erodes and source of food for both terrestrial and aquatic species which includes both resident and migratory stocks.	-	LT, R	√		

Topic Area	Activity	Primary or Direct Impact	Secondary or Indirect Impact	Dir. Impact	TS & Rev	Geo. Scope L	R	N
	Dredging and deposition of spoils	Increased turbidity and sedimentation adding pressure to primary and secondary productivity from mangroves, and already stressed patch reef and seagrass bed located at the southern fringes of the mouth of South Grennel's channel.	Net loss of primary and secondary productivity manifested in decreased abundance of fin-fishes and other aquatic organisms.	-	MT, R		√	
	Traffic	Death and injury from collision of power boats with manatees	Decline in manatee populations would mark decrease in herbivory from an important link in the food chain.	-	ST, IR	√		
	Noise from construction activities	Noise disturbing marine and terrestrial wildlife, especially when coinciding with breeding season.	Displacement of birds having direct impact on herbivory and prey/predator relationships in and around Project site.	-	ST, R	√		
Impacts on Lower Sibun River Ecosystem	Bridge and access road construction	Increased runoff and sedimentation	Degradation of wild life habitat and coastal ecology.	-	LT R	√		
	Dredging and sand abstraction from the mouth of Sibun River.	Increased turbidity and sedimentation.	Net loss of primary and secondary productivity manifested in decreased abundance of fin-fishes and other aquatic organisms.	-	ST, R	√		

Topic Area	Activity	Primary or Direct Impact	Secondary or Indirect Impact	Dir. Impact	TS & Rev	Geo. Scope L	R	N
Impacts on Social/Human Environment	Solid waste production and management.	Attraction and introduction of feral animals and household pest to site as a consequence of availability of food and suitable habitat.	Increased presence of crocs and raccoons scavenging garbage and discards and possibility of attacks on guests and tourists. Rats & mice as well as raccoons are carriers of diseases such as Leptospirosis and Rabies, these may be transmitted to guests/tourists as well as workers through biting and other forms of contact with these animals.	-	*LT, R*	√		
	Dredging, spoil discharge/disposal	Berthing of dredge and deployment of spoil discharge pipes during land reclamation operation poses a threat to human health and safety.	Berthing of dredge and spoil discharge pipes poses threat to mariners in terms of 'Collision at Sea' accidents.	-	*ST, R*	√		
	Dredging	Decline in health status of patch reef and seagrass beds close to the mouth of South Grennel's channel from sedimentation and turbidity impacts	Decline in fish stocks including snappers and grunts as well as invertebrate stocks with consequent decline in fish landings by subsistence fishermen.	-	*LT, R*	√		
	Dredging	Noise and boat traffic causing injury and displacement of manatees and other marine life	Decline and displacement of manatees endangering livelihood for tour guides who utilize site in vicinity of project site for manatee/bird-watching tourists	-	*LT, R*	√		

Topic Area	Activity	Primary or Direct Impact	Secondary or Indirect Impact	Dir. Impact	TS & Rev	Geo. Scope		
						L	R	N
	Traffic to transport construction material and personnel	Threat of injury and death to humans from increase vessel traffic during construction.	Threat of injury and death to humans on the pier from transferring to and from vessels.	-	*ST, IR*	√		
	Occupancy and operation of port facilities	Introduction of pathogenic organisms such as E. coli and Shigella into the water column from sewage.	Introduction and permeation of pathogenic viruses and bacteria in surrounding seas poses threat of diseases to divers during construction activities.	-	ST, R		√	
	General construction	Standing water in tin cans, tires, plastic bottles forming habitat for the breeding of mosquitoes.	Mosquitoes are carriers of various diseases such as Malaria and Yellow Fever which may be transmitted to human beings, including residents and workers of the facilities.	-	*ST, R*	√		
	Operation of construction machinery, tools, etc.	Increase risk for injuries to workers.		-	***P, IR***	√		
Socio-economic impacts	All construction and operation activities	Employment opportunities Governmental tax income	Improve livelihood security Stimulate local economy Contribute to GDP	+	ST	√		√

Table 12-13: Impact Characteristics Matrix - Operational Phase

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir. Impact	TS & Rev	Geo. Scope		
						L	R	N
Impacts on Marine Water Quality	Use of sewage system	Water contamination from liberated eutrophic or nutrient enrichment substances.	Liberation of nitrates and phosphates from sewage into water column of surrounding sea may lead to increase in photosynthesis and primary production at lower end of pollution spectrum. At extreme end of spectrum leads to mass mortalities or 'crash' of microalgal blooms. Stimulus for overgrowth of patch reef by macro-algae and seagrasses located at the mouth of south Grennel's channel.	_	LT, R	√		
	Dockside boating/ berthing operations for cruise ship	Increased disturbance of water column and possible leaks of hydrocarbon/other toxic material	Increased contaminants and water column disturbance on marine life form in vicinity of cruise liner access channel Increase mechanical turbulence	-	LT, R	√		

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir Impact	TS & Rev	Geo. Scope		
						L	R	N
		Increased turbidity and TDS.	Effects from sedimentation and turbidity influences in form of blanketing of sedentary and slow-moving benthic invertebrates as well as impairment of photosynthesis and secondary production in algae and seagrass.	-	MT, R	√		
	Recreational beach activities	Disturbance of sand and sediment on beach floor	Physiological stress and death to aquatic fauna, especially sedentary and slow-moving inverts.					
				-	LT, R	√		
	Sea transports	Dissolved fraction from outboard engines and heavier fraction from lubricating oils spilled into the environment.	Direct toxic effect of petroleum pollutants on aquatic fauna, especially sedentary invertebrates. Spillage of heavier lubricating oils potentially deleterious to seabirds in regards to loss of waterproofing and buoyancy.	-	LT, R		√	

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir. Impact	TS & Rev	Geo. Scope		
						L	R	N
Impacts on Nearshore Ecosystems - Ecology and nature conservation	Solid Waste Accumulation	Attraction of feral and household pests in the form of crocodiles, raccoons, rats and vagrant birds.	Interaction of invasive species with native fauna in form of prey/predator relationships, as well as parasite/host relationships and disease introduction situations, and competition/displacement scenarios.	-	LT, R	√		
		Alteration of species diversity indices driven by induced and incidental introduction of non-native flora and fauna, and inorganic pollutants	Disruption of ecological balance and gene frequency with threat of altering course of evolution of native fauna.	1	LT, R	√		
		Marine litter pollution and interaction of land-based and aquatic fauna with plastics, glass, tin-cans, rubber, etc.	Injury or death from ingestion of plastic bags by juvenile sea turtles mistaken for prey items such as jelly fish. Entrapment of sharks and other marine fauna by Six Pack Ring Beer Containers etc.	-	LT, R		√	

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir Impact	TS & Rev	Geo. Scope		
						L	R	N
		Leaching of toxic, pH altering and oxidative substances from discards.	Direct mortality and morbidity of marine-based fauna.	-	LT, IR	√		
	Maintenance dredging and deposition of spoils	Loss of primary and secondary productivity from seagrass beds and patch reef on southern fringes of South Grennel's channel. Increased sedimentation / TDS in water column	Impairment of seagrass and patch reef by sedimentation This results in net decrease of primary and secondary productivity manifested in decreased aquatic life.	-	MT, R		√	
	Boat traffic and access coastal road traffic from project site to Belize City and other locations	Death and injury from collision of power boats with manatees.	Decline in manatee populations would with marked decrease in herbivore from an important link in the food chain.	-	LT, R	√		
	Operation of vessels and vehicles	Noise disturbing bird populations, especially during breeding season.	Displacement of birds having direct impact on herbivory and prey/predator relationships in and around the coast near the project site.	-	ST, R	√		

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir. Impact	TS & Rev	Geo. Scope		
						L	R	N
Impacts on Land-based to Northern Lagoon Ecosystem	Inland tours	Land-based spillages of oils and petrol and diesel from fuel pumps, generators, land-based vehicles.	Direct toxic effects to soil microbes with consequent negative consequences of soil fertility, including denuding areas of vegetation with attendant erosion from wind and water.	-	LT, R		√	
		Disturbance of wildlife and wildlife habitat	Wildlife dispersal and migration resulting in decreasing wildlife presence	-	LT, R		√	
	Solid waste accumulation	Leaching of toxic, pH altering and oxidative substances from discards.	Direct mortality and morbidity to land-based fauna such as iguanas, geckos, blue land crabs, crows, vultures, etc	-	LT, IR	√		

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir. Impact	TS & Rev	Geo. Scope		
						L	R	N
	Additional land clearing during operational phase for expansion and road maintenance	Loss of habitat and fruit trees with need for development of infrastructure and amenities in the coastal zone/river mouth near project site	Active clearing and incidental loss of native fruit trees erodes and eliminate coast near the project site as source of feed for certain woodland species of birds which includes both resident and migratory stocks.	-	LT, R	√		
Impacts on the Sibun River Ecosystem	River tours	Spillages of oils and petrol from boats.	Direct toxic effects to riverine flora and fauna. soil microbes with	-	LT, R		√	
		Disturbance of wildlife habitat (birds, turtles racoons, iguana etc.) from traffic noise.	Wildlife dispersal and migration resulting in deceasing wildlife presence	-	LT R	√		

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir. Impact	TS & Rev	Geo. Scope		
						L	R	N
	Increased human presence in lower Sibun River watershed	Direct impact on flora and fauna in the lower reaches of the Sibun River watershed, including the marine (estuary) area. Reduction and disruption of natural resources in the area	Reduction in turtle, manatee and fish species in the area. Disruption/degradation of biological diversity and connectivity Increase pollution of fresh and marine water resources Increased air pollution	-	LT R	√		
Human Environment	Sea traffic increase (local vessels and cruise ships)	Noise and boat traffic causing injury and displacement of manatees	Decline and displacement of manatees endangering livelihood for tour guides who utilizes site in the vicinity of the development project area for manatee watching/bird watching tourists.	-	LT, R	√		

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir Impact	TS & Rev	Geo. Scope		
						L	R	N
	Waste production and management	Attraction and introduction of feral animals and household pest to site as a consequence of availability of food and suitable habitat.	Presence of large crocs and raccoons scavenging garbage and discards and possibility of attacks on guests and tourist. Rats & mice as well as raccoons are carriers of diseases such as Leptospirosis and Rabies, these may be transmitted to guests/tourists as well as workers through biting and other forms of contact with these animals.	-	LT, R	√		
	Manoeuvring and berthing of cruise ships along channel and turn basin	Poses a threat to human safety.	Poses significant threat to mariners in terms of 'Collision at Sea' accidents.	-	MT, R	√		
	Movement of smaller vessels to and from Port	Threat of injury and death to divers and snorkelers from boat accidents.	Divers and snorkelers at risk of injury and death from motorized crafts plying the waters of the nearshore reefs or cayes east of the project site. Area currently used by subsistence and commercial fishers, sand miners, etc.	-	LT, IR	√		

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir Impact	TS & Rev	Geo. Scope		
						L	R	N
	Daily operation at Cruise Terminal facilities and other establishment connected with Port of Magical Belize	Standing water in tin cans, tires, plastic bottles forming habitat for the breeding of mosquitoes.	Mosquitoes are carriers of various diseases such as Malaria and Yellow Fever which may be transmitted to human beings, including tourists, residents and workers of the facilities	-	LT, R	√		
		Introduction of pathogenic organisms such as E. coli and Shigella into the water column from sewage	Introduction and permeation of pathogenic viruses and bacteria in surrounding seas poses threat of diseases to divers, snorkelers and swimmers utilizing the nearshore waters of the facilities.	-	LT, R		√	

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir Impact	TS & Rev	Geo. Scope		
						L	R	N
	Dockside Boating/ Berthing operations for cruise ship, disembarkation and tours.	Contact between tourists and locals with differing traditions and language and value systems can make for unplanned and unanticipated negative consequences.	Foreign tourists involved in nearshore snorkelling and scuba diving may take umbrage at or indeed may be discomfited by extractive economic activities such as traditional line fishing for fin-fishing and spearfishing for lobster by local. This animosity and discomfiture may also extent to access to the beach and seafront areas by locals, which would pre-date developmental activities in the Coastal Zone	-	LT, R	√		
Impacts on Economic Activity	Dockside Boating/ Berthing operations for cruise ship Marina berthing and operation for local vessels Nature trails through mangrove forest to Northern Lagoon Main Building occupancy & operations	Employment opportunities and stimulate local and national economy	Increase in foreign exchange Livelihood security for Belizean workers and enhance purchase power of locals Enhance social fabric and help reduce crimes Enhance Belize as regional and global attractive tourist destination	+	MT - LT	L	R	N

Topic Area	Dev. Activity	Primary or Direct Impact	Secondary or Indirect Impact	Mag. & Dir Impact	TS & Rev	Geo. Scope		
						L	R	N
	Recreational beach activities near Cruise Terminal site Increased Road Traffic and transportation to and from Port of Magical Belize Cruise Terminal site Helicopter pad & Operations							

12.5 Environmental Impact Risk Assessment during Construction and Operational Phase

Table 12-17 and **Table 12-18** present the Environmental Risk Assessment for the construction and operational phases of the project respectively. Key used for ranking severity of consequences from impacts associated with Port of Magical Belize is presented in table below.

Table 12-14: Key used for ranking severity of consequences from impacts associated with Port of Magical Belize

SEVERITY (S)/CONSEQUENCE	
3	Major **Beneficial** Impact
2	Moderate **Beneficial** Impact
1	Minor **Beneficia**l Impact
-1	Minor **Adverse** Impact
-2	Moderate **Adverse** Impact
-3	Major **Adverse** Impact

The impact assessment matrix is used to compare the likelihood of occurrence (L) for each impact against the potential severity of its consequence (S) to produce the degree of significance of each impact. The degree of significance will later on determine whether mitigation is needed and if so, to what level.

