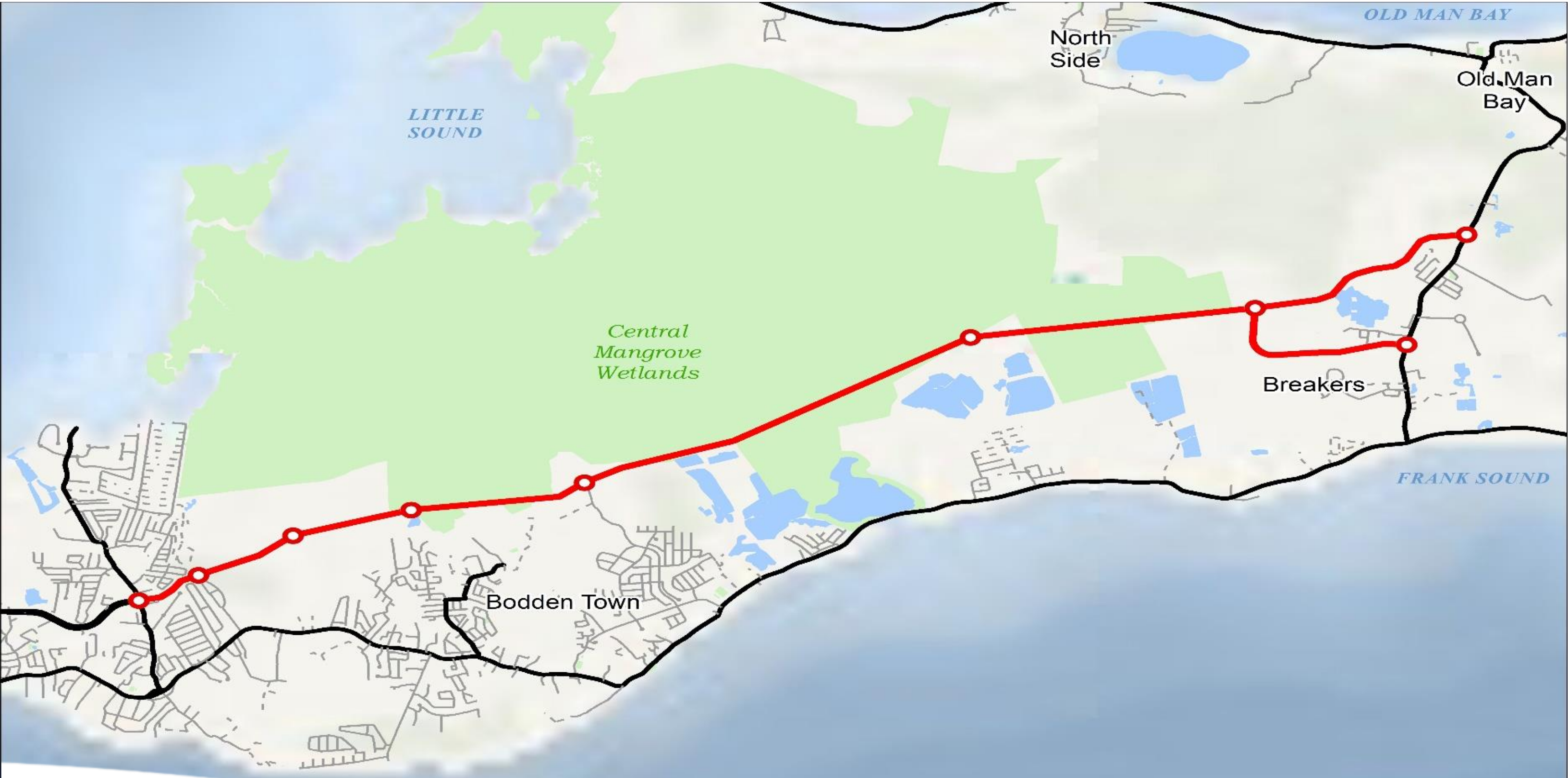

Final Terms of Reference Environmental Impact Assessment for the East-West Arterial Extension:

Section 2 (Woodland Drive – Lookout Road)
Section 3 (Lookout Road – Frank Sound Road)

NATIONAL ROADS AUTHORITY

April 4, 2023

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List of Terms

BNL	Baseline Noise Levels
C	Celsius
CBA	Cost Benefit Analysis
CIEEM	Chartered Institute of Ecology and Environmental Management
CIG	Cayman Islands Government
CM	Centimetres
CO	Carbon Monoxide
CO^2	Carbon Dioxide
Council	National Conservation Council
CPI	Ministry of Commerce, Planning, and Infrastructure
CRTN	Calculation of Road Traffic Noise
CSF	Critical Success Factor
DEH	Department of Environmental Health
DMOY	Do Minimum Opening Year
DMRB	Design Manual for Roads and Bridges: Noise and Vibration Manual
DoE	Department of the Environment
DoP	Department of Planning
DSFY	Do Something Future Year
DTM	Digital Terrain Model
EAB	Environmental Assessment Board
EDGAR	Emissions Database for Global Atmospheric Research
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ES	Environmental Statement
EWA	East-West Arterial
F	Fahrenheit
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FT	Feet
GHG	Greenhouse Gases
H&H	Hydrologic & Hydraulic
Ha	Hectare
IEMA	Institute of Environmental Management and Assessment
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
KM	Kilometres
KM^2	Square Kilometres
KPH	Kilometres Per Hour
LID	Low Impact Design or Development
LOAEL	Lowest Observable Adverse Effect Level
LOS	Level of Service
M	Metre
Mi	Miles
Mi^2	Square Miles
MPH	Miles Per Hour

NEP	National Energy Policy Unit
NO^2	Nitrogen Dioxide
NOEL	No Observable Effect Level
NRA	National Roads Authority
NRCS	Natural Resources Conservation Service
NTCI	National Trust for the Cayman Islands
SO^2	Sulphur Dioxide
SOAEL	Significant Observable Adverse Effect Level
TDM	Traffic Demand Model
TNM	Traffic Noise Model
ToR	Terms of Reference
TT	Travel Time
TTI	Travel Time Index
UNFCCC	United Nations Framework Convention on Climate Change
VMT	Vehicle Miles Travelled
WAC	Water Authority Cayman
WRA	Whitman, Requardt and Associates, LLP
Yd^3	Cubic Yards

List of Figures

Executive Summary

The National Roads Authority (NRA) is the Government entity responsible for planning, design, construction, and maintenance of public roads on the island of Grand Cayman. In 2022, the NRA acquired the services of Whitman, Requardt & Associates, LLP to perform an Environmental Impact Assessment (EIA) for the East-West Arterial (EWA) Extension, Sections 2 and 3. The corridor is gazetted as an approximate 10-mile (16.09 kilometres [km]), 160-foot-wide (48.77 metres[m]), roadway from Woodland Drive in Bodden Town, to Frank Sound Road in North Side. At its eastern end, the gazetted roadway also includes an 80-foot-wide (24.38 m) southern connector road. The proposed road will:

- Create a highly disaster-resilient “central highway”;
- Serve as an emergency route when coastal roads are compromised;
- Reduce travel times between George Town and East End, North Side and Bodden Town; and,
- Promote public transportation (dedicated bus lines).

The Environmental Assessment Board (EAB), a subcommittee of the National Conservation Council (Council), in accordance with Section 3(13) of the National Conservation Act of 2013, will oversee the preparation and implementation of the EIA. The EAB is chaired by the Director for the Department of Environment (DoE), who is a Council member. The Deputy Director of the DoE and the Director of Planning, also Council members, are statutory members. For this project, other members include the Water Authority Cayman (WAC) and the Public Works Department’s Major Projects Office.

The EIA will undertake the necessary environmental studies for the proposed EWA Extension study area to determine the best location and design for constructing the new highway facility. Avoidance and minimisation efforts will be implemented to reduce impacts to environmental resources, as well as impacts to existing communities and community resources, such as noise and stormwater management. Remaining unavoidable impacts will be identified and mitigated to the greatest extent possible. The assessment will address at a minimum:

- Route Alignment and Assessment of Alternatives;
- Socio-economic Considerations;
- Hydrology and Drainage (including climate resiliency);
- Geo-Environmental;
- Terrestrial Ecology;
- Cultural and Natural Heritage Sites;
- Greenhouse Gas Emissions; and
- Noise and Vibration.

Chapter 1

Proposed East-West Arterial Extension

1 Proposed East-West Arterial Extension

In accordance with the EIA Directive, the DoE issued a Screening Opinion on 12 October 2016 for a 10-mile extension of the East-West Arterial which extended eastward from the Hirst Road intersection to just beyond the Frank Sound Road intersection at what was proposed to be the Ironwood Village and Golf Club intersection. At its Special General Meeting of 26 October 2016, the Council reviewed the Screening Opinion and took a decision to require an EIA of the proposed road extension. The NRA were informed of this requirement.

On 24 September 2019, the Ministry of Commerce, Planning, and Infrastructure (Ministry of CPI) submitted information indicating that they were currently proposing only part of the road previously considered in October 2016 and that the Ministry wished to proceed with the construction of the portion of the East-West Arterial Extension from Hirst Road to Lookout Gardens. At a meeting with NRA and Ministry officials on 22 October 2019 it was agreed that Phase 1 from Hirst Road to Woodland Drive could be constructed prior to the EIA being completed because it is within a densely developed area with minimal environmental concerns and minimal opportunity for amending the design of the route. It was also confirmed on 22 October 2019 that an EIA would need to be conducted for the route from Woodland Drive to Lookout Gardens.

This was endorsed by the Council at its meeting on 30 October 2019 and an EAB was empanelled to guide the EIA. On 19 November 2019, in accordance with the Directive, a Scoping Opinion was issued by the EAB for the portion of road from Woodland Drive to Lookout Gardens. The proponents (the Ministry of Commerce, Planning, and Infrastructure [CPI] and NRA) did not commence an EIA for this portion of the road at that time.

On 9 October 2021, the NRA requested a Scoping Opinion for the proposed East-West Arterial Extension from the Woodland Drive area to Frank Sound Road. This Scoping Opinion was issued on the 5 November 2021 and outlines the likely significant effects of the EWA Extension project which will need to be assessed under the EIA framework. These ToR provide a greater level of detail on the studies and assessments which will be carried out on those identified direct, indirect, and cumulative effects on the natural and developed environment. Establishing measures that will avoid, minimise, and/or mitigate these concerns is a primary objective of the EIA.

1.1 Project Background

1.1.1 Project Description

The EWA Extension comprises three sections. Section 1 extends between Hirst Road and Woodland Drive which is currently under construction. Section 2 as proposed is from Woodland Drive to Lookout Road, and Section 3 as proposed is from Lookout Road to Frank Sound Road. The corridor for Sections 2 and 3 is gazetted as an approximate 10-mile-long (16 km), 160-foot-wide (49 m), roadway from Woodland Drive, in Bodden Town, to Frank Sound Road in North Side. At its eastern end, the gazetted roadway also includes an 80-ft-wide (24 m) southern connecter road.

1.1.2 Need for the Project

The Cayman Islands are made up of three independent islands: Grand Cayman, Little Cayman, and Cayman Brac, situated in the Caribbean Sea west of Jamaica and south of Cuba. Grand Cayman, at roughly 76 square miles (mi2) (197 square-kilometres [km2]) is the largest of the three islands having a population of over 69,000 people, representing roughly 97% of the total Cayman population. The geography of the Cayman Islands is unique, being extremely flat with its highest elevation being 71 ft. (21 m) above sea level.

The Cayman Islands are facing increasing challenges from climate change and sea level rise; particularly, to infrastructure in low lying coastal areas. Existing coastal roads are especially vulnerable and without an alternative travel corridor, portions of Grand Cayman become isolated during a major storm, such as during Hurricane Ivan. Elevating roads has become a standard flood abatement measure; however, doing so requires more right-of-way, which can be a constraint when residential and commercial properties are directly adjacent to the roadway. Transportation resilience is critical for the stability and safety of the population. It will be a major evaluation criterion in the EIA document for all alternatives including the no-build.

With its flat topography and minimal rise above sea level, Grand Cayman is susceptible to climate change and the effects of sea-level rise. During extreme weather events, the lone coastal route, Bodden Town Road, easily becomes compromised and inaccessible, stranding East End residents from accessing goods and services mainly located on the west side of Grand Cayman. In addition, with Bodden Town Road being the only roadway providing access between the east and west districts, it is frequently congested during the morning and evening peak commuting hours.

In May 2005, the proposed EWA Extension corridor **(Figure 1)** was initially planned and gazetted by the NRA in the Cayman Islands Gazette, Extraordinary Supplement, Number 13/2005, in accordance with Section 25 of the Roads Law (2000 Revision), now Section 26 under the Roads Law (2005 Revision). The 2005 EWA Extension corridor, from Hirst Road to Frank Sound Road, was part of the NRA's long-term projection for road infrastructure expansion and network improvements and constituted a modification to the existing Development Plan. The EWA Corridor with Collector Road Connection was published in the Cayman Islands Extraordinary Gazette No 13 of 2005.

The EWA Extension was proposed to provide Grand Cayman with an additional travel route between the districts of North Side/East End and George Town/West Bay to aid in easing the traffic congestion currently experienced on the coastal, two-lane Bodden Town Road. This is especially important for emergency services, enhancing evacuation capability, user delay, and travel time reliability for employment opportunities, equity, and overall quality of life when Bodden Town Road is unpassable or compromised. In addition to operational factors, a multimodal safety component is also important to provide insight into potential safety benefits and/or implications of the EWA Extension.

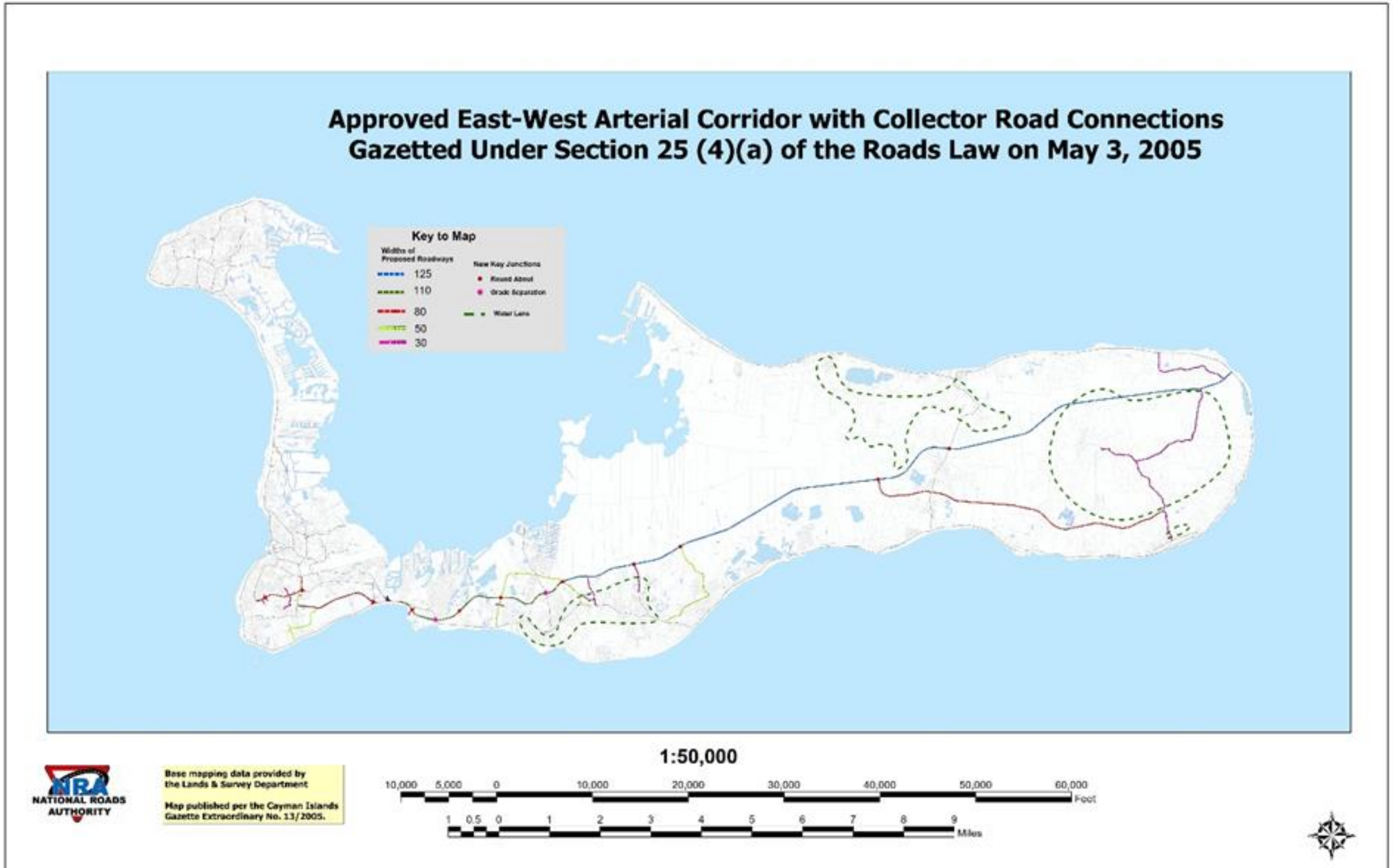


Figure 1: NRA's long-term 2005 plan including EWA Extension

From NRA 2005 Long-term plan

Additionally, the NRA, in their long-term planning, recognized the need for a transportation network that is highly disaster-resilient and climate-resilient. Storm surges combined with wave action have been responsible for much of the roadway damage caused by hurricanes, especially in the low-lying coastal areas. With climate change and sea level rise, hurricanes are only expected to increase in intensity and rainfall, resulting in reoccurring damage to coastal roadways. The EWA Extension would serve as a central and alternative route when low-lying coastal areas are compromised by storm surges.

The United Kingdom defines climate resilience as "the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate (Ramboll, 2022)." Essentially, climate resiliency is the ability to manage and respond to the effects of climate change without further increasing their impacts. Resiliency has three main aspects: **preparation,** which involves building infrastructure and services to withstand the effects of climate change; **adaptation,** which involves the ability for infrastructure and services to respond flexibly to any potential effects; and **recovery**, which involves plans and courses of action to respond to and resolve any negative effects of climate change. In developing the EWA Extension Corridor, consideration will be given to ensure that any development is adequately able to prepare, adapt, and recover from any potential effects of climate change.

1.1.3 Project Study Area

The proposed EWA Extension study area encompasses Section 2, from Woodland Drive to Lookout Road; and Section 3, from Lookout Road to Frank Sound Road within Bodden Town and North Side districts, northwards to North Sound and south to the coastline **(Figure 2).** This area encompasses the initially identified EWA Extension Corridor, which has been gazetted to encompass an area to allow room for future expansions as well as buffer areas. This study area is sufficiently wide enough to allow for the identification of other roadway and multi-modal alternatives. This study area was also established to evaluate potential indirect effects, which are impacts caused by the project, which occur later in time or removed in distance, but are reasonably foreseeable to occur. This area is outlined in red in **Figure 2**. It should be noted that much of the land within the study area and specifically within the direct project footprint is under private ownership.

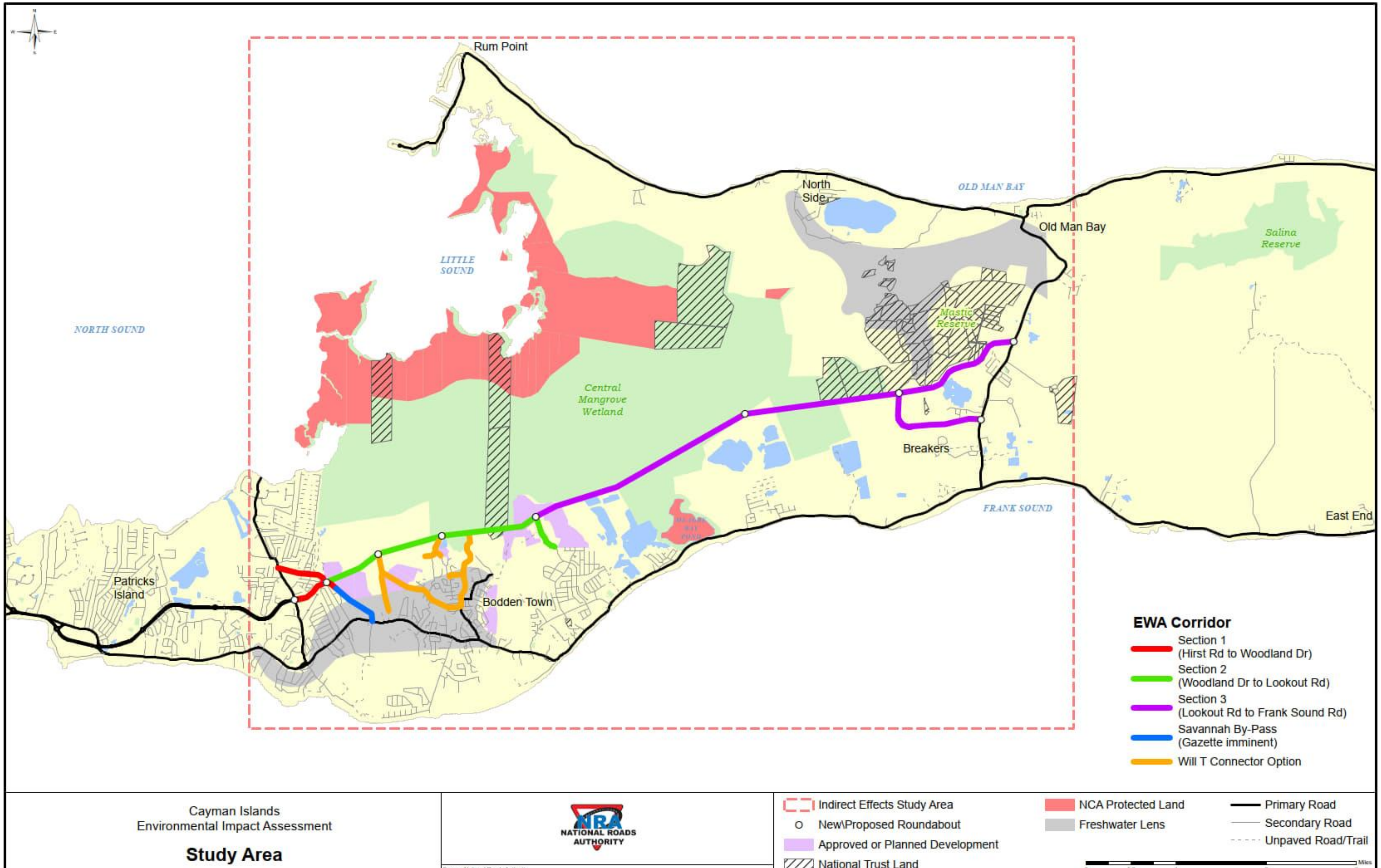


Figure 2: Study area limits established for EWA Extension EIA and associated roadways

1.2 Summary of Current Conditions

1.2.1 Population

The Cayman Islands are made up of three independent islands: Grand Cayman, Little Cayman, and Cayman Brac, situated in the Caribbean west of Jamaica and south of Cuba. Grand Cayman is the largest of the three islands with a population of almost 69,000 people, representing roughly 97 percent (%) of the total population. Cayman Brac and Little Cayman have a population of just over two thousand people, making the total population of the Islands just above 71,000 people (Economic and Statistics Office, 2022).

The Cayman Islands population comprises both Caymanians and non-Caymanians, representing 53.5% and 46.5% of the population, respectively (Economic and Statistics Office, 2022). Of the non-Caymanian population, residents are from 162 different countries and territories from around the world, with the highest percentage of people being born in Jamaica, the Philippines, the United Kingdom, and the United States. Furthermore, a significant number of Caymanians hold dual citizenship in another country, such as the United Kingdom (UK), Jamaica, the United States, and Canada (Economic and Statistics Office, 2022).

The island of Grand Cayman is separated into five districts: West Bay, George Town, Bodden Town, North Side, and East End. George Town is the most populated district of the five, with just under 35,000 residents, followed by the districts of West Bay and Bodden Town, with roughly 15,000 residents in each district. North Side and East End are the least populated districts on Grand Cayman, with under 2,000 residents in each district (Economic and Statistics Office, 2022).

1.2.2 Geography, Wildlife, & Natural Areas

The geography of the Cayman Islands is unique, being primarily flat with limited elevation and they are relatively small, being just under 100 mi^2 (259 km^2) total across the three islands. Grand Cayman's geography is made up of mangroves, forests, and coral reefs. Mangroves comprise approximately 30 mi^2 (78 km^2) or 36% of Grand Cayman's total land area. The Central Mangrove Wetland is a fundamental component to the natural ecosystem of the Cayman Islands. It is home to numerous animal and plant species, such as the native West Indian Whistling Duck, where 83% of the population can be found (Bradley et al, 2004). Mangroves are also essential as a natural defence mechanism reducing the impacts of storm surges or other extreme environmental events, filtering out nutrients, and acting as natural carbon sequesters, removing and storing carbon dioxide from the atmosphere (Alongi, 2012).

There are four species of mangroves that are found on the Cayman Islands: red mangroves, white mangroves, black mangroves, and buttonwood. All four of these species are present in the Central Mangrove Wetland, with each providing different ecological benefits to the ecosystem. The Grand Cayman Parrot is a subspecies of the Cuban Parrot and is one of two endemic parrot species on the Island, the other being the Cayman Brac Parrot. The Grand Cayman Parrot has historically relied on black mangroves for nesting. Older tree trunks within black mangroves develop hollow trunks which are then used by the Grand Cayman Parrot for nesting. This reliance on black mangroves highlights the importance of the Central Mangrove Wetland on the species present on the Island. Sea level rise is a major challenge to Black Mangrove populations in that they depend on shallow seawater habitats with high saline concentrations to which they have uniquely adapted.