The resulting interaction between the likelihood of occurrence and severity of the consequences is rated/ranked between 'low' and 'critical' and results in the degree of significance of that impact.

Table 12-15: Table C- 5. Key used for ranking the interaction between "Likelihood" and "severity of consequences" from impacts associated with Port of Magical Belize

RISK RANKING = LxS	
Major Benefit	(+10 +12)
Moderate benefit	(+7 +9)
Low benefit	(+4 +6)
Unbeneficial / Low Risk	(-3 +3)
Medium Risk	(-6 -4)
High Risk	(-9 -7)
Critical Risk	(-12 -10)

The impact risk factor is determined from the product of likelihood of the impact and the severity of its consequence. The risk ranking is tabulated below. The high risk and Critical Risk impacts are those considered for practical and cost-effective mitigation response.

Table 12-16: Key used for ranking the interaction between "Likelihood", "severity of consequences" and 'Risk ranking' from impacts associated with Port of Magical Belize.

			Likelihood (L)			
			Unlikely	Possible	Likely	Certain
			1	**2**	**3**	**4**
Severity (S)	Beneficial - Major Impact	**3**	3	6	9	12
	Beneficial - Moderate Impact	**2**	2	4	6	8
	Beneficial - Minor Impact	**1**	1	2	3	4
	Adverse - Minor Impact	**-1**	-1	-2	-3	-4
	Adverse - Moderate Impact	**-2**	-2	-4	-6	-8
	Adverse - Major Impact	**-3**	-3	-6	-9	-12

RISK RANKING = LxS	
Major Benefit	(+10 +12)
Moderate benefit	(+7 +9)
Low benefit	(+4 +6)
Unbeneficial / Low Risk	(-3 +3)
Medium Risk	(-6 -4)
High Risk	(-9 -7)
Critical Risk	(-12 -10)

Table 12-17: Likelihood, severity and risk level of impacts during construction phase of the Port of Magical Belize Cruise Terminal project.

Activities - Construction Phase. Likelihood, Severity and Risk Factor																																					
		Dredging to deepen arrival channel and turning basin for cruise ships			Land reclamation with spoils for pier to accommodate cruise ships			Increase barge traffic			Excavation for construction along and near shore for terminal structures			Construction of main access Pier			Construction of restaurants, shops, and other service buildings			Installation of sewer infrastructure			Installation of water supply system and standby supply			Installation of power utility			Installation and operation of Diesel Generator(s)			Pre-development land clearing			Bridge construction			Landfilling and building of access road		
		L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Impacts on Marine Water Quality	Increase in nutrients	1	-1	-1	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2
	Increase in Sedimentation	4	-1	-4	3	-3	-9	1	-1	-1	2	-2	-4	1	-2	-2	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-3	-6	2	-3	-6
	Increase in Faecal Coliform	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2
	Increase in BOD	1	-1	-1	2	-2	-4	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	1	-2	-2
	Increase in Hydrogen Sulphide	1	-1	-1	1	-2	-2	1	-1	-1	2	-2	-4	1	-2	-2	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	2	-1	-2	1	-2	-2	2	-2	-4
	Increased hydrocarbon pollution	2	-1	-2	1	-1	-1	2	-2	-4	2	-2	-4	2	-3	-6	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-1	-2	1	-2	-2	2	-2	-4
	Fluctuation of water column temperature	1	-1	-1	1	-2	-2	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1
	Decrease in Dissolved Oxygen	1	-1	-1	2	-2	-4	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-2	-2	1	-1	-1
	Increase landscaping pesticides and herbicides	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increase turbidity	4	-2	-8	3	-2	-6	1	-3	-3	2	-3	-6	2	-2	-4	2	-2	-4	2	-2	-4	2	-1	-2	2	-1	-2	1	-1	-1	2	-2	-4	2	-3	-6	2	-2	-4
	Increase in Salinity	1	-1	-1	1	-2	-2	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1
	Total dissolved solids	1	-1	-1	2	-2	-4	1	-1	-1	1	-3	-3	2	-2	-4	2	-2	-4	1	-1	-1	2	-1	-2	2	-1	-2	1	-1	-1	2	-2	-4	1	-2	-2	2	-1	-2
Impacts on hydrological and bathymetric characteristics	Increased Salinization of Soils and River	2	-2	-4	2	-2	-4	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2
	Increased Erosion	3	-2	-6	1	-3	-3	1	-1	-1	2	-3	-6	1	-2	-2	1	-2	-2	1	-2	-2	1	-2	-2	1	-2	-2	1	-1	-1	3	-2	-6	2	-2	-4	4	-2	-8
	Changes to Sediment Transport	4	-2	-8	2	-3	-6	1	-1	-1	2	-3	-6	1	-3	-3	1	-2	-2	1	-2	-2	1	-2	-2	1	-2	-2	1	-1	-1	3	-2	-6	2	-2	-4	2	-2	-4
	Increased Solid Waste	1	-1	-1	1	-1	-1	1	-2	-2	1	-3	-3	2	-2	-4	4	-2	-8	1	-2	-2	4	-1	-4	2	-2	-4	1	-1	-1	4	-2	-8	1	-2	-2	2	-2	-4
	Increased in Anoxic Sediment	2	-3	-6	2	-2	-4	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-3	-3	1	-2	-2
	Increased Land Runoff	3	-2	-6	2	-2	-4	1	-1	-1	2	-2	-4	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-2	-6	2	-2	-4	3	-2	-6
Impacts on General Ecology	Change in Pelagic Habitat	1	-2	-2	1	-1	-1	1	-1	-1	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Loss of Benthic Habitat	4	-2	-8	2	-2	-4	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-1	-3	1	-1	-1	1	-1	-1
	Decrease in Nursery Habitat	2	-2	-4	2	-2	-4	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-2	-6	1	-1	-1	3	-2	-6
	Increase in Feral Animals	1	-1	-1	2	-2	-4	1	-1	-1	1	-2	-2	1	-2	-2	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	2	-2	-4
	Change in Aquatic Fauna near Cruise Terminal Site	2	-1	-2	2	-3	-6	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	3	-1	-3	1	-1	-1	1	-1	-1	1	-1	-1
	Decrease in productivity of Mangroves	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	3	-2	-6	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-2	-6	1	-2	-2	4	-2	-8
	Decreased Mangroves Prop. Root Habitat	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	3	-1	-3	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-2	-6	1	-2	-2	3	-2	-6
	Change in Bird Population	1	-1	-1	2	-2	-4	1	-1	-1	1	-1	-1	2	-1	-2	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	3	-2	-6
	Decrease in Seagrass	2	-2	-4	1	-2	-2	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Decrease in Coral Reef Colonies and Diversity	2	-2	-4	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Air Pollution	2	-2	-4	2	-2	-4	2	-1	-2	2	-2	-4	2	-2	-4	2	-2	-4	2	-1	-2	2	-1	-2	2	-1	-2	2	-3	-6	2	-1	-2	2	-3	-6	2	-2	-4
Impacts on Nearshore Ecosystems	Fringing Mangrove Prop Root Productivity	3	-2	-6	2	-2	-4	1	-1	-1	3	-2	-6	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-2	-6	3	-2	-6	3	-2	-6
	Fringing Mangrove Canopy Biomass & Productivity	3	-2	-6	2	-2	-4	1	-1	-1	3	-2	-6	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-2	-6	3	-2	-6	3	-2	-6
	Sea-grass Productivity	3	-1	-3	2	-2	-4	1	-1	-1	2	-2	-4	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2
	Macro-Invertebrate Population	3	-2	-6	1	-2	-2	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	2	-2	-4
	Fin-Fish Population	2	-1	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	2	-2	-4
	Seabird Population	2	-1	-2	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1
	Coral Reef Cover and Diversity	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2
	General Pelagic Fish Populations	3	-1	-3	1	-2	-2	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Reef Fish Abundance and Diversity	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Seagrass Productivity	2	-2	-4	1	-2	-2	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Macro-invertebrate Populations	3	-2	-6	1	-2	-2	1	-1	-1	1	-2	-2	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1
	General Lobster Populations	2	-1	-2	1	-1	-1	1	-2	-2	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Salt water crocodile	3	-3	-9	2	-2	-4	2	-2	-4	3	-3	-9	3	-3	-9	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	2	-2	-4
	Dolphin population	3	-3	-9	2	-2	-4	2	-2	-4	3	-3	-9	3	-3	-9	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1

Activities - Construction Phase. Likelihood, Severity and Risk Factor																																									
		Dredging to deepen arrival channel and turning basin for cruise ships			Land reclamation with spoils for pier to accommodate cruise ships			Increase barge traffic			Excavation for construction along and near shore for terminal structures			Construction of main access Pier			Construction of restaurants, shops, and other service buildings			Installation of sewer infrastructure			Installation of water supply system and standby supply			Installation of power utility			Installation and operation of Diesel Generator(s)			Pre-development land clearing			Bridge construction			Landfilling and building of access road		
	Wading Seabird Population	2	-1	-2	2	-1	-2	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-2	-2
	Sea turtle	3	-3	-9	2	-2	-4	1	-1	-1	3	-3	-9	3	-3	-9	1	-1	-1	1	-2	-2	1	-1	-1	1	-2	-2	1	-1	-1	1	-3	-3	2	-2	-4	2	-2	-4
	Manatee Population	3	-3	-9	1	-3	-3	2	-3	-6	2	-3	-6	3	-3	-9	1	-2	-2	2	-2	-4	1	-1	-1	1	-2	-2	1	-1	-1	2	-3	-6	3	-3	-9	3	-2	-6
Impacts on Land-based to Northern Lagoon Ecosystem	Mangrove Canopy Biomass	2	-1	-2	2	-2	-4	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	3	-2	-6
	Swamp Floor Productivity	3	-1	-3	2	-2	-4	1	-1	-1	1	-2	-2	2	-2	-4	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	2	-2	-4
	Littoral Forest Productivity	1	-1	-1	3	-1	-3	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	2	-2	-4
	Woodland Bird Population	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-1	-2	2	-2	-4
	Wadding Bird Populations	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-1	-2	1	-1	-1
	Invasive Feral Fauna Abundance & Diversity	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4
	Resident Iguana Populations	2	-1	-2	2	-2	-4	1	-1	-1	2	-2	-4	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	2	-2	-4
	General Faunal Diversity	3	-1	-3	2	-2	-4	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	2	-2	-4
Impacts on Sibun River Ecosystem	Mangrove Canopy Biomass	2	-1	-2	2	-2	-4	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-2	-6	2	-1	-2	3	-2	-6
	Swamp Floor Productivity	2	-1	-2	2	-2	-4	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-1	-2	3	-2	-6
	Littoral Forest Productivity	2	-1	-2	2	-1	-2	1	-1	-1	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-2	-6	2	-2	-4	2	-3	-6
	Woodland Bird Population	1	-1	-1	2	-2	-4	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-1	-2	2	-1	-2
	Central American River Turtle (Dermatemys mawii)	2	-2	-4	2	-2	-4	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	2	-2	-4	2	-2	-4
	Hicatee turtle population	2	-1	-2	2	-2	-4	1	-1	-1	2	-2	-4	1	-2	-2	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	2	-2	-4
	Fish abundance & diversity	2	-1	-2	1	-1	-1	1	-1	-1	2	-2	-4	1	-2	-2	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1
Impacts on Economic Activity	Increase sea-going boat traffic near project site and on the Sibun River	3	-2	-6	1	-1	-1	2	-1	-2	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-3	-6	1	-2	-2
	Boat Access for Subsistence Fishers	3	-2	-6	1	-1	-1	2	-2	-4	1	-2	-2	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-3	-6	1	-2	-2
	Tour Operation	3	-1	-3	2	2	4	2	-1	-2	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	1	-2	-2
	Sports fishing activities	2	-2	-4	1	1	1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4
	Increased boat traffic in Northern Lagoon	3	-1	-3	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4
	Cruise Liners channel maintenance & docking/berthing	2	-3	-6	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
Impacts on Human Settlements/Social	Pathogenic Diseases	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2			
	Mosquitos, Sand-flies &Associated Pests	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	2	2	1	-2	-2	2	-1	-2
	Culture conflicts	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Injury and physical trauma	1	-3	-3	1	-2	-2	1	-1	-1	1	-2	-2	2	-2	-4	2	-2	-4	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	3	-2	-6
	Noise Pollution	1	-2	-2	2	-2	-4	2	-2	-4	3	-2	-6	3	-2	-6	3	-2	-6	2	-2	-4	1	-2	-2	2	-1	-2	1	-2	-2	2	-2	-4	2	-2	-4	3	-2	-6
	Odour pollution	1	-1	-1	2	-2	-4	2	-1	-2	3	-2	-6	2	-2	-4	2	-1	-2	2	-1	-2	2	-1	-2	1	-1	-1	1	-2	-2	1	-1	-1	2	-2	-4	2	-2	-4
	Aesthetics Pollution	1	-2	-2	2	3	6	1	-2	-2	3	-2	-6	3	-1	-3	2	-2	-4	2	-1	-2	1	-2	-2	1	-1	-1	1	-2	-2	3	-1	-3	2	-2	-4	3	-2	-6
	Increase in migrant and City workers in the project zone	1	-1	-1	2	2	4	1	-1	-1	1	-1	-1	1	-1	-1	4	-1	-4	3	3	9	2	-1	-2	2	-1	-2	1	-1	-1	2	-1	-2	2	2	4	3	-1	-3
	Increased road traffic on GPH	1	-1	-1	2	-1	-2	1	-1	-1	1	-2	-2	1	-1	-1	3	-2	-6	2	-1	-2	2	-1	-2	2	-1	-2	1	-1	-1	2	-1	-2	2	-2	-4	4	-1	-4
	Job Creation/Poverty Reduction	1	3	3	2	3	6	1	-1	-1	1	3	3	1	3	3	4	3	12	3	3	9	2	3	6	2	3	6	1	3	3	3	3	9	3	3	9	4	3	12
	Increased commerce	1	3	3	2	3	6	1	-1	-1	1	3	3	1	3	3	3	3	9	2	3	6	2	3	6	2	3	6	1	3	3	2	3	6	2	3	6	3	3	9
	Decreased traffic in Belize City	1	2	2	1	2	2	1	-1	-1	1	3	3	1	2	2	2	2	4	1	2	2	1	2	2	2	2	4	1	2	2	2	2	4	1	3	3	2	2	4
	City expansion	1	2	2	2	3	6	1	-1	-1	1	2	2	1	2	2	2	2	4	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
	Infrastructure development	1	3	3	2	2	4	1	3	3	2	3	6	1	3	3	3	3	9	2	3	6	1	3	3	2	3	6	1	3	3	2	3	6	2	3	6	4	2	8
	Foreign exchange	4	3	12	2	3	6	1	2	2	1	3	3	1	3	3	3	3	9	2	3	6	1	3	3	1	3	3	1	3	3	2	3	6	2	3	6	4	3	12
	Economic stimulation/GDP growth	3	3	9	2	3	6	1	2	2	1	3	3	1	3	3	2	3	6	1	3	3	1	3	3	2	3	6	1	3	3	2	3	6	2	3	6	4	3	12

Table 12-18: Likelihood, severity and risk level of impacts during operational phase of the Port of Magical Belize Cruise Terminal project.