Located east of Bodden Town is the protected area of the Meagre Bay Pond. Meagre Bay Pond is a 2.0 mi (3.22 km) pond surrounded by roughly 300 ft. (91.4 m) of mangroves. In 1976, the area was originally designated as an Animal Sanctuary to protect the resident and migratory birds that relied on this area. Following the implementation of the National Conservation Act of 2013, the Meagre Bay Pond was re-designated as a Protected Area, which allowed for the development of a management plan to promote the protection and conservation of the area (DoE, 2020).

Additionally, the Mastic Reserve contains the largest contiguous area of primary dry forest remaining on Grand Cayman and represents one of the last remaining examples of Caribbean subtropical, semi-deciduous dry forests (NTCI, 2022). In 1992, the Mastic Reserve was founded following the donation of 145 acres (58 ha) of land to the National Trust for the purpose of protection and conservation of the old-growth forest and has since grown to 834 acres (338 ha). Prior to its establishment, the area was historically used as a passageway to traverse the many wetlands on the Cayman Islands. In 1995, the passageway was re-established as an official trail, the Mastic Trail, allowing users to experience the natural, undisturbed areas of Grand Cayman (National Trust, 2022).

Like the Central Mangrove Wetland, the Mastic Reserve serves as primary habitat to a variety of plants, and animals. Identified by BirdLife International, the Mastic Reserve is recognized as an Important Bird Area (IBA), providing habitat for threatened and near-threatened bird species such as the Vitelline Warbler, the White-crowned Pigeon, and the Grand Cayman Parrot. Visitors can find these bird species living in the endemic Silver Thatch Palms, Royal Palms, Mahogany, or Cedars. The Reserve is also home to several endemic species, including four reptile species, five butterfly species, and ten plant species, and has the highest level of endemism in the Cayman Islands (Bradley et al., 2004).

Grand Cayman contains four freshwater lenses: the Lower Valley freshwater lens, the North Side freshwater lens, the East End freshwater lens, and the South Sound freshwater lens. They not only provide a stable drinking water and agricultural water source but are also integral to the water flow systems of the Central Mangrove Wetland. While there are four freshwater lenses on Grand Cayman, the Lower Valley and North Side freshwater lenses will be relevant to the EWA Extension. There is a minor possibility for the project to impact the East End freshwater lens; therefore, a review of the potential impacts will be evaluated by the EIA. Sea level rise is also a threat to freshwater by influencing groundwater elevations of seawater.

1.2.3 Roadway Connections

Grand Cayman residents and visitors alike face a variety of mobility and traffic movement issues. Much of the development on Grand Cayman is within George Town and West Bay districts, establishing the districts as the commercial, financial, and tourist hubs. As a result, many residents from East End, North Side, and Bodden Town must commute to George Town and West Bay for work.

Within West Bay, George Town, and Bodden Town there exists a network of local streets, major roadways, and highways connecting the various communities of Grand Cayman. In West Bay, Esterly Tibbetts Highway is a four-lane divided highway connecting southeast West Bay to northern George Town. Within George Town, Linford Pierson Highway, Crewe Road, Shamrock Road, and the existing EWA are the major arterial roadways connecting to other local streets and coastal areas (Google Maps, 2022). Currently, the Linford Pierson Highway is being expanded from two lanes of travel to six lanes, significantly increasing its capacity (NRA, 2022). The existing four-lane EWA begins in the Grand Harbour region of George Town and connects George Town to Poindexter Road; from that point, it is a two-lane divided roadway to Hirst Road.

In place of highway ramp exits to connect to local roads, roundabouts are being used to help maintain the flow of traffic and prevent delays and stoppages. As of January 2022, there were more than two dozen roundabouts on Grand Cayman; many which are three-lane roundabouts. Shamrock Road extends from Grand Harbour in George Town, to just past the Bodden Town Primary School in Bodden Town, where it becomes Bodden Town Road and ultimately, connects to Frank Sound Road. Frank Sound Road is the only centrally located road on Grand Cayman.

Historically, those that resided on the Cayman Islands relied on the sea to make a living, with shipbuilding and fishing being the primary income sources. In the North Side and East End, the network of roadways and transportation infrastructure has been guided by this history and has been localised in coastal areas. The major coastal road begins with Bodden Town Road which travels east along the coast, being renamed several times as Sea View Road, Old Robin Road, and North Side Road, before terminating as Rum Point Road on the north side of the island (Google Maps, 2022). This coastal roadway has only one lane of travel in each direction, greatly limiting the roadway capacity and creating travel issues for the residents of East End, North Side, and Bodden Town, many of whom rely on the coastal roads to commute to work.

In 2022, the NRA conducted traffic modelling to determine the existing roadway and traffic conditions, as well as estimate future traffic conditions because of continued population growth and development, specifically the development of the EWA Extension. The NRA utilized Travel Demand Modelling (TDM) to estimate travel behaviour and demand for the future by using existing travel and population data. The process of TDM incorporates four phases to determine future conditions: trip generation (number of trips estimated), trip distribution (where the trips go), mode choice (how trips are divided among types of travel), and trip assignment (the predicted trip route).

The traffic modelling completed by the NRA found that 47% of registered voters live east of the Grand Harbour neighbourhood and are subjected to heavy AM and PM peak travel period congestion. (NRA, 2022). During the AM peak travel period, traveling from Old Man Bay in North Side to the Government Administration Building in George Town takes roughly 90 to 120 minutes, often with a travel speed between 10 – 15 miles per hour (mph) (16-24 kilometres per hour [kph]). In the PM peak travel period, this route takes roughly 50 to 60 minutes. With the construction of the EWA Extension, it is estimated that the AM peak travel period would be reduced to approximately 60 minutes in 2026. The PM peak travel period is estimated to be reduced to 50 minutes in 2026 (NRA, 2022).

It should be noted that separate from this study, the NRA recognizes the need for improvements to the existing roadways west of the study area. The NRA is actively developing a multimodal improvement plan to reduce congestion, which includes the area between the Tomlinson and Silver Oaks Roundabouts. The potential impacts of this project to areas further west will be addressed as part of secondary and cumulative impacts of this study.

Chapter 2

Environmental Impact Assessment Process

2 Environmental Impact Assessment Process

2.1 Legal Requirements

This section establishes the legislative and policy framework relevant to the Environmental Impact Assessment (EIA) process and the preparation of an Environmental Statement (ES). Relevant policy and legislative frameworks will be utilised to establish the scope of studies and ensure conformity with any existing guidelines and standards.

2.1.1 International Finance Corporation of World Bank Group's Performance Standards on Environmental and Social Sustainability

The International Finance Corporation (IFC), a member of the World Bank Group, developed Performance Standards on Environmental and Social Sustainability. These standards establish baseline requirements for doing business sustainably, creating guidelines for identifying and subsequently addressing potential risks and impacts to environmental and social sustainability. The EIA will utilise these standards where appropriate to properly assess the potential risks.

> *"To provide guidance on how to identify sustainability risks and impacts and are designed to help avoid, mitigate, and manage them as a way of doing business in a more sustainable way."*

2.1.2 Cayman Islands Constitution Order, 2009

The Cayman Islands Constitution Order of 2009 was developed in order to establish the powers and activities of the legislative, executive, and judicial branches of government, as well as the rights of all citizens. Section 18 of this Constitution provides the basis for the legal protection of the environment, and states the following:

> *(1) Government shall, in all its decisions, have due regard to the need to foster and protect an environment that is not harmful to the health or well-being of present and future generations, while promoting justifiable economic and social development.*
>
> *(2) To this end government should adopt reasonable legislative and other measures to protect the heritage and wildlife and the land and sea biodiversity of the Cayman Islands that –*
>
> *(a) limit pollution and ecological degradation;*
>
> *(b) promote conservation and biodiversity; and*
>
> *(c) secure ecologically sustainable development and use of natural resources.*

2.1.3 Environment Charter, 2001

In 2001, the governments of the Cayman Islands and United Kingdom entered into an agreement establishing the responsibilities of each government in the protection and conservation of the environment, known as the Environment Charter. This Charter provides guiding principles for the protection of the environment, and the commitments and responsibilities of each government in ensuring environmental protection.

2.1.4 Public Management and Finance Act, 2020 Revision

The rules and regulations regarding the use of government funds and implementation of government projects by "Statutory Authorities and Government Companies" are established in the Public Management and Finance Law, 2013. This act delineates the differences between 'core government' authorities and 'statutory authorities.'

2.1.5 National Roads Authority Act, 2016 Revision

The National Roads Authority (NRA) was established in July of 2004 to build and maintain the roads in the Cayman Islands. The establishment of the National Roads Authority, as well as the rules, regulations, and responsibilities of the NRA are authorised through the National Roads Authority Act, 2016 Revision.

2.1.6 Roads Act, 2005 Revision

The Roads Law, 2005 Revision, provides guidelines for the development and building of roads on the Cayman Islands. This law establishes the basis for which roadways in the Cayman Islands must be developed and implemented, and any necessary legal requirements for roadway development and implementation.

2.1.7 National Conservation Act of 2013

The National Conservation Act (NCA) of 2013 (Parliament of the Cayman Islands, 2013) was developed to "promote and secure biological diversity and the sustainable use of natural resources in the Cayman Islands." As a result of the NCA, the National Conservation Council was established in order to guide and oversee the implementation of the NCA. This Council comprises members from the Ministries of the Cayman Islands Government, as well as additional members listed below, and others appointed by the Office of the Cabinet:

- Director of the Department of Environment;
- Deputy Director of Research in the Department of Environment;
- Member from Department of Agriculture;
- Member from Department of Planning;
- Member nominated by the National Trust and appointed by the Cabinet; and,
- Eight persons appointed by the Cabinet with at least one person from West Bay, George Town, Bodden Town, North Side, East End, Little Cayman, and Cayman Brac.

The NCA establishes the basis for the appointment of an EAB, which is comprised of technical and subject matter experts and exists to guide the EIA process.

2.1.8 Directive for Environmental Impact Assessments, 2016

The development of an EIA with the results summarised in an Environmental Statement is required under the Directive for Environmental Impact Assessments, Section 43 of the National Conservation Act ('the EIA Directive'). This directive was issued in conjunction with Sections 3(12)(j) and 43(2)(c) of the National Conservation Act.

Section 41(3) of the National Conservation Act establishes the basis for the policy's framework, and states the following:

> *"Every entity shall, in accordance with any guidance notes issued by the Council, consult with Council and take into consideration any views of the Council before taking any action including the grant of any permit or license and the making of any decision or the giving of any undertaking or approval that would or would be likely to have an adverse effect on the environment generally or any natural resource."*

2.2 Environmental Impact Assessment Process

The need for an EIA was originally discussed in 2005 during initial planning. In 2016, with the gazettal of the EIA Directive, the Council required an EIA for the road.

Discussions between the NRA and the Council centred around the need to conduct an EIA for the proposed EWA Extension between Hirst Road in George Town to Frank Sound Road in North Side. The EWA Extension is proposed to be constructed in three segments: Section 1 from Hirst Road to Woodland Drive, Section 2 from Woodland Drive to Lookout Road, and Section 3 from Lookout Road to Frank Sound Road. The EAB determined through their 2019 Scoping Opinion, that Section 1 did not require an EIA since it is in a heavily disturbed and populated area. However, an EIA was required for Sections 2 and 3.

The EAB's final EIA Scoping Opinion for the EWA Extension, from Woodland Drive to Frank Sound Road, was issued on 5 November 2021. The EIA Scoping Opinion identifies those environmental impacts arising from the project which will likely be significant, and which will need to be addressed as part of the EIA. The process for approving the Terms of Reference, Environmental Statement, and the Environmental Management Plan is outlined in **Figure 3**.

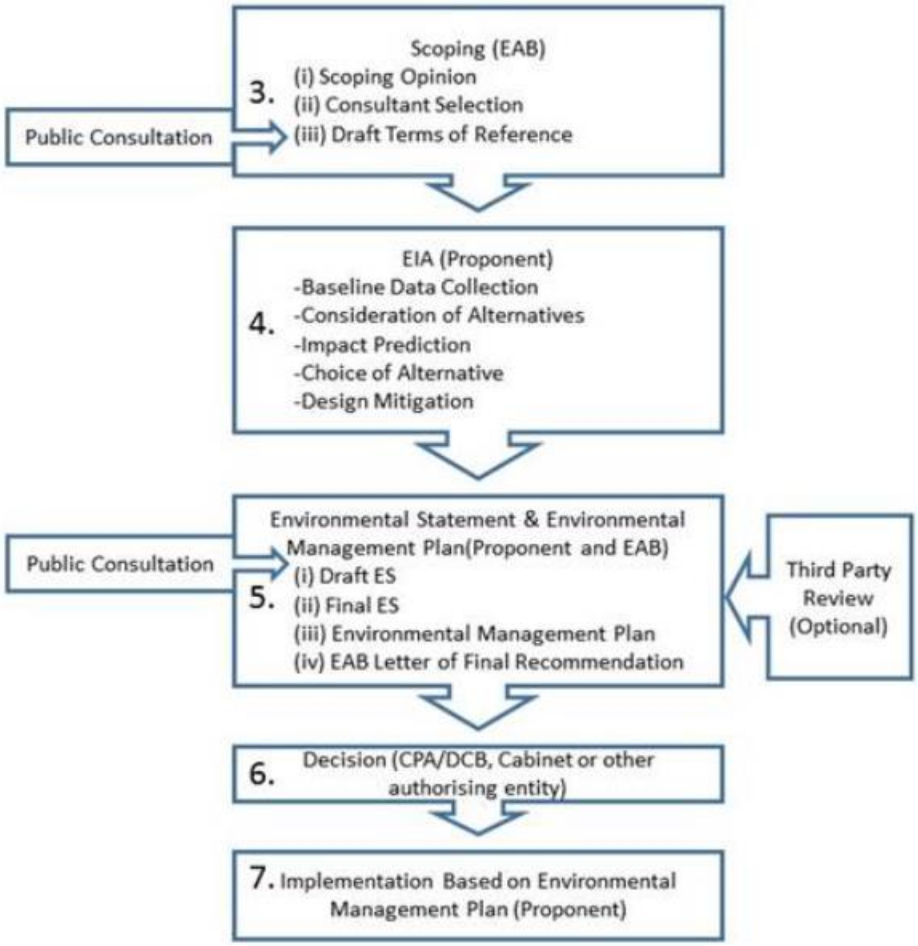


Figure 7: Excerpted EIA Directive from NCC

From EIA Directive

2.3 Terms of Reference

The Terms of Reference (ToR) refine the scope of the EIA established in the Scoping Opinion, including through public consultation. They provide a consistent protocol for assessing a project's potential to cause environmental, social, and economic harm. The ToR identifies the applicable environmental laws and regulations, establish the assessment methodologies, and guide the overall activities required for the environmental studies. Chapter 4 of this document describes the potentially affected resources, the existing conditions, potential project impacts, and potential mitigation measures that may be investigated. Specifically, this ToR will address the following resources:

- Socio-Economic Considerations;
- Hydrology and Drainage (including climate resiliency);
- Geo-Environmental;
- Terrestrial Ecology;
- Cultural and Natural Heritage Trust-Protected Areas;

- Greenhouse Gas Emissions; and,
- Noise and Vibration.

Aside from these identified resources, this ToR also specifies the need to assess key areas of uncertainty in the implementation of the EWA Extension, issues arising from choosing a "no-build" or "do nothing" scenario, any potential cumulative impacts, or indirect effects, and finally provide conclusions and recommendations on how the effects on these resources can best be avoided or mitigated.

2.4 Environmental Impact Assessment

The EIA evaluates the potential direct and indirect effects of a project on the environment and ensures that the mitigation of impacts to minimize or eliminate these effects are properly considered prior to any development occurring. The assessment starts with the baseline data collection to establish and understand the existing environmental conditions against which likely significant effects will be assessed. An important aspect of the EIA is the consideration of alternatives, including a ''no-build'' situation, whereby no road is constructed. This involves the evaluation and assessment of reasonable alternatives to the proposed EWA Extension, and the effects on the environment. Other key requirements of an EIA include the following:

- Describe and state the need for the project;
- Confirm the nature of the proposal;
- Identify the range of likely effects on the environment;
- Identify and agree on methodologies to be employed;
- Define data availability and further data gathering required;
- Set the indicative thresholds and significance criteria to be used in evaluation of impacts; and,
- Identify mitigation measures to be secured in an Environmental Management Plan.

2.5 Environmental Statement

Following the completion of the EIA, an ES will be developed to summarise the results of the EIA. The ES will act as a guidance document for decision makers by providing them with any necessary information and the technical studies regarding the potential environmental effects of the project. The following information will be included in the ES, at a minimum:

- Description of the development;
- Description of the alternatives studied and the reason for selecting the chosen alternative;
- Description of any potential environmental effects that could occur because of project development;
- An evaluation of impact significance and a description of the likely significant effects of the development on the environment;
- Description of any other direct, indirect, or cumulative effects the project may have on the environment;
- Description of mitigation measures to avoid or mitigate the environmental effects;

- Non-technical summary; and,
- Any difficulties that occurred during the EIA process.

2.6 Environmental Management Plan

Using the results of the EIA, an Environmental Management Plan (EMP) will be developed. This EMP will establish the basis and plan for environmental monitoring and mitigation during project implementation.

2.7 Public Consultation and Stakeholder Engagement

2.7.1 Public Consultation

Due to the nature of this project and its potential impact on the residents of Grand Cayman, public consultation will be imperative in project development. The National Conservation Act's EIA Directive establishes two requirements for public involvement during the development of an EIA.

The first is during development of the draft ToR. The draft ToR document will be available on the DoE's website for a total of 21 consecutive days. The notice of availability for the ToR will be advertised twice, minimum, in the local press within the 10-day period immediately prior to the start of the 21-day review period. The second public consultation opportunity is during development of the draft ES. The draft ES document will also be available on the DoE's website for a total of 21 consecutive days. As with the publication of the ToR, publication of the ES will be advertised at least twice in local press within the 10-day period prior to the start of the 21-day review period.

During the ToR and ES review periods, the public can submit comments directly to the EAB c/o the DoE, either via email, direct mail or hand delivery to the offices of the DoE. These comments will then be jointly assessed by the EIA consultants and the EAB and relevant changes will be incorporated into the final documents. Responses to all comments received will be appended to the Final ToR and ES respectively. For the EWA project, two public meetings will be held during each review period to allow the public to review the project and engage with the EWA Extension project team regarding any questions or concerns they have about the project. These two public meetings will be held on Grand Cayman, with one meeting each on the eastern and western sides of the island to provide opportunities to all Cayman residents. These meetings will be held at least 7 days prior to the end of the public consultation review period.

The public comments and responses from the draft ToR public involvement effort are included in Appendix A thru Appendix D.

2.7.2 Stakeholder Engagement

In addition to public meetings and the publication of relevant documents, stakeholder engagement will be conducted throughout the EIA process. A variety of outreach and communication strategies may include stakeholder meetings, targeted meetings and interviews, project newsletters, and website updates. Stakeholders would be engaged at key decision-making points in the project, such as identification of alternatives, assessment of impacts and development of avoidance measures and mitigation strategies, and reviewing alternatives to discuss findings and identify preferred solution(s). The information gathered from this outreach will allow the NRA and its partner agencies to hear insights and potential impacts first-hand, which can help inform their future decisions.

Chapter 3

Assessment of Corridor Alternatives

3 Assessment of Corridor Alternatives

3.1 Roadway Operations

The EAB's EIA Scoping Opinion states that the objectives for assessing roadway alternatives and future operations is to ensure that the preferred EWA Extension Corridor design offers the best outcome for both the surrounding communities and for preserving the unique environments of Grand Cayman. Transportation investments have major influences on society, with a wide variety of economic, social, and environmental considerations. An analysis of forecasted land uses along with a determination of future travel needs projected through traffic modelling data will be used to guide the design of the EWA Extension. Current policies, including the Development Plan and the National Energy Policy, will also be consulted in guiding the design and measures needed to provide a new roadway facility that effectively meets the transportation needs while best avoiding and minimising impacts to the natural, cultural, and human environments.

For the population projections, the future year 2026, 2036, and 2046 forecasted volumes will be developed using growth rates from the 2021 Census and approved development data. Beyond future year 2046, a scenario planning approach will be applied to and pivoted off of the 2046 projections to reflect the larger level of uncertainty when estimating to future year 2074 (i.e., 50-year projection). Up to three (3) land use/population scenarios, referred to as "Alternate Futures" will be evaluated for future year 2074, which may include geographical-based and/or intensity-based components. Alternate Futures will be determined with the Department of Planning and consultation with key governement ministries; and may include a variety of population estimates (e.g., low/medium/high) and/or travel demand management strategies such as adding employment east of George Town, staggered work or school hours, accounting for sea level rise, or densification of development.

The development of the typical sections and intersection concepts for Section 2 and Section 3 will use the traffic volumes from existing roads near the study area and anticipated future traffic volumes to determine the appropriate number of lanes for the future corridor and roundabouts. Roundabout concepts will be developed with enough detail to show the approximate impacts to the areas around the intersection. Typical sections were initially designed for the proposed EWA Extension, from Hirst Road to Lookout Gardens; additional facilities were also proposed to provide multimodal accessibility such as for pedestrians, bicyclists, and/or transit **(Figure 4).** It should be noted that the designs in Figure 4 are examples to show the varying levels of detail and subject to change based on the findings of the EIA.

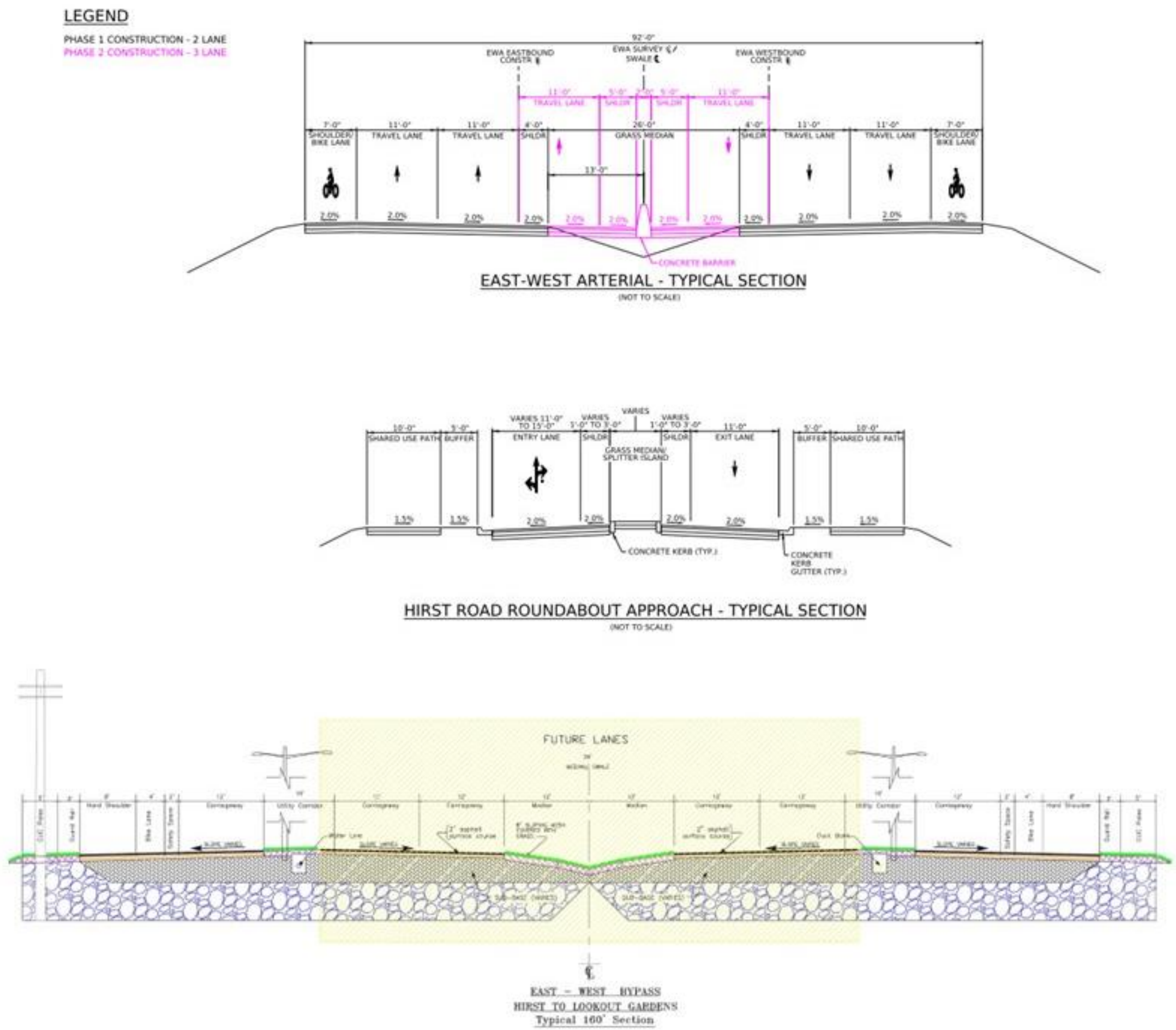


Figure 8: Example Typical Sections with Multimodal Accessibility

Source: National Roads Authority

3.2 Alternative Solutions and Analysis

It has been projected that current traffic congestion, fuelled by population increases over the coming years, will continue to worsen due to the lack of roadway options that interconnect the eastern with central and western districts of Grand Cayman. **Figure 5** and **Figure 6** capture the October 2019 AM peak westbound traffic congestion along Shamrock Road as motorists travelled toward the western half of the island. The EWA Extension project would provide a disaster-resilient alternative route and improve traffic conditions while offering an enriched quality of life through improved mobility and accessibility for residents and visitors alike.

Figure 9: Shamrock Road near Countryside Shopping Village

The focus of the analysis will be to ensure that the design of the project provides the best possible outcome for meeting the existing and projected travel needs while effectively preserving the environment as well as accommodating the needs of the surrounding communities.

Figure 10: Shamrock Road near Ocean Club Condominium Complex

With the focus on improving connectivity, safety, and emergency evacuation capability, an initial longlist of alternative solutions will be identified, which may include the No-Build, On-Alignment, EWA Extension, alternate alignments, and mass transportation options. Note that all alternatives will take into consideration future sea level rise estimates by 2074, including necessary mitigations. Additionally, the proposed corridors would have the width and ability to include alternative modes of transportation as deemed appropriate (or solely passenger transit), as well as pedestrian facilities.

Each Build Alternative will be designed to the concept level in an effort to meet the Critical Success Factors (CSFs) of the project (e.g., engineering feasibility, traffic operations, multimodal safety). During development of the alternatives, environmental and cultural features that need to be avoided entirely, or encroachment minimised, will be identified. These alternatives would then undergo a high-level transportation and environmental screening process to determine the viability of each alternative and determine which one(s) should move forward based upon CSFs, as well as constraints and dependencies (e.g., construction considerations and the evaluation of mitigation opportunities for unavoidable impacts). Through each step the alternatives will be further refined, and will be narrowed down based upon CSFs, constraints and dependencies, as well as the results of the Cost Benefit Analysis (CBA).

The steps in the alternative development process are illustrated below **(Figure 7**) and described on the following page:

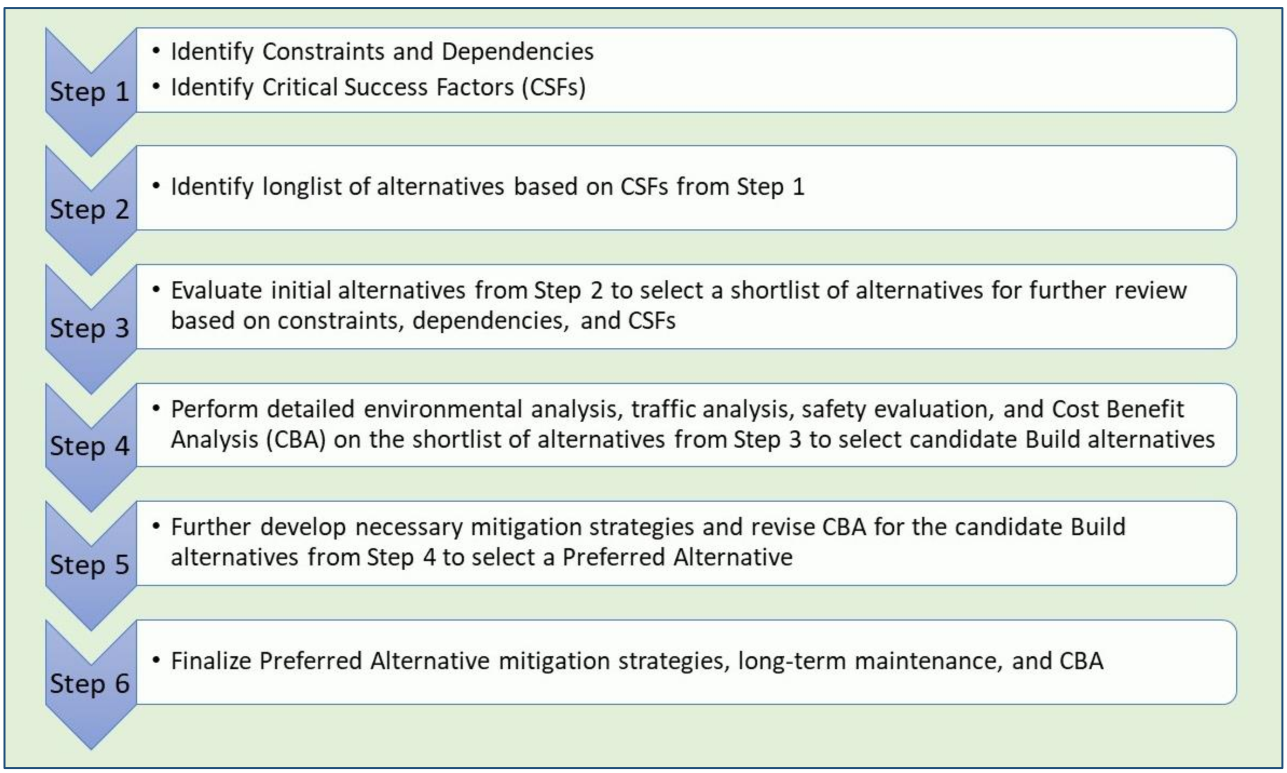


Figure 11: Steps of Alternative Solutions Evaluation

Step 1: Clearly identify the constraints and dependencies, as well as the CSFs

- Create a baseline of the project area to identify constraints and dependencies of the project. Engineering constraints such as unstable rock areas, along with environmental constraints, such as wetlands or proximity to Protected Areas, cultural or natural heritage sites, will be overlaid on a GIS-based map so the areas without constraints, can be identified. For example, existing condition information will be identified and mapped for resources described in Section 4 below. The goal is to avoid mangroves, wetlands, Protected Areas, species of concern, cultural or natural heritage sites and any other sensitive areas to the extent possible. Additionally, existing and proposed residential and community facilities will be mapped with the goal to set the roadway back from current and known planned developments to minimise construction- and operational-related disturbances for those facilities.
- Clearly define the CSFs of the project. These would be the goals of what the completed project would accomplish.

Step 2: Identify longlist of alternatives, based on CSFs from Step 1, which could be capable of being constructed.

Step 3: Evaluate longlist of alternatives identified in Step 2 based on the CSFs and constraints and dependencies, including a high-level traffic analysis. A shortlist of alternatives, including the No-Build, will be identified to move forward to Step 4. An explanation will be provided for why selected alternatives were eliminated from further consideration.

Step 4: Additional analysis would be conducted on the shortlist of alternatives that move forward from Step 3 to select candidate build alternatives. This would include the following analyses:

- A comparison matrix of alternatives and the No-Build will be developed. The comparison matrix will include sustainability topics (community well-being, program-project management, and environmental stewardship). Sustainability measures will include:
    - Cost Effectiveness – the level to which the sustainable action will be estimated to be cost effective in terms of life cycle costs (short and long term);
    - Environmental and Natural Resource Conservation – the level to which environmental resources (wildlife, water quality, air quality, virgin materials, etc.) are being conserved, protected, or enhanced by the sustainable action;
    - Ease of Implementation – the level to which implementing the sustainable action is viable and easy to perform based upon NRA contractual and policy procedures or existing operating conditions and circumstances;
    - Community Context Sensitivity- the level to which the sustainable action promotes, maintains and/or enhances the local/regional community or driving public by improving their safety quality of life and sense of place.
- A traffic analysis will be conducted from a multimodal perspective of project mobility benefits and impacts for each of the alternatives and for Years 2026, 2036, and 2046, and 2074. These future year traffic projections will be developed and based upon growth rates

from the census along with known approved and planned land development, which will provide a future land use condition. This analysis will feed back into the roadway design to determine the solution(s) that meet the CSFs, which may include refinements such as number of through lanes, intersection configurations, and turn bay lengths at intersections.

- A multimodal qualitative or quantitative safety evaluation will also be conducted to determine potential safety benefits and/or implications for each of the alternatives.
- A CBA will be performed to provide a monetary measure of the relative economic desirability of project alternatives, weighed against non-monetised effects, and impacts of the project. The CBA will include performance metrics such as:
    - Travel time reliability (TTR) for employment opportunities, equity, and overall quality of life as well as enhancement to local tourism sector;
    - User delay (e.g., loss of productivity) based on the additional travel time spent in the vehicle due to congestion;
    - Travel time (TT) to key destinations such as the George Town/Owen Roberts Airport, the George Town Cruise Port, the Camana Bay and Seven Mile Beach areas, schools, hospitals/healthcare, etc.;
    - TT to outlying tourist attractions such as Botanic Park, Cayman Crystal Caves, and Rum Point;
    - Travel Time Index (TTI), which is used to measure the severity of recurring congestion; it is a proportion of travel time compared to free-flow travel time (Travel Time / Free-Flow Travel Time);
    - Vehicle Miles Travelled (VMT) – used to compare both operational and air quality factors;
    - Overall roadway network Level of Service (LOS);
    - Fuel usage (e.g., unit – gallons) based on speed distribution of % VMT;
    - Emissions (e.g., unit metric tonnes CO_2) – based on speed distribution of % VMT;
    - Land use accessibility to occupational, recreational, and shopping areas/facilities within a certain amount of time (e.g., opportunities within 25 minutes);
    - Vehicle throughput;
    - Overall network performance (e.g., unit – delay per mile);
    - Intersection delay and LOS;
    - Maximum queues (e.g., unit – feet);
    - Multimodal safety assessment using crash modification factors (CMFs) qualitatively or quantitatively to evaluate potential safety benefits and/or implications;
    - As well as other measures deemed appropriate after discussions with stakeholders.

Step 5: Based upon the evaluations in Step 4, candidate Build alternatives and the No-Build alternative will be further developed through detailed engineering analyses and the development of necessary mitigation strategies. The CBA candidate Build alternatives will be refined and a Preferred alternative will be selected.

Building upon the comparison matrix from Step 4, will be an expanded matrix (**Table 1**) for the refined preliminary alternatives to summarize the anticipated impacts (direct, indirect, and cumulative) to each resource element and the severity of the impacts on the alternatives selected to be evaluated in the EIA.

Table 1: Summary of Anticipated Impacts by Alternative.

Alternatives	**No-Build**	**Alt. 1**	**Alt. 2**
Socio-Economic Impacts:			
Hydrology & Drainage Impacts:			
Geo-Environmental Impacts:			
Terrestrial Ecology Impacts:			
Cultural & Natural Heritage Impacts:			
Greenhouse Gas Impacts:			
Noise & Vibration Impacts:			
Traffic Operational Impacts			
Multimodal Safety Impacts			

Step 6: Based upon the evaluations in Step 5, a Preferred alternative(s) will be selected.

Chapter 4

Key Potential Impacts and Considered Mitigation Measures

4 Key Potential Impacts and Considered Mitigation Measures

4.1 Overview of Assessment Parameters

The implementation of a transportation improvement project has the potential to affect social, economic, natural, and cultural resources; therefore, it is essential that the existing environmental conditions and potential project related impacts are identified and understood. Previously, Figure 2 showed the area that would be directly impacted by the construction of the proposed roadway; however, each resource may have a different buffer around the construction area to evaluate impacts. To identify the extent of the impacts, a matrix similar to that shown in **Table 2** will be developed for each affected resource.

Table 2: Example Table for Significance Evaluation of Impacts on Affected Resources.

		Importance/Sensitivity of Resource			
		High	**Medium**	**Low**	**Negligible**
Magnitude of Change	High	Very Substantial	Substantial	Moderate	None
	Medium	Substantial	Substantial	Moderate	None
	Low	Moderate	Moderate	Slight	None
	Negligible	None	None	None	None

In addition, the assessment will identify whether effects are:

- Direct or indirect,
- Certain or potential,
- Secondary or induced,
- Short, medium or long term,
- Permanent or temporary, and
- Positive or negative (beneficial or adverse).

Additionally, as described in Paragraph 5 of Schedule 2 of the EIA Directive (NCC, 2016), the evaluation must evaluate the potential indirect and cumulative effects of the proposed roadway, both positive and negative. As noted in Section 1.1.3, indirect effects are impacts caused by the project, which occur later in time or removed in distance, but are reasonably foreseeable to occur. Cumulative impacts are the effects of past and present actions, and effects of reasonably foreseeable future actions by others on the same resources of concern.

Indirect effects could occur as a result of the direct impact, such as changes to water flow after the construction of the roadway. Induced residential or commercial growth could also occur due the new access provided by the new roadway and/or reduced commute times. The impacts caused by these new developments would also be considered as indirect effects. For this analysis, the potential for induced growth will be evaluated within approximately 1.5 miles of each new access point. The area that is protected from development, such as NCA lands, would be excluded, then the impact associated with the remaining land would be estimated and evaluated. The effect of increased traffic associated with any new developments shall also be included in the qualitative discussion.

Several proposed developments have been identified and shown on **Figure 8**. Through coordination with stakeholders and government agencies as well as discussions with the public at the public meetings, the status of these developments will be confirmed, and any new proposed developments or other projects will be identified. The impact of these projects combined with the proposed roadway and past actions will be assessed to determine the cumulative effect to each resource of concern.

The assumed induced growth areas and the identified developments/projects will be described at the beginning of the section that discusses the analyses and impacts so that all analyses include the same list of developments/projects. The direct, indirect, and cumulative effects of each resource topic shall be described within their respective sections.

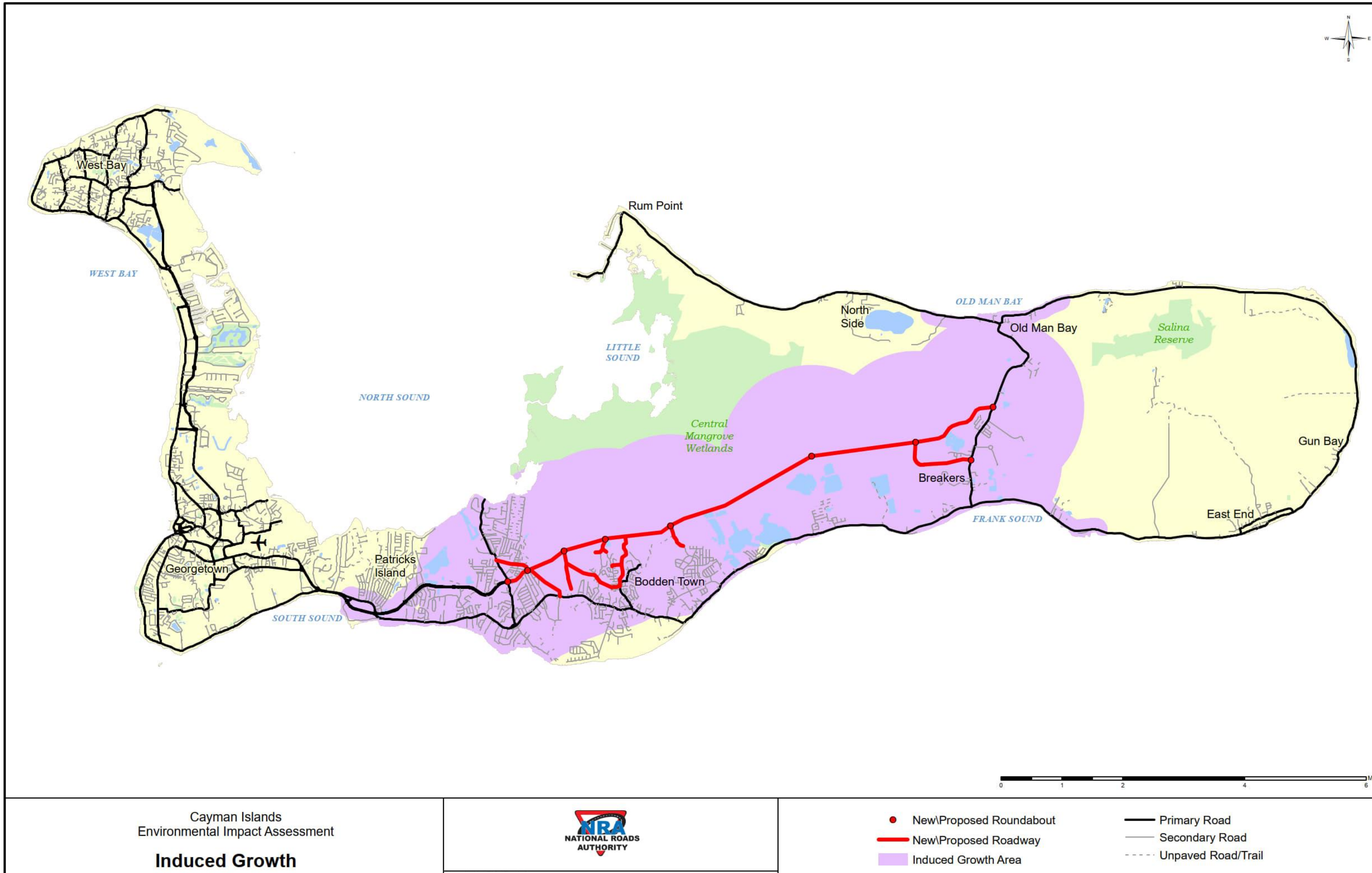


Figure 12: Induced Growth Study Area

4.2 Socio-Economic

4.2.1 Introduction

Social-economic components such as employment, income, and education affect how humans and communities live. Assessing the proposed project's potential to affect changes in these factors will aid in providing an understanding of the comprehensive and interrelated needs of individuals and the local communities.

4.2.2 Baseline Conditions

The Cayman Islands are made up of three independent islands: Grand Cayman, the western-most island, Cayman Brac, the eastern-most island, and Little Cayman, located just west of Cayman Brac. With nearly 70,000 people, Grand Cayman has approximately 29,000 households; of which only 25% include children and 80% having a vehicle (Census, 2021). **Figure 9** generally illustrates the distribution of population and employment centres on Grand Cayman.

Grand Cayman comprises five districts: West Bay, George Town, Bodden Town, North Side, and East End. With Owen Roberts International Airport and the George Town Cruise Port located in George Town, both George Town and West Bay are the primary locations for commercial and retail businesses such as hotels and restaurants, with a mix of residential uses **(Figure 10).** Further east, Bodden Town, North Side, and East End, are primarily residential with some minor retail and community facilities interspersed along the main roadway. Bodden Town is currently the fastest growing district, almost tripling in size since the turn of the 21st century, while North Side and East End remain relatively sparse (Economic and Statistics Office, 2022).

The population of the Cayman Islands is relatively young, with more than 91% of the population being under the age of 65 and making up much of the workforce. Unemployment in the Cayman Islands comprises 5.7% of the working age population, which is lower than the 2021 global unemployment rate of 6.2% (Economic and Statistics Office, 2022).

The economy of the Cayman Islands relies heavily on the tourism and the financial services industry, which represent roughly 17% and 32% of the Gross Domestic Product (GDP) of the Cayman Islands, respectively. Before the COVID-19 Pandemic, the Cayman Islands had more than one million visitors each year.

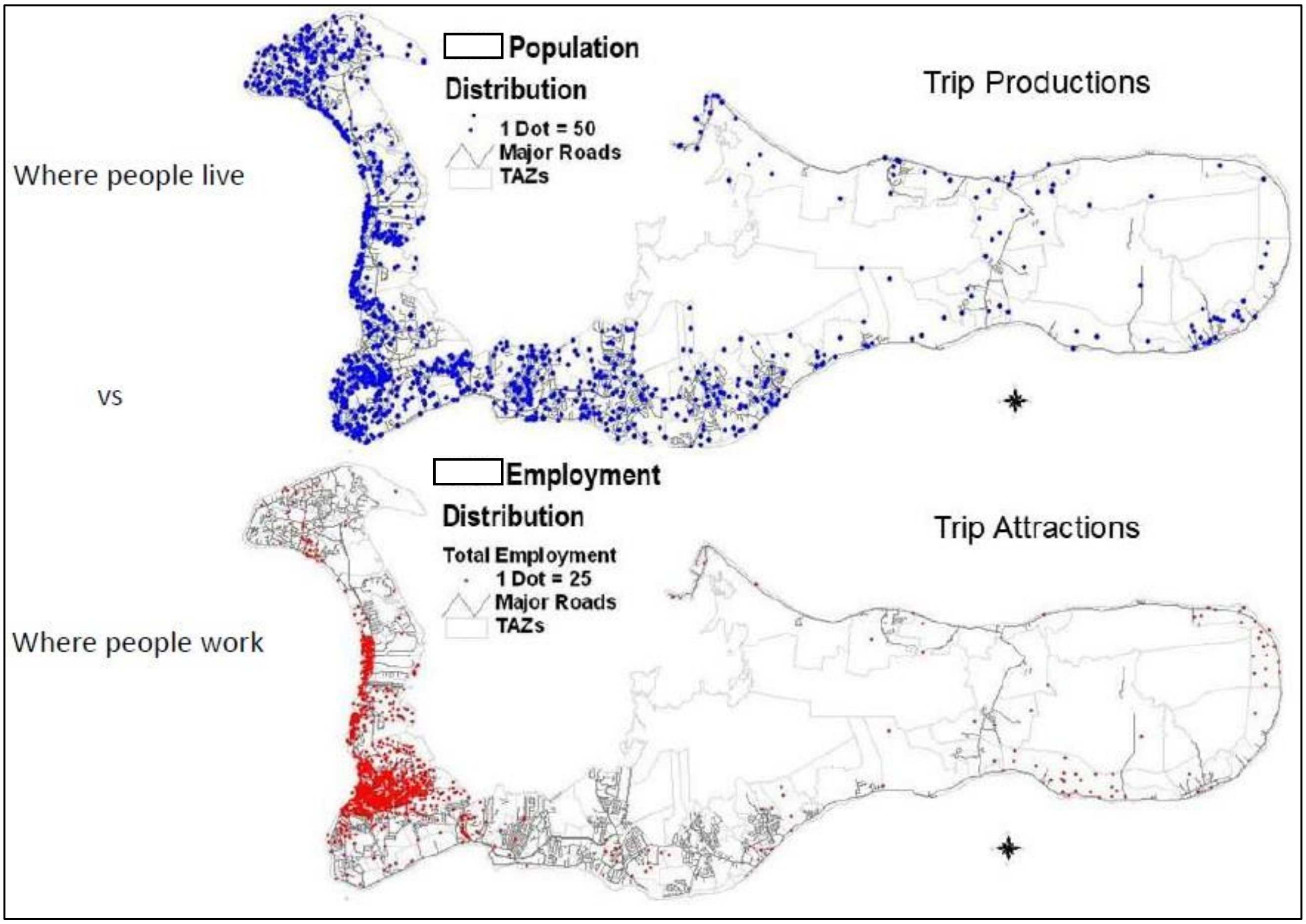


Figure 13: Distribution of Population vs Employment Centres on Grand Cayman

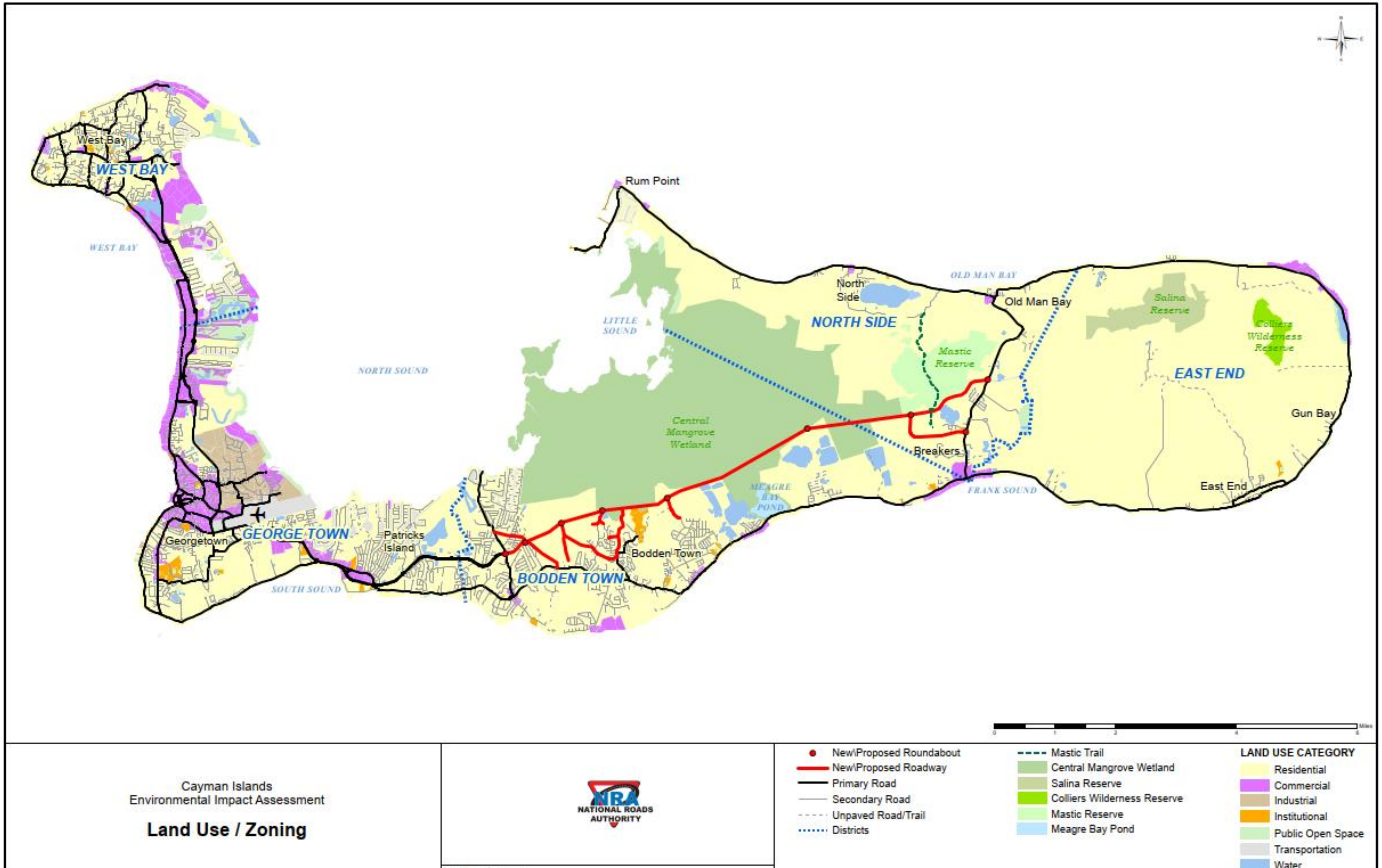


Figure 10: Land use and zoning on Grand Cayman

4.2.3 Applicable Standards and Guidelines

To evaluate the potential social and economic effects of the project, the EIA will consider the established rules and regulations of the Cayman Islands. Relevant laws applicable to this project include:

- Workmen's Compensation Act, 1996 Revision,
- Land Acquisition Act, 1997 Revision,
- Poor Person's Relief Act, 1997 Revision,
- Tourism Act, 2002 Revision,
- Employment Act, Law 3 of 2004,
- Education Act, Act 48 of 2016,
- Trade Union Act, 2019 Revision,
- Public Health Act, 2021 Revision,
- Labour Act, 2021 Revision, and,
- Data Protection Act, 2021 Revision.