Activities - Operational Phase. Likelihood, Severity and Risk Factor																																
		Fuel storage piers/marina			Marina berthing and operation for local vessels			Dockside Boating/Berthing operations for cruiseship			Nature trails through mangrove forest to Northern Lagoon			Land access coastal road to GPH			Main Building occupancy & operations			Recreational beach activities near Cruise Terminal site			Shore excursions			Other Nature Trail Operations			Road Traffic			Helicopter pad & Operations		
		L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R	L	S	R
Impacts on Marine Water Quality	Increase in nutrients	1	-1	-1	1	-2	-2	1	-2	-2	1	-2	-2	1	-2	-2	3	-3	-9	2	-2	-4	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1
	Increase in Sedimentation	1	-2	-2	1	-1	-1	1	-2	-2	1	-1	-1	1	-3	-3	1	-1	-1	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increase in Faecal Coliform	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	3	-3	-9	1	-3	-3	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increase in BOD	1	-2	-2	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increase in Hydrogen Sulphide	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increased hydrocarbon pollution	3	-3	-9	3	-2	-6	3	-2	-6	3	-1	-3	3	-2	-6	1	-1	-1	3	-2	-6	3	-2	-6	1	-1	-1	3	-2	-6	3	-2	-6
	Fluctuation of water column temperature	1	-2	-2	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Decrease in Dissolved Oxygen	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increase landscaping pesticides and herbicides	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increase turbidity	1	-1	-1	3	-2	-6	3	-2	-6	1	-1	-1	1	-1	-1	2	-1	-2	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increase in Salinity	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Total dissolved solids	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
Impacts on hydrological and bathymetric characteristics	Increased Salinization of Soils and River	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increased Erosion	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	2	-2	-4	1	-2	-2	1	-2	-2	1	-2	-2	1	-2	-2
	Onshore/Offshore Sediment Transport	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	2	-2	-4	1	-1	-1	2	-2	-4	1	-2	-2	1	-2	-2	1	-2	-2	1	-2	-2
	Increased Solid Waste	1	-2	-2	2	-2	-4	2	-2	-4	2	-2	-4	1	-2	-2	4	-2	-8	4	-2	-8	2	-2	-4	2	-2	-4	2	-2	-4	1	-1	-1
	Increased in Anoxic Sediment	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	4	-1	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increased Land Runoff	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	4	-1	-4	2	-2	-4	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1
Impacts on General Ecology	Change in Pelagic Habitat	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Loss of Benthic Habitat	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Decrease in Nursery Habitat	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Increase in Feral Animals	1	-2	-2	1	-2	-2	1	-1	-1	2	-2	-4	2	-2	-4	2	-2	-4	3	-2	-6	1	-1	-1	2	-2	-4	1	-1	-1	1	-1	-1
	Change in Aquatic Fauna near Cruise Terminal Site	1	-1	-1	1	-1	-1	3	-2	-6	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1
	Decrease in productivity of Mangroves	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Decreased Mangroves Prop. Root Habitat	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Change in Bird Population	1	-2	-2	1	-1	-1	2	1	2	3	-2	-6	3	-2	-6	2	-2	-4	2	-2	-4	2	-2	-4	2	-2	-4	1	-2	-2	2	-1	-2
	Decrease in Seagrass	1	-1	-1	1	-2	-2	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1
	Decrease in Coral Reef Colonies and Diversity	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1
	Air Pollution	1	-2	-2	1	-2	-2	2	-2	-4	1	-1	-1	2	-2	-4	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	3	-2	-6	2	-2	-4
Impacts on Nearshore Ecosystems	Fringing Mangrove Prop Root Productivity	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Fringing Mangrove Canopy Biomass & Productivity	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Sea-grass Productivity	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Macro-Invertebrate Population	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Fin-Fish Population	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Seabird Population	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Coral Reef Cover and Diversity	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	General Pelagic Fish Populations	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Reef Fish Abundance and Diversity	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Seagrass Productivity	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Macro-invertebrate Populations	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	General Lobster Populations	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Salt water crocodile	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1
	Dolphin population	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1

Activities - Operational Phase. Likelihood, Severity and Risk Factor																																			
		Fuel storage piers/marina			Marina berthing and operation for local vessels			Dockside Boating/Berthing operations for cruiseship			Nature trails through mangrove forest to Northern Lagoon			Land access coastal road to GPH			Main Building occupancy & operations			Recreational beach activities near Cruise Terminal site			Shore excursions			Other Nature Trail Operations			Road Traffic			Helicopter pad & Operations		
	Wading Seabird Population	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1
	Sea turtle	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1	2	-1	-2	1	-2	-2	3	-2	-6	3	-2	-6	3	-2	-6	1	-2	-2	1	-1	-1
	Manatee Population	1	-1	-1	1	-3	-3	1	-2	-2	2	-2	-4	2	-2	-4	1	-2	-2	3	-2	-9	2	-3	-6	2	-2	-4	1	-1	-1	1	-1	-1
Impacts on Land-based to Northern Lagoon Ecosystem	Mangrove Canopy Biomass	1	-1	-1	1	-1	-1	1	-3	-3	3	-2	-6	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1
	Swamp Floor Productivity	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1
	Littoral Forest Productivity	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1
	Woodland Bird Population	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Wadding Bird Populations	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Invasive Feral Fauna Abundance & Diversity	1	-1	-1	3	-1	-3	1	-1	-1	2	-1	-2	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1
	Resident Iguana Populations	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-2	-4	1	-1	-1	2	-1	-2	1	-2	-2	1	-1	-1	1	-2	-2	1	-1	-1
	General Faunal Diversity	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-2	-4	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1
Impacts on Sibun River Ecosystem	Mangrove Canopy Biomass	1	-1	-1	1	-1	-1	1	-1	-1	3	-1	-3	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1
	Swamp Floor Productivity	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1
	Littoral Forest Productivity	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1	1	-1	-1
	Woodland Bird Population	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-1	-2	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Central American River Turtle (Dermatemys mawii)	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	2	-2	-4	1	-1	-1	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Hicatee turtle population	1	-1	-1	1	-2	-2	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	2	-2	-4	2	-2	-4	2	-2	-4	1	-1	-1	1	-1	-1
	Fish abundance & diversity	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-2	-2	1	-2	-2	1	-1	-1	1	-1	-1	1	-1	-1
Impacts on Economic Activity	Increase sea-going boat traffic near project site and on the Sibun River	1	-1	-1	1	-3	-3	2	-1	-2	1	-2	-2	1	-2	-2	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-2	-2	1	-1	-1
	Boat Access for Subsistence Fishers	2	2	4	2	-2	-4	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	2	-2	-4	2	-2	-4	1	-2	-2	1	-1	-1
	Tour Operation	2	3	6	3	-2	-6	3	3	9	2	-2	-4	1	-3	-3	1	3	3	2	-2	-4	3	-2	-6	3	-2	-6	1	-2	-2	2	3	6
	Sports fishing activities	2	3	6	3	-2	-6	3	3	9	2	-2	-4	1	-2	-2	1	3	3	2	-2	-4	3	-2	-6	3	-2	-6	1	-2	-2	1	-2	-2
	Increased boat traffic in Northern Lagoon	2	2	4	3	-2	-6	2	-1	-2	2	-2	-4	1	-2	-2	1	-1	-1	2	-2	-4	2	-2	-4	2	-2	-4	4	2	8	1	-2	-2
	Cruise Liners channel maintenance & docking/berthing	2	2	4	1	-2	-2	3	3	9	2	-1	-2	1	-1	-1	1	-1	-1	2	-1	-2	2	-1	-2	2	-2	-4	1	-1	-1	2	-2	-4
Impacts on Human Settlements/Social	Pathogenic Diseases	1	-1	-1	1	-1	-1	2	-2	-4	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1
	Mosquitos, Sand-flies &Associated Pests	1	-1	-1	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	2	-1	-2	2	-1	-2	2	-1	-2	1	-1	-1	1	-1	-1
	Culture conflicts	1	-1	-1	1	-1	-1	3	-2	-6	2	-1	-2	1	-1	-1	1	-1	-1	2	-1	-2	2	-1	-2	2	-1	-2	1	-1	-1	1	-1	-1
	Injury and physical trauma	2	-1	-2	1	-2	-2	2	-2	-4	2	-1	-2	2	-2	-4	1	-1	-1	2	-2	-4	2	-2	-4	2	-2	-4	3	-2	-6	3	-2	-6
	Noise Pollution	1	-1	-1	2	-2	-4	2	-2	-4	1	-1	-1	2	-1	-2	1	-1	-1	2	-2	-4	1	-2	-2	1	-1	-1	2	-3	-6	2	-3	-6
	Odour pollution	2	-2	-4	2	-1	-2	2	-1	-2	1	-1	-1	2	-1	-2	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	2	-2	-4	1	-2	-2
	Aesthetics Pollution	2	-2	-4	2	-2	-4	2	-2	-4	2	-1	-2	2	-2	-4	1	-1	-1	2	-1	-2	1	-2	-2	1	-1	-1	2	-2	-4	2	-2	-4
	Increase in migrant and City workers in the project zone	1	2	2	1	-2	-2	3	-1	-3	2	-1	-2	2	-1	-2	1	-1	-1	2	-1	-2	1	-1	-1	1	-1	-1	2	-1	-2	1	-1	-1
	Increased road traffic on GPH	1	2	2	1	-1	-1	2	-2	-4	2	-2	-4	3	-1	-3	1	-1	-1	2	3	6	2	-1	-2	2	-1	-2	4	-1	-4	1	-2	-2
	Job Creation/Poverty Reduction	1	2	2	2	3	6	3	3	9	3	3	9	3	3	9	2	3	6	2	3	6	2	3	6	2	3	6	1	3	3	1	3	3
	Increased commerce	1	3	3	2	3	6	3	3	9	2	2	4	3	3	9	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6	1	3	3
	Decreased traffic in Belize City	1	2	2	2	2	4	2	3	6	1	2	2	2	2	4	2	2	4	1	2	2	1	2	2	1	2	2	4	2	8	1	2	2
	City expansion	1	2	2	1	2	2	2	2	4	1	1	1	1	2	2	1	2	2	1	2	2	1	2	2	2	2	4	1	2	2	1	2	2
	Infrastructure development	1	2	2	2	3	6	3	3	9	2	2	4	2	3	6	2	3	6	1	3	3	2	3	6	2	3	6	1	3	3	2	3	6
	Foreign exchange	1	3	3	2	3	6	3	3	9	2	2	4	2	3	6	2	3	6	1	3	3	2	3	6	2	3	6	2	3	6	3	3	9
	Economic stimulation/GDP growth	1	3	3	2	3	6	3	3	9	2	2	4	2	3	6	2	3	6	2	2	4	2	3	6	2	3	6	1	3	3	3	3	9

PART D- CONCLUSIONS / RECOMMENDATIONS

13 Alternatives for Development

This section provides a description of the types of project alternatives that could result in a major change in the significance of project's social and environmental impacts.

13.1 'No project' alternative

The first step in alternative assessment is to consider the "no project" alternative. If the project will not be developed, no impacts due to construction and operation (air and noise impacts, impact on water quality, etc.) will occur. However, the tourist industry will grow in other places as for instance in Belize City. If this is the case the unsafe situation with the tendering of passengers and arriving in Belize City will continue to exist and will become even more a safety and security issue next to the nuisance due to congestion.

Moreover, every new development needed for the increasing amount of cruise passengers will need developments involving dredging and construction of terminals leading to more or less the same impacts.

If the development will not be in Belize but in neighbouring countries, the related economic benefits of future cruise tourism will not be for Belize as well.

Considering the above the 'no project 'option is discarded.

13.2 Location alternatives

The development of the port on an alternative site is not assessed in the EIA as such but earlier while purchasing the required land for the development. The particular site is chosen because the site is considered to be sufficient close to Belize City (short transport routes), free of any housing or roads (no displacement), and the local marine environment is considered by the local experts as not-sensitive.

13.2.1 Shape of the development

Several varieties on the shape of the development has been considered, ranging from a development completely on land, on a peninsula and a development totally on an island at sea. Basically, the peninsula shape (development partially on land and partially on reclaimed land in front of the coast) has been chosen on the best ratio between 'cut' and 'fill'. Although financial driven, an optimal use of dredge spoil is also environmentally preferred as there is an optimal reuse of dredge spoil (less disposal and less additional raw material use).

13.2.2 Navigational routes

In an early design phase several navigational routes are considered, based, among others, on navigation possibilities and risks, and volumes to be dredged. Two preferred options are considered and assessed in the EIA (**Table 13-1**).

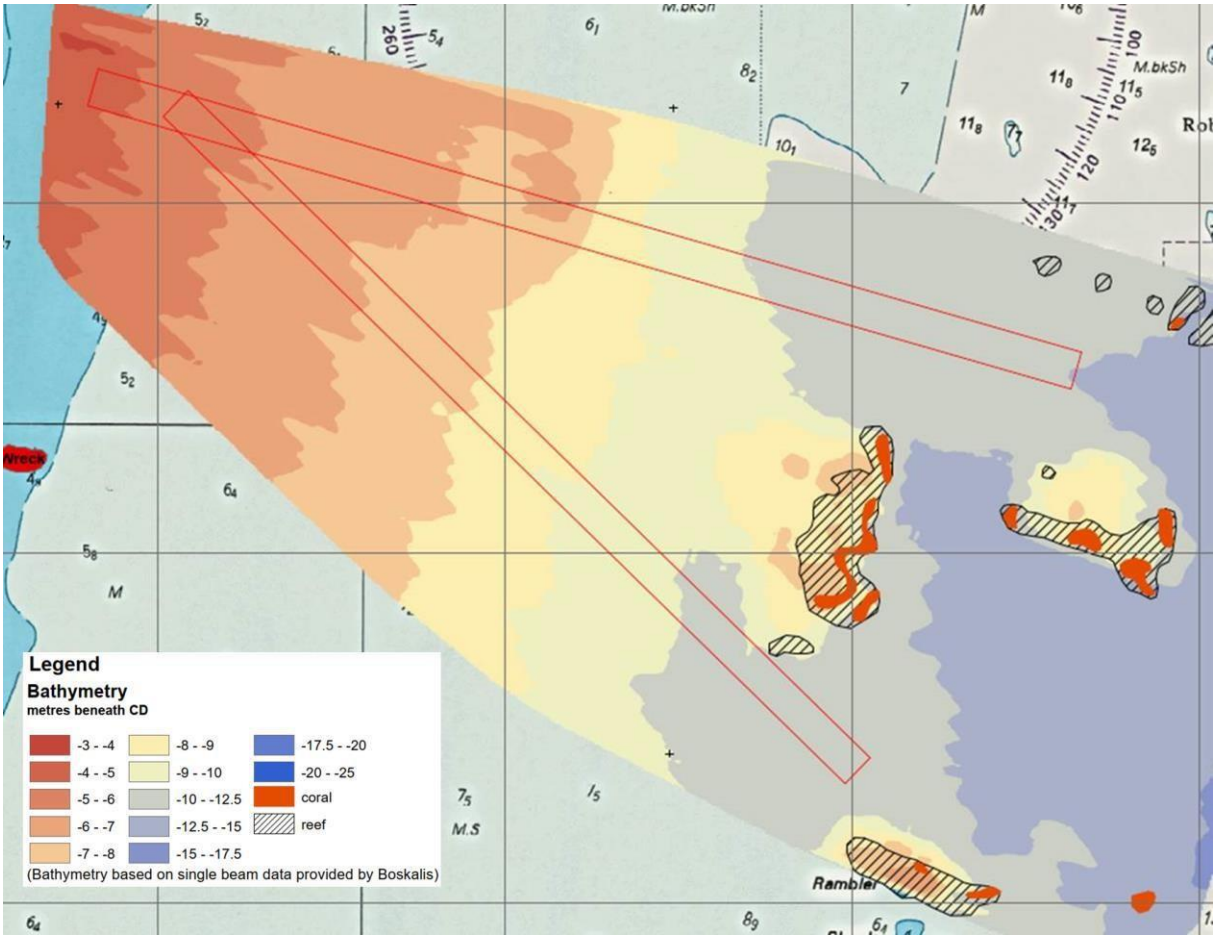

Table 13-1: approach routes are considered.

The most important conclusions of this assessment can be summarized as follows:

- Coral reefs are located 600 to 700 m from the offshore onset of the access channel.
- The vast majority of the released fines westward of the CD-9m contour is not expected to reach the (patches of) coral reefs.
- Because of the already large depth, the required dredging volumes close to the coral reefs are limited.
- Nonetheless it can be expected that fines will be released, and under certain wind conditions be directed with the current towards the coral reefs.
- For a realistic dredging methodology, it is estimated that the silt particles will settle within 100 m from the dredger and will this not reach the coral reefs.
- Clay particles will spread 400 to 800 m and might just of just not reach the coral reefs.
- The associated sediment concentration is estimated to be limited but that needs to be confirmed with an in-depth study once more in-situ data has become available and monitoring will be implemented.

13.2.3 Dredging

The various dredging techniques are discussed in the relevant sections, with their pros and cons. In practice the choice of one or the other is based among others on water depth, sediment type and distance to disposal area.

13.2.4 Dredge spoil disposal

Some 50% of the dredged material will be reused in the area to be reclaimed. The other 50% will need to be disposed. The disposal option as considered in this EIA is disposal on land. Although not preferred in Belize, disposal offshore could be an option as well and could be further assessed when for instance a disposal area on land is no longer available.

13.2.5 Utilities

Utilities as water supply, energy supply, waste management with the various alternatives are in detail discussed in the relevant chapters.

13.2.6 Road connection

For the road connection several options have been considered as the infrastructure in the area is not much developed. The preferred routing is connected with the north-south tracks already existing in the area as for this alternative relative limited vegetation needs to be cleared.

14 Impact Mitigation

This section is intended to cover mitigation for activities described in this EIA report. It covers project activities during construction and operation phases of the project and will be subject to thorough reviews prior to the commencement of activities to ensure completeness. The mitigation does not include measures for activities related to equipment and facility fabrication being done offsite. It should be noted that this provides the outline requirements for environmental management.

This section is essential for successfully implementing the project. Having this framework in place ensures a systematic approach to bringing environmental and social considerations into decision making and day-to-day operations. It establishes a framework for tracking, evaluating and communicating environmental and social performance and helps ensure that environmental and social risks and liabilities are identified, minimised and managed.

In particular, the objectives of the mitigation measures are to:

- Promote environmental and social management.
- Ensure that all workers, subcontractors and others involved in the project meet legal and other requirements with regard to environmental and social management.
- Incorporate environmental and social management into project design and operating procedures.
- Address concerns and issues raised in the EIA's stakeholder consultation process and those that will likely continue to arise during the project's lifetime.

For each of the impacts identified as major or moderate specific mitigation measures have been defined as part of the EIA process. The general rule in designing such measures is:

- Avoidance of major impacts: major impacts are in principal considered as unacceptable, certainly the ones that would endure into the long-term or extend over a large area.
- Reduction of major and moderate Impacts to as low as reasonably practicable (ALARP) by planning, designing and controlling mitigation measures. This implies that mitigation measures will be applied up to the limitations of cost-effectiveness and practical application are reached.

Implementation of good Contractor practices for aspects having minor impacts will ensure that such impacts are not neglected but managed adequately.

Those impacts that have been assessed as having a 'moderate adverse impact' or a 'major adverse impact', as shown in Table C.10 and Table C-11.

14.1 Roles and responsibilities

The project is committed to provide resources essential to the implementation mitigation measures in the construction and the operation of the project.

Prior to assigning any contract, the project will pre-qualify each contractor according to commercial, technical, quality assurance and its past performance on EHS standards so as to satisfy project's requirements and policies. Each contractor will assign an ESHS Manager whose responsibility is to ensure that environment, health and safety regulatory requirements are met and that mitigation requirements are properly implemented.

14.2 Training and Awareness

The project will identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact upon the environment or social conditions. The project recognises that it is important that employees at each relevant function and level are aware potential impacts of their activities; and roles and responsibilities in achieving conformance with the policy and procedures.

14.3 Checking and Corrective Actions

Checking includes inspections and monitoring as well as internal audit activities to confirm proper implementation of checking systems as well as effectiveness of mitigations. Corrective actions include response to out-of-control situations, non-compliances, and non-conformances. Actions also include those intended to improve performance.

14.3.1 Monitoring

Monitoring will be conducted to check compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts (please see sections below for more detail).

14.3.2 Auditing

Beyond the routine inspection and monitoring activities conducted, audits will be carried out internally by project team to verify compliance with regulatory requirements as well as their own EHS standards and policies. Audits to be conducted will also cover the contractor self-reported monitoring and inspection activities. The audit shall be performed by qualified staff and the results shall be reported and addressed.

The audit will include a review of compliance with the requirements of the Environmental Compliance Plan.

There will be a cycle of audits into specific areas of the project. The frequency of audits will be risk based and will vary with the stage of the Project and will depend on the results of previous audits.

14.3.3 Corrective Action

Investigating a 'near-miss' or actual incident after it occurs can be used to obtain valuable lessons and information that can be used to prevent similar or more serious occurrences in the future.

The project will implement a formal non-compliance and corrective action tracking procedure for investigating the causes of, and identifying corrective actions to, accidents or environmental or social non-compliances.

14.4 Waste Management

The project construction and operation will generate hazardous and non-hazardous (or inert) waste, which will comprise a range of solid waste, liquid waste or a mix of both solid and liquid waste. Initial information regarding the waste streams associated with the project is presented in **Part B**.

The likely waste management pathways for project construction wastes will include:

- Solid domestic waste, concrete and cementitious wastes and wood waste that are non-hazardous are likely to be disposed of to a landfill.
- Steel, paper and plastic wastes are likely to be recycled.
- Waste water and sewage are likely to be treated at the Waste Water Treatment Plan.

The likely waste management pathways for project operational wastes will include:

- Solid domestic waste and wood waste that are non-hazardous are likely to be disposed of to a landfill.
- Steel, paper and plastic wastes are likely to be recycled.
- Waste water and sewage are likely to be treated at the Waste Water Treatment Plan.

The waste from the vessel will not be allowed to be taken onshore and therefore no mitigation measures are proposed.

14.4.1 Waste Water

Construction

Construction site runoff and drainage should be minimized and prevented, the specific mitigation measures and practices could include the following points:

- Provision of perimeter drains to intercept storm-runoff from outside the works area. These shall be constructed in advance of site formation works and earthworks. Earth bunds or sandbag barriers should be provided on-site to direct storm water to silt removal facilities. The design of the temporary on-site drainage system will be undertaken by the Contractor prior to the commencement of construction.
- Silt removal facilities, channels and manholes should be maintained, and the deposited silt and grit should be removed as needed, at the onset of and after each rainstorm to ensure that these facilities are always functioning properly.

- Open stockpiles of construction materials (e.g. aggregates, sand and fill material) on sites should be covered with tarpaulin or similar material during rainstorms. Measures should be taken to prevent the washing away of construction materials, soil, silt or debris into any drainage system.
- Construction works should be programmed to minimize surface excavation works during the rainy seasons (May to November) where applicable. Where needed exposed earth areas should be completed and vegetated as soon as possible after earthworks have been completed.
- Manholes (including newly constructed ones) should always be adequately covered to prevent silt, construction materials or debris from getting into the drainage system, and to prevent storm run-off from getting into foul sewers. Discharge of surface run-off into foul sewers must always be prevented in order not to unduly overload the foul sewerage system.
- Minimizing the vegetation clearance where possible, allowing natives species to grow in the area.

Construction waste water:

- Water used for water drilling works, testing, boring and precast concrete casting should be reused/recirculated after sedimentation. When there is a need for final disposal, the wastewater should be discharged into storm drains via silt removal facilities.
- Water used in ground boring and drilling for site investigation or rock/soil anchoring should as far as practicable be recirculated after sedimentation. When there is a need for final disposal, the waste water should be discharged into storm drains via silt removal facilities.
- The generation of waste water should be kept to a minimum.
- The entrance/exit and public road should be paved with backfill to prevent site runoff from flowing onto the public road.

Operation

During the operational phase the proposed mitigation measures are directly linked to the ability to monitor and enforce international and local laws and regulations regarding cruise ship waste management and operations while in Belizean waters. The cruise industry will normally sign Memoranda of Understanding (MOU) or "Environmental Guidelines" with the Government of the country they are visiting regarding specific environmental practices they need to follow. Enforcement of these environmental practices present its own challenges; however, the port administration can enforce certain measures to mitigate cruise related environmental impacts by establishing regulations and enforceable laws, including frequent monitoring for compliance and significant penalties for noncompliance. The list of potential measures is presented below.

Ballast water

To reduce the risk of introducing invasive species into Belizean territorial water, discharge of ballast water needs to adopt strict measures, modelling the California's Law (Cruise Control 2002) which prohibits discharging of ballast water inside the Exclusive Economic Zone (370km or 200 nautical miles from the nearest land) needs to be legislated in Belize. While current national legislation directly governing the release of ballast water in Belizean waters does not exist, a draft marine pollutions bill has been drafted since 2009 and presently being considered for enacting.

Bilge water

The principal discharges of waste oils from shipping activities are the discharges of oily bilge water during emptying of vessel bilges. These discharges are regulated by international convention and national law; in particular Annex I of the MARPOL Convention 73/78, which is applied in Belize.