Relevant planning documents and data applicable to this project include:

- The Cayman Islands' 2021 Census of Population and Housing Report,
- Draft National Planning Framework
- Existing Land Use and Community/Emergency Facilities,
- Approved and Proposed Developments,
- Existing and Proposed Utilities,
- National Tourism Management Plan 2019-2023,
- GO EAST: A Strategy for the Sustainable Development of the Eastern Districts of Grand Cayman,
- Compendium of Statistics, 2021,
- Cayman Islands Government 2022-2024 Strategic Policy Statement, and,
- United Nations Sustainable Development Goals, 2015.
- Meagre Bay Pond Management Plan

4.2.4 Potential Impacts

Socioeconomic status encompasses both objective characteristics (e.g., income or education) and subjective characteristics (e.g., people's sense of their placement). Groups that will be evaluated include residents, businesses, short-term renters, and marginalised/vulnerable groups. The socio-economic study area includes the entire Grand Cayman Island, since the effects to population, employment, and businesses could affect the entire island.

As part of the EIA, the following components shall be analysed in consideration of potential socioeconomic benefits and impacts in comparison to a ‘‘no-build’’ scenario:

- Aesthetics "Quality of Life"
    - The effect on traffic measures, such as travel time and level of service, compared to existing and future conditions;

    - The effect of the project on accessing adjacent land, including environmentally sensitive lands;
    - The potential for changes to existing environmental conditions due to changes in tourism;
    - The potential for changes to community resiliency from new roadway facility compared to existing and future impacts of sea-level rise under a "no-build" scenario (for this project, community resiliency is assumed to be the ability of communities to prepare, adapt, and recover from any negative impacts to the social, physical, and environmental health of the community);
    - The potential for changes to the noise and visual, environment for land uses located along the new roadway and connector roadways; and,
    - The effect of the project on lifestyle/wellness associated with changes to commute times.
- Access & Mobility
    - The project's effect on access needs along and adjacent to the project corridor based on an analysis of trip origination and destinations;
    - The projects effect on community mobility and connectivity;
    - The potential for changes in evacuation routes;
    - The potential for increased transit reliability for existing routes and anticipated transit benefits associated with the new facility;
    - The potential for changes in tourism as a result of increased or decreased access to resources; and,
    - Potential for impacts on economic resiliency as a result of tourism changes.
- Income & Economics
    - The potential for job creation during project construction and implementation;
    - The prioritisation of equitable business and employment opportunities; and,
    - Effects to tourism based upon improved access.
- Housing
    - The potential for relocations necessary for project construction;
    - The potential for new development; and,
    - The potential for impacts to housing availability and affordability.

4.2.5 Assessment Methodology

The assessment will include identifying statistics and trends of the area, identifying data from before COVID-19 as well as recent data. This analysis will identify changes in tourism as well as other effects associated with the change in the world economy. Data collected for Districts intersected by the study area will be used to identify the location of marginalised persons, types of businesses, residential neighbourhoods.

This baseline information will be collected from secondary data sources including, but not limited to local population census data, government planning documents, international financial institutions' statistics, nongovernmental organisations (NGOs) and business reports. Additionally, primary data sources will include consultation via email and virtual meetings with key stakeholders, local community and business representatives, and NGOs. This list of stakeholders will be developed during the initial public and agency outreach.

Relevant socio-economic indicator data will be gathered including information on income sources and livelihoods, and access to employment and business opportunities, as well as social services such as education and health.

This information will be used to identify potential impacts of the proposed project and the level of possible changes to the community, economic benefits, employment opportunities, housing, and health & wellbeing. The evaluation shall include:

- Effects caused by additional accessibility to the existing communities of Bodden Town, North Side, and East End;
- The potential changes to the local economy, including growth in residential development and land value changes;
- Assessment of the existing land uses based upon aerial imagery and field visits, as well as proposed changes to land uses based upon proposed development plans;
- Identification of existing public infrastructure, including water, sewer, and utilities;
- Determination to what extent that existing public infrastructure facilities can support new growth in the area;
- Evaluate the economic and social stratification of the neighbourhoods and identify how the project could affect this stratification;
- Evaluate impacts to travel patterns to work, school, and community facilities;
- Evaluate impacts to travel-related costs;
- Evaluate emergency service providers access routes/response times;
- Evaluate the creation of physical and/or visual boundaries;
- Assess the effects of temporary workers with potential impacts to local inhabitants; and,
- Evaluate the potential for new developments.

Unequal impacts to any marginalised or vulnerable groups will be identified and established for significance. Significance will be determined using clearly defined qualitative criteria considering:

- Sensitivity of socio-economic receptors (individuals or social or economic groups), determined by their vulnerability to change or ability to take advantage of opportunities; criteria would include those with income below the average, no access to vehicles, renters, persons over 65; and,
- Magnitude of impacts, determined by effect on receptors, wellbeing, which refers to the financial, physical, and emotional conditions of people or groups.

4.2.6 Mitigation Measures

Potential mitigation measures for unavoidable socio-economic impacts will be identified. Measures and practices will be suggested that have the potential to minimise the possible impacts of the project construction including, but not limited to:

- Identifying measures to maximise the use of local employment;
- Reviewing existing planning and zoning policies and regulations to account for project components and providing recommendations for updates or revisions; and,
- Recommending updates or new policies to encourage the location of new developments that would minimise impacts to existing communities and natural resources.

4.3 Hydrology and Drainage, Including Climate Resiliency

4.3.1 Introduction

Hydrology and drainage are important processes on Grand Cayman that support the health and safety of residents and natural resources. The Digital Terrain Model (DTM) and local observations indicate that during storms and hurricanes, flood waters drain from the south to the north through the Central Mangrove Wetland. The construction of the proposed roadway along the southern boundary of the Central Mangrove Wetland will impact these natural drainage processes. As part of the EIA, the applicable standards and guidelines will be reviewed, and the baseline conditions will be assessed for the Island's hydrology and drainage processes. Potential impacts of the proposed project, along with potential mitigation measures that avoid or minimise impacts of the proposed roadway project, will be identified in the EIA.

4.3.2 Baseline Conditions

4.3.2.1 Data Gathering Methodology

Although the study area includes the part of the island along the proposed roadway alignment, hydrology and drainage topics are inclusive to the entire island. An initial review of published data and publicly available information will be used to develop the existing conditions considerations. Information on hydrology and drainage, including topography, climate, tropical storms and hurricanes, storm surge and flood risk, and mangroves, along with climate and land use changes will be collected and analysed to define the hydrology and drainage processes. This review may determine gaps in available information that will need to be addressed in the specific studies that follow. The following describes each of these components that will be included in the EIA.

4.3.2.2 Hydrology and Drainage Overview

Hydrology and drainage on the Island are influenced by topography, geology, climatic factors, tropical storms and hurricanes, and a large mangroves population. The flat and low-lying island is vulnerable to winds and flooding caused by hurricanes and tropical storms. There are two dominant seasons: the wet, hot summer season and the relatively cooler, dry winters. In the wet, hot summer season, rain is generated by thunderstorms, tropical storms, hurricanes, or evapotranspiration from vegetation. In the dry winter months, occasional surges of cooler air from continental North America are the major producers of rainfall. Flooding varies on Grand Cayman, generally depending on the underlying bedrock formation. Areas that have underlying rock formations with high permeability typically do not flood unless they occur at the water table. Areas with less permeable bedrock are highly prone to surface water flooding. Mangroves, specifically the Central Mangrove Wetland, have an important role in the hydrologic cycle, including rainfall generation, local freshwater hydrology, groundwater replenishment, and hurricane protection.

Within the study area, the hydraulic function is largely determined by the flow of rainfall runoff and storm surge flows from the area south of the Central Mangrove Wetland, including parts of Northward, Bodden Town and Frank Sound toward the wetlands due to the change of elevation. In addition, the surface rock along Section 2 in the vicinity of the Lower Valley Fresh Water lens results in overland flow from storm surges crossing into the Central Mangrove Wetland via a "V" in this formation at the western end of Section 2 and at other, less-defined areas along what will become the southern edge of Section 2 EWA Extension. A map showing surface flow is found in **Figure 11.**

4.3.3 Topography

Grand Cayman is irregularly shaped with an approximate area of 76 mi^2 (197 km^2). The island is relatively flat, low-lying, and has no natural external drainage system. The maximum elevation is approximately 71 ft. (20 m) above sea level. The low-lying topography is vulnerable to winds and flooding caused by hurricanes and tropical storms. The island lacks rivers and streams due to the negligible elevation and the porous limestone rocks.

4.3.4 Climate

Grand Cayman has a tropical marine climate and is hot and humid throughout the year. The overall average temperature is 80.8°F (27.1°C) (Johnston & Cooper, 2022) and the average annual relative humidity between 2011 and 2021 was 79% (Economics and Statistics Office, 2022) Since it is located in the north-west Caribbean, the island is affected in the winter by cold fronts and influenced by tropical waves and is subjected to tropical storms and hurricanes with very intense rainfall during the summer. The dry, relatively cold months are from late November to mid-April. Winter cold fronts bring cooler temperatures, stronger winds and rough sea swells known locally as a ‘Nor-wester’, which occur suddenly and can be severe, with sustained wind speeds of up to 40 knots (60 knots gust). The wet season of warm, rainy summers is from mid-May through October. In July to November, low pressure systems moving west across the Caribbean frequently bring weather conditions ranging from weak tropical waves to hurricanes. The region has increasing higher average and extreme temperature events as average temperatures have increased approximately 3.9°F (2.2°C) over the past 40 years, at a rate of around 0.09°F (0.06 °C) annually (Pinnegar et. al, 2022).

The average precipitation is almost 55 in (139 cm) a year, with rainfall amounts increasing from east to west due to the evaporation of water in the Central Mangrove Wetland that is deposited as rainfall in the western side of the island. Observational trends appear to show a decrease in total precipitation, but an increase in rainfall intensity resulting in an increased occurrence of flood and drought events. Fewer but more severe rain events in recent years were observed from rainfall data collected at the Owen Roberts International Airport (Pinnegar et. al, 2022). During summer months, rainfall is typically the result of tropical thunderstorms or localised rain, generated from the evaporation of water in the central mangroves. In the dry winter months, occasional surges of cooler air from continental North America are the major producers of rainfall although precipitation is of much shorter duration and lesser amount than summer. Typically, heavy showers are interspersed by long dry spells during summer, which leads to periodic flooding in low-lying areas and depressions as well as moisture deficiency which is accentuated by shallow soil depth and low water holding capacities.

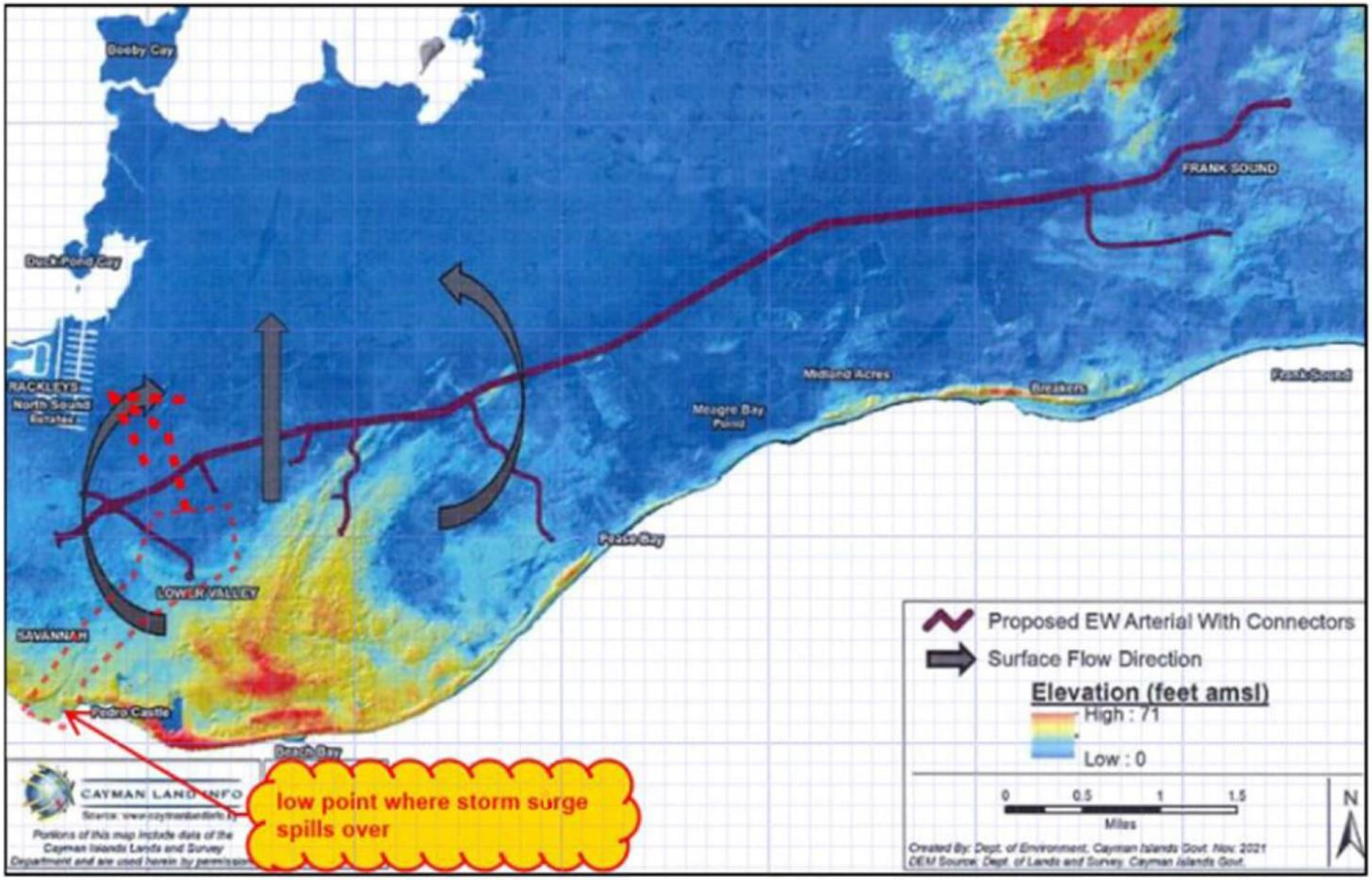


Figure 11: Surface flow drainage. Low point locally known as "Savannah Gully"

From Cayman Islands Department of Environment

4.3.5 Tropical Storms and Hurricanes

Hurricanes are a major climatic factor because the Island is located within the Caribbean hurricane belt, a region of the Atlantic Ocean that extends from the Gulf of Mexico to north of the Lesser Antilles where hurricanes are most likely to form. The months of September, October and November are typically the most active for hurricanes, when storms tend to form in the southern Caribbean and move north. The intense tropical storms and hurricanes are accompanied by very intense rainfall. Storm surges combined with wave action are responsible for much of the damage usually caused by hurricanes, especially in large, low-lying coastal settlements.

On average, the Cayman Islands are affected, brushed, or hit by hurricanes every 2.23 year and directly hit by hurricanes every 9.06 years. More recently, hurricanes have increased in intensity and rainfall, which is likely a result of warming ocean temperatures and more moisture in the air. Hurricanes have been more active in the North Atlantic Ocean since the 1980s, and on average, the quantity, strength, and number of hurricanes that intensify has increased (Colbert, 2022). The proportion of very intense tropical cyclones (Category 4 and 5) is anticipated to increase globally with increased warming (IPCC, 2021).

Hurricane Ivan was a Category 5 Atlantic hurricane that occurred in September 2004 and is considered one of the most impactful hurricanes recorded in the Caribbean region. It caused sustained winds of 160 mph and gusts of up to 217 mph, producing storm surges of 8 to 10 ft. (2.4-3.0 m) and wave heights of 20-30 ft. (6.1-9.1 m). The storm surges flooded large portions of the coastal areas and deposited major amounts of sand over roads, houses, and infrastructure. Most of the Island low lying areas were under water during and following the storm and widespread property damage resulted. It is estimated that the hurricane caused CI $2.86 billion (US $3.4 billion) in damages across the Cayman Islands, equivalent to over 180% of GDP (Pinnegar et. al, 2022).

4.3.6 Storm Surge and Flood Risk

There are two main types of flooding on the Island- coastal and surface water. Coastal flooding has caused much damage in the Cayman Islands with both the intensity of tropical storms and their frequency. Coastal flooding occurs because of the combined increase in water level from storm surge and waves on an elevated sea level. Due to the overall low elevation of Grand Cayman, coastal flooding extends to large areas of the island even in less severe storms (Category 3).

Surface water flooding typically occurs when a tropical depression settles over the island, and it rains for days. There are few surface water flow paths, and surface water flooding is typically widespread and of low velocity. Flooding varies on Grand Cayman, generally depending on the underlying bedrock formation. Areas that have underlying rock formations with high permeability, such as the Cayman Formation and Pedro Castle Formation, typically do not flood unless they occur at the water table. Rainfall either evaporates, percolates, or accumulates in depressions. Areas with underlying Ironshore Formation are much less permeable and are highly prone to surface water flooding. Much of the Ironshore surface when unbroken is “case hardened” and only allows water to percolate down sinkholes, which are very variable in terms of spacing and distribution, and which, like deep wells, cease to function in lower lying areas when the groundwater horizon surges during prolonged and heavy rainfall events. Even with the case-hardened surface broken, the Ironshore rocks are quite clay-like and are not as permeable as the Cayman and Pedro Castle formations. Developed and undeveloped areas with low elevation and/or soil, peat, or cap rock with low permeability are also prone to frequent flooding. More information on geology, including Figure 14: Sketch Map of Surface Geology can be found in Section 4.4.2 Geo-Environmental Baseline Conditions.

No generally accepted, delineated floodplain mapping exists for the Cayman Islands; however, the proposed EWA Extension corridor, like much of Grand Cayman, is low-lying and likely vulnerable to tidal flooding and hurricane/tropical storm-associated flooding, both of which can create numerous potential hazards. Novelo-Casanova and Suarez (2010) delineated flood zones resulting from hurricanes according to hurricane categories on the Saffir-Simpson Scale. The level of exposure to hurricanes and associated flooding and storm surge varies along the proposed roadway alignment. The proposed roadway in the western area near the Central Mangroves is within an area of high exposure and the proposed eastern roadway section is within an area of moderate exposure. Storm surges combined with wave action are responsible for much of the damage usually caused by hurricanes, especially in large, low-lying developed coastal areas.

The dense vegetation on the Cayman Islands appears to provide flood protection by intercepting and absorbing rainwater before it reaches the ground runoff conditions, holding back water temporarily, and mitigating peak flows that cause the greatest flooding by slowing the passage of water through the catchment. These conditions appear to act as a source of friction against moving water, resulting in a reduction of wave heights. In addition, soil cohesion is increased through the presence of root systems, reducing sediment load in flood waters.

4.3.7 Mangroves

Mangroves are important for both the terrestrial and marine ecology of Grand Cayman as they provide many ecosystem services, such as influencing hydrology and stormwater water drainage patterns; protection of beaches and coastlines from storms, waves, and floods; reduction of beach and soil erosion; providing nursery grounds, food, shelter, and habitat for a wide range of aquatic species; and carbon sequestration. Mangroves prevent erosion by acting as buffers and catching alluvial materials, thereby stabilizing land elevation by sediment accretion that balances sediment loss. They functionally act like a natural water treatment plant by retaining heavy metals, trapping sediments, and providing chemical buffering and water quality maintenance.

Mangroves are flow-through ecosystems. Tidal streams begin at the terrestrial edge of the inland side from ground water, springs, and stormwater runoff and continue to the sea. Tidal streams facilitate the exchange of tidal waters in and out of the mangrove area. Tidal fluctuation brings saltwater up estuaries against the outflow of freshwater, and transports sediments, nutrients, and clean water into the mangrove habitat, which is important for mangrove distribution. When tidal streams are disturbed, a mangrove may dry out, and die over time.

Mangroves are sensitive to environmental factors. Mangroves prefer low wave energy and are very sensitive to soil modifications, mainly due to shifts in substrate elevation relative to water level. The normal hydrologic patterns, including depth, duration, and frequency of tidal inundation and tidal flooding, influence the distribution and growth of existing natural mangrove plant communities. In addition, a change in salinity can result in a change or loss of mangrove species.

Specifically, the Central Mangrove Wetland is part of a large-scale water flow system, filtering and conditioning the surface water and shallow ground water which flows into the North Sound and provides a constant flow of nutrients, which form the base of a complex food chain for both terrestrial and marine wildlife. In addition, the Central Mangrove Wetland has an important role in the hydrologic cycle of the Island, including rainfall generation, local freshwater hydrology, groundwater replenishment, and hurricane protection. An estimated 40% of the rainfall in western districts is because of evapotranspiration in the Central Mangrove Wetland (Bradley et al, 2004). The evaporation of water from mangrove swamps creates a seaward hydraulic gradient for the regional flow regime (Ng et al, 1992). The evaporative loss for Grand Cayman is estimated to be approximately 75% to 85%. In addition, under normal conditions, a seaward hydraulic gradient drains ground water into the sea.

4.3.8 Applicable Standards

Applicable standards will be reviewed to ensure the project adheres to regulations and follows the most up-to-date guidance. Since there are no specific standards for water quality in the Cayman Islands, the British and International standards will be assessed, along with consultation with the Cayman Islands Government.

The following standards will be reviewed during preparation of the EIA:

- The Environmental, Health and Safety Guidelines, General EHS Guidelines: Environment (IFC, 2007) Wastewater and Ambient Water Quality - provides supplementary international guidance on water quality;
- Stormwater Management (Cayman Islands Planning Department and NRA) Guidelines Levels (2008) - provides national guidance on the formation of Stormwater Master Plans and primarily focuses on management of stormwater volume;
- Florida Department of Transportation (FDOT) Drainage Manual (January 2023) and associated FDOT Handbooks and Florida Administrative Code Rule Chapter 62-777 Contaminant Clean-up Target Levels;
- Consultation with DoE, WAC and Department of Environmental Health (DEH) to determine the applicable standards that should be adopted for this part of the assessment;
- EIA Directive (2016) issued in accordance with the National Conservation Act (2013);
- United States Department of Agriculture Natural Resources Conservation Service (NRCS) National Engineering Handbook, 2021; and,
- International standards such as the UK’s and Canada’s Environmental Quality Standards.

4.3.9 Potential Impacts

Potential impacts from the proposed project may include a change of water circulation patterns, increase of stormwater runoff volume and velocity, decrease of water quality, and impact on the ecology of natural resources. Potential receptors include the adjacent developed areas, Central Mangrove Wetlands, the Mastic Reserve, the Meagre Bay Pond and the Lower Valley and North Sound freshwater lenses. Potential impacts to be further assessed shall include:

- A damming effect caused by the construction of the proposed roadway changing the water circulation patterns, which may result in:
  - Restricting hydrology to the Central Mangrove Wetland north of the proposed EWA Extension of hydrology and causing inundation of the mangroves and adjacent developed areas south of the proposed roadway;
  - Alterations of hydrology, water flow, water levels, surface drainage, salinity levels, nutrient balance, oxygen concentration or temperature that may be harmful to mangrove trees and wildlife or the ecological or aesthetic value of the area or that may exacerbate erosion; and,
  - Damage to existing drainage infrastructure and subsequent flooding of neighbouring properties or infrastructure.
- Impacts on groundwater and surface water flows and drainage patterns may impact both the Lower Valley and North Side freshwater lenses;
- Increase of stormwater run-off volume and velocity from impervious surfaces (pavement), which may potentially increase flood risk;
- Temporary storage and stockpiling of materials may change surface water drainage patterns and locally increase flood risk;
- The loss of mangroves reduces transpiration, may increase runoff, and could reduce floodplain roughness, which in turn could increase run-off velocity and reduce protection from tropical storms and hurricanes. In addition, the cutting or drowning of mangroves may decrease precipitation on the western end of the island;
- The proposed roadway has the potential to release contaminants that may potentially pollute sensitive habitats and the underlying aquifers; and,
- The potential negative impact on hydrology may impact the ecology of the Central Mangrove Wetlands, the Mastic Reserve, and the Meagre Bay Pond Protected Area.

4.3.10 Assessment Methodology

An assessment will be completed as a part of the EIA development to gather critical information and fully understand the hydrology, drainage, hydrogeology, and geology characteristics and the potential impacts of the proposed roadway construction within the study area. The assessment methodology presented below overlaps with the assessments addressed in Section 4.4.5 as all four features are intertwined. This information will be used to determine if potential impacts from the construction of the proposed roadway can be avoided or minimised especially for water flow, water quantity and quality and sensitive habitats, including the Central Mangrove Wetland, Meagre Bay Pond, and the Mastic Reserve, and the developed areas south of the proposed roadway corridor.

The scope of the assessment shall include a review of applicable regulations, rainfall analysis, determination of drainage patterns, flood risk assessment addressing risks to neighbouring residential communities and other sensitive receptors with flood and hydraulic modelling, stormwater management plan with mitigation measures, water quality assessment, study of sensitive habitats, and impact of sea-level rise and climate change. Additional investigations shall be required, such as:

- Identification of applicable Governing Regulations, including regulations for stormwater and for the protection of the Central Mangrove Wetland and Mastic Reserve, and Meagre Bay Pond;
- Compilation and analysis of existing rainfall data for Grand Cayman, including large storms and tropical cyclones, to determine design rainfall amounts for flooding assessments and roadway storm water designs;
- Review existing drainage infrastructure mapping from the NRA;
- Conduct a site visit to confirm the local topography, verify the existing drainage network, and identify potential surface water flow paths;
- Review of 2004 Hurricane Ivan flood map;
- Analysis of daily rainfall for water quality assessments;
- Analyse inland conveyances and watersheds hydrology. Determine watersheds, storm runoff, and hydrologic and hydraulic effects of the proposed roadway on the watersheds and receiving water bodies and lands. Additionally, determine storm runoff for roadway drainage conveyance, embankment heights, and bridge dimensions and elevations.
    - For the large and extreme storms, use the US National Resources Conservation Service, NRCS, Type III storm hydrograph and the NRCS soil cover-complex method to determine runoff volume, hydrographs, and rates;
    - The soil-cover complex runoff curve number will be determined from observation and research on the soils and vegetation covers in Grand Cayman literature in comparison to the published runoff curve numbers. Future land build out will be included in the runoff calculations;
    - Time of concentration for the runoff from the most hydraulically distant point in the watershed to the point of analysis will be determined using the NRCS segmental method, the average velocity method, or a combination of both methods.
    - The appropriate hydrograph shape factors will be determined following the Florida Department of Transportation Drainage Design Guide;
    - Runoff volumes generated by the hydrographs will be used to assess overland flow captured by ponds, quarries, and significant depressions. What is not captured will be part of the hydrograph and peak flow rates used for analyses at points of interest and for future design of the East-West Arterial bridges and any impoundments associated with the roadway;
    - If the data from Hydrologic Research and Analyses generate sufficient rainfall intensities for short duration, high rainfall storms (five minutes to one hour) the rainfall intensities calculated will be used with the rational method for calculation

of peak flow rates. The rational method and peak flow rates will be utilized for future design for roadway conveyances with small contributing drainage areas; and,
    - Ridge lines, watersheds, and drainages along with their conveyances will be plotted using the topographic mapping.
- A Hydrologic and Hydraulic Analysis to determine flood water level/design water level;
    - Calculate flood water surface elevations without the effects of storm surge and wave run-up using the US Army Corps of Engineers Hydraulic Engineering Centre River Analysis System, HEC-RAS, software model;
    - Use modelling methods, such as the US Federal Highway Administration HY-8 Culvert Hydraulic Analysis for uniform flow calculations for pipes less than full capacity, hydraulic grade lines for pipe systems flowing full, manning's normal depth analyses for ditches, and culvert analyses;
    - Sheet flow methods will be utilized where runoff is concentrated by the topography and channel hydraulics will not adequately characterize the flow; and,
    - Using the flood and conveyance elevations, alternatives can be considered for the East-West Arterial elevation roadway and bridge elevations can be determined. Impacts upon existing roads, quarries, ponds, lands, and existing and proposed communities can be made with runoff elevation and widths determined.
- Develop topographic mapping for the Hydraulic Analyses and mapping of the data using topographic mapping provided by the NRA with field observations and data obtained from other sources;
- Evaluate soils and geology information to determine the runoff curve number for the hydrologic analyses. Data from the Cayman Islands Government, past experience, and field observations will be utilized for the soils and geologic hydrologic components. In addition to the dense vegetation and the limestone and dolostone underneath, the large amounts of evaporation will also be a factor to determine the runoff coefficient;
- Satellite Imagery/ Geographical information will be utilized with the topographic data to develop base mapping;
- Evaluate future land use patterns; for estimating flood peak discharge at arbitrary points of crossing structures such as bridges, viaducts, culverts, etc. With the NRA and Planning coordination, the future land use patterns and their effects on the hydrology will be characterized. Areas for development will be incorporated into the analyses with their corresponding changes in runoff and flow patterns. Existing roadways and developed areas will be observed in the field for their hydrologic responses during the rains. Key future land use areas include:
    - Lookout Gardens;
    - Lower Valley Area;
    - Northward Area watershed; and
    - Breakers and Frank Sound Areas.
- Assess and design culvert/bridge conveyances using 1-dimensional and 2-dimensional H/H models (e.g. HEC-Ras and HEC-RAS 2D) and embankment "flow-though" in lowland floodplains (e.g. "Darcy" flow models) to minimise flood risk and environmental impacts; and,

- Consider sea level rise and climate change in the project's hydrologic/flooding assessments and stormwater management evaluation and perform an assessment of risk significance. Sea level rise and climate change will be projected out to 50 years. The assumed height of sea level rise is 1.64 feet (0.5 meter) for the year 2074.

4.3.11 Mitigation Measures

Mitigation measures will be assessed that avoid or minimise the potential hydrology and drainage impacts and protect residents and natural resources. These potential mitigation measures evaluated during preparation of the EIA and/or recommended by the EIA for further consideration during preliminary and final design may include:

- Consideration of flow through the aggregate roadway embankment to prevent the "damming" effect of the roadway;
- Maintain water flow with the use of box culverts to reduce the potential of altering salinity and hydrological gradients;
- Identify portions of the road that should be elevated to preserve hydrological flow in critical areas;
- Corridor-wide implementation of culverts or other "levelling" devices;
- Identification of, along with any necessary mitigation measures, existing drainage infrastructure or overland flow routes which may be affected by the proposed roadway;
- Design the roadway to be accessible during intense rainfall events and not increase flood risk to surrounding properties or infrastructure. Address stormwater management and flood risk for existing and future development along the EWA corridor from a regional perspective to provide greater resiliency to the effects of climate change;
- Design of drainage infrastructure with adequate capacity to safely convey the design rainfall intensity and minimise potential flood and water quality impacts, as well as to provide greater resiliency to the effects of climate change. Select stormwater management options to avoid or minimise impact on Lower Valley and North Side freshwater lenses, Meagre Bay Ponds, Central Mangrove Wetland, and Mastic Reserve. Ensure that hydrological regimes are maintained and surface water flow into the Central Mangrove Wetland is minimally impacted. Identification of appropriate locations to discharge stormwater from the roadway;
- Implement deep wells within individual catch basins. Restrict catch basin and well drainage areas to less than 6,000 square feet and provide adequate pre-treatment of roadway runoff to minimise discharge of floatable debris, oil, grease or other pollutants which could impede long-term well function;
- Assess potential for Green Stormwater Infrastructure and Low Impact Design or Development (LID) approaches, which manage stormwater runoff and water quality of both small and large storm events and reduces the amount of polluted stormwater runoff using nature-based solutions. Potential structures may include bioretention cells, bioswales, vegetated swales, raingardens, bioretention basins, and enhanced stormwater basins with natural ecological functions. Consider use of native plantings and wetland plants to filter pollutants;

- Ensure that the road design and storm water drainage system, including discharge points, takes into consideration the effect of climate change, including more frequent, larger storms and sea level rise;
- Reduce soil compaction with the use of low-impact construction vehicles and/or mats;
- Proper siting of temporary stockpiles to maintain drainage; and,
- Use best practice pollution prevention techniques during construction.

4.4 Geo-Environmental

4.4.1 Introduction

Geo-environmental processes on Grand Cayman contribute to sourcing potable water to residents and support natural resources. The construction of the proposed EWA Extension may affect the existing geo-environmental systems within the island. As part of the EIA, the applicable standards and guidelines will be reviewed, and the baseline conditions will be assessed for the Island's geo-environmental processes. Potential impacts of the proposed project along with potential mitigation measures that avoid or minimise impacts of the proposed roadway project will be identified in the EIA.

4.4.2 Baseline Conditions

4.4.2.1 Data Gathering Methodology

Although the study area includes the part of the island along the proposed roadway alignment, most geo-environmental topics are inclusive to the entire island. An initial review of published data and publicly available information will be used to develop the existing conditions considerations. This will include trial pit information collected in 2008 within the vicinity of the proposed roadway between Hirst Road and Lookout Gardens, and in 2014 for the proposed road corridor between Lookout Road and Frank Sound Road. Information on geology, soils, peat and hydrology along with climate and land use changes will be collected and analysed to define the geo-environmental processes. The following describes each of these components that will be included in the EIA.

4.4.2.2 Geology

Grand Cayman is generally low-lying, with the highest areas being approximately 71 ft. (22 m) above sea level. Grand Cayman is located on the Cayman Ridge which forms the southern margin of the North American plate. The Cayman Ridge is a block, uplifted above the surrounding seafloor, that is bounded by dipping fault planes. A map of the Caribbean area and a cross section showing the Cayman Ridge are in Figures 12 and 13, respectively. **Figure 12** is from Ren and Jones (2017) which was modified from Jones (1994) based on Perfit and Heezen (1978) and MacDonald and Holcombe (1978). **Figure 13** is from Jones (1994).

Carbonate rock reaching back 30 million years old is exposed on Grand Cayman. A sketch map showing the surface geology is in **Figure 14**, which is from Ren and Jones (2017) and modified from Jones (1994) and Ng (1990). The Bluff Group is divided (from oldest to youngest) into the Brac Formation, the Cayman Formation, and the Pedro Castle Formation. The name of the Bluff Group suggests its cliff-forming habit. The Brac Formation is not exposed on Grand Cayman.

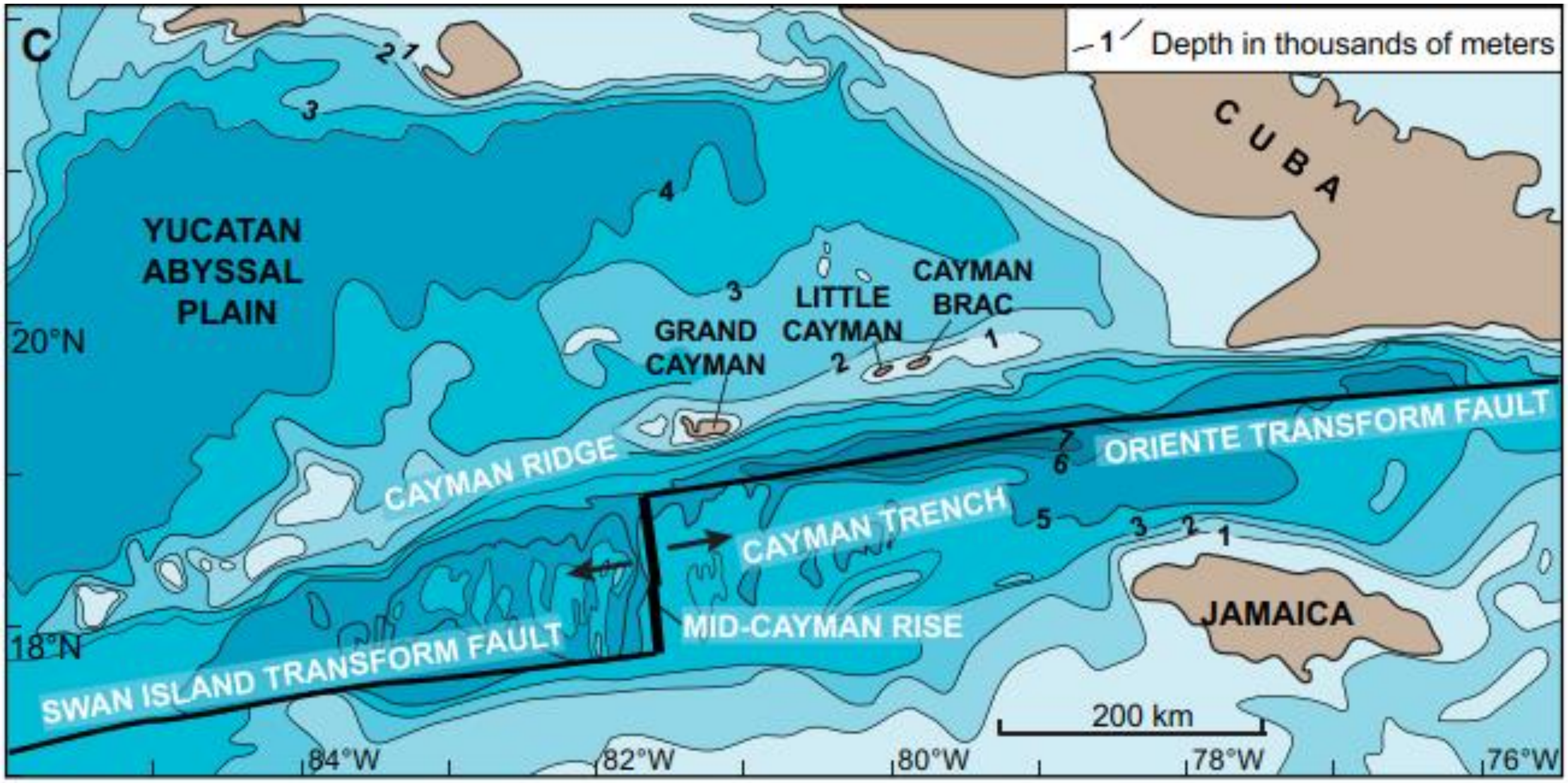


Figure 14: Map of the Caribbean Area

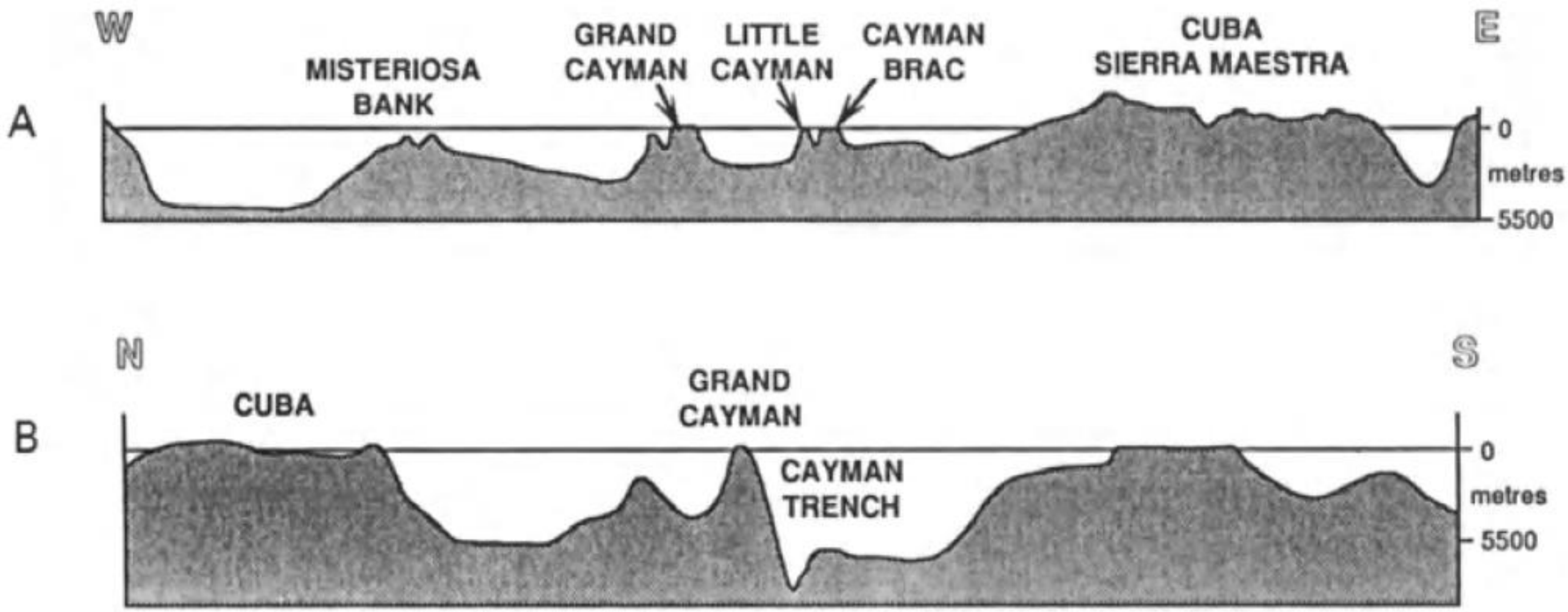


Figure 15: Cross section of Cayman Ridge. (A) Location of Grand Cayman on Cayman Ridge (B) Cayman Trench

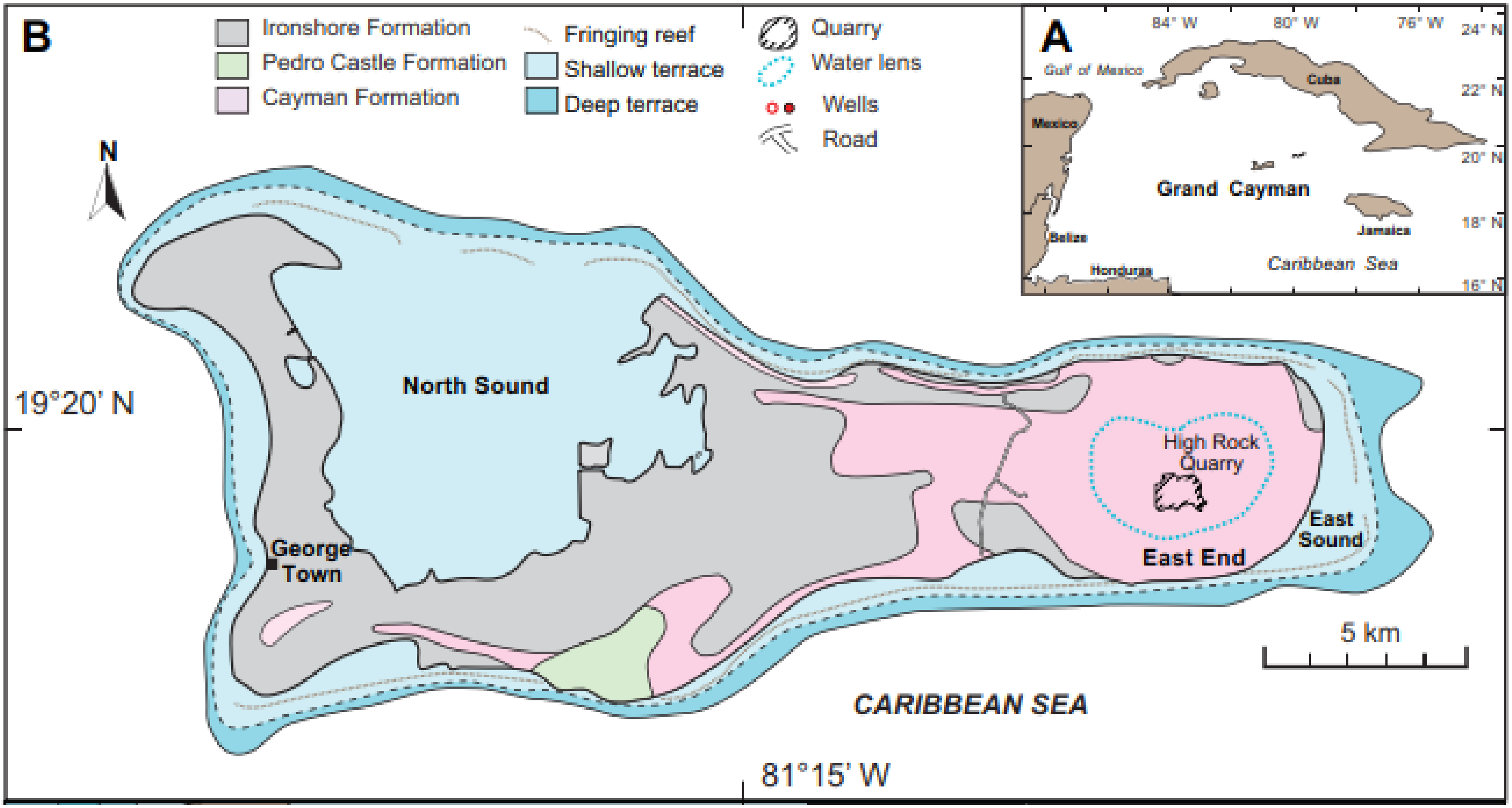


Figure 16: Sketch Map of Surface Geology

The Cayman Formation underlies the study area. It consists of relatively hard, microcrystalline dolostone containing the mineral dolomite (calcium magnesium carbonate). The thickness of the Cayman Formation is approximately 69 ft. (21 m), but it may be greater. Exposed Cayman Formation may have an irregular surface from karst landscape development, and it commonly has caves.

The Pedro Castle Formation overlies the Cayman Formation. The Pedro Castle Formation outcrops mainly in the southernmost part of Grand Cayman which is called Lower Valley. It is approximately 33 to 49 ft. (10 to 15 m) thick, or less where eroded. The Pedro Castle Formation may be relatively soft close to its stratigraphic contact with the underlying hard Cayman Formation.

Surrounding and partially onlapping the Bluff Group is the Ironshore Formation. Its thickness ranges from a thin veneer to 29.5 ft. (9 m). The Ironshore Formation consists of friable, poorly consolidated reef limestone, calcarenite, and oolitic limestone. The Ironshore Formation is the surficial geologic unit in most of western Grand Cayman.

4.4.2.3 Soils

Soils are generally thin on Grand Cayman. The sediments in the extensive mangrove swamps have a particular sequence which is described as transgressive by Woodroffe (1981). The basal unit is a crust that formed on rock during subaerial conditions predating the marine transgression, colloquially referred to as "caprock" by locals. Overlying the crusts is plastic mud deposited in seasonal floods. On top of the mud is peat formed from mangrove vegetation in an intertidal environment.

The NRA has developed conceptual plans and a subsurface profile for Section 2 of the EWA Extension (dated 2008) from approximately STA 0+00 ft. to 155+00 ft. STA 0+00 is at the existing terminus of the EWA, which is located at the intersection with Hirst Road, and STA 155+00 is at the Lookout Gardens. In addition, the NRA has developed similar information for part of Section 3 (dated 2014) between stations 155+00 and 455+00, which extends from the Lookout Gardens to Frank Sound Road. Their subsurface profiles include data from test pits along the project alignment. The spacing between test pits was typically 300 ft. (91.4 m), although the spacing was closer in some areas.

The test pits measured the depth to rock, and soil and peat thicknesses. In places, rock was at the land surface. At its deepest, the top of rock was approximately 14 ft. (4.3 m) below the land surface. Some test pits encountered a layer of soil up to about 1 ft. (0.30 m) thick on top of bedrock. Resting on this thin soil (or directly on top of bedrock) was a peat layer. Several test pits encountered the water table at, or just below the land surface.

It is anticipated to be necessary to excavate below weak materials such as peat and carbonate-derived residuum to construct the highway. Secondary and creep settlement is a risk to consider when soils are left in place. Karst landscape conditions including voids may influence the project, for example for foundations bearing on rock.

4.4.2.4 Peat

Mangrove-derived peat deposits underlie most of the mangrove swamps and cover the bedrock in many areas of Grand Cayman. Peat is mainly composed of organic remains from the mangroves themselves, principally from the two mangrove species *Rhizophora mangle* and *Avicennia germinans*. Peat deposits are fibrous, with abundant roots and rootlets. The peat does not have carbonate, and molluscs are rare. Much of the peat is less than 3 ft. (1 m) thick, but locally may be as thick as 20 ft. (6 m).

Peat has historically been connected to climate change as it has been determined to sequester greenhouse gases. It is anticipated that peat underlies a portion of the proposed roadway alignment. Trial pit data collected in 2008 within the vicinity of the proposed roadway between Hirst Road and Lookout Gardens demonstrated that much of the proposed roadway does not have significant peat depths. However, there are areas close to Lookout Gardens with approximately 5 ft. (1.5 m) in depth on average and up to 14 ft. (4.3 m) thick.

For the roadway construction, peat and other unsuitable material may need to be removed and replaced with aggregate to create a firm foundation. The aggregate material will need to be mined from the existing authorised commercial quarries. In August 2018, the Water Authority estimated that there are approximately 32 million cubic yards (yd^3) (244 million cubic metres) of aggregate in the authorised commercial quarries. An alternative to removing peat and replacing with aggregate is to elevate the proposed roadway using bridges and other design options.