Annex I of the MARPOL Convention 73/78 establishes provisions for the prevention of pollution by oil including pollution by oil from shipping activities. These provisions include restricting the discharge of oily bilge water to times when the vessel is sailing (i.e. sailing to or from a port, rather than when at a port) and requiring use of an onboard oil filtration and/or separation system that reduces the oil content of the discharged bilge water to less than 15 parts per million. In addition, Annex I of the MARPOL Convention 73/78 recommends that vessels have an onboard oily bilge water holding tank in order to remove the need for discharging oily bilge water to maintain vessel stability when berthed in ports and, thereby, enable vessels to discharge oily bilge water when sailing.

The shipping activities that take place during the project operation will conform to the provisions of Annex I of MARPOL 73/78. Therefore, it can be concluded that no oily bilge water will be discharged into the sea within the port since this action is prohibited , and it can be concluded that oily bilge water will only be discharged into the sea beyond the port from vessels that are sailing to or from the port and are equipped with onboard systems that ensure the oil content of any discharged bilge water is less than 15 parts per million.

Fuel Bunkering

The project will not provide fuel bunkering for cruise vessels. The port will not provide fuel bunkering for the port's service vessels (i.e. the pilot vessels).

Storm Water Drainage

A storm water drainage system will collect, convey, treat (where necessary) and discharge the storm water that will run off the port. All storm water conveyance drainage infrastructure will be designed to handle peak flows resulting from rainy season.

14.4.2 Solid waste

Construction

Hazardous Waste – Oily Contaminated Soil

Port construction and/or operation may lead to the unplanned contamination of soil by spills of oils (or similar substances). It is expected that oily contaminated soil will be subject to bioremediation; either in situ (i.e. at the location within the port) or ex situ (i.e. excavated and transported away from the port to a dedicated treatment site). Bioremediation is likely to involve the use of additives to reduce contamination to acceptable levels over a period of approximately one or two months.

Debris and litter

The contractors should ensure proper site management takes place to prevent any solid materials, litter or waste from entering the fresh or marine waters.

Oils and Solvents

- Storage space should be equipped with locks and be in sealable areas;
- Fuel tanks should be within an area that has bunds that provide 110% greater storage capacity than that of the largest tank.
- The contractor should ensure proper site management to prevent damage to fuel tanks, sumps and containers to prevent leakage.
- In the event of oil leakage or spillage, the oil should be contained and cleaned up immediately.
- Vehicle and plant servicing areas, vehicle wash bays and lubrication bays should be located within roofed areas where possible. Drainage should be connected to local sewer via oil interceptor.

Operation

The solid waste accruing from the general commissioning of the Cruise Terminal operation includes biodegradable and non-biodegradable components. The biodegradable components include in large part discarded and unconsumed food from the restaurant and bar and refreshment stands. The non-biodegradable component relates to packaging materials, construction wastes and damaged and abandoned equipment and equipment parts. A major component of the non-biodegradable wastes would be ‘plastics’ in general in the form of bottles, cups, boxes and wrappings.

One of the major impacts of the wastes generated by the development would be the attraction of feral animals and household pests such as rats, crocodiles and vagrant birds to the area to scavenge. The mitigative responses to be implemented by Cruise Terminal Development are the judicious collection and segregation of the wastes into biodegradable and non-biodegradable components. These wastes are to be composted and/or transported from the Project Site on a regular and recurrent basis. The implementation of a public education

campaign focused on the core clientele and transient visitors is also a part of the mitigative response.

The entanglement and ingestion of plastics by sea turtles, birds and other fauna is also a relevant concern that will be dealt with in a judicious manner.

Table 14-1: Mitigation measures for waste management.

Development Activity	Primary Impacts or Environmental Disturbance	Secondary and Tertiary Level Environmental Impacts	Mitigation Measures
Construction			
All construction activities	Discarding of waste food and food containers.	Attraction of feral animals such as rats, crocodiles, and birds to the area to scavenge and in effect shift the ecological balance in a way not induced by nature.	Judicious collection of discards by staff with composting biodegradable component and storage of non-biodegradable component in impervious plastic bins for transportation to the solid waste transfer station at Mile 2 (Belize City) on the GPH
Operation			
Human Waste and Domestic Effluents	Nutrient enrichment from the liberation of macro- nutrients into the environment.	Stimulus to plant growth on land and in the water column, in the case of the latter this includes phytoplankton.	Installation of Treatment technology to treat waste to 'Secondary' Levels, where Total Nitrogen Loads are reduced to less than 10 mg/l and Phosphorus are reduced to 2-3mg/l.
			Reduce effluents going into the environment by recycling to flush toilets – effluents from Treatment Plant will be stored and disinfected.

Development Activity	Primary Impacts or Environmental Disturbance	Secondary and Tertiary Level Environmental Impacts	Mitigation Measures
			Further reduce nutrients going into the environment by using stored effluents from Treatment Plant to irrigate lawn and hedgerows as much as possible.
	Pathogenic microbes that can negatively impact human health.	Infection of residents and visitors to project by pathogenic viruses and bacteria.	Disinfection of effluents potentially going into water column or otherwise making contact with humans by use of Sewer Treatment Plant, which incorporates disinfection of effluents.
			Reduction of effluents going into the environment by use of a Treatment Plant. And incorporation of recycling and reuse of effluents for flushing of toilets and watering of lawn.
	Suspended Solids from un- dissolved components of human waste and domestic effluents.	Suspended solids would impede light penetration in the water column and erode or arrest photosynthesis.	Application of Treatment technology reduces TSS to less than 10 mg/l, this in combination with effluent recycling and reuse regime reduces suspended solids to insignificant levels in the water column.

Development Activity	Primary Impacts or Environmental Disturbance	Secondary and Tertiary Level Environmental Impacts	Mitigation Measures
	Sedimentation associated with settlement of flocculent faction of human waste and domestic effluents.	Blanketing of seafloor and suffocation of slow- moving and sedentary invertebrates.	Application of Treatment technology reduces TSS to less than 10 mg/l, this in combination with effluent recycling and reuse regime reduces to insignificant levels suspended solids in the water column.
	Increase in BOD substances and consequent reduction in dissolved oxygen.	Precipitation of physiological stress and in extreme circumstances death in relation to sessile and slow-moving invertebrates.	Application of a Treatment technology reduces BOD to less than 10 mg/l.
Commissioning of all aspects of the development	Discarding of waste food and food containers.	Attraction of feral animals such as rats, crocodiles, and birds to the area to scavenge and in effect shift the ecological balance in a way not induced by nature.	Judicious collection of discards by staff with composting biodegradable component and storage of non-biodegradable component in impervious plastic bins for transportation to the solid waste transfer station at Mile 2 (Belize City) on the GPH.
			Definition and implementation of public education campaign focused on tourists and visitors in general, in the form of interactive posters and brochures posted in strategic locations such as restaurants, gift shops, rest rooms and beach.
			Waste separation.

14.5 Utilities

The primary source of potable water for the proposed Cruise Terminal Development will be directly from the BWS main out of Belize City. The volume requirement for the development fits easily within the capacity of the water service provider. The mitigation measures that will be put in place are mainly in relation to human health and safety.

Table 14-2: Mitigation measures for impacts arising from installation of freshwater supply infrastructure

Development Activity	Primary Impacts or Environmental Disturbance	Secondary and Tertiary Level Environmental Impacts	Mitigation Measures
Construction			
Utilities construction	Excavations associated with utilities construction	Clearing of vegetation and soil removal.	Minimize vegetation clearing and install sediment traps. Landscaping Timing of the works to avoid rainy season if possible. Minimise working areas.

14.6 Dredging and Land Reclamation Activities

The primary impacts related to the actual dredging or excavations itself are:

- Substrate removal and thus habitat and species removal.
- Re-suspension of sediments and increase of turbidity leading to attenuation of light impeding photosynthesis of macro- algae, seagrass and patch reef (mouth of South Grennel's channel) and other autotrophs.

Responses to these impacts include, among others, careful selection of equipment, adequate training of staff, adapted speed of the dredging operation, season of the dredging activity, monitoring, etc. These and other measures will be included in a Dredge Spoil Management Plan. Moreover, the dredging activities for this development will be subject to a decision-making framework called ''Adaptive Dredging Management'' (AM), this facilitates flexible decision making that can be refined in response to future uncertainties, as the results of current and future management actions (due to monitoring) are better understood. This means that with adaptive management the effects of dredging operations are continuously monitored and evaluated to determine the need for modifications to the dredging plan. The initial dredging plan can be adapted or reformulated based on what's on the road. This can be done based on new information obtained such as field tests, water quality (turbidity) monitoring (real time), sensitive species, and hydrodynamic and morphological changes, among others during dredging.

Adaptive management contains 6 basic steps (CEDA, 2015). These steps together form the cycle of adaptive management. In this cycle, there is a continuous cycle of implementation of a design that monitors/evaluates and then adjusts if necessary, to achieve certain objectives.

1. Planning: define desired goals and objectives
2. Design: identification or design of flexible management actions to address deviations
3. Implementation: implement the selected action according to its design
4. Monitoring: monitor the results of the management action
5. Evaluation: evaluate the response system in relation to specific goals and objectives
6. Adaptation: adapt actions if necessary to achieve established objectives

Further information on the use of AM applied to dredging for a similar project is provided in **Annex 16**.

Additionally, mitigation related to impacts of dredging activities is large based on the disposal method and the management of the disposal site. As Belize is not in favour of disposal offshore, the development will have disposal also on land nearby the project area. The disposal site will be designed such that a minimum of fines is discharged from the disposal site to the sea.

The dredge material will arrive via floating and land pipeline at the discharge location in the closed reclamation. A closed reclamation is enclosed by bunds with a weir box installed in the bund (**Figure 14-1**).

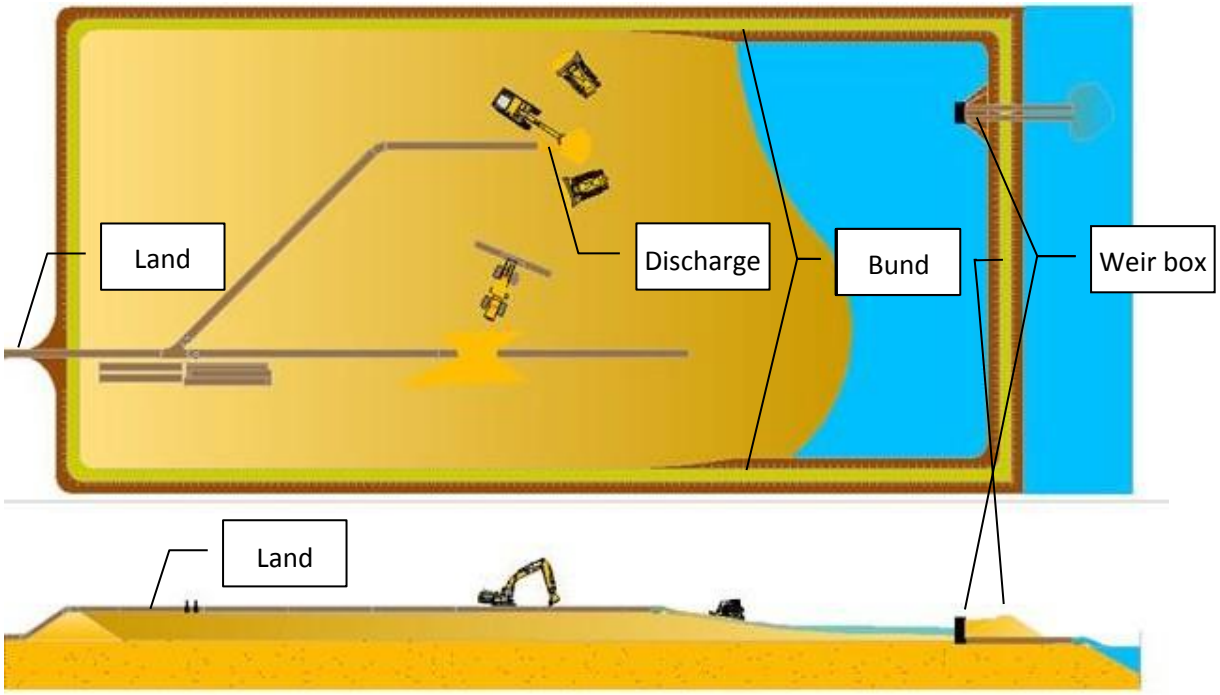

Figure 14-1: Closed reclamation, top and side view.

A weir box is a steel framed box which is installed in the reclamation bund. The front side, towards the reclamation, is open and the back side is closed with holes to which discharge pipelines will be installed (**Figure 14-2**). The weir box will enable the outflow of the pumped transport water back to the sea and to keep the dredge spoil within the reclamation

The bottom of these discharge pipes will be placed at the lowest level of the reclamation area. In the front side of the weir box wooden boards will be installed as a weir. By adjusting the amount of wooden boards, the water level within the reclamation can be managed. The weir box discharge capacity combined with the water storage capacity of the reclamation area dictates the number of weir boxes to be used side by side. The location of the weir boxes will be chosen to have the longest possible length between the discharge location and the weir box. This enables the discharged sediment to settle in the reclamation and the transport water to flow over the weir, through the discharge pipelines out of the reclamation back into the sea.

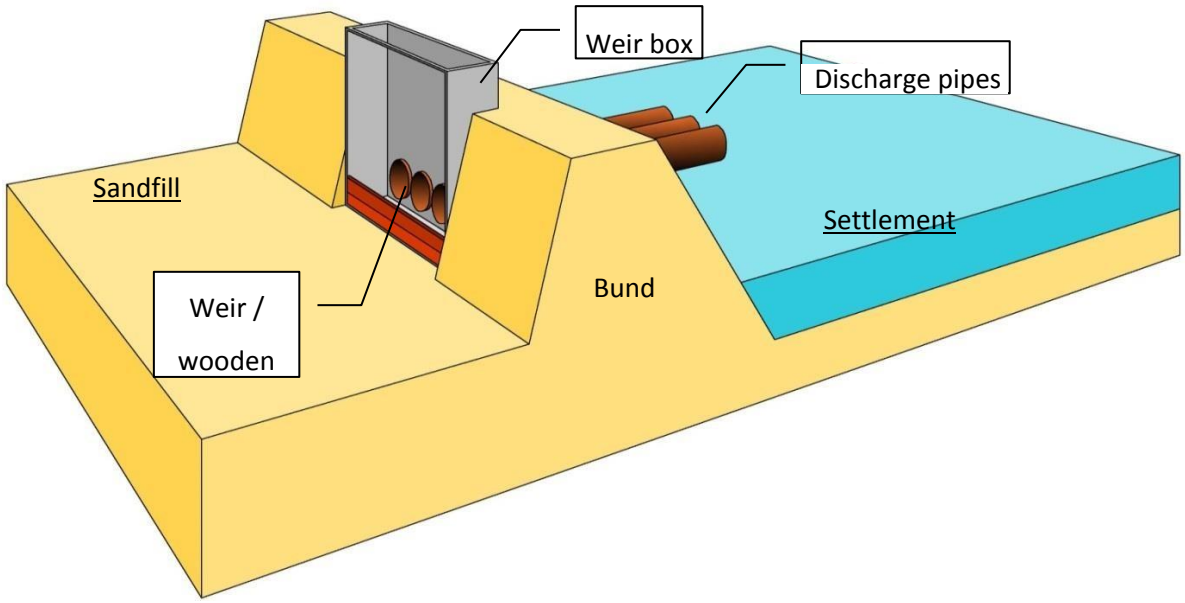

Figure 14-2: Weir box.

Actively managing the outflow of the discharged transport water will influence the following:

- loss of the dredged material
- initial compaction rate of the reclamation
- outflow turbidity from the weir box discharge pipes

All these points can be optimised by decreasing the speed of the water flow and increasing the dwell time (retention time) of the water in the reclamation area.

The water flow is controlled by the amount of wooden boards installed in the weir box. Adding or removing wooden boards to the weir box will increase or decrease the water level in the reclamation. This regulates the speed of the water sand mixture coming from the discharge location to the weir box. Without the necessary retention times, insufficient sediment will settle in the reclamation area such that the dewatering effluent will be too turbid and adverse effects on water quality will arise. By reducing the speed of flow, fine material will be allowed to settle faster, minimizing loss of dredged material, optimizing initial compaction and lower turbidity outflow. The effectiveness of turbidity prevention measures will be monitored.

Finally, the area will need to be rehabilitated. An early start for the rehabilitation will limit the impacts on flora and fauna in the area. Section 3.13 gives general guidance for the rehabilitation/reforestation.

Table 14-3: Mitigation measures for impacts associated with dredging.

Development Activity	Primary Impacts or Environmental Disturbance	Secondary and Tertiary Level Environmental Impacts	Mitigation Measures
Actual Dredging or excavation	Direct physical destruction of benthic habitat and disturbance of seafloor, The re-suspension of fine sediments. Blanketing of seabed	Attenuation of light impeding photosynthesis of macro- algae, seagrass and patch reef (mouth of South Grennel's channel) and other autotrophs. Smothering effects on benthic habitat	Apply Adaptive Dredge Management Assist re-colonization of seafloor by benthic plants and invertebrates by ensuring that slope of the channel walls is not at an angle greater than 35 degrees.
	Deterioration of water quality due to uncontrolled sediment releases	Impacting marine ecology	Monitoring and where necessary repairing and/or replacing leaky pipes/tubings, and faulty couplings of spoil discharge pipes.
	Decrease in Dissolved Oxygen and increase in BOD.	Physiological stress and lethal effects on benthic invertebrates and to a lesser extent, fin- fishes.	Limit re-suspension and overflow
Disposal of dredge spoil on land	Destruction of flora at the disposal site Disturbance to terrestrial fauna Salinization of the subsoil and groundwater	(Temporarily) limited habitat for flora and fauna	Careful selection of the final disposal area Works which may cause disturbance should be commenced prior to, or after, the nesting season. Early rehabilitation of the dredge spoil

Development Activity	Primary Impacts or Environmental Disturbance	Secondary and Tertiary Level Environmental Impacts	Mitigation Measures
			disposal area
Disposal of dredge spoil on land	The discharge of fine sediments back into the sea	Deterioration of water quality Attenuation of light impeding photosynthesis of macro- algae, seagrass and patch reef (mouth of South Grennel's channel) and other autotrophs.	Disposal in a closed reclamation with active management of weir boxes
Navigation, Spudding of dredger and deployment of spoil discharge pipes.	Collision risk	Injury and possibly death	Ensure that marker buoys and navigational lights are deployed and activated on the dredge and the spoil discharge pipes Buoys are to be large and brightly coloured: Navigational lights are to be fully operational from 6:00 a.m. to 6:00 p.m. daily.

14.7 Air Quality

Construction

The IAQM guidance (IAQM, 2014) identifies appropriate site-specific mitigation which aims to prevent significant effects on receptors through the use of effective mitigation. These measures are related to the identified risk of dust impacts for each construction activity. Specific mitigation measures that will be adopted are listed below.

Site Layout

- The site layout will be planned so that machinery and dust causing activities are located away from sensitive receptors, as far as is practicable.
- Runoff of water or mud from the site will be controlled, particularly at site entrances.
- Wind Fencing / Screening. Enclosure of site or specific operations will be considered where there is a high potential for dust production and the site is active for an extensive period. Site fencing, barriers and scaffolding will be kept clean using wet methods.

Construction Equipment

- Cutting, grinding or sawing equipment will only be used where fitted or in conjunction with suitable dust suppression techniques, such as water sprays or local extraction (e.g. suitable local exhaust ventilation systems).
- Equipment will be readily available on site to clean any dry spillages. Any spillages will be cleaned up as soon as reasonably practicable after the event using wet cleaning methods.
- Covered skips will be used.

Handling / Storage of Materials

- Handling large quantities of potentially dusty material will be carried out in an enclosed or shielded environment.
- Storage piles will be sited away from sensitive receptors.
- Loading and unloading from storage piles will be carried out on the downwind side of the storage pile where practicable.
- Inactive storage piles will be managed and covered where appropriate, with either tarpaulins or temporary material.
- Where practicable, wind fences and screens will be erected on the upwind side of stockpiles. Keep site fencing, barriers and scaffolding clean using wet methods.
- Stockpiles will be covered, seeded or fenced to prevent wind whipping.
- All vehicles will switch off engines when stationary to ensure that the idling of vehicles is minimised.
- An adequate water supply will be provided on the site for dust suppression of storage piles, particularly when heavy wind speeds are forecast.
- Materials that have a potential to produce dust will be removed from site as soon as possible.

On-site Vehicle Movements

- The number of vehicle trips on unpaved haul roads will be limited as much as possible.
- A maximum speed limit of 15 miles per hour (24km per hour) will be implemented on internal haul roads, and 10 miles per hour (16km per hour) on unmade surfaces.
- On-site haul routes will be inspected for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.
- All inspections of haul routes and any subsequent action will be recorded in a site log book.
- Hard surfaced haul routes will be installed, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and will be regularly cleaned.

Construction Works

- Bulk cement and other fine powder materials will be delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent the escape of material and overfilling during delivery. For smaller supplies of fine power materials, bags will be sealed after use and stored appropriately to prevent the release of dust.
- Bonfires and burning of waste materials will not be permitted.

Earthwork Activities

- Earthworks and exposed areas/soil stockpiles will be vegetated to stabilise surfaces as soon as practicable.
- Hessian, mulches or tackifiers will be used where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.
- Any cover to reduce dust emissions from earthworks areas will be removed in small areas during work and not all at once.

Track out (Off-site Vehicle Movements)

- Any hardstanding areas will be regularly cleaned using wet sweeping methods;
- Dry sweeping of large areas will be avoided.
- Vehicles entering and leaving sites will be covered to prevent escape of materials during transport.

Operation

To ensure that the air quality within the nearby area remains below the WHO standards and within the standards of the EPA for air emissions. Additionally, the cruise port must ensure that all the cruise ship that dock at the port follow United Nation's International Maritime Organization (IMO) protocol for emission control equipment and docking procedures.

Examples of docking procedures:

- Avoidance of unnecessary energy use via switching off the machinery when not needed.

- As a rule, all non-essential and not-required machinery that do not affect the ship and personnel safety should be stopped.
- Such items should be identified first and then procedures for the execution of tasks to be developed and implemented.
- Avoidance of parallel operation of electrical generators; when one is sufficient for the purpose.
- Optimized HVAC operation on board. The HVAC system operation should be aligned to outside and inside weather conditions.
- A proper coordination should be maintained on board between deck and engine departments especially for use of machinery/equipment.
- There are significant numbers of redundant machinery on board ships. In practice, they are normally used more than necessary. This could include many fans and pumps.
- Proper planning of use of the number of machineries versus operation mode is an effective way of achieving this objective. For example, when ship is in port, the plan should include switching off one or two engine room ventilation fans as main engine is not operating any more.

14.8 Noise

To reduce the impact of noise the port development will implement a multidisciplinary approach, which encompasses technological, regulatory and administrative solutions. Since noise pollution is generally treated as an environmental health related matter, the Department of Environment (DOE) is charged with administering the noise pollution regulations.

According to the Noise Abatement Regulations, Part XI, Chapter 328, Revised Edition 2003 of the Subsidiary Laws of Belize, "a person who on any premises uses or causes or allows to be use any equipment in such a way as to cause or allow it to emit unreasonable noise from those premises commits an offence".

General mitigation measures are:

- Operate noise-generating equipment during regular working hours (e.g. 7 am – 7 pm) so as to reduce the potential of creating a noise nuisance during the night. Other lower noise emitting activities could be programmed for later if work is to proceed late into the night
- Construction workers operating equipment that generates noise should be equipped with noise protection. As a guide, workers operating equipment generating noise of 80 dB (A) continuously for 8 hours or more should use earplugs. Workers with more prolonged exposure to noise levels of 70 - 80 dB (A) should wear ear muffs. Also, rest periods between work hours shall be considered as an additional mitigating factor.
- Preferably using drilling instead of pile driving for jetty construction.
- Use machinery and equipment that has low noise emissions.
- Maintain power tools in optimum condition.
- Use new and well maintained vehicles.

- Fit silencers or mufflers on generators. Enclose house with generator engine in acoustic tiles and/or site the generator in such a way that the noise emitted is carried away from the occupied areas by the prevailing winds.

Occupational health

Staff should be provided with proper noise protection equipment to reduce the potential for health effects.

14.9 Energy

The primary source of electrical energy is to be from the national BEL Grid which is to be installed directly to the project site. The primary source of electricity is to be complimented by standby power in the form of diesel generators. The following sections summarizes the main legal requirements and mitigation measures.

Above-Ground Fuel Tanks at Construction Sites

- Environmental Clearance from the Department of the Environment;
- Permit from the Police Department for storage and use of dangerous goods;
- Permit from the Fire Department;
- Permit from the relevant building authority in whose jurisdiction the proposed facility falls;
- Trade License from the local municipality in whose jurisdiction the proposed facility falls.

The following best practices will be followed for stationary above-ground fuel storage tanks and powerline construction:

- Above-ground storage areas shall be kept free of weeds and other combustible material.
- Smoking, open flame or other sources of ignition shall be prohibited within 7.6m (25 feet) of the dispensing area. Legible signs with the words “NO SMOKING” printed on them shall be posted in highly visible locations around the dispensing area.
- Electrical wiring and equipment in the dispensing area shall be installed in accordance with the electrical code.
- When Class I or Class II liquids are dispensed, adequate grounding and bonding shall be provided to prevent the accumulation of static electricity.
- Tanks shall be clearly marked with the name of the product that they contain and “Flammable-Keep Fire and Flame Away.” Tanks shall bear the additional marking “Keep 50 Feet from Building.”
- A portable fire extinguisher with a minimum classification 2A-20-B:C shall be provided and located within 23m (75 feet) of the tank.
- Tanks shall be of single-compartment design constructed in accordance with the Belize fire code.
- Tanks shall be provided with a method of normal and emergency venting. The diameter of normal and emergency vents shall be in accordance with the Belize fire code.

Emergency vents shall be arranged to discharge in a manner that prevents overheating or flame impingement on the tank in the event vapours from such vents ignite.

- Fill openings shall be equipped with a closure designed so that it may be locked. The fill openings shall be separate from the vent opening.
- Tanks shall be kept outside and at least 15m (50 feet) from any building or combustible storage. Also, any vehicle, equipment or container being filled directly from such tank shall be more than 15m (50 feet) from any structure or combustible storage.
- Tanks with top openings shall be mounted on well-constructed metal legs connected to shoes or runners designed so that the tank is stable and can be moved as one unit or on a stable base of timbers or blocks approximately 15cm (6 inches) high to prevent the tank from contacting the ground.
- Tanks with top openings only shall be equipped with a tightly and permanently attached approved pumping device having an approved hose of sufficient length for filling vehicles, equipment or containers to be served from the tank. Either the pump or the hose shall be equipped with a padlock to its hanger to prevent tampering. An effective anti-siphoning device shall be included in the pump discharge unless a self-closing nozzle is provided. Siphons or internal pressure discharge devices shall not be used.
- Supports for elevated tanks shall be of adequate strength and designed to provide stability.
- Bottom or end openings for gravity discharge shall be equipped with a valve located adjacent to the tank shell that will close automatically in the event of fire through the operation of an effective heat-actuated releasing device. If this valve cannot be operated manually, it shall be supplemented by a second manually operated valve. The gravity discharge outlet shall be provided with an approved hose equipped with a self-closing valve at the discharge end of a type that can be padlocked to its hanger.
- The area surrounding a tank or group of tanks shall be provided with drainage to an approved basin or shall be diked to prevent accidental discharge of liquid from endangering adjacent tanks, adjoining property or reaching waterways. Construction of dikes shall be in accordance with the fire code.
- Fuel tanks shall be placed in an enclosed bond-wall with 110% capacity of fuel tank.