4.4.2.5 Hydrogeology

Since 1982, the Water Authority in the Cayman Islands has operated as a water and wastewater utility and regulatory agency to protect and manage groundwater. It operates a central sewerage system, and it regulates on-site wastewater treatment systems. The Water Authority operates a central water supply system that uses reverse osmosis treatment of saline groundwater. The Water Authority, under the Water Authority Act (2022) Revision, is charged with the management, control, and protection of water resources.

Ng and Beswick (1994), and Jones, Ng, and Hunter (1997) described groundwater occurrence in the Cayman Islands. An unconfined aquifer exists in fractured carbonate rock. The unconfined aquifer is hydraulically connected with the ocean, and the water table elevation is typically less than 1.6 ft. (0.5 m) above Mean Sea Level. Owing to the high permeability of the karst rock, surface streams are absent, and the water table gradient is low. Freshwater lenses consist of three zones: a freshwater zone with a chloride concentration less than or equal to 600 milligrams per litre (mg/l); and a brackish zone (chloride of 600 to 19,000 mg/l); and a saline zone where chloride is at least 19,000 mg/l. The water zones radiate around the water lenses. In other areas, there is only brackish water underlain by saline water or there is only saline water.

Freshwater occurs in Grand Cayman in lens-shaped bodies beneath topographic highs in the Bluff Group. Tidal oscillations generate mixing of brackish and fresh water. The source of the freshwater on Grand Cayman is precipitation. Recharge of the lenses mainly occurs during large rainstorms. There are dynamic hydrogeological conditions at the boundaries of the larger freshwater lenses, in particular the boundary between potable and brackish water, which is a major contributor to the development of cave networks. Most of the larger known cave systems are situated near these boundaries.

The Hydrogeological Survey of Grand Cayman (a 1:50,000-scale map) shows the locations and dimensions of the three largest, usable freshwater lenses on the island **(Figure 15)**. Figure 15 is from Jones et. al. (2001), which was modified from Ng (1990). The Lower Valley Lens is the smallest and is about 2.5 mi (4 km) long and about 0.6 mi (1 km) wide. It underlies and/or is adjacent to Section 1 and Section 2 of the highway project. The North Side Lens is larger and exists about 0.6 mi (1 km) north of the east end of Section 3. The East End Lens is the largest lens. Its edge is about 2.5 mi (4 km) east of the limit of Section 3.

4.4.2.6 Future baseline

Climate and land use change could affect the geo-environmental conditions within the project area in the future. Climate change could affect the amount, intensity and duration of rainfall, temperature, and evapotranspiration, as well as occurrence of extreme weather (e.g., hurricanes). In addition, it has been predicted that the Cayman Islands may experience a decrease of between 0.4 and 2 in (10 and 50 mm) in annual rainfall totals between 2011 and 2099 (National Climate Change Committee, 2011). The Intergovernmental Panel on Climate Change predicts that there is a likely decrease in rainfall during the boreal summer in the Caribbean and that this drying trend will likely continue in the coming decades (Arias et al., 2021). Between December 2021 and November 2022, the rainfall monthly totals were 4.9% lower than the 30-year average (Cayman Islands National Weather Service, 2022). The change in rainfall patterns, evaporation, and extreme weather could impact the recharging of the freshwater lenses.

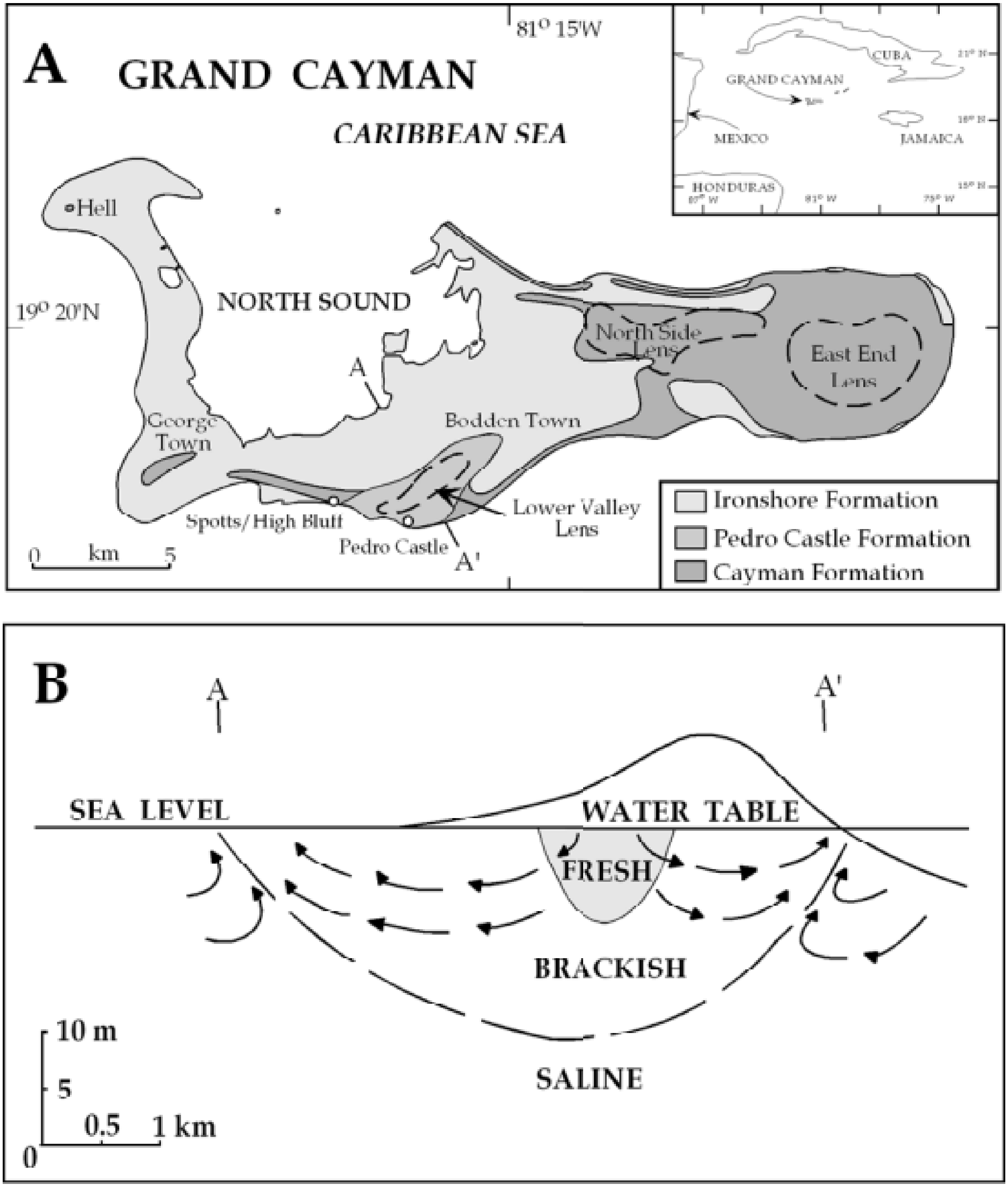


Figure 17: Location of the Freshwater lenses (A) and the cross section of the Lower Valley freshwater lens (B)

4.4.3 Applicable Standards

Applicable standards will be reviewed to ensure they are considered during project development and follow the most up-to-date guidance. Currently, there are no specific standards for water quality or geo-environmental assessment in the Cayman Islands. Therefore, assessments and analyses will be guided using UK and International standards from the United States including the State of Florida along with consultation with the Cayman Islands Government.

The following standards will be reviewed and applied as appropriate:

- Consider international standards such as the UK and Canadian Environmental Quality Standards. The Environmental, Health and Safety Guidelines, General EHS Guidelines: Environment (International Finance Corporation (IFC), 2007);
- Stormwater Management (NRA) Guidelines Levels (2008) which provides guidance on the formation of Stormwater Master Plans and primarily focuses on management of stormwater volume;
- Florida Department of Transportation (FDOT) Drainage Manual (January 2023) and associated FDOT Handbooks and Florida Administrative Code Rule Chapter 62-777 Contaminant Clean-up Target Levels;
- Directive for EIAs (2016) issued in accordance with The National Conservation Act (2013);
- Water Authority Act (2022 Revision) which states in Section 19 that groundwater vests in the name of the Crown and appoints the WAC as the custodian of groundwater in the name of, and on behalf of, the Crown;
- Cayman Islands Development and Planning Regulations (2022), specifically Regulation 18. Mangrove Buffer zones and Regulation 19. Land above water lenses;
- United States Department of Natural Resources Conservation Service (NRCS) National Engineering Handbook (2021); and,
- Consultation with DoE, WAC, and DEH to determine the applicable standards that should be adopted for this part of the assessment.

4.4.4 Potential Impacts

Potential impacts that may occur due to the construction of the proposed project include changes to the quantity and quality of peat and groundwater. Potential receptors include the adjacent developed areas, Central Mangrove Wetland, the Lower Valley and North Side freshwater lenses, and possibly the East End freshwater lens. The potential impacts from the proposed EWA Extension project centres on the freshwater lenses which are critically important water supplies on Grand Cayman. Potential impacts include the addition of impermeable surfaces that could diminish groundwater recharge or redirect stormwater away from the freshwater lenses. Certain changes in recharge could potentially negatively influence hydraulic conditions in and around freshwater lenses or degrade the quality of recharging water. In addition, changes in drainage patterns also have the potential to impact the freshwater lenses.

The potential impacts that shall be investigated include:

- Peat may potentially be removed, covered over, compacted, and contaminated, which may impact the Central Mangrove Wetland. The peat substrate is required for new growth for many species of flora, including but not limited to true mangroves. It's a vital component of a healthy wetland ecosystem and also sequesters and purifies toxins from the surrounding groundwater. An unknown factor is how currently undeveloped lands south of the proposed road corridor will impact drainage conveyance, given there are no proper regulations to ensure developments are built in a sustainable manner with functional drainage plans;
- The removal of peat may contribute to the release of greenhouse gases (see Section 4.7);
- The disturbance of peat during construction may contribute to the release of hydrogen sulphide, which could potentially cause health impacts for construction workers. Although poorly ventilated working conditions will likely be infrequent during construction of the roadway as most of the work will be conducted above ground, eye and lung irritation could be a potential hazard in the event that a particularly deep succession of peat is encountered during excavation activities;
- Changes in drainage patterns/stormwater management within the study area may potentially impact the developed areas south of the EWA and possibly the area east of Frank Sound Road;
- The freshwater lenses can be damaged as potential sources of potable supply if the groundwater flow system supporting the lens undergoes changes that could diminish the volume of freshwater and may result in eventual salt-water contamination of all but the shallowest wells used to abstract fresh groundwater;
- Soil compaction and the increased impervious surface (pavement) may result in reduced infiltration, which may impact the recharge rate and water level in the Lower Valley and North Side freshwater lenses;
- Storm-water drainage patterns and recharge rates may be impacted if the project requires construction of vertical stormwater drainage wells, or other means for the conveyance or drainage of stormwater;
- Temporary dewatering during the construction phase for the excavation for the proposed roadway foundations may result in localised and temporary decline in groundwater levels and deterioration in groundwater quality via induced saline intrusion; and,
- The potential release of contaminants may impact water resources. Due to the karst geology of the Cayman Islands and the absence of shallow low permeability confining zones, contaminants released directly (e.g., spillages) or indirectly (via surface water runoff) from the proposed roadway have the potential to migrate into the underlying aquifers leading to deterioration in groundwater quality.

4.4.5 Assessment Methodology

An assessment will be completed as a part of the EIA to gather critical information to fully understand the geo-environmental characteristics and the potential impacts of the proposed roadway construction within the study area. This information will be used to determine if potential impacts from the construction of the proposed roadway can be avoided or minimised especially for mangrove peat and to the water quantity and quality of the Lower Valley, North Side, and East End freshwater lenses.

The scope of the assessment will include a review of applicable regulations, a mangrove peat assessment, a proposed aggregate quantity assessment, and a freshwater lens assessment in the study area, if necessary. The other components related to determining the geo-environmental processes will be completed for the entire study area as part of the Hydrology and Drainage effort, described in Section 4.1.

Other additional investigations shall include:

- Identification of applicable Governing Regulations, including the Water Authority Act (2022 Revision);
- Development of a hydrogeological model for the study area;
- A mangrove peat assessment will be completed to map the location and depth of mangrove peat within the project area. A geotechnical review will be completed, and an underlying stratigraphy assessment will be prepared. The trial pit information collected in 2008 will reviewed and supplemented with data collected from new pits further east along the corridor, as needed, to establish average peat depths and total volume of peat expected to be removed;
- A proposed aggregate quantity assessment will be completed by estimating the amount of aggregate required for fill based on proposed roadway design;
- If necessary, the Freshwater Lens Study would include researching the water budget for groundwater recharge with data available from the Water Authority – Cayman and developing a water budget for use as a base model for the proposed effects of the East-West Arterial on infiltration, which will be used to determine the effects upon the groundwater and freshwater lenses. In addition, the existing water quality and quantity data of the Lower Valley and the North Side freshwater lenses will be reviewed;
- Review assessment of impacts of canals on the project area and freshwater lenses from the 1980's to evaluate the potential impact of shallow conveyance canals that drain stormwater from the project area on freshwater lenses;
- Site investigations will be completed to confirm the local topography and verify the existing drainage network of the freshwater lenses; and,
- Identification of the interaction of potential stormwater wells and other stormwater management approaches with the freshwater lenses will be completed; and
- Identification of cumulative impacts and the selection of potential avoidance and mitigation opportunities.

4.4.6 Mitigation Measures

Mitigation measures will be assessed that avoid or minimise the potential geo-environmental impacts. These potential mitigation measures may include:

- Salvage and reuse mangrove peat, to the greatest extent possible;
- Ensure that aggregate for fill can be obtained from the licensed reserve in commercial quarries. Reduce need to fill by elevating roadway and employing other design options;
- Avoid placing staging and stockpile areas and access on peat and on or near freshwater lenses;
- Protecting peat and existing ground near freshwater lenses from compaction during construction with the use of low-impact construction vehicles and/or mats;
- Recommending portable hydrogen sulphide detectors and personal protection equipment, such as tight safety goggles and gas masks, during peat disturbance when working in poorly ventilated conditions to minimise health impacts from the potential release of hydrogen sulphide;
- Assessing the interaction of the wells and the freshwater lenses to prevent inadvertent draining of the lenses into underlying Karst formations through a comprehensive subsurface (i.e., drilling) program to determine the underlying stratigraphy to ensure minimal impacts to resources;
- Evaluate protection from regional head changes by requiring careful designing of the roadway in portions of the flow system supporting the lenses;
- Designing mitigation measures to maintain good water quality in the discharged water;
- Developing best practice pollution prevention techniques to minimise release of contaminants during construction and operation;
- Developing construction plans so that any discharges from the site to ground and surface water must meet applicable water quality discharge criteria;
- Determining stormwater management options that will avoid or minimise impacts on Lower Valley and North Side freshwater lenses and ensure that hydrological regimes are maintained, and aquifers are recharged like existing conditions;
- Designing stormwater systems so they will be effective with rising sea level both from surface and ground water, i.e., pump stations rather than gravity-based systems; and,
- Use of elevated structure in highly vulnerable areas.

4.5 Terrestrial Ecology

4.5.1 Introduction

The findings in the EIA Scoping Opinion included concern that the proposed EWA Extension Corridor could significantly affect ecological resources directly from construction activities and indirectly through operation of the roadway, resulting in a loss of function and value. Government commitments under the Cayman Islands Environmental Charter, NCA, and the National Biodiversity Action Plan require that this functional loss be evaluated with the goal of achieving No Net Loss of Biodiversity.

4.5.2 Baseline Conditions

The diverse habitats of Grand Cayman include dry forests, dry shrublands, and dwarf shrublands, typically occurring on land that is at least 6 ft. (1.8 m) above the groundwater table. Additional habitat types that are present within the island include: seasonally flooded forests, mangrove forests, coastal shrublands, and mangrove shrublands, along with limited sedge, tidally flooded succulents, and beach sand communities. The local climate is influenced by the location of the Islands and can be described as a tropical marine climate with two distinct seasons: a wet season from May through November and a relatively dry season from December through April (see prior discussion of climate trends in Section 4.1.4).

During the EIA process, technical reports, publications, government documents, websites, and the following GIS datasets, provided by the DoE, will be reviewed to develop a thorough understanding of the baseline existing conditions within, adjacent to, and in the vicinity of the proposed EWA Extension Corridor.

- Grand Cayman Landcover and Habitat (2018);
- Dry Forest Above 20-ft Elevation;
- Grand Cayman National Trust Sites (2022); and,
- Grand Cayman National Conservation Act Sites (2022).

Ecological resources identified within, adjacent to, or in the vicinity of the proposed EWA Extension Corridor **(Figures 16** and **17** and **Table 3)** include two National Trust sites, four NCA protected sites, and NCA marine protected resources. The remaining habitat within the Central Mangrove Wetland is also highly functional and biodiverse. Not included in the table but also of importance are ecologically sensitive areas that are not yet designated as Protected Areas under either the National Conservation Act or the National Trust Act immediately adjacent to the north and south of the proposed EWA Extension Corridor that may be affected by the proposed project. Marine turtle nesting beaches and critical habitat are located along the northern and southern side of Grand Cayman and will be considered when analysing the proposed EWA Extension Corridor.

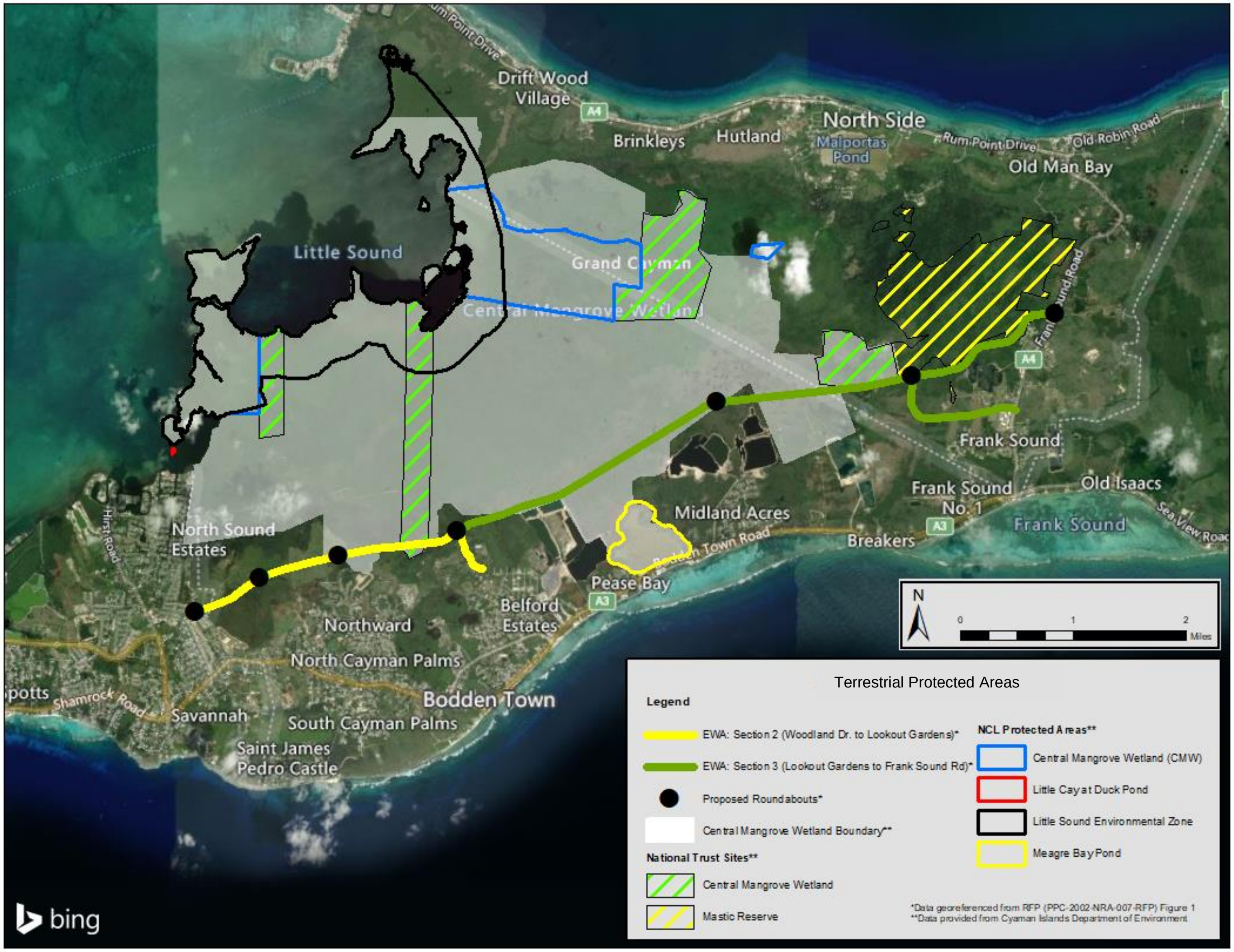
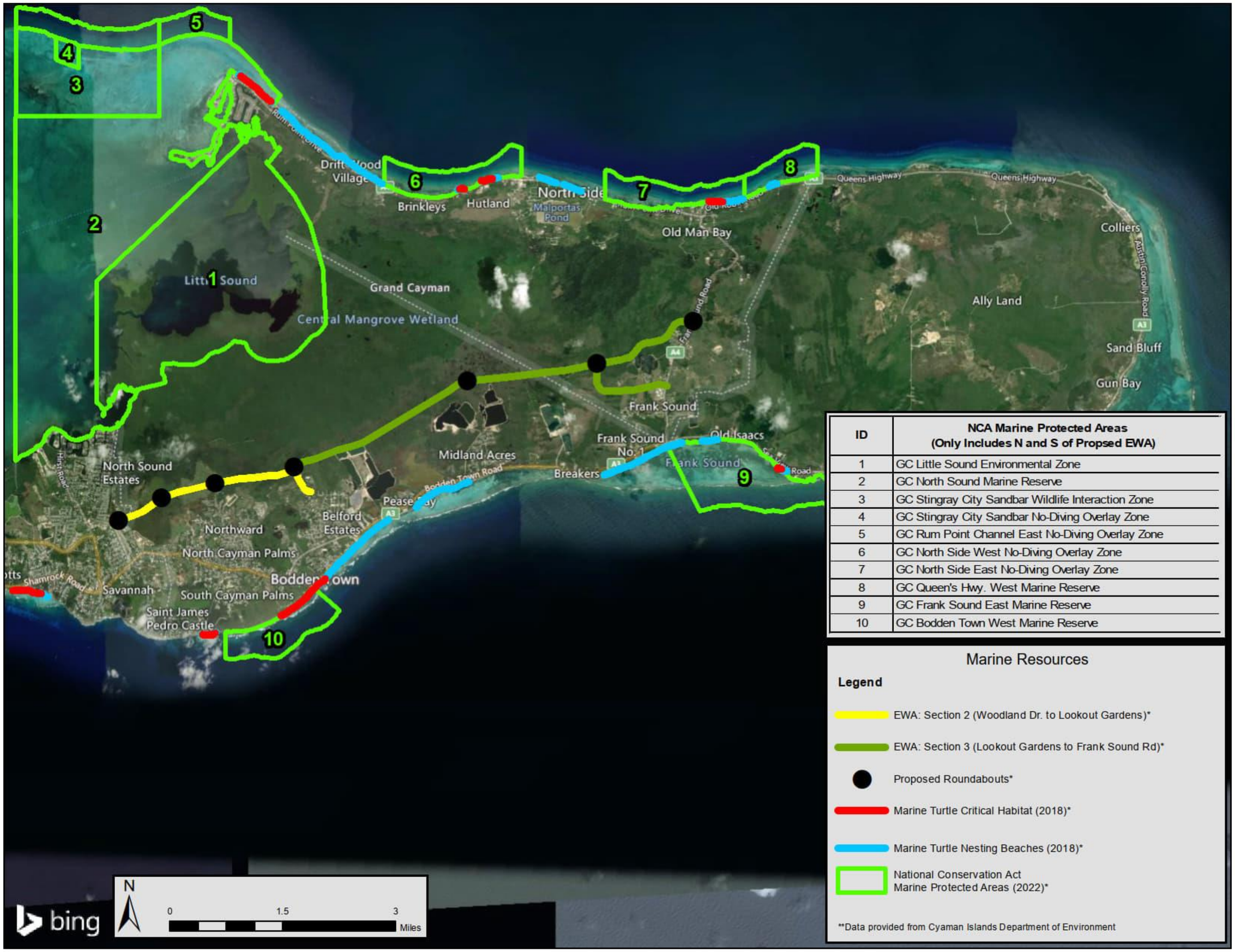


Figure 18: Map of Terrestrial Protected Areas



ID	NCA Marine Protected Areas (Only Includes N and S of Propsed EWA)
1	GC Little Sound Environmental Zone
2	GC North Sound Marine Reserve
3	GC Stingray City Sandbar Wildlife Interaction Zone
4	GC Stingray City Sandbar No-Diving Overlay Zone
5	GC Rum Point Channel East No-Diving Overlay Zone
6	GC North Side West No-Diving Overlay Zone
7	GC North Side East No-Diving Overlay Zone
8	GC Queen's Hwy. West Marine Reserve
9	GC Frank Sound East Marine Reserve
10	GC Bodden Town West Marine Reserve

Figure 19: Marine Resources and Marine Protected Areas

Table 3: Protected and proposed-for-protection sites within, adjacent to, or in the vicinity of the proposed EWA Extension Corridor.