Mitigation measures of powerline construction are:

- Minimise vegetation clearing along the power line route
- Rehabilitate the trench as soon as possible. Cover trenches overnight.
- Leave undergrowth and saplings along route of line as wildlife habitat.

14.10 Traffic

Construction

In accordance with GIP/GIIP, all vessels and equipment, including the project's construction vessels such as dredgers and equipment such as pipelines, will be appropriately navigated and lit in accordance with requirements of the internationally recognised requirements such as the provisions of the Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs). Accordingly, all vessels will navigate and manoeuvre predictably (i.e. in accordance with general rules for steering and sailing) and will have a crew member dedicated to keeping a look out for other vessels and marked / lit structures (this includes watching radar systems) and maintaining communications (e.g. via radio communications).

All vessels will have lighting that will be visible at minimum ranges and will be able to issue signals indicating distress and need of assistance. These measures would reduce the collision risk (and, therefore, the impact) associated with watch-keeper error or mechanical breakdown leading to drifting.

In addition, prior to and during construction works, it is expected that information about the construction activities (e.g. breakwater construction) will be communicated to local stakeholders (i.e. port authorities, fishing representatives, etc.) through notices to mariners (or equivalent forms of communication) so that all navigators are aware of construction vessel movements and the presence of partially built structures and how they might affect navigation.

Operation

The recommended mitigation measures are based on the specific option selected for the proper management of the ships and boat traffic close to and within the project area.

The project location has already several advantages to the tourism industry compared to the present situation as follows:

- Safer navigation route to port location; avoids navigating through "One Man Caye channel" which features a 145 degree turn to starboard for access to Belize City area. This channel is narrow and cruise line executives have expressed concern about having their larger ships (6,000 passengers plus crew) sailing through this channel.
- Additionally, ships will consume less fuel to access new area (fuel consumed by larger ships is estimated at 11,300 gallons per hour and smaller ships 6,600 gallons per hour.
- Eliminates tendering; therefore, ships will be able to spend at least an additional hour or more in Port. This means more time for tours and other revenue generating activities for cruise passengers and crew.
- Bypasses narrow and congested streets in Belize City, which will result in faster access to traditional tour sites and more time spent by tourists in Belize. Additionally, it avoids exposure to the overcrowded and less developed parts of Belize City which would clearly be visible from the upper decks of ships.
- Larger ships that are coming on stream will be able to access and dock directly at a port facility.

- Location provides the opportunity for exciting new shore excursions.
- With the building of a 9.5 km (6 mile) road and a bridge over the Sibun River, all existing attractions are more readily available as travel time through Belize City is avoided Belize City will become a Tour Destination

Utility of Cruise Ship as definitive mode of transportation tied into clientele of proposed development. There are a number of risks and threats related to this: These ranges from direct injury and death from collision incidents to nuisance and health threats from air pollution and noise.

The mitigation associated with these threats range from the posting of signage and the observance of building setback to adjustments in the orientation of the access channel to the marina.

To enhance mangrove community viability along proposed road it will be important to leave as much natural standing mangroves strip between the sea and the road. Allow natural regeneration of mangrove species on roadside and clear only necessary vegetation. Nevertheless, the relatively small size of the area to be used for roads, the significance of the impacts on terrestrial habitats should not be underestimate. More detailed studies should indicate the final route of the road, the specific loss of (sensitive) habitat and the potential applicable mitigation measures. Within the property it is recommended to leave as much untouched natural vegetation as interconnected fragments through corridors. This will facilitate movement of much sessile wildlife such as amphibians and smaller reptiles. Development's landscaping is recommended to incorporate as much as possible natural flora, especially species that provide a food source for birds and small mammals. The use of pesticides in landscaping is to be avoided preventing negative impacts to other wildlife.

Table 14-4: Mitigation measures for impacts arising from water traffic.

Development Activity	Primary Impacts or Environmental Disturbance	Secondary and Tertiary Level Environmental Impacts	Mitigation Measures
Operation			
Cruise Vessel Traffic	Threat of injury and death to people on the ground/Pier	Direct mechanical impact from vessel to persons on pier including staff, guests and ground crew.	Undertake Navigation Assessment. Undertake Berthing Assessment

Development Activity	Primary Impacts or Environmental Disturbance	Secondary and Tertiary Level Environmental Impacts	Mitigation Measures
		Noise and air pollution	Offset of pier from coastline and Cruise Terminal structures housing welcome centre, recreational areas, business and offices.
	Death and injury to marine mammals and reptiles		Set water vessels speed limits in order to avoid collision with manatee and crocodile.

14.11 Social Impact

The mitigation measures in relation to social impacts have been focused on issues of human settlement, education, human health and safety, the recruitment of labour and in- migration. In the case of the latter this includes the illegal immigration and settlement of citizens mainly from Honduras, Guatemala and El Salvador. On the issue of human health and safety collision accidents at sea as a consequence of the construction phase of the project as well as general boat traffic associated with recreational use and servicing of the facilities during the operational phase of the proposed development.

Table 14-5: Mitigation responses in relation to Social Impacts

Activities and Conditions	Activity	Mitigation
Land Tenure	Location and size of development.	Keeping land-based development coverage as low as reasonably possible and off-setting into nearshore seas, villas that would have otherwise been located on smaller mangrove-dominated shoreline
Construction activities related to human settlement as well as human health and safety	Transportation of construction supplies and equipment during all phases of development.	All marine crafts and road-based vehicles transporting construction supplies are to be covered and secured to guard against spills and to ensure safety during transportation.
	Operation of construction machinery	Operators are to be trained in the proper operation of machinery and equipment as well as in safety procedures.
	Increase in populationduring construction phase of the Development	Save access by road gate to control access to site
	Establish accommodations and safe sanitary facilities for staff during operational phase of development. This is in the designs of Cruise Terminal facilities.	Although shift system is to be implemented, where workers are to be ferried to and from site every 8 hrs, staff quarters are to be constructed to accommodate 20 workers at any given point in time to cope with basic domestic needs and any unforeseen eventualities.
	Increase in number of boats and barges between Belize City and project site transporting construction material	During construction phase, movement of workers, machinery/equipment and cargo is to be planned and operated on a scheduled that does not conflict with or exacerbate pre-existing marine traffic. Self-regulation of marine traffic by Port of Belize authorities including confining boats and other marine crafts to designated “shipping lanes”. Demarcation of berthage, ‘no wake zones’, speed limit, etc., through installation of marker buoys, beacons, flags and signage. Ensure Sea/Ocean crafts lights (including emergency

Activities and Conditions	Activity	Mitigation
		lights) and speed control during night operations
Marine and overland traffic	Increase in local labour force connected with the Port of Magical Belize project may create a strain on existing housing infrastructure. Increased pressure on existing Health and other social services.	Meeting of the project proponent with stakeholders and other community groups to sensitize them about the existence of project and demand on infrastructure and social Services. Stakeholders need to engage real estate and housing authorities on issues related to any development in the area. Working with communities and Central Government to make adjustments in schools and health care facilities as a function of the increase in population associated with the proposed Port of Magical Belize Development. Central Government will need to be engaged in this discussion to make necessary accommodations in additional classrooms and teachers, as well as expansion of medical facilities and the number of health care workers in area.
Post-construction Worker Population & Potential Strain Social Services	Labour relations during both construction and operational phase of project.	Employment of skilled labour from other parts of the country necessary. Cruise Terminal project management will actively encourage on-the-job training of people from immediate area, who will also be employed during construction phase.
Employment	Labour relations during both construction and operational phase of project. Senior management jobs are often reserved for outsiders while the local people are employed for the lower paying jobs only.	Laborers are to be paid relative to skills and experience at competitive rates with pre-existing construction activities, and hotels and resort development.
		The Belize labour laws are always to be observed, especially as they relate to the number of working hours per day and per week, minimum wage, sick days entitlement, unionization and the observance of public and bank holidays.
		The project proponent will develop employment criteria to assure fair labour practice…Much effort is to be expended in the training of unskilled and junior staff from the area. Training.
	Competition for labour with banana, shrimp farming, artisanal fisheries and tourism industry.	Tourism sector has always paid higher wages. Competition within the Sector will assure improved quality of service relative to wages paid. In the medium-, to long-term it is postulated that the wage structure in the various industries will stabilize the availability of labour.

Activities and Conditions	Activity	Mitigation
Employment (Cont'd)	Direct damage to the various habitats (mangrove, coral reef, seagrass beds) resulting in declines in productivity and biodiversity that would negatively impact livelihood of fishers and tour guides.	In regards to supra-tidal and emergent vegetation, project proponent will limit overall as much as reasonably feasible. Coastal areas will be subjected to limited land clearance. Impacts to nearshore seagrass beds and coral reef expected to be minimal to non-existent…Thus impact to livelihood of fishers and tour guides in the Belize District expected to be insignificant to indiscernible.
Criminal Activities	Increase in migrant population may result in increase in crime in general project area	Meeting between project proponent and stakeholder communities including the Police to discuss prospects for increase in crime. Need to also engage Central Government vis-à-vis Police Dept to address issue of Police and likely Private Security presence. Security will be ensured in and around Port of Magical Belize.

14.12 Marine environment

Construction

Fish species

Relevant mitigation measures include:

- The implementation of soft-start and ramp-up procedures.
- Acoustic Deterrent Devices (ADDs) may be used during autumn and winter periods and should be used during the spring and summer.

Marine mammals

These relate to marine piling activities which have a potentially high impact and are designed to reduce the impact overall significance by negating the risk of fatality, physical injury or auditory injury (PTS). Relevant mitigation measures include:

- The establishment of a mitigation zone around the piling location to encompass the areas at which marine mammals are at risk of fatality and/or injury (including PTS and TTS), with a minimum radius of 500m.
- A pre-piling marine mammal search will be undertaken by fully qualified MMOs in order to ensure no marine mammals are present within the pre-defined mitigation zone prior to piling.

- PAM to be used; at the minimum as support to MMOs in times of poor visibility (i.e. they cannot see the full mitigation zone due to poor weather conditions, times close to darkness) and ideally to be used at all times alongside the MMO.
- The implementation of soft-start and ramp-up procedures.
- ADDs may be used in addition to MMOs and PAM during autumn and winter periods and should be used during the important calving periods in spring and summer.

Operation

Marine mammals

Given that the marine mammals in the area are able to detect and avoid an approaching cruise vessel, and that project vessels will move slowly (<10 knots) and reduce their speed as they approach the port, the worst-case impact significance is assessed as minor therefore, no specific mitigation measures are proposed.

14.13 Terrestrial Biodiversity

The construction of the project will result in the loss of habitat including mangrove forest, intertidal habitat (which forms part of the reef mangrove ecosystem) and wetland habitats. In light of the CP/21 (Paris Agreement) Belize established its Nationally Determined Contribution (NDC) is guided in order to transition to low carbon development while strengthening its resilience to the effects of Climate Change. The commitments made included protection of the existing mangroves from deforestation and restoration of lost mangroves. It is also recognized that many mitigation actions will produce co-benefits that promote adaptation and resilience to climate change. Forest protection and replanting of mangroves that are implemented for mitigation purposes and landscaping are expected to protect the coastline against storm surges and erosion; which are increasing in frequency as a result of climate change. To address potential habitat loss, an equivalent area of the habitat could be restored to achieve a no net loss outcome, with the objective to achieve a 'Like-For-Like or better' outcome. The compensation activities could include reforestation including removal of invasive species and planting target native species where there has been excessive loss. However, it is often the cumulative impacts of several developments which cause significant losses for nature conservation, it is important that this is recognised.

Plants of local provenance, preferably grown from seeds collected in the project area will be used. This will help to ensure the genetic integrity of populations of native species. It should also be noted that the advantage of new habitats with a broader genetic base was recently recognised by ecologists as this may create more resilience in the face of threats such as climate change, pests and diseases. Using a wider range of native species with local provenance and including some planting stock of non-local, but still national provenance, may help this by increasing genetic diversity in new native woods.

Reforestation Approach

Stage 1 – Detailed floristic survey

The project will undertake a survey of the area to be lost to identify any potentially range-restricted species between. At this stage, seeds could be collected in the on land project area and on land disposal area.

Stage 2 - Stakeholder Engagement

Portico will discuss the proposals with local stakeholders.

3. Stage 3 – Detailed Reforestation Management Plan

A detailed Reforestation Management Plan will be developed and will include details of the replanting programme. The management plan will implement a requirement to manage vegetation which will involve removing dead trees and thinning out living trees so that the best specimens are retained as well as additional individual plans. The management plan will also propose a programme and scope during the post-development forest monitoring. This will allow measurable successes to be recorded.

4. Stage 4 –Implementation

Implementation will be planned once all relevant permits have been obtained.

5. Stage 5 – Monitoring

A monitoring strategy will be developed to monitor success of the reforestation programme. The monitoring will be aimed, not only at determining success, but also the need for remediation where replanting or management has not worked.