Resource Name	Governing Entity	Approximate Distance and Direction from the proposed EWA Extension Corridor	Description
Central Mangrove Wetland Parcels	National Trust and NCA	Intersected Section 2 EWA Extension, ~1.6 mi (~2.6km) north of Section 2 ~1.5 mi (~2.4 km) north of Section 3	The Central Mangrove Wetland regulates nutrient flows to North Sound; provides storm and wave protection; sequesters carbon; and provides habitat for a wide assemblage of species. Meets criteria for designation as a Ramsar site*
Mastic Reserve	National Trust	Intersected by Section 3 EWA Extension (Section 3)	The Mastic Forest is the home to endemic flora and fauna and a rare variety of black mastic tree (*Termenalia eriostachya var margaretiae*). Also stores carbon, regulates overland water flow, and prevents degradation of the underlying freshwater lens.
Little Cay at Duck Pond	NCA	~1.4 mi (~2.25 km) northwest of Section 2	Small island located south of the Little Sound Environmental Zone
Little Sound Environmental Zone	NCA	~1.4 mi (~2.25 km) north of Section 3	Large, protected swath of the Central Mangrove Wetland that encircles the Little Sound.
North Sound Marine Reserve	NCA	~1.25 mi (~2 km) northwest of Section 2 ~4.5 mi (~7.25 km) northwest of Section3	A 13,838 ac (5,600 ha) semi-enclosed, shallow lagoon, historically fringed with mangrove swamp to the west, south, and east, and with an exposed fringing reef to the north.
Meagre Bay Pond and Animal Sanctuary	NCA has an adopted Management Plan	~0.6 mi (~1 km) south of Section 3	Pond with ~300-ft (~91-m)-wide band of surrounding mangroves. Provides seasonally important foraging habitat to resident and migratory birds. Meets criteria for designation as a Ramsar site*
Marine Turtle Critical Habitat	NCA	Designated shorelines north and south of the study area	Designated Marine Turtle Critical Habitat Protection Zones
Marine Turtle Nesting Beaches	NCA	Designated shorelines north and south of the study area	Designated Marine Turtle Nesting Beaches

*Ramsar Site: wetlands of international importance that have been designated under the criteria of the Ramsar Convention on Wetlands for containing representative, rare, or unique wetland types or for their importance in conserving biological diversity. The Ramsar Convention provides the only international mechanism for protecting sites of global importance and is thus of key conservation significance.

Portions of the proposed EWA Extension Corridor will be contiguous with identified areas of wetlands and uplands, including the Central Mangrove Wetland and Mastic Forest. Each of these ecosystems are unique and important to Grand Cayman. The Central Mangrove Wetland is about 8,500-acres (3,440-ha) in size and comprises approximately 30 percent of Grand Cayman, making it the largest contiguous mangrove wetland in the Caribbean. Much of the wetlands are still in their natural state and are comprised of dense red (*Rhizophora mangle*), black (*Avicennia germinans*), and white mangroves (*Laguncularia racemosa*) with buttonwoods (*Conocarpus erectus*) in more upland parts.

The Central Mangrove Wetland provides carbon storage, local climate regulation, water flow regulation, water quality improvement, habitats for wetland dependent species, and coastal protection. The Central Mangrove Wetland provides filtered water and nutrients to the North Sound which provides the base for the North Sound food web. The North Sound is directly linked to the Central Mangrove Wetland; consequently, effects to the Central Mangrove Wetland will also affect the North Sound ecosystem.

The Little Sound Environmental Zone is a large, protected swath of the Central Mangrove Wetland that encircles the Little Sound. Adjacent to the Little Sound is the North Sound, a 3,838 acres (~5,600 ha) semi-enclosed, shallow lagoon, historically fringed with mangrove swamp to the west, south, and east, and with an exposed fringing reef to the north. Both the Little Sound and North Sound provide habitat and nurseries for fish, clear water diving, and support many livelihoods on Grand Cayman.

The Mastic Forest is approximately 1,571.6 acres (636 ha) in size and is the largest contiguous evergreen woodland remaining on Grand Cayman. It represents one of the last remaining examples of Caribbean subtropical, semi-deciduous dry forest. The forest is largely untouched, other than selective logging and small-scale agriculture that occurred in the past. The part of Grand Cayman containing the forest has been above water nearly 1.9 million years longer than the rest of the island and is the location where the native flora and fauna evolved. Grand Cayman’s endemic orchids, trees, and birds inhabit this area along with other rare and protected species including a rare variety of black mastic tree (*Termenalia eriostachya var margaretiae*). Functions provided by the forest include carbon storage, local climate regulation, water for human consumption, water flow regulation, habitats, and water quality treatment.

4.5.3 Applicable Standards and Guidelines

The establishment of existing baseline conditions information described in Section 4.3.2 will be supplemented through consultation with local environmental organizations, field surveys, and available hydraulic and hydrologic modeling information. This baseline information will provide a reference for comparison for evaluating the potential effects from the construction of the proposed EWA Extension Corridor. The Chartered Institute of Ecology and Environmental Management’s (CIEEM) *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine* (Updated April 2022), will be used as guidance to develop the methods to identify current baseline conditions.

In addition to the CIEEM guidelines, other legislation and relevant Cayman guidance materials that will be consulted as part of the ecological studies include, but are not limited to:

- Cayman Islands National Biodiversity Action Plan (2009);
- National Trust Law (2010 Revision);
- National Conservation Act (2013);
- National Conservation (General) Regulations (2016);
- The Mangrove Conservation Plan (2020);
- National Conservation (General) (Amendment) Regulations (2021);
- Development and Planning Act (2021 Revision); and,
- Development and Planning Regulations (2022 Revision).

The Cayman Islands are also included in the UK's ratification of the following Conventions, which will also be consulted as part of the ecological studies:

- Convention on Biological Diversity;
- Convention on Wetlands of International Importance (Ramsar Convention); and ,
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

4.5.4 Potential Impacts

The potential impacts from the construction and operation of the proposed EWA Extension Corridor on terrestrial ecology will be determined during the EIA study. Additionally, potential secondary impacts to marine resources downstream and upstream of the project will be evaluated. As previously noted in the baseline conditions discussion, effects to the following ecological resources will be analyzed: the Central Mangrove Wetland, Meagre Bay Pond and Animal Sanctuary, Mastic Reserve, Little Sound Environmental Zone, North Sound Marine Reserve, mangrove habitat to the north and south of the proposed EWA Extension Corridor, Marine Turtle Critical Habitat, and Marine Turtle Nesting Beaches. The zone of influence for determining project impacts will be refined based on the data collected, the engineering designs, and on field assessments performed during the EIA studies. Direct and temporary impacts will be evaluated for the construction phase as will secondary, indirect, and cumulative impacts for the operation of the EWA Extension.

These effects to ecologic features from the construction and operation of the proposed EWA Extension Corridor will include, but are not limited to:

- Loss of habitat and habitat fragmentation;
- Loss of species through disturbance or wildlife-vehicle collisions;
- Restriction of animal migratory movements;
- Fugitive dust;
- Construction and roadway runoff (sedimentation and/or contamination);
- Construction and traffic noise;

- Light trespass into surrounding natural areas; and,
- Reduced hydrologic connectivity.

4.5.4.1 Potential Receptors

Potential receptors include those ecological features that are determined to be unique in context to the proposed project. An ecological feature as defined in the CIEEM Guidelines, pertains to habitats, species and ecosystems and their functions/features. Unique ecological features can be those that are rare; threatened; sensitive to anthropogenic impact; and/or designated or protected by international, national, and/or local regulations. The terrestrial and marine ecological features listed below, but not limited to, have been initially identified as potential receptors:

- Central Mangrove Wetland;
- Mastic Reserve;
- Little Sound Environmental Zone;
- North Sound Marine Reserve;
- Meagre Bay Pond Protected Area;
- Migratory birds;
- Protected Species (flora and fauna); and,
- Marine Protected Species.

The identification of any additional receptor sites will be evaluated as part of the EIA studies.

4.5.5 Assessment Methodology

Baseline existing conditions as described in Section 4.3.2 will be refined through continued desktop and field review assessments. Field biologists will characterize and map ecological features within, adjacent to, or in the vicinity of the proposed EWA Extension Corridor using hand-held GPS receivers. The use of drone technology to collect field data will also be utilised, as appropriate. Floral and faunal species and their respective habitats that may be affected directly or indirectly within, adjacent to, or in the vicinity of the proposed EWA Extension Corridor will be evaluated for potential construction and operational impacts including habitat fragmentation and roadway mortality.

Potentially impacted wetlands will be evaluated not only in terms of size and type, but also using established wetland functional tests that have been developed in the United Kingdom or in the United States. These tests have been designed and refined to not only look at quality and quantity of wetland vegetation but also the diversity they create for faunal species. The most relevant and current test is the Uniform Mitigation Assessment Method (UMAM) that provides a standardized rapid assessment method (RAM) tool for the determination of compensatory mitigation requirements to offset unavoidable impacts to mangrove wetlands and surface waters. UMAM evaluates the functionality of unavoidable impacts to tropical wetland ecological systems, including plant cover, benthic communities, and uplands in support of protecting wetlands. A detailed discussion of the importance of hydrology to the Central Mangrove Wetland and surrounding natural areas was explained in Section 4.3, but is noted here as well, as an important component of the terrestrial and marine ecology to be evaluated.

The results of the desktop and field reviews along with the hydraulic and hydrologic modeling data will be used to identify potential ecological effects of the proposed EWA Extension Corridor. The significance evaluation of the effects to ecological resources will be assessed by considering the following characteristics and assessed based on criteria presented in **Table 4**:

- Positive or negative – environmental change resulting in improved or reduced environmental quality;
- Extent – the spatial or geographical area over which the environmental change may occur;
- Magnitude – the size, amount, intensity or volume of the environmental change;
- Duration – the length of time over which the environmental change may occur;
- Frequency – the number of times the environmental change may occur;
- Timing – the periods of the day/year during which an environmental change may occur; and,
- Reversibility – whether the environmental change can be reversed through restoration actions.

Table 4. Magnitude of Change in Terrestrial Ecology Resources.

Magnitude of Change	Criteria and Resultant Effects
High	The change permanently (or over the long-term) affects the conservation status of a habitat/species, reducing or increasing the ability to sustain the habitat or the population level of the species within a given geographic area. Relative to the wider habitat resource/species population, a large area of habitat or large proportion of the wider species population is affected. For protected sites, integrity is compromised. There may be a change in the level of importance of the receptor in the context of the project.
Medium	The change permanently (or over the long term) affects the conservation status of a habitat/species reducing or increasing the ability to sustain the habitat or the population level of the species within a given geographic area. Relative to the wider habitat resource/species population, a small-medium area of habitat or small-medium proportion of the wider species population is affected. There may be a change in the level of importance of this receptor in the context of the project.
Low	The quality or extent of protected sites or habitats or the sizes of species' populations, experience some small-scale reduction or increase. These changes are likely to be within the range of natural variability and they are not expected to result in any permanent change in the conservation status of the species/habitat or integrity of the protected site. The change is unlikely to modify the evaluation of the receptor in terms of its importance.
Very Low	Although there may be some effects on individuals or parts of a habitat area or protected site, the quality or extent of sites and habitats, or the size of species populations, means that they would experience little or no change. Any changes are also likely to be within the range of natural variability and there would be no short-term or long-term change to conservation status of habitats/species receptors or the integrity of designated sites.
Negligible	A change, the level of which is so low, that it is not discernible on designated sites or habitats or the size of species' populations, or changes that balance each other out over the lifespan of a project and result in a neutral position.

4.5.6 Potential Mitigation Measures, Environmental Enhancements and Educational Opportunities

Mitigation measures will be investigated to offset unavoidable impacts from the proposed EWA Extension Corridor. The goal in developing mitigation measures is to best compensate for the functional loss resulting from unavoidable project impacts. Mitigation measures will be evaluated using the Natural England's Biodiversity Metric 3.1 Calculation Tool with the goal of achieving No Net Loss of Biodiversity. There is also opportunity for environmental enhancements and education; focusing on ecological regional improvements. Potential measures that may be investigated include, but are not limited to:

- Replacement of property;
- Conservation;
- Replanting/establishment of habitat;
- Dedicated wildlife crossings or protective fencing;
- Creation of hydrological components;
- Viewshed enhancements/Visual screening;
- Landscaping;
- Land contouring; and,
- Environmental awareness campaigns.

4.6 Cultural and Natural Heritage Sites

4.6.1 Introduction

Cultural and Natural Heritage sites are important resources on Grand Cayman. These heritage site resources include both designated features protected by legislation and features of national or local archaeological, historical, or architectural interest. Based on the type and location of the proposed project the studies for the EIA will focus on terrestrial heritage resources within the project study area.

Heritage site resources are identified and/or protected under the following legislation:

- NCA – Under Part 3-Conservation of Land, the Cabinet may designate any area of Crown Land or Cayman waters as a "protected area".
- National Trust Act
    - National Trust for the Cayman Islands (NTCI) ownership or management of specific sites – allows the NTCI to protect those sites from offences "for actions which could harm Trust property or otherwise contravene the purposes of the Trust." (National Trust Law, 2010 Revision).
    - Heritage Register – records the Islands' "natural, historic and cultural resources which are recognised and designated by the Council of the National Trust as being nationally significant and worthy of preservation." Entries are predominantly historic homes, civic and religious structures. Listing on the Heritage Register does not afford individual sites legal protection.
- Public Lands Act – affords legal protection to resources that are located within the public right of way.

4.6.2 Baseline Conditions

The EAB's EIA Scoping Opinion identified the proposed EWA Extension having the potential to impact two NTCI owned or managed areas: portions of the Central Mangrove Wetland and the Mastic Reserve. The Mastic Trail within the Mastic Reserve is also protected by the Public Lands Act, since it is within the public right of way.

The proposed EWA Extension has the potential to affect natural features from the southern portion of the Central Mangrove Wetland, along with the connection between the Mastic Trails' trailhead and parking lot. The Central Mangrove Wetland is one of the largest intact mangrove wetlands in the Caribbean and it is important to the health of Grand Cayman's ecosystem (NTCI, 2022). This mangrove wetland provides area for fish nurseries, storm protection, conditioning the flow of nutrients into North Sound, and filtration of surface water.

The Mastic Reserve contains the largest contiguous area of primary dry forest remaining on Grand Cayman and represents one of the last remaining examples of Caribbean subtropical, semi-deciduous dry forests (NTCI, 2022). It is home to several Cayman endemic species such as the Black Mastic tree, white-crowned pigeon, and Grand Cayman parrot. The forest regulates overland water flow and prevents degradation of the North Side freshwater lens, which it sits over. The

Mastic Reserve was established in 1992 and the 2.3-mile Mastic Trail was opened to the public in 1995, both providing recreational opportunities for hiking, wildlife viewing, and cultural identity.

4.6.3 Applicable Standards

A comprehensive review of applicable standards will be completed to ensure the project adheres to the required regulations and follows the most up-to-date guidance. Coordination with the DoE Research and Assessment Section will be undertaken to assist in determining the applicable standards that will be used for the assessment. The following standards will be reviewed and incorporated into the studies, as appropriate:

- National Environmental Policy Framework, 2002;
- National Biodiversity Action Plan, 2009;
- National Trust Act (2010 Revision);
- International Finance Corporation (IFC) Performance Standards (PS) on Environmental and Social Sustainability, 2012 such as:
    - PS No. 1: Assessment and Management of Environmental and Social Risks and impacts;
    - PS No. 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
    - PS No. 8: Cultural Heritage.
- National Conservation Act, 2013 and ancillary documents such as Species Conservation Plans and Management Plans;
- Directive for EIAs (2016) issued in accordance with The National Conservation Act (2013); and,
- Public Lands Act (2020 Revision)
- Development and Planning Act, 2021.
- Principles of Cultural Heritage Impact Assessment in the UK, 2021; and
- World Heritage Resource Manual: Guidance and Toolkit for Impact Assessments, 2022
- Institute of Environmental Management & Assessment (IEMA) Principles of Cultural Heritage Impact Assessment.

4.6.4 Potential Impacts

The proposed EWA Extension has the potential to affect portions of cultural and natural heritage sites within the project study area including the Central Mangrove Wetland, the Mastic Reserve and the Mastic Trail. The EIA studies shall investigate potential construction impacts including but not limited to:

- Land use changes – partial and full loss of property:
    - Severance or loss of features such that the physical or visual integrity of a cultural and natural heritage site is compromised and the ability to understand and appreciate the remaining elements may be diminished;
    - Permanent or temporary alteration and/or visual intrusion into the cultural and natural heritage site affecting the setting or character of a designated site; and
    - Access to the cultural and natural heritage site.

- Overall habitat reduction;
- Noise impacts associated with temporary construction and with the operation of the proposed EWA Extension;
- Cumulative effects from the accumulation of different effects on the same resource, or accumulation of impacts; and,
- Affects due to the potential release of contaminants that may potentially pollute sensitive habitats and the underlying aquifers.

4.6.5 Assessment Methodology

The assessment will gather critical information to understand the characteristics and the potential impacts of the proposed EWA Extension project on cultural and natural heritage site resources. The assessment will describe potential direct, indirect, and cumulative effects to the known heritage site resources within the study area and consider the protocol in the case of a discovery of unknown archaeological sites. Consultation with Cayman Island groups including, but not limited to the DoE, the National Museum, and the NTCI, along with local community members will be completed to aide in identifying any additional known and potential future heritage site resources during the assessment process.

The assessment shall include:

- A review of published data and publicly available information, including but not limited to:
    - The Land Reserve Fund;
    - The Historic Buildings and Sites Inventory;
    - The Conservation and Historic Preservation Awards;
    - National Trust Mastic Reserve and Trail data;
    - National Trust Central Mangrove Parcel data;
    - Published and unpublished sources (documentary material, archaeological and architectural studies, fieldwork reports, local histories); and,
    - Geographic Information System / Geotechnical data.
- A review of Mapping/Cartographic information.
- A review of the appropriate standards and guidelines as outlined in Section 4.4.3.
- A review of assessment guidance materials including but not limited to:
    - The Assessment and Management of Environmental and Social Risks and Impacts; PS Nos. 1, 6, and 8.
    - IEMA Principles of Cultural Heritage Impact Assessment in the UK; and
    - World Heritage Resource Manual: Guidance and Toolkit for Impact Assessments
- Consultation with project stakeholders including but not be limited to:
    - DoE;
    - NTCI;
    - Cayman Islands National Museum;
    - Cayman Islands National Archive;
    - Non-profit organizations;

- Interested stakeholders; and,
- Local community.

Based on the guidance documentation outlined above, the analysis will be divided into the following key steps:

Step 1. Establish understanding of cultural and natural heritage site resources:
Update baseline condition to include all reviewed material and consultation efforts noted above. This step will also include confirmation/identification of cultural and natural heritage site resources, establishment of current resources status, field reviews to determine each identified resource's current condition and sensitivity to impact, and coordination with project stakeholders to determine the context of each resource's importance. For example, is it important locally, nationally, or some combination. This data will be combined, and a scale will be developed to establish each resource's intolerance to change based on designated agreed upon status [the scale would be from 1 to 5 with 1 being the least intolerant to change] (**Table 5**). For example, if an identified resource's level of sensitivity is considered "very high" and importance is considered "high", then it would be given a value of 15, which would be most intolerant to change, whereas a resource considered "very low" in sensitivity and importance would be less intolerant of change (perhaps due to its use, a parking lot, that is only used by locals to access a trail, where minor changes would not affect the use of the property or its character).

Table 5: Understanding the Importance of Resources

Intolerance to Change		Importance of Resource		
		High (3)	Medium (2)	Low (1)
Sensitivity of Resource	Very High (5)	15	10	2
	High (4)	12	8	4
	Medium (3)	9	6	3
	Low (2)	6	4	2
	Very Low (1)	3	2	1

Step 2. Evaluate impacts:
This step will highlight the proposed changes that could potentially effect/impact the cultural and natural heritage site resources and will include an assessment of the change in the baseline condition if the proposed project is implemented. Equally important will be the assessment of how the baseline condition would change in the future without the proposed project. To properly consider these effects (direct, indirect, and cumulative) relative to these changing conditions and building upon the scale of importance developed in Step 1, the degree of the effect will be developed by determining the changes incurred by the resources and whether the change is considered significant. The degree of impact would also use a scale similar to that noted above. For example, shifting trail access may be a low degree of impact, whereas removing a substantial amount of forest from the Central Mangrove Wetland would be a high degree of impact. The impact value would then be combined with the intolerance to change to develop a weighted effect to each resource (**Table 6**).

Table 6: Evaluating the Degree of Impacts

Weight of Impact		Degree of Impact		
		High (3)	Medium (2)	Low (1)
Intolerance to Change	Very High (5)	15	10	5
	High (4)	12	8	4
	Medium (3)	9	6	3
	Low (2)	6	4	2
	Very Low (1)	3	2	1

Step 3. Document impacts:
Based on the impact findings, recommendations will be provided on potential opportunities to avoid or minimise impacts of the proposed EWA Extension upon the cultural and natural heritage site resources and compiled into a Cultural and Natural Heritage Sites memorandum that will be appended to the EIA.

4.6.6 Mitigation Measures

The EIA study will identify potential mitigation measures to compensate for the unavoidable impacts of the proposed EWA Extension. Potential mitigation measures may include, but are not limited to:

- Replacement of property;
- Conservation
- Replanting/establishment of habitat;
- Creation of hydrological components;
- Viewshed enhancements/Visual screening;
- Regional ecological restoration;
- Consideration of wildlife crossings to avoid habitat fragmentation;
- Landscaping;
- Land contouring; and,
- Environmental awareness campaigns

4.7 Greenhouse Gas Emissions

4.7.1 Introduction

The proposed project will require the removal of peat during construction, decreasing the amount of greenhouse gas (GHG) storage (specifically carbon storage), which would allow more GHG emissions to be released into the atmosphere. The main GHGs associated with peat removal are carbon dioxide (CO_2) and methane (CH_4). This assessment will include a quantitative annual and aggregated emissions total associated with the construction of the project. Operational GHG emissions based on expected traffic volumes and vehicle fleet will also be quantitatively determined for both pre- and post-construction operations. Pre-construction will include the expected GHG emissions for current traffic patterns, while post-construction will consist of the expected GHG emissions from the new arterial.

4.7.2 Baseline Conditions

The DoE states that the Cayman Islands emitted a total of metric tonnes of CO_2 in 2014 was 714,000, with the majority derived from the energy supply and transportation sectors (DOE, 2022). Additionally, the European Commission's Emissions Database for Global Atmospheric Research (EDGAR) provides emission estimates for the Caymans through 2021 (European Commission, 2022). In the framework of the United Nations Framework Convention on Climate Change (UNFCCC), countries are developing national emissions inventories and propose/implement actions to mitigate GHG emissions. CO_2 emissions, which are mainly responsible for global warming are still increasing at world levels despite climate change mitigation agreements. In this context, EDGAR provides an independent estimate of greenhouse gases for each world country, based on a robust and consistent methodology stemming from the latest Intergovernmental Panel on Climate Change (IPCC) guidelines and most recent activity data.

The EDGAR data are broken down into five general categories which are provided in **Figure 18** from 2010-2021. The decrease in 2020 and abrupt increase in 2021 are most likely a direct reaction to the COVID-19 pandemic and reopening. In a literature search, it was noted that there are multiple GHG datasets that illustrate minor differences of island-wide emissions, but generally the levels are generally similar. Greenhouse gas emissions do not have a direct effect on receptors, although they do influence overall changes in climate over a prolonged period.

In September 2011, the National Climate Change Committee issued a draft Climate Change Policy, which is undergoing revisions and updates. The updated policy's goals will be incorporated into the EIA process once it's released. The current policy outlines a series of goals which include:

- Reducing GHG emissions in line with national targets;
- Setting a national GHG reduction target;
- Encouraging energy conservation and renewables;
- Creating and maintaining a more environmentally responsible tourism sector; and,
- Developing and adopting an energy code and supporting legislation to increase energy efficiency amongst all sectors.

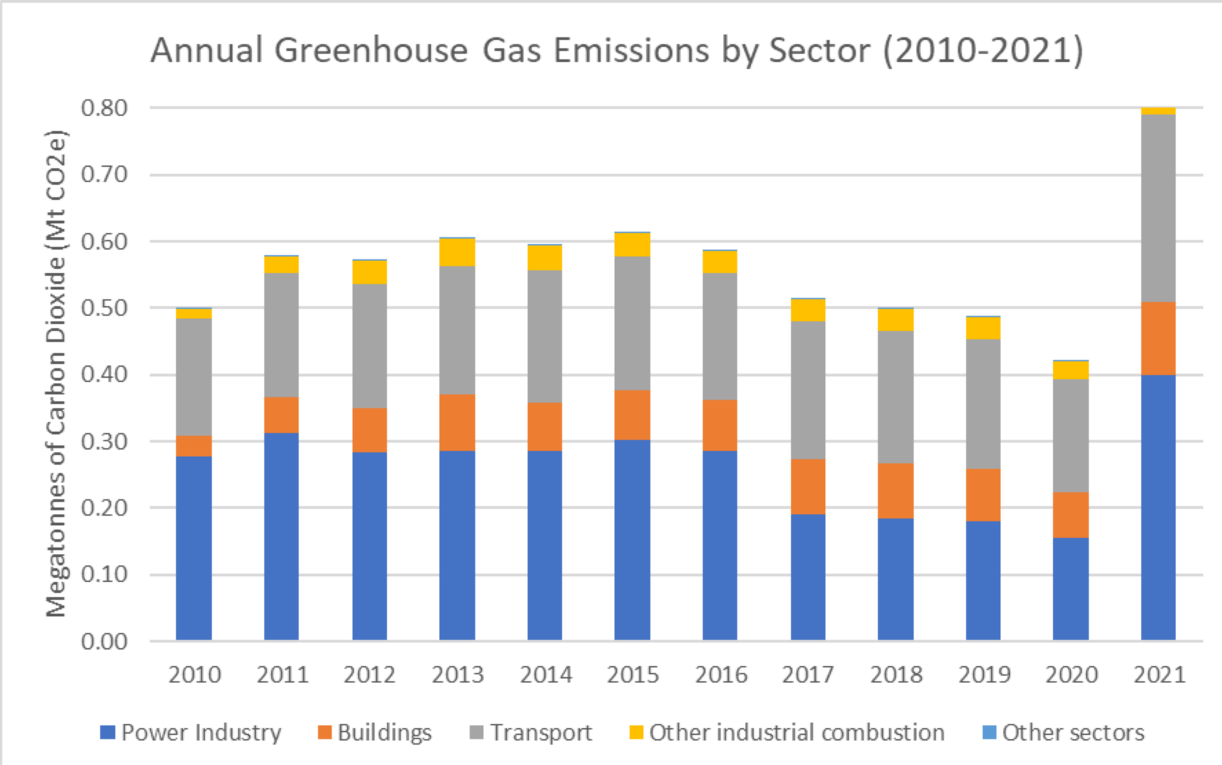


Figure 20:21 Annual Greenhouse Gas Emissions by Sector in the Cayman Islands (2010-2021)

Additionally, the National Energy Policy Unit (NEP) developed the National Energy Policy 2017-2037 (NEP, 2021). The focus is to utilise more renewable energy, promote energy efficiency/conservation measures, and reduce reliance of imported fossil fuels. As of 2014, the Cayman Islands produced 12.3 metric tons of CO_2 equivalent per capita. The 2030 goal is to reduce that to 4.8. Ultimately, the policy is geared toward 62% utility solar, 3% wind, 3% waste to energy and 2% distributed solar by 2037 (NEP, 2021).

4.7.3 Applicable Standards

Reporting on GHG emissions for the Cayman Islands is undertaken by the UK as part of its GHG emissions inventory obligations under the UNFCCC and the Kyoto Protocol. As part of this agreement, greenhouse gas emissions are reported annually by the Department of Environment for electricity generation and fuel consumption. Data is also collected and submitted on solvent use, waste management, mobile machinery, aircraft and air transport, shipping, and agriculture and forestry.

The air quality analysis will rely on standards and guidance as summarized below**.**

- Cayman Public Health Law, 2002 Revision;
- International Finance Corporation Guidance Note 3, 2006;
- Draft Cayman Islands' Climate Change Policy, 2011;
- UK National Highways: Introduction and General Requirements for Sustainable Development and Design (GG103), Revision 0, 2019;

- Cayman Islands National Energy Policy 2017-2037 (*2022 Progress Report forthcoming*), and,
- UK National Highways Carbon Tool Guidance Version 2.5, 2022.

4.7.4 Potential Impacts

The construction of the EWA extension will consist of potential GHG emissions associated with construction equipment and the removal of peat overburden within the project corridor. During construction, it is anticipated that there will be two primary sources of short-term GHG emissions: the operation of heavy equipment via combustion of diesel fuel, and tailpipe emissions from the vehicles that deliver the construction materials.

The removal of peat overburden is another source of GHG emissions of a more permanent nature. Peat and vegetation are terrestrial "sinks" that store atmospheric GHGs (specifically CO_2 and methane). Trial pit information collected in 2008 between Hirst Road and Lookout Road, showed that the proposed road corridor contains peat, although not in significant quantities. The proposed study area for the EWA Extension now stretches to Frank Sound Road, approximately 8 miles east of Lookout Road. The volume of peat may be much higher in the eastern sections, given the elevation and the characteristics of the wetlands in the corridor. When these carbon sinks are disturbed or removed, its potential to store carbon is reduced. This loss will be incorporated into the overall project impacts.

4.7.5 Assessment Methodology

The analysis will utilise the trial pit information collected from 2008 and supplement it with data collected from new pits further east along the proposed corridor, as needed, to establish average peat depths and total volume of peat expected to be removed. This data will be analysed to develop an accounting of: 1. the loss of carbon storage from the peat removal, which leads to increased GHG emissions, and 2. the release of GHG as the exposed peat begins decomposing. The analysis will also examine the loss of carbon sequestration services provided by the mangroves.

The GHG analysis will include the following emission sources to establish project totals.

- Construction Equipment tailpipe emissions;
- Material/delivery vehicle tailpipe emissions;
- Peat removal carbon sequestration losses; and,
- Road material (concrete, asphalt etc.).

A blended approach of modelling software and emissions factors guidance, as appropriate, including the IPCC Inventory Software, Version 2.691, with guidance from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (2006 IPCC Guidelines) and the *2013 Supplement to the 2006 IPCC Guidelines: Wetlands – Methodological Guidance on Lands with Wet and Drained Soils, and Constructed Wetlands for Wastewater Treatment* and the recommendations published in the December 2014 U.S. EPA Report EPA-420-R-14-030, *Emission Factor for Tropical Peatlands Drained for Oil Palm Cultivation: Peer-Review Report.* The analysis will include researching the current state of academic research into carbon sequestration in tropical and non-tropical peat and apply more recent emissions factors where appropriate, including reviewing the IPCC's Emission Factor Database and US EPA datasets.

Additional sources of GHG are associated with construction and heavy-goods vehicle movements from the demucking operations and production of concrete and aggregate material operations. The diversity of engine categories, sizes, and applications complicates the process of analysing non-road vehicles. Modelling is essential to identifying and assessing sources, forecasting future activity and emissions, and evaluating the impacts of potential projects.

The analysis will review favoured non-road emissions inventory models from the U.S. EPA (MOVES3 – NONROAD), European Environment Agency, and International Council on Clean Transportation to determine the most appropriate model to calculate non-road emissions in the Cayman Islands. These emissions are likely to be addressed by generating g/veh-hr emission rates for each type of construction equipment (equipment type and horsepower rating). These g/veh-hr rates will then be applied to project-specific activity data, such as number of units of each type of equipment and hours of operation during each phase of construction. A qualitative review of alternatives and route options, including the "no-build" alternative, will be provided along with a quantitative assessment of the preferred route. It should be noted that MOVES3 is also capable of generating methane emission factors for the construction equipment that are likely to be used on this project for earth/peat-moving, demucking, and heavy material haulage.

Operational emissions inventory development will also utilise MOVES3. The No-Build Alternative will include an evaluation of current traffic patterns at the worst-case intersections based on specific traffic data. These may include total number of vehicles per link (i.e. northbound left turn and northbound through), length of each link and the representative average speed. This scenario would be representative of 2023, but the vehicle fleet representative of the Caymans in the model would be approximately 15-20 years behind from an emission standards perspective on average.

Post-construction operational GHG emissions will be applied at the end of the construction schedule for the Year 2074. It will again be assumed that the vehicle emissions are 15-20 behind the model year.

To calculate non-road emissions, the analysis will make general assumptions regarding the following:

- Expected construction schedule;
- Expected total disturbance area;
- Construction activity
    - Total number of workdays per year
    - Daily schedule of operations (hr/day)
    - Expected type of equipment, size, and number (i.e., four 400 hp bulldozers)
- Expected number of material trucks per construction activity per day;
- Expected number of round-trip material trucks trips per day (i.e., 5 total trucks, 3 round trips per day for activity A); and,
- Expected round trip maximum distance (miles).

The United States Environmental Protection Agency (USEPA) and the State of Florida determines that 25,000 metric tonnes of GHG emissions requires reporting to the agency, and 100,000 metric tonnes equates to a large or major source. For the purposes of this analysis, the GHG project significance threshold will be equivalent to the large source threshold. If the project exceeds 100,000 metric tonnes CO_2e on an annual basis, mitigation measures as described in Section 4.7.6 will be implemented to reduce emissions. However, many of the mitigation measures will be utilized regardless of the projected emission totals. It should also be noted that all construction related GHG emissions will be short-term. Lastly, all scenario GHG emissions will be quantified and compared to each other and discussed qualitatively in a real-world context. This likely includes the use of the USEPA's GHG Equivalency Calculator[1]

4.7.6 Mitigation Measures

Greenhouse gases generated from road construction activities can include heavy vehicle emissions, type of pavement materials and methods, removal of vegetation, and soil disturbance. Potential mitigation measures to control or reduce greenhouse gas emissions are:

- Lowering asphalt production temperature and increasing recycling rates;
- Using cement clinker substitutes in concrete;
- Using scrap-based steel;
- Ensuring efficient use of materials (i.e., "right-sizing");
- Maintaining machinery frequently or replacing with newer machinery;
- Installing engine retrofit devices;
- Restricting vehicle idling;
- Using robust materials that require less maintenance, repair, and refurbishment;
- Choosing materials that can be reused or recycled instead of landfilled;
- Reducing amount of vegetation removed;
- Landscaping bare areas to re-establish vegetative cover; and,
- Revising road design to reduce the need for removal of peat overburden.

[1] USEPA Equivalency Calculator - https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

4.8 Noise and Vibration

4.8.1 Introduction

Noise and vibration generated by the construction and operation of a new road can change the environment. This can lead to effects on adjacent residential properties, protected species or other noise-sensitive developments. These effects may be increased if the construction is carried out during evening hours, when people are generally more sensitive to noise.

The assessment of noise and vibration will consider effects from construction noise, construction vibration, and operational noise caused by vehicles. Operational vibration is dependent on a well-maintained road surface free of irregularities and vehicle weight limit restrictions, thus operational vibration is unlikely to have the potential for significant adverse effects and will not be considered.

4.8.2 Baseline Conditions

Currently, there is no information available to quantify the baseline noise level for the EWA Extension study area. An initial desktop review of maps and aerial photography indicates that the main sources of noise in the vicinity of the EWA corridor would be ambient noise associated with the existing residential neighbourhoods, light commercial businesses, and quarries located south of the proposed EWA Extension corridor. The main source of noise for the uses along Bodden Town Road, Shamrock Road, and Frank Sound Road would be the traffic noise along the way.

To document baseline noise levels, noise monitoring shall be performed. To document hourly sound levels over a 24-hour period, two (2) long-term (24-hour) unattended measurements are proposed (**Figure 19**), one along the existing roadway and one in the vicinity of the proposed alignment. Additionally, approximately seven (7) short-term (20-minute) attended measurements would be conducted in the vicinity of the new alignment, Frank Sound Road, Bodden Town Road, and Shamrock Road (20-minutes is typically sufficient to obtain a representative value of steady background and ambient noise). For measurements along existing roadways, traffic shall be conducted concurrently. The measurement devices shall be Type I ANSI sound level meters. Measurements shall be carried out under dry conditions when the road surface is dry and wind speeds are 11.2 mph (5 m/s) or less.

In accordance with the Design Manual for Roads and Bridges, (DMRB), the study area for the new roadway shall extend approximately 2,000 ft (600 m) to each side of the proposed roadway, and 165 ft (50 m) to each side of existing roadways.

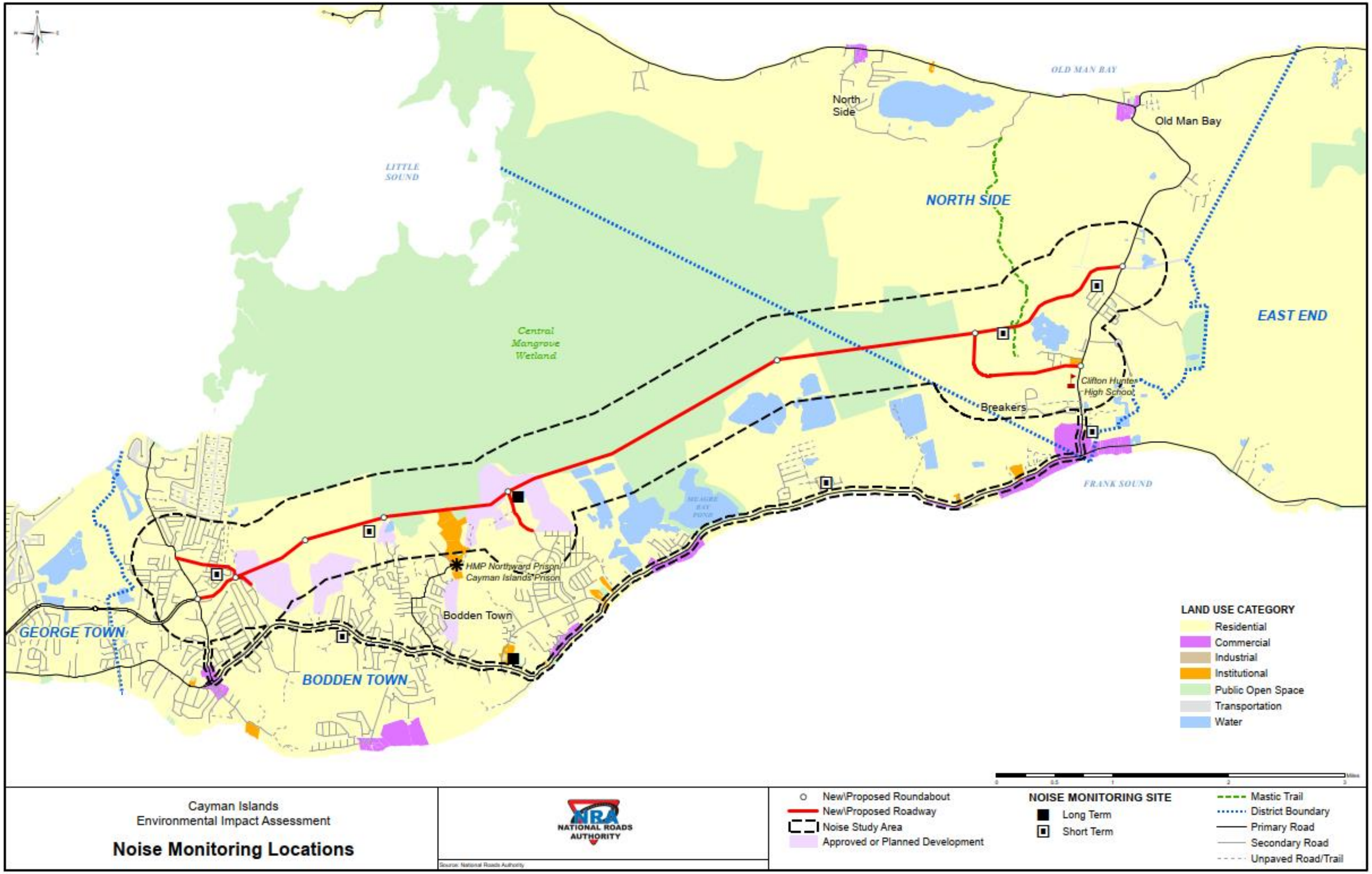


Figure 19: Noise Monitoring Locations

4.8.3 Applicable Standards

Since the Cayman Islands Government does not have published standards or guidance on noise and vibration, this assessment will rely on the DMRB Noise and Vibration Manual, reference document LA 111, supplemented by the Institute of Environmental Management and Assessment (IEMA) Guidelines for Environmental Noise Impact Assessment.

Additional applicable standards to be considered are as follows:

Operation Noise:

- The Noise Policy Statement for England, 2010;
- Guidelines for Environmental Noise Impact Assessment, Institute of Environmental Management and Assessment, 2014;
- Development and Planning Act, 2021 Revision; and,
- Development and Planning Regulations, 2022.

Construction Noise:

- BS 5228: Code of practice for noise and vibration control on construction and open sites; Part 2: Vibration, British Standards Publications, 2014;
- Cayman Islands Builders Act, 2020 Revision;

Construction Vibration:

- BS 6472: Code of practice for noise and vibration control on construction and open sites – Part 1: Noise, British Standards Publications, 2018;
- BS 5228: Code of practice for noise and vibration control on construction and open sites; Part 2: Vibration, British Standards Publications, 2014;
- Cayman Islands Builders Act, 2020 Revision;

4.8.4 Potential Impacts

The proposed EWA Extension has the potential to generate noise and vibrations at a level to affect sensitive receptors. Construction noise levels can range from barely perceptible to annoying or even hazardous. Ground vibration associated with construction can create a wide range of issues for structures, from foundations cracking or softening the soil causing the structure to settle, depending on the amplitude, frequency, duration, and the engineering properties of the structure.

Adjacent to the EWA corridor, there are potential sensitive/local receptors that have been initially identified through aerial photography. Sensitive receptors that may experience construction or operational noise impacts may include residential and other properties close to the proposed project, as well as along roads that may intersect with the proposed project, including the following:

- Residential housing along Will T Road, Fig Tree Drive and Dominica Drive;
- Cayman Islands Prison and HMP Northward Prison;
- Potential residences and dwellings along Lookout Road;
- Users of the Mastic Trail;
- Protected species within the Mastic Reserve and Central Mangrove Wetland;

- Housing west of the Frank Sound Fire Station; and,
- Clifton Hunter High School.

The significance of the effect is dependent on both the sensitivity of the receptor and the magnitude of the impact at the receptor. Receptor sensitivity and the assessment criteria for magnitude of change is derived from the criteria in the DMRB.

The DMRB determined the significance of noise effects by establishing the no observed effect level (NOEL) and both the lowest observable adverse effect level (LOAEL) and the significant observable adverse effect level (SOAEL) for all noise sensitive receptors within the corridor during the time periods when they are typically in use (for example schools would only need daytime LOAELs and SOAELs). NOEL is the “level below which no effect can be detected…below this level, there is no detectable effect on health and quality of life due to the noise.” LOAEL is “the level above which adverse effects on health and quality of life can be detected.” SOAEL is “the level above which significant adverse effects on health and quality of life occur” (DMRB). DMRB established LOAEL and SOAEL for operational noise, as shown in **Table 7.**

Table 7: Operational Noise LOAELs and SOAELs

Time Period	LOAEL	SOAEL
Day (06:00 – 24:00)	55 dB $L_{A10,\ 18hr}$ (façade)	68 dB $L_{A10,\ 18hr}$ (façade)
Night (23:00 – 07:00)	40 dB L_{night} outside (free-field)	55 dB L_{night} outside (free-field)

The magnitude of impact for both operation of the new facility and construction traffic on the existing roadways is based upon the Baseline Noise Level (BNL). **Table 8** displays the Magnitude of Impact that would occur for sensitive receptors located near the roadway, during the long-term. The long-term analysis compares the Do Minimum Opening Year (DMOY) to the Do Something Future Year (DSFY). For the purposes of this analysis, the magnitude of operational noise will be studied for the long-term. **Table 9** displays the Magnitude of Impact that would occur for sensitive receptors near roadways used for construction traffic.

Table 8: Magnitude of Operational Change at Receptors

Long Term Magnitude	Long Term Noise Change (dB $L_{A10,\ 18hr}$, or L_{night})
Major	≥ 10
Moderate	5.0 - 9.9
Minor	3.0 - 4.9
Negligible	≤ 3.0
Note: Difference in change of baseline noise level and operational noise level	
* Design for Roads and Bridges – LA 111 Noise and Vibration	

Table 9: Magnitude of Impact at Receptors

Magnitude of Impact	Increase in BNL of Closest Public Road Used for Construction Traffic (dB)
Major	≥ 5.0
Moderate	≥ 3.0 and ≤ 5.0
Minor	≥ 1.0 and ≤ 3.0
Negligible	≤ 1.0
* Design for Roads and Bridges – LA 111 Noise and Vibration	

4.8.5 Assessment Methodology

A noise model shall be prepared using the U.S. Federal Highway Administration (FHWA) Traffic Noise Model ® (TNM v3.1). TNM v3.1 is the United States approved highway noise prediction model. FHWA's TNM calculates sound levels in a similar approach to the UK's Calculation of Road Traffic Noise (CRTN) spreadsheet calculations; however, TNM is composed of many variables that allows for the calculation of many receptors at once at varying distances with variations accounting for vehicle type and speed, as well as topography and shielding. This software creates a 3-D model of the existing roadways, the proposed roadways, noise-sensitive receptors, and topography to use traffic volumes and speeds to predict sound levels. The noise data collected during the short-term monitoring, as well as field notes, topography, and aerials shall be used to develop the existing model. Traffic data collected along existing roadways shall be entered into the model. The results shall then be compared to the data collected during noise monitoring (validation) to ensure the model accurately reflects existing conditions of the area.

Additional modelling points will then be added to represent noise-sensitive receptors that would most likely be affected by the proposed development. This would include existing or planned residential dwellings, schools, hospitals, community facilities, places of worship, open air amenities (including the Mastic Trail), cemeteries, farms/kennels, and wildlife sites (including the Mastic Preserve and the Central Mangrove Wetlands). The sound levels reported from the model would represent the BNL.

Operational Noise Impact Analysis

Existing DMOY and DSFY TNM-classified hourly traffic volumes and speeds calculated from traffic diagrams (for all roadways carrying traffic within the project corridor) will be input into the validated TNM models and TNM model elements will be incorporated into the validated TNM model(s) to represent the project design. TNM-predicted traffic noise levels will be evaluated at all project noise-sensitive receptors for the DMOY and DSFY conditions. Traffic noise impacts will be assessed per the DMRB criteria. DSFY noise level impact contours will be identified to assist land use planning efforts by the local governments.

Construction Noise Impact Analysis

Project-related construction noise will be evaluated for potential impacts to noise-sensitive receptors throughout the project corridor, and in areas of anticipated project construction activities outside the project corridor, specifically along construction haul routes. The degree of noise impact will vary, as it is directly related to the types and number of equipment used. Any noise impacts that do occur, as a result of roadway construction measures, are anticipated to be temporary in nature and will cease upon completion of the project construction phase. While noise levels will vary for different construction tasks, the maximum expected noise levels would occur from stages of construction involving heavy equipment.

All residences and exterior frequent-human-use areas near the proposed alignment are most likely to be temporarily impacted by loud construction activities. Should extremely loud construction noise activities such as usage of pile-drivers and impact-hammers (jack hammer, hoe-ram) be needed, they will provide sporadic and temporary construction noise impacts in the near vicinity of those activities. It is the recommendation that construction activities that will produce extremely loud noises be scheduled during times of the day when such noises will create as minimal disturbance as possible.

Construction Vibration Impact Analysis

Construction vibration is rarely associated with building interruption or damage, but may, at times, reach levels of perception and annoyance to the general population in areas closest to the source. Continuous vibration inducing activities (i.e., pile driving) can increase the possibility of damage and perception, depending on the receiver's positioning to the source. These types of vibration effects are also contingent upon source, path, and receiver adjustments. In most cases, peak vibrations due to construction activities will only last as long as the immediate impact and then quickly dissipate to less significant levels. A qualitative assessment of vibration influences from the proposed project will be undertaken to predict possible impacts to adjacent land uses. Assumptive adjustments to the source, along the path, and at the receiver will be applied to identify the sensitivity and magnitude of the vibration effects.

To calculate construction noise and vibration impacts, the analysis will make general assumptions regarding the following:

- Expected construction schedule;
- Expected total disturbance area;
- Construction activity
    - Total number of workdays per year
    - Daily schedule of operations (hr/day)
    - Expected type of equipment, size, and number (i.e., four 400 hp bulldozers)
- Expected number of material trucks per construction activity per day;
- Expected number of round-trip material trucks trips per day (i.e., 5 total trucks, 3 round trips per day for activity A); and,
  Expected round trip maximum distance (miles)

4.8.6 Mitigation Measures

While some noise and vibration disturbances to populated residential areas may be inevitable given the inherently noisy operations associated with a road construction project, the NRA is committed to control and minimise construction noise and vibration using all reasonable (i.e., cost implications) and feasible (i.e., physically achievable) means available.

At the conclusion of the noise and vibration impact assessment, the Project Team will analyse the feasibility and reasonableness of potential noise mitigation measures for those locations meeting or exceeding the DMRB SOAEL criteria. Primary abatement measures that would be analysed would be alteration of vertical or horizontal alignments.

The noise and vibration assessment will also include an evaluation of potential construction-related impacts and an evaluation of feasible noise and/or vibration mitigation measures where major impacts are expected. This analysis will be conducted in accordance with DMRB LA 111 and IEMA Guidelines for Environmental Noise Impact Assessment.

Noise compatible land use planning is one of the most effective means to prevent future traffic noise impacts. The compatibility of highways and neighbouring local areas is essential for continued growth and can be achieved if local governments and developers require and practice noise-sensitive land-use planning. Information from the noise analysis will be shared with the local jurisdiction with zoning control for their consideration should they choose to develop policies and/or ordinances to limit the growth of noise-sensitive land uses located adjacent to roadways.

Chapter 5

Summary of Direct, Indirect, and Cumulative Effects

5 Summary of Direct, Indirect, and Cumulative Effects

The following matrix (**Table 10**) will be completed to summarize the severity of direct, indirect, and cumulative impacts from each resource element (i.e., none, slight, moderate, substantial, very substantial) by alternative evaluated in the EIA, including a summary of key issues and recommended mitigation measures.

Table 10: Summary of Severity of Direct, Indirect, and Cumulative Impacts

Criteria	Beneficial Impact		No Impact	Adverse Impact		Cause & Mitigation
	Extent	Short or Long Term		Extent	Short or Long Term	
Socio-Economic Impacts:						
Hydrology & Drainage Impacts:						
Geo-Environmental Impacts:						
Terrestrial Ecology Impacts:						
Cultural & Natural Heritage Impacts:						
Greenhouse Gas Impacts:						
Noise & Vibration Impacts:						

Chapter 6

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