15 Monitoring Plans

The principles underlying environmental monitoring as it relates to any given development is to observe for any changes over time that may be associated with the development. These changes would in principle vary over time in both magnitude and direction. In the case of the latter it is important to understand that changes in environmental parameters and functions may be positive or negative. Thus, in principle a monitoring plan does not necessarily focus only on the perceived or anticipated negative changes precipitated by a given project activity, but also on the positive or beneficial changes. The parameters chosen are those that have been identified in the analytical process as being affected in the most significant way by the development.

The proposed monitoring plan for the port development has been derived from the EIA risk matrix. The parameters of relevance have been grouped into five (5) main areas, viz: water quality parameters, biodiversity, beach dynamics, engineering considerations and socio-economic issues. The proposed monitoring plan has been developed not only in relation to satisfying the statutory requirements of the EIA process, but also as a consequence of the proper implementation of the proposed development.

15.1 Water Quality Monitoring Program

15.1.1 Construction and Operation

- Water quality monitoring for the performance of the sewage treatment system will be necessary to ensure that national effluent discharge standards are kept as stipulated by Belize's DOE.
- Sample analysis of TDS, BOD and DO should be carried out daily during construction and the initial operations of the port and the monitoring frequency should be reviewed, after a period to be agreed with DOE and revised as necessary depending on the performance of the port.
- Sampling locations should be performed on locations agreed with DOE. Ongoing monitoring results can provide a basis for determining the monitoring requirements.
- Monitoring data should be recorded, stored and a regular report should be submitted to DOE at a frequency to be agreed. The report should include the following information: monitoring data, audit/review of the environmental monitoring data to ensure that the information is in compliance with regulatory requirements, policies and standards and if any remedial works was done in the event of an exceedance in the limits.

Table 15-1: Proposed Monitoring Plan for Port of Magical Belize Terminal project During Construction.

Parameter	Frequency	Critical Level	Geographic Area
Construction			
Water Quality Impact Marine			
TSS	Covered by adaptive management (see **Annex 16**)		Wider dredging area
Turbidity	Continuous	Adaptive Dredge Management uses continuous monitoring.	Wider dredging area
Turbidity	weekly	To be determined based on turbidity levels at the outlet	Outlet of disposal area
BOD	Monthly	200 mg/l (EPA/WHO)	At outflows
Beach Dynamics			
Beach erosion	Seasonally	Observable loss of beach material.	Recreational beach near Project Site
Engineering Aspects			
Safety in relation to navigational lights, marker buoy on dredge.	Construction phase activities to be done on a weekly basis.	All lights aboard the dredge as well as beacons marking the path of the spoil delivery pipes must be functional, and all marker buoys must be deployed appropriately.	Associated with the dredge, spoil delivery pipes.
Technical integrity of dredging operation.	Construction phase activity to be done on weekly basis.	Construction phase activity to be done on weekly basis.	Done along the entire path of the spoil delivery pipes.
Leachate dispersal into nearby surface/ground water source	Weekly checks	Inspection of coastal-based de-watering 'bund' for leakages and collapse of walls.	Done along perimeter of the retaining wall around the disposal site
Biodiversity			

Parameter	Frequency	Critical Level	Geographic Area
Bird Abundance	Twice per year, during December and in June (i.e. winter and summer)	Bird Abundance	Twice per year, during December and in June (i.e. winter and summer)
Marine mammal population	Twice per year during December and June.	Manatee population	Twice per year during December and June.
Feral Animal Population (Crocodiles, iguanas, vagrant birds)	Twice per year during June and December	Population changes to be observed over time.	Area of the coast in vicinity of project site Waters surrounding Cruise Terminal facilities up to 1km (0.5 mile) radius
Finfish Populations	Twice per year during June and December,	Population changes and shifts in diversity to be observed over time and compared with pre-development situation.	Patch Reefs off South Grennels
Operation			
Patch Reef Cover and Diversity	Post construction survey	Live coral Population changes and diversity profiles to be compared over time.	2 Patch Reefs off mouth of the South Grennel's channel
Sea-grass biomass and distribution	Post construction survey	Post construction survey distribution to be observed over time for any discernible trend that may be associated with the proposed development.	On the southern fringes of South Grennel's

16 Summary and residual impacts

The tables below present summary of the mitigation measures and the significance of the residual impacts following their implementation.

Table 16-1: Summary of the mitigation measures and residual impacts – Construction.

Topic area	Mitigation /Enhancement	Residual Impact
Impacts on Marine Water Quality	Adaptive dredging management Appropriate management of dredge spoil disposal area	**Minor**
Impacts on hydrological and bathymetric characteristics	Adaptive dredging management	**Minor**
Impacts on General Ecology	Biodiversity monitoring. The establishment of a mitigation zone around the piling. A pre-piling marine mammal search. The implementation of soft-start and ramp-up procedures. Timing of works	**Minor**
Impacts on Nearshore Ecosystems	Biodiversity monitoring. The establishment of a mitigation zone around the piling. A pre-piling marine mammal search. The implementation of soft-start and ramp-up procedures.	**Minor**
Impacts on ecology due to disposal on land	Timing of activities Early reinstatement of the area	**Minor**
Impacts on Land-based activities to Northern Lagoon Ecosystem	Biodiversity monitoring. Appropriate solid and waste management.	**Minor**
Impacts on Sibun River Ecosystem	Biodiversity monitoring. Appropriate solid and waste management	**Minor**

Impacts on Economic Activity	Employment of skilled labor from other parts of the country Laborers are to be paid relative to skills and experience at competitive rates with pre-existing construction activities, and hotels and resort development.	Positive
Impacts on health and safety	Operators and local staff are to be trained in the proper operation of machinery and equipment as well as in safety procedures.	Moderate

Table 16-2: Summary of the mitigation measures and residual impacts – Operation.

Topic area	Mitigation	Residual Impact
Impacts on Marine Water Quality	Appropriate solid and liquid waste management. Enforcement of the international and local laws and regulations regarding cruise ship waste management and operations while in Belizean waters. A storm water drainage system will collect, convey, treat (where necessary) and discharge the storm water that will run off the port. All storm water conveyance drainage infrastructure will be designed to handle peak flows resulting from rainy season.	**Minor**
Impacts on hydrological and bathymetric characteristics	No mitigation	**No impact**
Impacts on General Ecology	Biodiversity monitoring Waste Management. A storm water drainage system will collect, convey, treat (where necessary) and discharge the storm water that will run off the port. All storm water conveyance drainage infrastructure will be designed to handle peak flows resulting from rainy season.	**Minor**
Impacts on Nearshore Ecosystems	Biodiversity monitoring Waste Management. A storm water drainage system will collect, convey, treat (where necessary) and discharge the storm water that will run off the port. All storm water conveyance drainage infrastructure will be designed to handle peak flows resulting from rainy season.	Minor
Impacts on Land-based to Northern Lagoon Ecosystem	Biodiversity monitoring Waste Management. A storm water drainage system will collect, convey, treat (where necessary) and discharge the storm water that will run off the port. All storm water conveyance drainage infrastructure will be designed to handle peak flows resulting from rainy season.	Minor

Impacts on Sibun River Ecosystem	Biodiversity monitoring Waste Management. A storm water drainage system will collect, convey, treat (where necessary) and discharge the storm water that will run off the port. All storm water conveyance drainage infrastructure will be designed to handle peak flows resulting from rainy season.	Minor
Impacts on Economic Activity	The project proponent will develop employment criteria to assure fair labour practice. Much effort is to be expended in the training of unskilled and junior staff from the area.	**Positive**
Impacts on Human Settlements/Social	The Belize labour laws are to be observed at all times, especially as they relate to the number of working hours per day and per week, minimum wage, sick days entitlement, unionization and the observance of public and bank holidays.	**Minor**

17 Extent and Quality of Available Data

The extent of the data collected for this EIA surpasses the requirements set forth in the Terms of Reference for the project. For example, water and soil sample analysis were made in local laboratories as well as in accredited laboratories in Europe to encompass other parameters (eg. heavy metal and pesticides) that were not requested in the TOR and that also cannot be tested by local laboratories. Similarly, bathymetric survey, assessment of turbidity plume dispersion, wind driven current modelling, metocean data (wind, current and wave modelling), geophysical survey among others, were carried out by renown and experienced international companies. These measures ensure that the impacts identified for the project are grounded on the best data available. That being said, the availability of secondary data in Belize required to complement the primary data gathered for this EIA, is very deficient. Unfortunately, this is a problem that EIA preparers for all EIAs done in Belize have to deal with. This leads to challenges, for example, in this study local current patterns required to understand sediment transport along the coastline, had to be predicted through modelling as opposed to obtaining it through available data that in many countries is already in existence. Because of these challenges, it is recognized that the extent of impacts identified to be associated with turbidity and sediment transport from dredging as well as those associated with coastal erosion, requires monitoring and further assessment during the construction phase of the project; more specifically during dredging activities, disposal of spoils and creation of reclaimed area.

Annexes

Annex i Approved copy of the ToR
Annex ii List of preparers including CVs
Annex iii Copy of Land Tenure Documents
Annex iv Company Documents
Annex v Water quality analysis results
Annex vi Field data collected
Annex vii Preliminary nautical design
Annex viii Masterplan as prepared by BEA architects (June 2019)
Annex ix Drawings
Annex x Equipment sheets
Annex xi Metocean data
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Annex xiii Benthic sampling
Annex xiv Morphological impact assessment
Annex xv Turbidity assessment
Annex xvi Adaptive dredging management
Annex xvii Social survey interview data
Annex xviii Ecological survey raw data

Annex i Approved copy of the ToR

Annex ii List of preparers including CVs

In this annex the CVs are provided of the following list of preparers:

- Abel A. Carrias
- Boris Miguel Arevalo
- Mark A. Velasquez
- Ramon Frutos
- Mandela Wade
- Joaquín David Magaña
- Josué Hiram Aké
- Antonio Cano
- Arnoldo Jorge Melendez

Annex iii Copy of Land Tenure Documents

Annex iv Company Documents

In this annex the following documents are included:

- Companies act (Cap.250, section 17) Certificate of compliance, 28th August 2017
- Memorandum of Association of Portico Enterprises Ltd. 28th August 2017
- Articles of Association of Portico Enterprises Ltd. 28th August 2017
- Portico Enterprises Ltd. – Form of annual list of members and summary of a company having a share capital as of the 28th August 2018
- Certificate of good standing, 4th March 2019
- Certificate of registration, 9th August 2017
- Certificate of incorporation 28th August 2017

Annex v Water quality analysis results

This annex provides a description of the water quality baseline study as performed in October 2019 and the laboratory results

Annex vi. Field data collected

This annex provides the following geotechnical and geological field data collected:

- ❑ OIC, 2018,'Robinson point soil boring report – 8-11 December 2018' (5 pages)
- ❑ Geotech Belize, 2019 laboratory results of Dec. 2018 borings (27 pages)
    - Particle size distribution
    - Atterberg limits
    - Moisture content
    - Specific density
- ❑ Deltares, 2019, report 'Sub Bottom Profiler investigation for the access channel Magical, Belize' (39 pages)
- ❑ Boskalis, 2019 memo 'Magical Preliminary Soil Interpretation' (5 pages)
- ❑ Boskalis environmental 2019 laboratory results (sieve curves) of vibrocore samples (4 pages)
- ❑ Boskalis environmental 2019 laboratory results (geotechnical parameters) of vibrocore samples (4 pages)
- ❑ Additional onshore soil investigation, October 2019 (4 pages)
- ❑ Eurofins laboratory results 04-11-2019 (37 pages)
- ❑ Eurofins laboratory results 12-11-2019 (25 pages)

Annex vii Preliminary nautical design

The following document is included in this annex:

- Hydronamic (2019) memo ‘Port of Magical, Belize : preliminary nautical design’ doc. nr. P34020-1-FJOL-3-0, 2 December 2019

Annex viii Masterplan as prepared by BEA architects

Master plan concept, prepared by BEA Architects, June 2019 (35 pages)

Annex ix Drawings

Drawing number	Description
MB-DRA-0001	Land property boundary
MB-DRA-0002	Bathymetric survey
MB-DRA-0003	Existing navigation routes
MB-DRA-0004	Phase 1 nautical layout
MB-DRA-0005	Phase 1 reclamation layout
MB-DRA-0006	Masterplan Reclamation layout
MB-DRA-0007	Access road
MB-DRA-0008	Indicative onshore disposal location
MB-DRA-0009	Leading lights and navigation buoys
MB-DRA-0010	Masterplan Turning circle and berthing area
MB-DRA-0011	Phase 1 Turning circle and berthing area
MB-DRA-0012	Masterplan dredge volume
MB-DRA-0013	Masterplan reclamation volumes
MB-DRA-0014	Phase 1 reclamation volumes
MB-DRA-0015	Phase 1 dredge volumes

Please note that the drawings are indicative and may change during detailed design

Annex x Equipment sheets

In this annex, the following equipment sheets are presented:

- Bachhoe dredger Odin
- Hopper and transportation barges Terraferra 301/302
- Cutter suction dredger Taurus II
- Trailing Suction Hopper Dredger Beachway

Annex xi Metocean data

Monthly wind roses from offshore location 17.5°N 87.5°W

Annex xii Wind driven currents

Hydronamic memo '*Current modelling Port of Magical – Belize'*, doc.nr. DT1801143-ANRE-1-MME-M-003, 4th December 2019

Annex xiii Benthic sampling

Annex xiv Morphological impact

Hydronamic (2019) memo '*Morphological assessment Port of Magical'*, doc.nr. DT1801143-MAKN-1-MME-M-01-A, 4th December 2019

Annex xv Turbidity assessment

Hydronamic (2019) memo '*Turbidity assessment Port of Magical*', doc. nr. DT1801143-MAKN-1-MME-M-01-B, 5th December 2019

Annex xvi Adaptive dredging management

Annex xvii Social survey interview forms

Annex xviii Ecological assessment raw data